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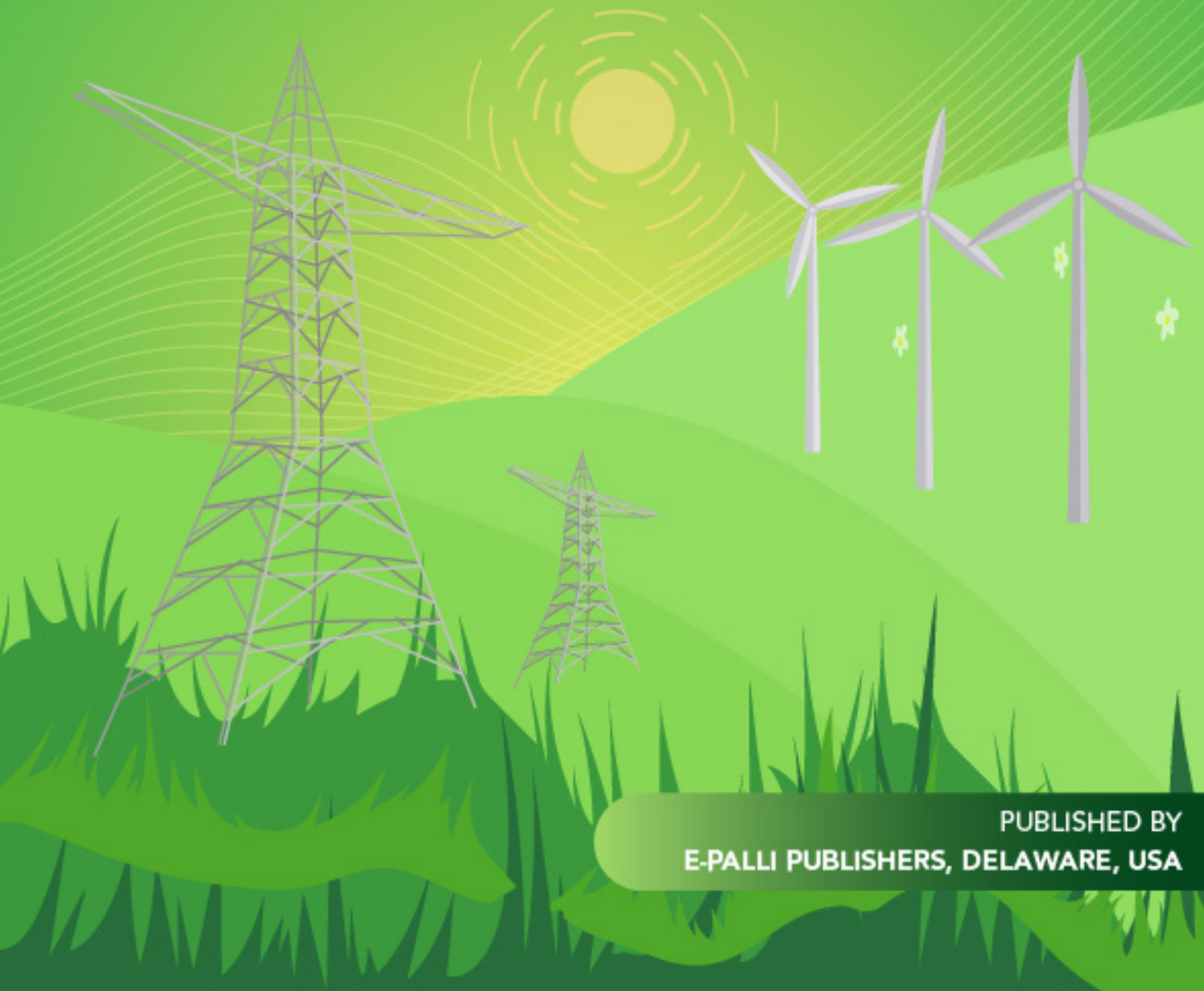

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Community Perceptions of Nature Based Solutions for Climate Adaptation in Kalapara Coastal Bangladesh

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ABSTRACT

Coastal adaptation needs strategies that reduce exposure to the environment and maintain the livelihoods of people whose lives rely on the natural environment. The study focuses on the perception of the effectiveness of NbS for climate adaptation by people in the community from Kalapara Upazila in Patuakhali District, Bangladesh. A mixed methods design was used which relied on four key informant interviews, two focus group discussions (25 participants) and field observations in addition to a structured survey of 100 households in five villages. Data was collected in June and July 2026. Data from the household responses was analysed descriptively and qualitative evidence was coded thematically and combined with quantitative responses. The main hazard category reported, 39% of respondents, was cyclones combined with salinity intrusion and agriculture was the most reported sector, 52%. The level of agreement with the perceived benefit of NbS was at 97% for reducing cyclone and storm surge impacts, 91% for protecting agricultural land, 91% for enhancing income opportunities, and 88% for enhancing biodiversity and ecosystem health. The participation in tree planting and willingness to participate in future initiatives were both 98%. 89% of the respondent's said NGOs were information providers. Areas of priority for implementation consisted of financial support, practical training, maintenance and institutional engagement. The results show that Eba is well received by the community and that a holistic framework that has links between coastal restoration, household livelihoods and participatory management is supported. This acceptance can become a lasting basis for adapting in a Kalapara if it is backed by ongoing investments and locally organised stewardship.

