



BRACE

Building Resilience through Agroecology for Coastal Emergencies

Technical report

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Bitter gourd growing in a homestead on a trellis system above flood prone land.

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Contents

Executive summary	2
Introduction	4
Potential of agroecology for building resilience	4
Methodology	5
Structure of the report	11
CHAPTER 1. Livelihoods in the delta	12
Demographic characteristics	12
Livelihood strategies	13
Land tenure	14
Farming profiles	14
Social networks	15
Geography	16
CHAPTER 2. Preparing for the storm	18
The agroecological status of the farms	18
Anticipatory capacities of households	22
CHAPTER 3. Exposure to and impacts of Cyclone Remal	26
Exposure	26
Hazard impact	26
CHAPTER 4. Recovering from the shock	28
Immediate coping strategies	28
Recovery time	29
Sequencing of recovery	29
Drivers of the recovery process	31
Depth of recovery	32
What shapes the recovery of households from the storm?	32
CHAPTER 5. Integration	34
Resilience is multifactorial	34
Summary of levers along the disaster risk management cycle	36
Recommendations	38
Programming recommendations for implementers	39
Policy recommendations	40
Annexes	41
Annex 1. Villages, sampling frame and sampling steps	41
Annex 2. Composite indices construction	41
Annex 3. Mapping of the survey variables to the 10 Elements of Agroecology	45
Annex 4. Detailed description of the agroecological status of farms	46
Annex 5. Variables of the Structural Equation Model (SEM)	47
List of figures, tables and acronyms	49
Declaration of the use of generative AI tools	50
References	51

Executive summary

Context

Coastal Bangladesh is among the most cyclone-exposed places on Earth. In May 2024, Cyclone Remal made landfall, flooding homes, destroying crops, and displacing thousands of farming households. As climate change intensifies tropical storms, the question of how farmers can better prepare for, withstand, and recover from such events has become central to climate adaptation policy.

This report presents findings from the BRACE study, a comparative assessment of 377 farming households in the Latachapli Union of Kalapara Sub-District, Patuakhali District; an area directly affected by Remal. The study asks: does participation in an agroecological farming programme make households more resilient to cyclones? And if so, how?

Findings

Programme households performed substantially better before, during, and after Cyclone Remal than comparable non-programme households – not because of where they lived or how much land they owned, but because of the capacities, practices, and social connections they had built.

Before the storm

Programme households had transformed their farming systems in line with agroecological principles: diversified crops and livestock, soil-building practices such as vermicomposting and mulching, seed banks, and integration of trees and animals. They scored three times higher on the agroecological composite index (3.11 vs. 0.96 on a 0–4 scale) than non-programme households. They were also far better prepared for the cyclone, with more permanent risk-reduction measures on their farms, stronger knowledge of what to do, and much deeper connections to farmer groups, cooperatives, and NGO support networks.

During the storm

Both groups experienced similar cyclone exposure. Yet programme households suffered roughly half the damage of non-programme households across all measures: crop losses, livestock deaths, infrastructure damage, and income loss. Importantly, distance to the sea or nearest river explained very little of the variation in damage. What mattered far more was the agroecological status of farms and the level of preparedness.

After the storm

Programme households recovered faster and more fully. They restarted farming within approximately 15 days, compared to around 30 days for non-programme households. Fourteen months after the cyclone, 72% of programme households reported full recovery, compared to only 12.5% of non-programme households. Programme households also relied on savings and farming practices to recover, while non-programme households depended more on loans and asset sales – strategies that weaken their ability to withstand the next shock.

Overall resilience

A main finding from the statistical modelling is that geography explains almost none of the differences in damage or recovery. What drives resilience is not where a household lives, but its social position: access to knowledge, embeddedness in networks, quality of support, and the practices built up over years of agroecological transition. Vulnerability to cyclones – and resilience to them – is a social phenomenon.



Asma Begum grows vegetables in sacks of vermicompost. This ensures good soil quality and means plants can be moved to protect against flooding.

KEY MESSAGES

- + **Agroecology builds resilience.** Higher adoption of agroecological practices is linked to lower cyclone damage, better coping, and faster recovery.
- + **Programmes matter most upstream.** Sustained, structured agroecological training is the single strongest factor associated with resilience – more than land size, financial access, or proximity to protective infrastructure.
- + **Preparedness reduces losses.** Households that invested in risk-reduction measures before the storm experienced less damage and needed fewer erosive coping strategies afterwards.
- + **Support quality drives recovery.** Timely, relevant, and coordinated support from NGOs, farmer groups, and services is one of the strongest predictors of post-cyclone recovery.
- + **Debt-based recovery is a trap.** Non-programme households relied more heavily on loans and asset sales during recovery, undermining their capacity to withstand future shocks.