INTRODUCTION

Climate risk faced by coastal communities is compounded by the interdependent environmental and livelihood stressors. The damages to housing and vegetation can happen within hours due to cyclone, and saline inundation can persist beyond the immediate emergency and impact the cultivation, drinking water and expenditure for households. Erosion causes loss of productive areas and of settlement space and poor drainage increases the period of water logoing (Caroppi *et al.*, 2024). These processes relate disaster exposure to day-to-day decisions on food production, employment, use of resources, and recovery. Adaptation thus needs an appreciation for how households face various hazards jointly and how environmental management can help build their ability to continue their key activities.

An examination of these relationships in the context of the coastal settlements of Bangladesh is important as the settlements themselves are embedded in a dynamic deltaic landscape (Shammin *et al.*, 2022). Household welfare is linked to ecological change through agriculture and fishing, aquaculture and wage employment. Production exposure to wind, waves, flooding and erosion are same as production exposure to landscapes. As a result, coastal forests and mangroves, as well as wetlands and vegetated homesteads are important, not only for conservation, but for many other reasons as well (Castelo *et al.*, 2023). They have to deal with the availability of resources; with the security of productive assets; with the conditions under which households will be able to maintain livelihoods and face environmental disturbances.

The linkages of Kalapara Upazila in Patuakhali District are clearly exemplified (Leal Filho *et al.*, 2022). Being adjacent to the Bay of Bengal and the presence of rivers makes settlements vulnerable to cyclones, storm surges, salinity intrusion, erosion and tidal flooding. Community livelihoods rely on resources that are vulnerable to these hazards, and coastal vegetation/wetland environments offer opportunities for adaptation (Haque *et al.*, 2022). Tree planting, mangrove restoration, home gardening and related resource management activities have already been incorporated in the existing adaptation landscape. It is important, then, to know how residents are judging these practices in order to decide their future, whether to improve or to continue, or incorporate them into more comprehensive development planning (Woroniecki *et al.*, 2022).

Conventional coastal protection measures include embankments, drainage structures, cyclone shelter etc. These investments have fundamental protective and preparedness roles, and ecosystem management aims at tackling other links between environmental conditions and household welfare (Mashiyi *et al.*, 2023). Vegetation can play a role in stabilising exposed landscape and diversified production can aid food and income options. However, this integration of an adaptation strategy can

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link these functions; considering the management of living systems as well as infrastructure and emergency preparedness (Faisal *et al.*, 2021). This is especial*ly* important when households are facing both a sudden disaster and ongoing stresses to land, water, and jobs.

NbS offer a lens on how to tackle societal issues using NbS to protect, restore and effectively manage ecosystems. In coastal environment, this involves interventions to integrate ecological functions, disaster risk reduction and livelihood security. Mangrove restoration and coastal afforestation happening at the shoreline and landscape scale, while the homestead garden and tree planting happens at the household scale. These are only of value if they are ecologically appropriate, are available for maintenance and if people can be involved and benefit meaningfully (Jordan *et al.*, 2023). It is therefore important to comprehend how these interventions relate to local adaptation practices, through an understanding of community knowledge.

Evidence gathered from an assessment of community perceptions gives insight to the benefits that the community members identify and the kind of support they feel they need. Adaptation is judged based on hands-on experiences like land cultivation, home protection, food acquisition and income opportunities (Quattrone, 2023). Institutional stakeholders bring complementary contribution of technical requirements, implementation arrangements, programme continuity (Seddon, 2022). These perspectives converge in favour of a socially-informed understanding of adapting to nature. It also serves to pinpoint areas of high acceptance that can be transformed into organised participation and long-term management of the ecosystem.

This study focuses on the NBs in five climate exposed villages of Kalapara based on household, community and institutional evidence. It aims to determine the key hazards mentioned and sectors impacted, analyze awareness and participation, measure perceived environmental and livelihood gains and prioritize implementation (Kim *et al.*, 2021). The analysis will use the effectiveness that residents feel and stakeholders talk about. It draws linkages between those perceptions and reality on the ground where adaptation programmes are put in place and sustained, providing locally informed guidance for the coastal restoration, livelihoods and participatory governance.

LITERATURE REVIEW

Nature Based Adaptation and Ecosystem Functions

NbA puts ecological processes on the menu of climate change risk management. Path 1) The central idea is that healthy ecosystems have a positive role in promoting social welfare, with the services they provide to humans involving habitat provision, soil protection, water regulation and livelihood support (Ashrafuzzaman, 2023). These services come together in coastal areas as spatial interactions. Vegetation can contribute to domestic purposes on a homestead, and affect a larger landscape on a coastal forest (Vasseur, 2021). These relationships are important to recognise when planning adaptation in order to ensure that the ecological conditions and availability of resources in one location are not compromised by the actions taken at another.

In coastal regions, mangroves or coastal forests are of particular relevance for exposed shorelines. The roots and vegetation help to bind the sediment, stabilize the soil and moderate the movement of the water. These functions are conditioned by physical habitat, vegetation type and condition of the surrounding ecosystem (Widelska *et al.*, 2023). Restoration is more than simply planting trees in a space that is available, therefore. Whether planting grows to form working habitat depends upon the appropriate species, appropriate planting locations, provision of water, protection during establishment, and subsequent maintenance (Perricone *et al.*, 2023). An intervention's adaptation value also includes the ecological quality of the intervention.

This view is extended beyond the shoreline vegetation by wetlands and natural drainage systems. Agricultural areas are connected to settlements, canals and receiving environments by water movement (Gijsman *et al.*, 2021). The maintenance of such connections can help with drainage, and minimize waterlogging under certain conditions. A canal and wetland's ecological and hydrological functions, and the needs of surrounding users therefore form the basis of its adaptation relevance (Stefanakis *et al.*, 2021). Existing resource use and impacts of management decisions on neighbouring households, farmland and aquatic habitats should be considered in defining restoration objectives.

There also needs to be particular regard given to the link between livelihoods and ecosystems integrity. When an activity is associated with natural resources, it is most relevant to the field of Nature based adaptation if it is managed in a way that also contributes to the ecological function of that resource and other social benefits (Keesstra *et al.*, 2023). In the light of the resource and livelihood impacts, therefore, homestead production, integrated farming and saline aquaculture should be considered. In Kalapara these practices are part of the local adaptation portfolio that is reported to happen (Johnson *et al.*, 2022). When the benefits of households, vegetation, soils, water and habitat maintenance are all talked about, their interpretations become more apparent.

Livelihood Diversification and Household Resilience

Household resilience is about having the capacity to continue with necessary activities, to react to the disturbance, and to 'reorganise' livelihoods to adapt to changes (Slinger *et al.*, 2021). The incomes of coastal households can be related to activities in which they earn income that varies according to the weather, the environment, and the availability of seasonal opportunities. With disruption in the primary source of livelihoods, the access to supplementary food and/or income becomes significant. NBLs can help build this

capacity by linking production to land, labour and skills available within the household (Hagedoorn *et al.*, 2021). Their relevance is twofold; in the resources that they produce and in their flexibility that it brings to livelihood management.

For example, bringing production closer to the household, as in the case of homestead gardening, works well. Food for consumption can be provided from gardens and opportunities for selling surplus products can be created and in the longer term the tree can contribute their own products (Runkle, 2022). These advantages are subject to planting options, water resources, management and access to appropriate space. The value gardening has for the household can thus be recognized through the frequent application and the evident yield. This visibility can impact on recognition of practice and a desire to continue it, especially if other income sources are vulnerable to interruption (Cilliers *et al.*, 2022).

Diversification also has to do with the relationship among activities. A portfolio of a household might include a combination of fishing and/or wage jobs and home production and offer a number of ways to satisfy needs (Ihinegbu *et al.*, 2023). Adaptation planning needs to take into account which activities share hazards, needs or other resources, or value different times of the year. Complementary livelihoods can enhance the value of ecosystem management by linking ecosystem protection with daily benefits (Roy *et al.*, 2022). This outlook embraces an evaluation approach which takes both the environment and livelihoods into account rather than separate results of unlinked interventions.

Participation and Collective Stewardship

Community participation links adaptation programmes with local knowledge, labour and decision making. Residents have experience with water movement, exposed areas, planting conditions and plant patterns of use. If they are part of this process, it can increase the match of an intervention to the context in which it is to be implemented (Barquet *et al.*, 2021). Participation also assists in creating accountability for ongoing maintenance of vegetation, shared areas and restored habitat. These functions are particularly appropriate in situations where the benefits are slowly realized and beyond the initial establishment period (Csete & Poyraz, 2022).

There are a number of ways people can participate, for instance, come to planting events, provide labour, be involved in planning, be responsible for maintenance (Islam *et al.*, 2023). The meaning of these forms varies in the sense of continuity of the programmes. Someone can make a donation towards tree planting and have little say in the plant species chosen and distribution of benefits. Thus, it is important to pay attention to the process of decision making as well as the implementation of activities within participatory governance (Paxton *et al.*, 2023). Willingness to contribute can be linked to opportunities for stewardship and shared responsibility by forming clear management arrangements.

There is also a variation in participation based on gender and livelihood position. People are increasingly exposed to various facets of environmental change due to a range of activities, such as household production, water management, fishing, cultivation, and wage employment (Caroppi *et al.*, 2024). The inclusive engagement helps adaptation planning benefit from this breadth of experiences. The involvement of various community groups can be facilitated through appropriate meeting schedules and accessible communication, as well as meaningful roles in decision making (Shammin *et al.*, 2022). In areas where the role of women in resource management is significant, women's knowledge is important for garden design, the act of planting and the arrangement of subsequent garden upkeep.

Information Institutions and Implementation

Awareness impacts how communities discover and realize an intervention is valuable and how they secure technical assistance. Communication can be through demonstration, training, extension visits and informal chats (Castelo *et al.*, 2023). Tends to be stronger when practices can be seen in the daily routines or when they offer benefits that can be easily seen by the households themselves. Landscape restoration sometimes needs further explanation as the functions are wider spread and of a longer duration. It is therefore crucial to communicate technical information and concepts in terms of local experiences of hazards, production and resource management (Leal Filho *et al.*, 2022).

There is the involvement of government institutions and non-governmental organisations (NGOs) and every of them brings different skills to this process (Haque *et al.*, 2022). Technical guidance and links can be established between public agencies and sectoral responsibilities and community engagement and field implementation can be supported by development organisations. Working together enables outreach, expert advice, and maintenance plans to assist each other. Coordination is invaluable because of the continuity and availability of support communities have (Woroniecki *et al.*, 2022). Shared planning can help ensure training, planting materials, restoration activities, and monitoring are targeted toward compatible objectives.