What this means in practice

For NGOs and implementers:

- Place agroecological programmes at the centre of resilience programming. Sustained, iterative learning – through farmer field schools, cooperatives, and peer networks – is the backbone of resilience.
- Explicitly connect farming practices to disaster preparedness, so households understand how soil management, crop diversification, and seed banking reduce their exposure to cyclone losses.
- Invest in post-disaster support quality: coordinated, timely assistance embedded in existing group structures is more effective than individual relief.
- Protect productive assets during recovery by promoting savings mechanisms and avoiding debt traps that lock households into slower, weaker recovery trajectories.

For policymakers:

- Adopt a systems-based approach to climate resilience that connects agroecological farming, disaster preparedness, and post-disaster recovery – rather than treating these as separate policy domains.
- Embed agroecology within national climate adaptation and agricultural strategies as a pathway to farm resilience, complementing investments in physical protection infrastructure.
- Balance infrastructure investments with long-term capacity building: embankments and shelters remain essential, but household-level capacities explain far more of the variation in cyclone outcomes.
- Align financial inclusion and social protection policies with resilience objectives – promoting savings over debt and ensuring post-disaster assistance protects rather than erodes productive assets.

Cyclone risk in coastal Bangladesh

In May 2024, Cyclone Remal made landfall on the coast of Bangladesh, flooding homes, destroying crops, and displacing thousands of households across the coastal belt. It was one event in a long and intensifying pattern. The location of Bangladesh within the Bay of Bengal places its coastal communities at the frontline of cyclonic activity. As sea surface temperatures rise and storm severity increases, the question of how farming households can better withstand, absorb, and recover from such shocks has become central to climate adaptation policy.

Globally, about 560 million people are exposed to cyclones each year and the number increased between 2019 and 2023 (Jing et al., 2024). Increasing sea surface temperatures and rising sea levels are expected to further intensify cyclone frequency and severity in the future (IPCC, 2021; Siddik and Islam, 2024). Although Bangladesh has made significant progress in developing early warning systems, providing access to cyclone shelters, and establishing coastal embankments to protect communities against flooding, the human and economic toll of cyclones remains substantial (Sonet et al., 2024). Bangladesh's location within the Bay of Bengal places it at the frontline of climate-induced cyclonic activity. Consequently, coastal communities are particularly vulnerable to related disasters.

In May 2024, Cyclone Remal made landfall and severely affected parts of the country, especially coastal areas. Remal caused flooding, landslides, and destruction of infrastructure, and left millions without power. Millions of coastal households were affected by storm surges, and thousands of homes were destroyed. As typical for such natural disasters, the greatest impacts of cyclones were borne by already vulnerable communities. Many of those communities rely on agriculture for their livelihood. As cyclone events intensify and increase in frequency, the question of how farming communities can better withstand, absorb, and recover from such extreme events has become central to adaptation policy.

Potential of agroecology for building resilience

In recent years, agroecology has gained prominence as a pathway for adaptation to climate change and a just transition of food systems (see e.g. HLPE, 2019, HLPE, 2025; IPCC, 2019; Leippert et al., 2020). Broadly defined as a holistic and integrated approach that simultaneously applies ecological and social concepts to the design and management of sustainable agriculture and food systems (FAO, 2018), agroecology encompasses a science, a set of practices, and a social movement (Wezel et al., 2009; HLPE, 2019). As a transdisciplinary field, agroecology combines knowledge from multiple scientific disciplines with local and traditional knowledge. Agroecology fosters co-learning among researchers, practitioners, and farmers across the food system (HLPE, 2019).

Evidence from Latin America, South Asia, and the Caribbean suggests that, under certain conditions, farming aligned with agroecology elements improved resilience of households to climate related shocks (e.g., Holt-Giménez, 2002; Holt-Giménez et al., 2021; McGuigan et al., 2024; Philpott et al., 2008).

Potential resilience effects are often attributed to combinations of diversified cropping, soil organic matter enhancement, polycultures, integrated trees and livestock, or community-based resource management.

Soleiman producing gourds on a trellis structure



If farms aligned with agroecology indeed exhibit higher resilience, then this could justify scaling related practices as part of national climate adaptation plans and disaster risk management strategies in cyclone-prone regions like Bangladesh. However, evidence on the resilience of farms aligned with agroecology elements to extreme weather events, such as cyclones in the Bangladesh Delta, remains thin.

This report presents a comparative case study from the Latachapli Union of Kalapara Sub-District, affected by Cyclone Remal in 2024. We assess whether households participating in the Proyash programme (Box 1) demonstrate greater resilience during cyclones compared to similar non-programme participants in coastal areas of Kalapara in the Patuakhali District of Bangladesh.

THE PROYASH PROGRAMME

Proyash (“Increasing marginalised household participation in climate-resilient livelihoods in the southern coastal belt of Bangladesh”) is a Caritas Bangladesh programme funded by CAFOD and launched in April 2019. The programme supports around 3,000 marginalised families to implement agroecological practices, build inclusive livelihoods, and improve market access.