Finance has an impact on each aspect of implementation such as site preparation, establishment, maintenance, and post-damage recovery. It may take multiple efforts to achieve and consolidate the protective and livelihood roles of a restoration project (Jordan *et al.*, 2023). The financing arrangements should hence take into account the length of ecological development and the expenses to participating households. The conceptual underpinning is simple: social acceptance forms the basis for action, and technical and ongoing supports allow people to act on their social acceptance (Kim *et al.*, 2021). Collectively, these dimensions form the basis for analysing the current study.

MATERIALS AND METHODS

Study Setting and Research Design

The study was carried out in Kalapara Upazila, Patuakhali District of the south-central coastal region in Bangladesh. The area is exposed to the Bay of Bengal and it a has settlements related to riverine and coastal zones. It is engaged in livelihood activities such as fishing, agriculture, aquaculture and taking up daily jobs. Local adaptation activities are carried out in the context of cyclones, saline inundation, erosion, tidal flooding, and waterlogging. Encouragement of existing activities such as tree planting, coastal afforestation, mangrove restoration, homestead gardening and associated resource management are activities.

A mixed methods research design was used, which included a household questionnaire survey and key informant interviews, focus group discussions, and field observations. The household component captured distribution of reported hazards, awareness, perceived benefits and participation (Vasseur, 2021). Interviews gained institutional insights on implementation and technical support, and group discussions focused on community priorities and shared experience. Field observations provided context knowledge of the local environment and current interventions. These components were synthesized and used to present nature-based adaptation from household, community and institutional perspectives.

Sampling and Study Participants

Five villages have been selected on the basis of their exposure to coastal hazards and previous exposure to nature-based interventions. They were Char Dhulasar in Dhulasar Union, Mistripara in Latachapli Union, Nizamur in Mohipur Union, Nobipur in Nilganj Union and Devpur in Champapur Union. In the selected setting, 100 households were selected by simple random sampling in the study area. There were 44 males and 56 females who were household respondents, whose ages were within 19 – 60 years. Household survey is denominator of the quantitative results in this paper.

To gather professional knowledge, four key informants were selected purposively, based on their participation in adaptation activities. This comprised the Upazila Agriculture Officer, Assistant Director of the Cyclone Preparedness Programme together with members from Caritas Bangladesh and from Good Neighbors. A total of 25 community members who have experience of local climate risks and adaptation activities participated in two focus group discussions (Ashrafuzzaman, 2023). Qualitative sample participants were selected for the purposes of discussing operational responsibilities, community practices and implementation need. The various participant groups provided evidence based on their experience and relationship with adaptation programmes.

Data Collection Instruments and Procedures

Data collection was done in primary mode during June and July 2026. Our semi-structured household questionnaire included information on sex, age, education, household size, livelihood, income, climate hazards reported, climate change affected sectors, NB solution awareness, sources of information, participation, perceived effectiveness, requirements for implementation, recommendations. Outside the study sample, the instrument was tested and clarified for better understanding. The household survey was undertaken using face to face interviews, which allowed respondents to verbally reply directly to the questions put by the researcher and to give their answers in relation to practices them familiar in their own locality. The effectiveness questions focused on the four outcome areas: protection of agricultural land from salinity and erosion, improving household income opportunities, improving biodiversity and ecosystem health, and reducing the impact of cyclones and storm surges. These statements are presented in the study questionnaire on a five-point response scale. For the aggregated results displayed here, responses are displayed in the groupings of agreement, neutral and disagreement available for this study. This will maintain evidence as reported and give a consistent foundation for comparing perceptions across outcome areas.

Semi structured guides were used for the key informant interviews and focus group discussions. The topics to be addressed in the interviews were the main hazards, current interventions, technical requirements, institutional involvement, maintenance and future priorities. Group discussions covered experiences in the community, perceived benefits, participation and locally appropriate improvement (Widelska *et al.*, 2023). The qualitative data analyzed were interview notes and discussion records. Field observations facilitated the interpretation of setting and interventions, and secondary materials consulted for this study provided background information on coastal adaptation, ecosystem management and the broader nature of NbS.

Data Analysis and Integration

Household survey data was coded, entered and analysed using Microsoft Excel. Categorical responses were summarised by frequencies and percents, while respondents' age, size of household and monthly household income were described by means. Each percentage in the survey is equivalent in number to the number of households in the 100-household sample. Distributions of the reported responses are shown as categories of principal hazard. Percentages for information sources, recognised practices, participation activities and implementation challenges do not have to total 100%, as more than one response was allowed for each category.

Qualitative material was analysed by thematic approach. The interview and discussion notes were analysed, coded and categorised according to: climate exposure,

adaptation practices, perceived outcomes, participation, institutional support, and implementation priorities. Recurring observations were compared with the household distributions. Integration aimed at identifying 'agreement' between sources, and how institutional and community perspectives provided context around the survey results. Qualitative accounts are provided in the form of summarised themes (Perricone *et al.*, 2023). A separation between the reported experiences and their interpretation of the adaptation significance, and recommendations for the programmes, is maintained throughout the discussion.

Ethical Procedures

The participation was on a voluntary basis and informed consent was provided prior to data collection. Each of the participants was informed about the goals of the study, the academic usage of the information and the right to refuse participation or withdraw from it. Analysis and reporting of the data were done on the basis of confidentiality and anonymity. Household-level results are reported as a group and qualitative results are reported as a group within a household and/or a group within an institution, without revealing individual identifiers (Gijsman *et al.*, 2021). These are procedures that enabled: respectful interaction with communities; and appropriate use of information about livelihoods, environmental exposure and adaptation experiences.