Proyash builds the technical skills and strengthens social networks that enable households to adapt to a changing climate in the coastal region. In Farmers’ Field Schools (FFSs), farmers learn through collective experimentation, observing soil improvements, testing crop varieties, and comparing ecological pest management techniques. These schools have gradually become community learning spaces where participants prepare and respond to disasters collectively. Participating households began producing vermicompost for their own use and as a source of income. Over time, several communities established seed banks that allow participating households to access climate-tolerant, locally adapted varieties before and after disasters.

Through Business & Information Centres, women gain access to training, market information, and support to develop small farm enterprises. These centres have evolved into hubs where women organise themselves, share knowledge among each other, and build their confidence to engage in agricultural and off-farm markets.

BOX 1. *The Proyash Programme at a glance.*



Akhi Aktar produces vermicompost which she will use as an organic fertiliser on her vegetables.

Methodology

Conceptualising household resilience as a dynamic condition

The resilience of a farming household results from the daily decisions. People make decisions about which crops to plant, which farm inputs to access, household labour, the amount and utilisation of savings, and how they respond to social obligations. In coastal Bangladesh, many of these decisions are taken under the constant threat of the next storm.

In this study, we focused on the resilience of households or farms to cyclones. We use the terms “household” and “farm” interchangeably to refer to the unit of analysis for this study. This is because – similar to Bacon et al. (2025) – we observed that one **household** is managing a single **farm**.

Adopting the resilience definition presented in the recent HLPE (2025) report, we define **household resilience as “a dynamic condition** achieved when [it] prevents, absorbs and transforms in the context of shocks” (p. 32). Resilience must therefore not be understood as an “end in itself” (Serfilippi & Ramnath, 2018, p. 647) but an ongoing **process**. This process is **multidimensional** (Bacon et al., 2025; Oxfam, 2013) and unfolding **before, during and after a shock** (HLPE, 2025; Uddin et al., 2020).

Operationalising resilience – Resilience building processes and outcomes

Resilience, unlike income or education, cannot be measured directly (Béné et al., 2020). Therefore, we infer resilience through the capacities and actions people employ that shape how households experience a shock. For coastal communities in Bangladesh, these include the ability of people to prepare for cyclones in advance, the strategies used to endure the cyclone as it happens, and the extent to which households recover afterwards.

Yet the key question remains **which capacities and actions are ultimately relevant** for household resilience in the face of a specific shock.

Building on previous studies (such as Béné et al., 2023; Smith & Frankenberger, 2018; Uddin et al., 2020; Al-Maruf et al., 2021) we address this by **linking pre-shock attributes to resilience outcomes**. With the term **resilience outcomes**, we mean the observed impacts, responses, and recovery trajectories that unfold during and after a shock (Béné et al., 2023; Uddin et al., 2020). Based on the assumption that the **resilience outcomes** represent the **tangible results of the resilience-building process** – i.e., the “ability of households to handle shocks” (Béné et al., 2020, p.3) – we use them as a proxy for household resilience to Cyclone Remal.

Constructing a multidimensional framework along the disaster risk management cycle

Following the approach just outlined, we constructed a **multidimensional framework** structured along the disaster risk management cycle – before, during, and after the shock.

The framework consists of six modules and several sub-modules. The modules were built based on a review of the food system, disaster and climate resilience literature, and adapted to the study context during fieldwork. The resulting framework covers multiple scales, from the individual household to the community and municipal level. [Figure 1](#) visually presents the organisation and components of the framework.

Conceptual framework for assessing household (HH) resilience to cyclones and the role of agroecology

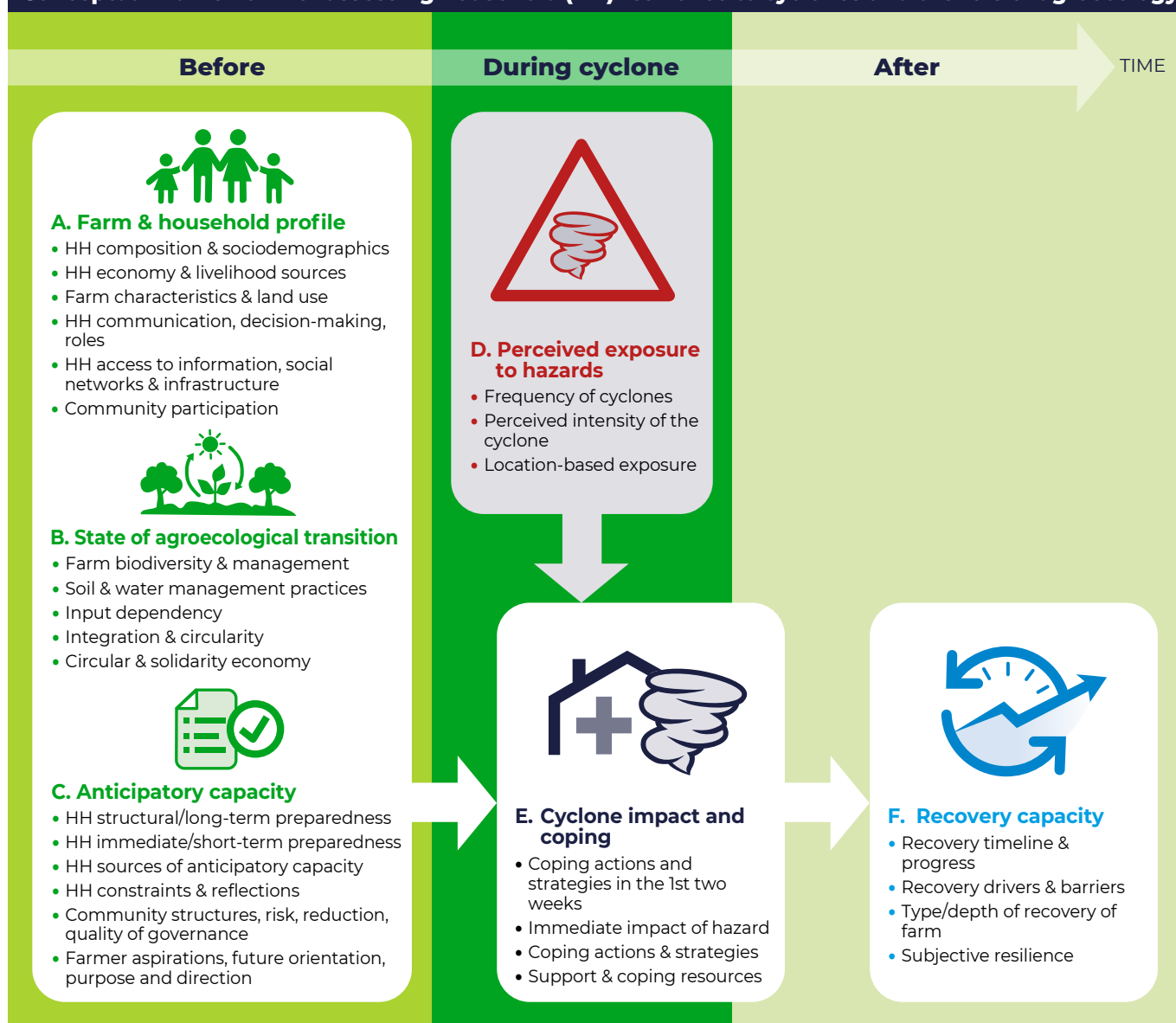


FIGURE 1. White boxes indicate the hypothesised pathway through which household characteristics, agroecology, and anticipatory capacity shape cyclone impact and post-shock recovery. Source: Own elaboration.

Integrating agroecology into the assessment of household resilience to cyclones

To explore how agroecology can potentially enhance farm resilience to cyclones, we use the **10 Elements of Agroecology** developed by the Food and Agriculture Organisation of the United Nations (FAO, 2018) to guide the transition toward sustainable food and agricultural systems as reference. This allows us to assess not only **whether** households with a certain degree of orientation towards agroecology fare differently, but also **through which pathways** agroecology influences their capacity to withstand, adapt to, and recover from shocks.

We examine whether and how the **degree of agroecological transition** of a household is associated with observed resilience outcomes. This is because farms embrace agroecology along a continuum rather than adopting agroecology as a fixed package of practices.

Along the disaster risk management cycle, we hypothesise that a higher degree of agroecological transition may be linked to more desirable resilience outcomes by

- strengthening anticipatory capacities before the shock (e.g., diversified livelihoods, knowledge exchange, access to social networks),
- reducing exposure and sensitivity during the shock (e.g., agricultural practices, on-farm diversity, use of local inputs), and
- enabling faster recovery after the shock (e.g., seed and labour exchange, local value chains).

In the next section, we outline how this assumption was operationalised.

Study area and design

The study was carried out in the Latachapli Union of Kalapara Sub-District in Patuakhali District – adjacent coastal District to the Bay of Bengal (see [Figure 6](#)). There, Caritas Bangladesh has implemented the Proyash Programme since 2019 (see Box 1 for more information).

To understand what builds households' resilience to cyclones and the potential contribution of agroecology, we constructed a comparative study design with two groups to allow for comparison:

While all respondents shared similar socio-demographic characteristics and the same context, one group had participated in Caritas' Proyash Programme (n=297). In the frame of this programme, different agroecological practices and formats – such as farmer field schools (FFSs) and organic farmers' markets – were introduced and implemented. The second group consisted of non-programme participants (n=80). The distribution of all respondents across the three villages – Mussuliabad, Misripara and Alipur – is shown in [Figure 2](#).



Ambia manages a community seed bank to ensure farmers have access to local varieties of climate resilient seed.