RESULTS AND DISCUSSION

Respondent Characteristics and Livelihood Context

The proportion of women responding to the household accounts for 56% and men for 44%. The ages of the respondents ranged from 19 to 60 years and the mean age was 43.4 years. The average size of the household was 3.99 persons and the average monthly income of the household was BDT 22,075. 63% reported to have received primary education, 18% reported to have received higher secondary education, 3% reported to have received secondary education and 16% reported to have received no formal education. The proportion of day labourers and fishers was 47% each and that of farmers was 6%. These are the attributes of the households who in whose perceptions the assessment is based.

Table 1: Respondent and household characteristics

Characteristic	Category or measure	Value
Sex	Female	56%
Sex	Male	44%
Age	Range	19–60 years
Age	Mean	43.4 years
Education	No formal education	16%
Education	Primary	63%
Education	Secondary	3%
Education	Higher secondary	18%
Principal occupation	Day labour	47%
Principal occupation	Fishing	47%
Principal occupation	Farming	6%
Household size	Mean	3.99 persons
Monthly household income	Mean	BDT 22,075

Household survey N = 100.

The occupational distribution is important as a setting for adaptation priorities. Household earnings are linked to environmental situation and job possibilities via fishing and daily wage jobs. A disturbance may impact on direct production, but also decreases the opportunities for labour and trade. As a result, supplementary production and the safeguarding of local resources could be relevant beyond households, whose main activity is agricultural. The results suggest paying attention to the broader livelihood system that expands how harm to the land, water, and infrastructure impacts individuals in the community (Keesstra *et al.*, 2023).

The presence of women in large numbers ensures that household resource management is on the evidence base. The adaptation portfolio reported is directly linked to the activities of homestead, provision of food and managing domestic resources. They can help with thinking about how ecosystem management relates to what people do at home. Based on the Educational profile you have, the importance of accessible communication will be seen. Technical guidance can be related to activities familiar to the local community through demonstration, hands-on training and discussion. Programme design can thus be based on existing knowledge, which can be made useable across varying formal education levels.

Interacting Hazards and Affected Sectors

The highest hazard category reported by the respondents was cyclone (39%), coupled with salinity intrusion. 26 % considered river and coastal erosion and 20 % indicated salinity intrusion alone, while 15 % pointed out cyclones alone. This high level of the combined category suggests

that there is recognition amongst the respondents on connected environmental pressures. Inundation by saline water can have lasting impacts on the land and water even after the initial physical damage, as in the case of an extreme event. Protection during the hazardous event, and the environmental conditions affecting the recovery process, are therefore issues of adaptation priorities.

52% of the participants listed agriculture as the most impacted sector. Additionally, 16% chose agriculture and housing, 12% chose drinking water, 10% fisheries and 8% livestock combined and 2% agriculture and fisheries. The percentage of those who report agriculture as their main occupation is lower than the percentage of those who report that farming is a prominent activity in their community, reflecting the broader significance of agriculture in the community. Food availability, wage possibilities and household expenditure can all be impacted due to agricultural disruption (Johnson *et al.*, 2022). The outcomes of the sectoral findings thus indicate adaptations that take into account the interdependencies of production, employment, houses and resources.

This interpretation is supported by the qualitative evidence. Community members reported damages to homes, agricultural crops, fish ponds, roadways, water sources, and employment and income. Cyclones, storm surge, tidal flooding, salinity, erosion and heavy rainfall were also considered as important concerns by key informants. These accounts put the household distributions in the context of an overall matrix of interrelated exposure. They suggest that local adaptation must be coordinated among productive activities and environmental systems as impacts of one event may be felt in a variety of household wellbeing areas.

Table 2: Reported hazards and most affected sectors

Domain	Response category	Respondents %
Principal hazard	Cyclones and salinity intrusion	39
Principal hazard	River and coastal erosion	26
Principal hazard	Salinity intrusion	20
Principal hazard	Cyclones	15
Affected sector	Agriculture	52
Affected sector	Agriculture and housing	16
Affected sector	Drinking water	12
Affected sector	Fisheries	10
Affected sector	Livestock	8
Affected sector	Agriculture and fisheries	2

Household survey N = 100. Each domain totals 100%.

It is important to give special consideration to drinking water in this pattern. It was chosen by 12 % of the respondents and was also a special concern in the group discussions – safer water and drainage. Therefore, water movements and water qualities extending between settlement and production areas should be considered in relation to the restoration activities. Connected spaces that are filled with coastal vegetation, canals, wetlands, and household production. Coordinating the planning of their management can facilitate the coordination of environmental interventions with what community's need in normal times and times of crisis.

Recognition of Practices and Sources of Information

The intervention most commonly identified by respondents was "homestead gardening" (76%). 24% identified mangrove plantation and 19% identified coastal afforestation. These answers show that there is variation between practices and scales. The inputs and uses of gardening are easily observable because gardening is very similar to household activity, and it happens on a daily basis. Mangrove and coastal forest interventions encompass larger areas and can be experienced in the form of community interventions or institutional activities. So, recognition is a reflection on interaction with a practice and the part that is given to it by the residents.