Sampling and data collection

In July 2025, we randomly sampled 297 programme participant households from the full Proyash programme membership list in the three study villages. We then purposefully sampled 80 non-programme households to match programme participants on key socio-demographic and livelihood characteristics (see [Annex 1](#)). All survey data we administered with the KoBoToolbox (2025). The survey was complemented with **informal interviews** with staff from Caritas Bangladesh, Proyash programme and non-programme participants, and local government officers. These conversations supported meaning-making and helped to contextualise and validate the findings from the quantitative analysis.

Operationalising the framework

We translated the multi-dimensional framework – explained in the previous section – into a structured survey by formulating the indicators within each of the six thematic modules into questions.

The multi-dimensional, systemic nature of agroecology makes it challenging to capture and assess impact (Wiget et al., 2020). Nevertheless, to **characterise the households' degree of agroecological transition**, we drew on Step 1 of the FAO Tool for Agroecology Performance Evaluation (TAPE) (Mottet et al., 2020). We formulated short questions for nine of the 10¹ FAO Elements of Agroecology. We tried to find a balance between covering the key themes of each Element, relevance to the study context, and length of the survey. The questions for each element and a short explanation can be found in [Annex 3](#).

Since agroecology is a multi-dimensional, systemic concept that encompasses ecological and social principles, some of its aspects are covered in the module *Farm and household profiles*, as well as the module *Sources of anticipatory capacity* and therefore have not been duplicated in the *State of agroecological transition* module.

It is important to note that the objective of this study was not to evaluate the success of the Proyash programme. Rather, we tried to set up a study approach to assess resilience-building processes and outcomes within the study context. While the framework – and resulting survey questions – include activities and initiatives introduced by the Proyash programme, it also accounts for other aspects that may explain observed resilience outcomes. With this approach, we aimed to gain a more comprehensive understanding of household resilience to cyclones, beyond a single project intervention.

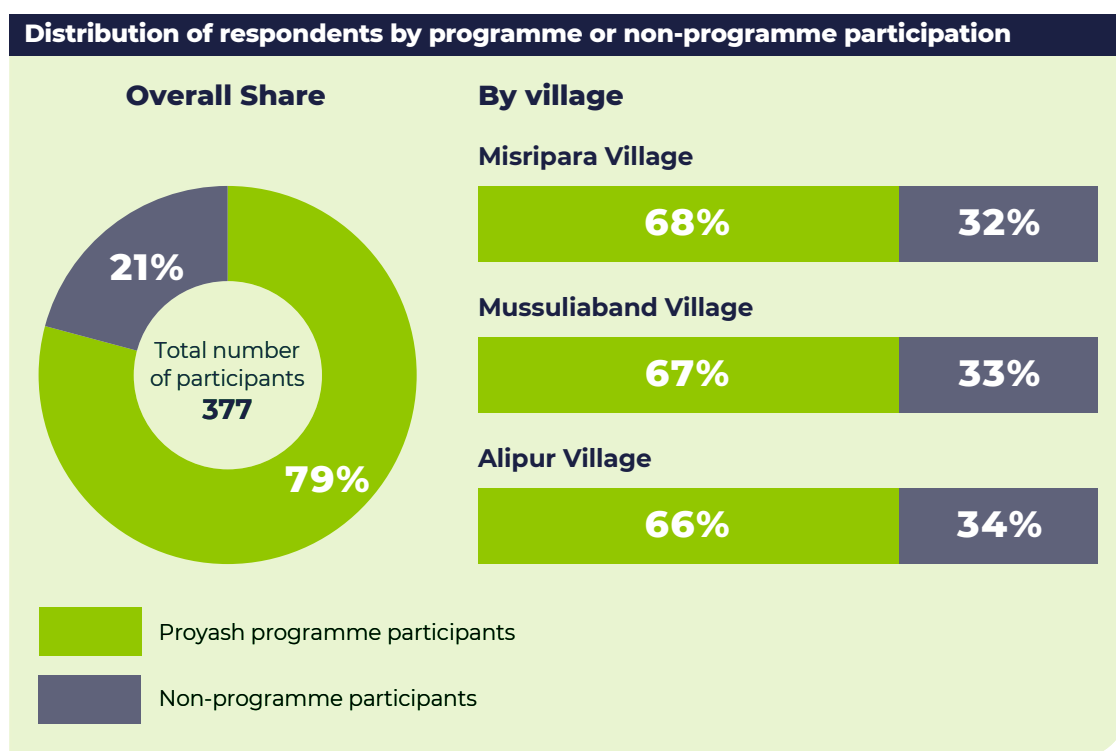


FIGURE 2. The pie chart on the left shows the overall share of respondents by participation status (Programme vs non-Programme participants). The bar chart on the right shows, for each village, the within-village distribution of respondents by participation status.

1. We omitted Element 6 “Resilience”, since it was the overall focus of the study.

Empirical Strategy

DATA PREPARATION

All analyses were conducted in R (Version 4.3) employing the package “tidyverse” and associated coding logic (R Core Team, 2023; Wickham et al., 2019). Data cleaning procedures included standardising factor levels and variable types according to predefined specifications and validating all data entries. Further, we incorporated GIS-derived distance-to-water measurements based on GPS coordinates of households, to supplement self-reported location data (see [Chapter 1](#)).

STEPS OF ANALYSIS

1. Comparative Statistics

Descriptive analyses compared programme participants versus non-programme households across all variables using Wilcoxon rank-sum tests for continuous variables and chi-square tests (with Yates correction and Fisher’s exact test fallback) for categorical variables.

2. Index Construction

Following Smith & Frankenberg (2018) we then constructed composite indices that combined single variables behind the different concepts within our framework. The quasi-experimental evaluation approach followed Béné et al. (2020):

A. Nine agroecological transition indices (0-4 scale) based on our survey questions for nine of the ten FAO Agroecological Elements (see above), aggregated into an **agroecological composite index**.

B. Anticipatory capacity index combining structural changes made to the farm, the participation in disaster training, access to supportive social networks related to disaster risk reduction and the availability of risk reduction services and infrastructure.

C. Hazard exposure and impact were assessed via several sub-indices capturing shock exposure (SHL_B), hazard intensity (INT) and household distance to the nearest water body (LBE).

D. Overall coping quality captured response strategies and their perceived consequences to the cyclone impact (e.g., loan or credit, selling assets, relocation).

E. Recovery indices and resilience outcomes were captured based on the following sub-indices: recovery speed, remaining deficits, assets recovered first, adaptation and subjective resilience as well as support availability and quality.

For all indices we used row-mean aggregation with minimum 50% data availability threshold for validity. Detailed information on indices construction is provided in [Annex 2](#) - Composite Indices construction.

3. Relationship Assessment using a Structural Equation Model (SEM) approach

Following our conceptual framework, we examined relationships between households’ anticipatory capacities, shock exposure and impact, and resilience outcomes. Shock exposure and anticipatory capacities were incorporated as independent variables, while we also controlled for other household characteristics (household size, education, land ownership, financial inclusion, service access).

Building on the prepared indices and conceptual framework, we constructed three comparative SEMs for the complete dataset, programme-only, and non-programme subsamples using the “lavaan” package (Rosseel et al., 2025; MLR estimator with FIML for missing data). Each SEM followed the same logic and tested pathways across the disaster risk management cycle:

A. Before the storm – anticipatory capacity of households, including the degree of agroecological transition

B. During the storm – hazard exposure (Intensity index (INT) ~ Distance to water body (LBE)) and impact (SHL_B)

C. After the storm – coping quality and recovery.

The models also included a latent Recovery construct that consisted of indicators for speed and type of recovery, with residual covariance between agroecological practices and anticipatory capacity. Details on the variables included in the SEM are provided in [Annex 4](#).

NOTE ON CAUSALITY

Our analysis cannot prove that the programme directly caused the observed resilience outcomes. Since we collected data after Cyclone Remal, we asked households to recall their situation before the storm, which limits what we can conclude about cause and effect.

The results show patterns and relationships that suggest the programme may have helped, but we cannot measure exactly how much. The Proyash programme combines many different activities, making it difficult to isolate the effect of any single intervention. Further, the programme was implemented in a real-life setting with multiple external factors influencing resilience outcomes.

Therefore, our findings should be seen as indicative rather than conclusive: they point to likely connections between agroecological practices and resilience, but do not prove definitive causal links (Smith & Frankenberger 2018; Béné et al. 2020).

LIMITATIONS

Our study has several practical limitations that one should keep in mind. First, as mentioned above, we collected all data after the cyclone hit. This means we had to rely on people's memories about their situation before the storm, which may not always be accurate. People might remember things differently when looking back, especially after experiencing a traumatic event.

Second, we worked within real-world conditions that come with complexities and challenges. The data collection happened in a short period of time while some households were still recovering from the cyclone. The survey was quite long, which may have tired some respondents out towards the end of the interview. Additionally, our local team conducted most interviews without the lead researcher present, which may have led to some variation in how questions were asked.

Third, Caritas staff helped **purposefully** sample the control group, which means some interviews may have been biased more toward families already connected to the organisation.

Lastly, our study focused on just three villages, so the findings can only be generalised to a certain extent, given cultural, socio-economical and geographical differences.

Structure of the report

Following a short presentation of relevant concepts and the study framework, we describe the methodological approach. In Chapter 1 we then outline the livelihoods in the delta including the demographic profiles of the households.

Chapters 2 to 4 trace the actions of households across the disaster risk management cycle: the agroecological status of farms based on the agroecological elements, anticipatory actions and capacities before Cyclone Remal, exposure to and impact of the cyclone, coping actions during/after the storm, and the households' recovery process after the impact.

In Chapter 5 we synthesise the findings and present key entry points for action in each phase of the disaster risk management cycle.

Findings presented in each chapter are based on the comparative statistics as well as the SEM. Each chapter highlights the main results through figures and concludes with a summary of the key findings.

The report closes with strategic recommendations to policy makers and programming for strengthening farm resilience to cyclones.