89% of respondents had information sources from

Table 3: Recognition of practices and information sources

Domain	Practice or source	Respondents %
Recognised practice	Homestead gardening	76
Recognised practice	Mangrove plantation	24
Recognised practice	Coastal afforestation	19
Information source	Non governmental organisations	89
Information source	Government agencies	31

Household survey N = 100. Multiple responses were reported.

non-governmental organisations (NGOs), 31% for government agencies. As respondents could name more than one source, these numbers refer to intersections in the communication channels. They highlight the importance of development organisations in the local information landscape and the role of public agencies in outreach technical work. The participation of NGOs in awareness programs and planting activities was also acknowledged during the community discussions. Institutional accounts enumerated broader packages of interventions, such as mangrove restoration, rehabilitation of the canal, integrated farming and climate resilient farming.

The pattern indicates an opportunity to connect the landscape to household familiarity in practice. Garden or homestead tree training can help convey concepts of connections between vegetation, soil protection, drainage and coastlands. Field demonstration can help to make the purposes of mangrove and coastal forest management more visible. These should explain what the various words used in the communication mean and the role of particular interventions. Residents require information that they can easily use about how to establish and care for these systems and the benefits they can expect, plus easy access routes for advice when changes are required in environmental conditions or management needs.

Data from the information findings is also used to help coordinate outreach. Complementary roles in community engagement, providing technical and follow-up advice may be undertaken by government agencies and NGOs. A collective schedule of demonstrations and field visits can be used to establish links between the specialised knowledge and existing community relationships. The goal is to have a continuity of support throughout activities and seasons. If a restoration or livelihood goal is the same for residents and implementing organisations, information is integral to a continually evolving management relationship rather than a one-off awareness-raising exercise.

Perceived Environmental and Livelihood Effectiveness

There was the highest level of agreement on reducing the effects of cyclone and storm surge at 97%, and 3% neutral. 91% of the respondents agreed with the protection of agricultural land against salinity and erosion while 9% remained neutral. There was also a consensus of 91% with 9% neutrality for improvement of household income opportunities. 88% agreed and 12% were neutral on biodiversity and ecosystem health. These four statements were not inconsistent.For these four statements, no disagreement was reported. The distribution reflects the wide acceptance of the adaptation functions respondents are using with the current portfolio of nature-based practices.

The high level of agreement for cyclone and storm surge protection matches the reported hazard profile for this area. Wind, inundation and erosion are issues affecting residents that make it useful for them to appreciate vegetation for shelter and landscape protection. Key informants spoke about mangroves as a natural barrier and the importance of planting trees to prevent erosion. Community members also related vegetation to decreased wind harm and shelter for houses. These all contribute to the significance of protective functions in local ecosystem-based adaptation assessments.

Table 4: Perceived effectiveness of nature based solutions

Perceived benefit	Agree %	Neutral %	Disagree %
Protection of agricultural land from salinity and erosion	91	9	0
Improvement of household income opportunities	91	9	0
Enhancement of biodiversity and ecosystem health	88	12	0
Reduction of cyclone and storm surge impacts	97	3	0

Household survey N = 100. Responses are presented in the aggregated categories reported for this study.

The agricultural protection result takes this knowledge from the immediate shelter to the productive land. Respondents correlated vegetation and land management to maintaining the soil and cultivation conditions. This perceived contribution is planning relevant, as agriculture was the most frequently mentioned affected sector. The distribution of protective planting should be tied to the spatial distribution of the farmland, water pathways and the management need of the households around the plantation (Slinger *et al.*, 2021). The outcome allows focus on landscape connections where restoration and production can be used to support the same target for adaptation.

Income opportunities show agreement, implying that livelihood benefits are also considered and used to evaluate NbS. Alternative farming practices, such as gardens and trees and the use of available resources in the fishery sector, were discussed as alternatives to help diversify production. The results of the survey do not necessarily reflect an actual increase in household income but instead an opportunity as perceived. The substantive meaning is, that this is the linkage making respondents relate environmental actions with economic security. This can be linked onto by adaptation programmes through providing technical guidance, as well as focusing on household consumption and production costs and options for using or selling outputs.

For other outcomes there was a lack of consensus on changes to biodiversity and ecosystem health. This goes with variation in perception of benefits. Production of food crops, tree planting and/or storm damage can be easily measured around a settlement, and habitat

change may need measuring at a larger scale. Community engagement and activities, such as observing vegetation, habitat use and water conditions, can help make ecological functions more tangible. Bridging the gap between these observations and day-to-day resource management can help build understanding of the ecological underpinning of adaptation (Cilliers *et al.*, 2022).

Placing all four outcome areas together, residents value both protection and production, along with environmental quality. These functions bolster the argument for a portfolio approach. Different aspects of mangrove restoration and planting at the household level, and coastal and water management, work "at different ends" of the coastal system. They should consider both ecological viability and manageability in their planning. The community evidence positive to the investment in this connected approach, and perceived benefits provide a base on which to select community priorities, as well as to organise continual engagement for community meaningful outcomes.

Participation and Readiness for Future Activities

The participation activity with the highest frequency of reports was tree planting, which was reported by 98% of respondents. Homestead gardening was 47% and crab farming in saline water was 8%. The percentage of willing, not willing and unwilling to participate in future initiatives was 98%, 2% and 0% respectively. Respondents could choose more than one option for participation. These results show a definite baseline of engagement with planting activities as well as high levels of interest in NBAdaptation, while engagement with livelihood practices that take a specific resource or skill into account was more differentiated.

Table 5: Participation and future willingness

Indicator	Respondents	Percentage
Participated in tree planting	98	98%
Participated in homestead gardening	47	47%
Participated in crab farming in saline water	8	8%
Willing to participate in future activities	98	98%
Unsure about future participation	2	2%

Household survey N = 100. Participation activities allow multiple responses. No respondent reported unwillingness.