Livelihoods in the delta

The delta of southern Bangladesh hosts communities whose agricultural livelihoods are deeply intertwined with land, fresh water, and the growing seasons influenced by the monsoon. For generations, these communities have adapted their farming systems to shifting river channels, saltwater intrusion during high tides, and recurring storms. Yet cyclones reveal the precarity underlying life in these coastal villages.

In this chapter, we present socio-demographic characteristics and livelihood strategies of respondents, their location within the delta region as well as land use and cropping patterns. While demographic features are broadly similar across all respondents, we observe differences in income activities, social networks and farming practices between programme and non-programme participants.

Demographic characteristics

Gender among respondents

Respondents were predominantly female across the whole sample (281 female, 96 male) (Figure 3). This reflects the intentional inclusion of women in the programme as central actors in farming and community decision-making. Respondents ranged in age from 18 to 78 years (average = 42.7 ± 12). Because non-programme participants were purposefully sampled to match programme participants, the proportions are similar across the two groups. We therefore treat this gender distribution as a feature of the sample rather than a relevant analytical difference.

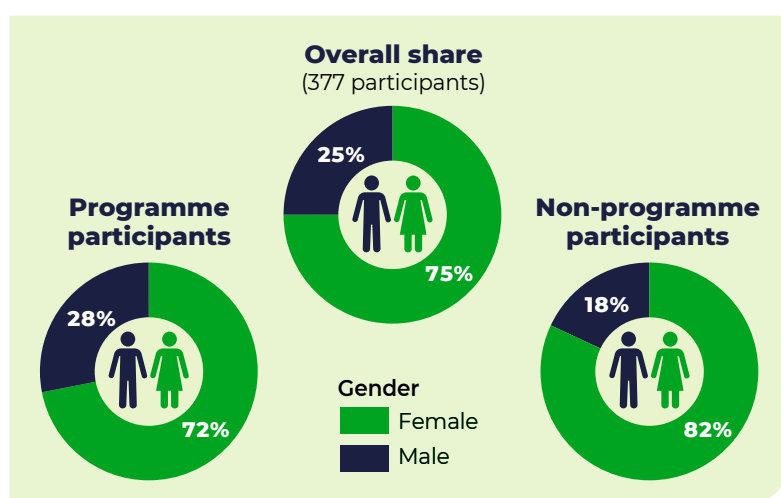


FIGURE 3. Gender distribution of the household members by programme and non-programme participation.

Age-distribution among respondents

Households of the respondents had on average **five members**. The age structure of **programme and non-programme participants was broadly similar** (Figure 4). Both groups were dominated by working-age adults. Children and adolescents made up a substantial share of household members. Programme households included a slightly larger proportion of youth, but overall, the two groups reflected comparable rural family structures.

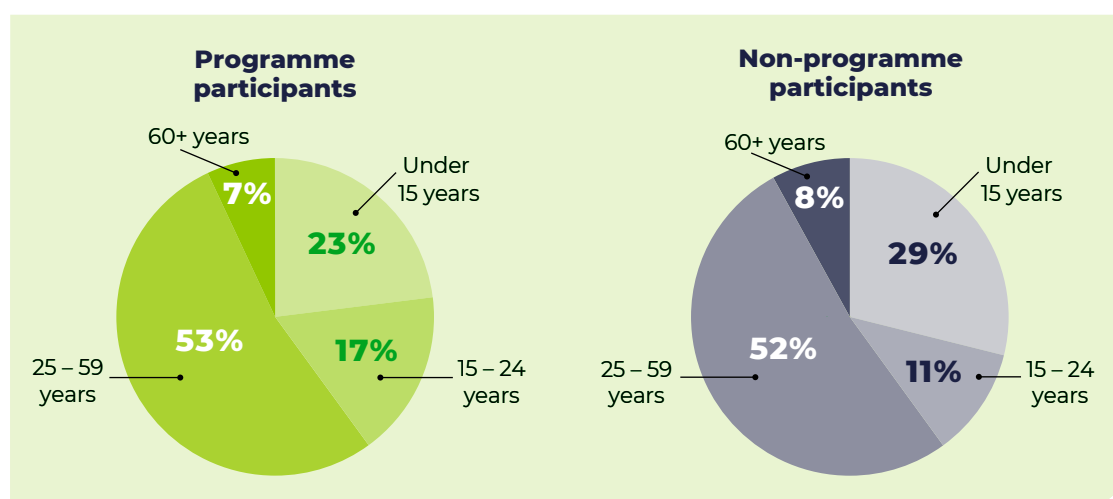


FIGURE 4. Age distribution of the household members by programme and non-programme participation.

Education levels among households

Education levels differed between the two groups (Figure 5). Programme households are more concentrated at lower education levels, especially **Primary school**. Non-programme participants have a more spread-out educational profile, with higher **Secondary school** completion, and more **College** and **University** representation.

This difference suggests that programme participants tend to come from more educationally disadvantaged households, which is important context for interpreting resilience and behavioural change outcomes.