Recognition and participation are different types of relationships with an intervention. 76% of the respondents acknowledged homemade gardening and 47% stated that they did it. This difference is handy when planning a programme as it provides an opportunity for practical support to happen, due to the familiarity. Maybe people know about practice but they don't have the resources, the conditions, or knowledge on how to perform the practice for themselves. Outreach can thus shift from awareness to demonstration, planting tips and household planning that can enable interested residents to find the right way to engage.

The level of tree planting reported is used as an organisational starting point for stewardship. Community groups who are already engaged to monitor planted areas, organize regular maintenance, or report damages / replacement requirements in the community can be leveraged to support existing engagement. Reflecting this, key informants stressed that participation was essential in planning, implementing and maintaining the project and group discussions focused on the need for ongoing care. These viewpoints indicate that future programmes should have a linkage between initial participation and also clear roles over time. Establishing clear roles and readily available technical information can help keep people engaged as the planted vegetation grows and management needs evolve.

Crab farming is a smaller and more specialised part of the portfolio reported. Being part of local adaptation discussions shows interest in adaptations for livelihoods that suits saline environments. Such activities should be related to ecological conditions, water management, skills, and household capacity, and should be part of programme decisions. The right implication is that there need to be differentiated approaches based on the activity and the participants involved (Ihinegbu et al., 2023). The needs of tree planting, gardening and aquaculture are different and pathways of participation should be designed to reflect this.

Implementation Priorities and Institutional Support

70% of those who responded mentioned the issue of insufficient funding, whereas 40% mentioned lack of awareness as a challenge in implementation. Both limited land and weak institutional support were reported by 5%. The results of these multiple responses reflect the relative importance of the concerns expressed. Funding refers to establishment, planting materials, maintenance and access to technical services. Awareness is the awareness of what is required to identify benefits and enable activities to be managed. The two top responses collectively define action priorities for shifting that community interest into tangible action.

86% said that there was a need for more government and NGO support, and 14% said there was "a need for more community participation". These preferences work in addition to the high readiness to take part in future activities. CBOs reported willingness to share, as well as the desire for resources and directions for

effective implementation. Institutional assistance and community ownership are thus interrelated needs. Technical agencies, development organisations and local groups can each take on different tasks, providing ongoing collaboration to connect the household effort to broader restoration goals and programmes.

Table 6: Implementation challenges and recommended support

Domain	Response	Respondents %
Implementation challenge	Insufficient funding	70
Implementation challenge	Lack of awareness	40
Implementation challenge	Limited land availability	5
Implementation challenge	Weak institutional support	5
Recommended improvement	Increased government and NGO assistance	86
Recommended improvement	Greater community participation	14

Household survey N = 100. Challenges allow multiple responses; recommended improvement categories total 100%.

The operational meaning of these priorities is provided in qualitative evidence. The focus group participants discussed the damage caused by cyclones on the newly planted trees, the necessity of training and the necessity for maintenance to continue after the project phase was completed. Monitoring, coordination, proper funding and technical capacity were all highlighted as key factors by key informants (Ihinegbu *et al.*, 2023). Themes are included that demonstrate why funding for establishment should be linked to ongoing care. Seedling replacement, protection during early growth and advice after damage are factors which may make the difference between an initial activity continuing as a lasting adaptation resource appreciated by the neighboring households.

Also at the lower frequencies, there is need to consider land availability and institutional support within the local planning. Finance and awareness were more frequently cited as concerns among the households surveyed as indicated by their relative position. Access and management requirements for sites shall nevertheless be clearly agreed upon where restoration is proposed (Roy *et al.*, 2022). There are practical ways to help make clear who can use an area, who gives care and how it is shared. Asking these questions upfront facilitates cooperation and technical and financial support can function in the framework understood by the parties concerned.

Integrated Interpretation of the Evidence

The three substantive relationships that highlight the results of the household survey, interviews, and group discussions. First, residents and institutions identify the connected hazards impacting land, water, housing and livelihoods. Secondly, they see nature-based interventions as protective and productive (Barquet *et al.*, 2021). Third, they see the need for ongoing support and the involvement of the community as conditions for the maintenance of these activities. There are various types of evidence brought forth from the sources; survey distributions provide evidence of the prevalence of responses, community discussion provides evidence of everyday experience, and evidence of institutional accounts provides evidence of implementation and management responsibilities.

The integration is a representation of a relationship of ecological care and social organisation that is ongoing and continuous. Planting provides a chance of protection and production, and subsequent maintenance and cooperation affects its development. Household gardens both ensure adaptation is linked with daily use, and landscape restoration other benefits and responsibilities are spread across communities (Csete & Poyraz, 2022). Institutions supply resources and technical knowledge and residents bring local experience and continued care. These can be combined through programme design, based on underlying objectives, that are clearly understood by communities and that are supported on a stable and consistent basis by the implementing organisations.

The Kalapara findings thus point towards a coordinated portfolio of interventions, as opposed to activities taking place in isolation. Exposed landscapes are addressed by adding coastal forests and mangroves, household production provides food and income alternatives and restoration of drainage links land and water management. These should be chosen based upon site conditions and should be planned inclusively. The high level of participation and acceptance revealed in the survey offer a usable base for this approach. They are most useful if programme design allows for continuity of care, and if they are associated with ecological processes and benefits that are relevant to local households.

Spatial Coordination and Practical Programme sequencing

The focus on distribution of reported benefits indicates that implementation should start with a common understanding on the protective—and productive—functions required. Exposed settlements, cultivated land, existing vegetation, canals and household production areas can be related in a village planning exercise (Islam *et al.*, 2023). This would bring together interventions at different levels, with a practical basis. The management needs for a shared coastal planting area for instance are different to a garden adjacent to a dwelling, but can be part of the same community adaptation plan. A spatial coordination allows these relationships to be made explicit and participants to know where collective management is needed.

Programme sequencing is also pertinent on the

community priorities which are reported in the study. It is important to have awareness and planning to set objectives prior to distribution of planting materials or other inputs. Site preparation and suitable selection then can be carried out with technical advice and planned maintenance and observation. This series provides real-life examples of the need for support that 86% of respondents outlined. Assistance can be a process that continues with implementation needs and community responsibilities can be agreed at a point where sufficient information is available to educate residents about the tasks and benefits of the deal.

Activities in the sequence should be chosen based on the ecological context. Mangrove restoration requires appropriate coastal conditions and homestead gardening needs resources around homes. Management of canal water, shared use and specialised livelihood practices have specific skills and management requirements (Paxton *et al.*, 2023). Support can be tailored to these needs and support decisions around these requirements can help the community identify activities to be considered that are feasible. This is a customized approach to the organisation of technical services and household assistance, backed by the survey findings of a more differentiated level of participation in gardening and crab farming and a widespread tree planting.

Inclusion benefit sharing and continuity of engagement

When there is strong willingness to participate, it is an opportunity to make adaptation governance more inclusive. Household participation agreements should take into account the number of members, the space, labour, and time available in the household and the work load of the household members. Fishing activities can also have different work hours than those working near home and household production might have regular activities that affect attendance at the meeting. These differences can be accommodated by flexible arrangements of engagement (Caroppi *et al.*, 2024). Inclusive planning should also give residents opportunities to communicate priorities and get information about decisions, and there needs to be a well-defined link between participation and activity management that impacts residents' lives.

Collectively used areas need special attention in relation to benefit sharing where planting or restoration is concerned. Discussions with community members can help clear up the arrangement of access, maintenance responsibilities, and the use of products. Clear frameworks enable participants to know how their contribution relates to what they will gain. They are also able to identify protection and environmental advantages which can be greater than those of people doing regular maintenance (Shammin *et al.*, 2022). These understandings foster cooperation between households and facilitate implementing organisations linking resource provision with local acceptance of responsibilities for management. The findings also suggest that stewardship should be structured in terms of continuity of engagement. While an activity can be introduced at a planting event, practical questions can be answered at the planting events as conditions change. Community representatives can liaise with technical staff in determining what needs to be replaced and arrange for that to happen, and report concerns post hazard events (Castelo *et al.*, 2023). This contact allows institutions to learn more about management conditions in the area, and provides an easy pathway for the inhabitants to access support. It directly reflects the qualitative emphasis of maintenance and protection of recently established vegetation.

Connecting Monitoring with Community Priorities

Monitoring arrangements must be concordant with the functions that communities value. Relevant observations for protective plantation may involve numbers of seedlings surviving, observed damage, continuity of vegetation and completion of agreed maintenance works. household gardens: residents may document continued production and the use of the outputs. Community observations can be used to discuss movement and maintenance of water in restored drainage areas (Leal Filho *et al.*, 2022). These are suggested management indicators that will be derived from the findings, which attempt to relate technical follow up with practical issues expressed by the households and institutional participants.

Sharing of the monitoring process can also positively influence the learning between activities. Community meetings are a good place to explore which management practices are effective, what help is required and if a management responsibility continues to be a feasible option. Technical staff should be able to make observations and make necessary adjustments. This establishes a relationship between the local experience and the specialised guidance with each other in a feedback environment (Johnson *et al.*, 2022). It also helps maintain linkages between acceptance and ongoing involvement in the program, as residents are able to catch a glimpse of the impact of their observations on the management process. The outcome is an adaptive strategy that leverages the same household and institutional views that were united in this study.

Monitoring can have thus an ecological function, as well as an organisational function. Ecological observations refer to the state of vegetation, soils, water and production areas and organisational observations refer to participation, advice and maintenance completion (Runkle, 2022). By looking at both dimensions, organisations that are implementing can react on the processes by which benefits are occurring. It also gives a practical means of keeping attention after establishment works are completed. This is aligned with the multi-faceted strategy in Kalapara, focusing on both protective and livelihood aspects, long-term financing, and engagement with communities.

CONCLUSION

The research highlights the potential for NbS in climate adaptation and gained a certain level of acceptance at the community level in the villages surveyed. Respondents

commented on interacting coastal hazards and strong trust of existing coastal protection, livelihoods and ecology. The range of agreement was between 88% for biodiversity and ecosystem health and 97% for cyclone and storm surge protection. Participation in tree planting was at 98% as well as participation in future activities. Institutional and community accounts reiterated the need for linkage between the restoration and well-being of the household, hands-on training, long-term maintenance and coordinated support.

A network of coastal vegetation management, homestead production and restoring appropriate drainage and wetland functions should be given high priority in local adaptation planning. The choice of remedies should consider the exposure to hazards as well as ecological, resource use, and community preferences. Consideration should be given to species suitability, site preparation and care during establishment in addition to protecting established vegetation when new planting is being undertaken. The methodology is designed to connect immediate implementation with ongoing growth of ecosystem services that are vital to the residents' perception of protection and livelihood resilience.

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