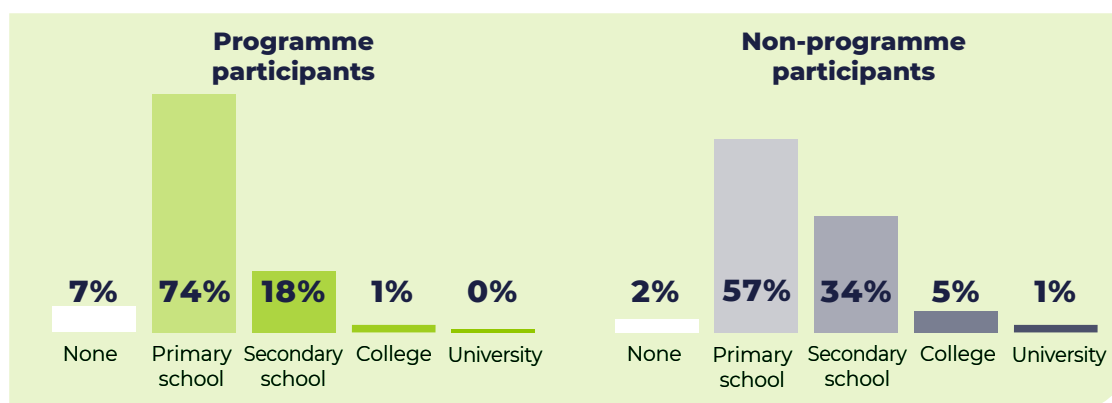


FIGURE 5. Distribution of respondent's highest level of education by programme and non-programme participants

Livelihood strategies

Income sources

Although households in the delta **combine a range of activities to make a living**, the way these combinations are structured differs markedly between programme and non-programme respondents (see Table 1). Our data shows that **programme households anchor their livelihoods more firmly in crop farming** and are more likely to pair these activities with a second income source. This results in a more diversified pattern overall.

Non-programme participants, by contrast, rely more on off-farm wage labour as their main income source. Their secondary activities are fewer and more unevenly distributed, reflecting a narrower set of options.

Another clear difference between the two diagrams is the role of **vermicompost**. It appears as a **common secondary activity** among programme households, while barely appearing at all for non-programme respondents. This contrast illustrates how the two groups draw on different sets of livelihood opportunities within the same region.

Income source	Programme households		Non-programme households	
	Primary income	Secondary income	Primary income	Secondary income
Crop farming (%)	72	14	48	40
Off-farm wage (%)	22	41	40	29
Livestock (%)	2	14	8	16
Vermicompost (%)	3	21	1	1
Aquaculture (%)	0.3	2	4	1
Other (%)	0.7	2	0	8
None (%)	0	6	1	4

TABLE 1. First and second largest household income sources of programme and non-programme participants before Remal.

Market integration

Patterns of **market participation** differ strongly between the two groups.

Programme households were strongly concentrated in organic markets. Many also combined selling at the organic farmers' market with produce kept for home consumption.

In contrast, non-programme participants relied mainly on conventional markets or did not sell produce at all. A substantial share produced food crops for their own needs only.

These contrasting patterns point to more diversified and market-oriented production systems among programme households. Non-programme participants, in contrast, remain more detached from formal marketing channels (Table 2).

Market channels	Programme households	Non-programme households
Households selling at organic farmers' markets (%)	72	1
Households selling at conventional markets (%)	26	79
Households combining production for market and self-consumption (%)	99	61
Households not selling at any market (%)	1	20
Households producing only for own consumption (%)	1	31

TABLE 2. Comparison of agricultural market integration for programme- and non-programme participants.

Land tenure

Households cultivated on average **37.3 decimals of land** (=0.15 hectare) with a high variation of ± 33.7 decimals. No clear trend was visible when looking at **land tenure** status. Across all respondents about 46% owned their farmland and 42% rented. A minor part was either Khas (=governmental) land or shared with someone else.

Farming profiles

Understanding how households in the delta farm is essential for interpreting their resilience, recovery pathways, and capacity to adopt agroecological practices. Although the delta appears – at first glance – to be characterised by smallholder agriculture with similar crops and livestock, a diverse set of farming systems exists. Yet these systems differ not only in their **crop portfolios but also in the degree to which households integrate livestock, trees, and mixed cropping** arrangements into their farms.

We here describe four main farming profiles. These profiles differ not only in crop composition but also in the extent to which households integrate livestock, trees and mixed-cropping arrangements into their production system.

Since our sample sizes for the farming profiles are not representative – as this was not the primary focus of the study – we here only describe these profiles to offer a better understanding of the diversity of farming systems present in the study region and outline assumptions about their potential to buffer shocks. We did not include these profiles in the statistical model constructed to assess differences in resilience outcomes.

Rice–livestock mixed farms

The most common farming profile, accounting for around 38% of households, centres on rice–livestock mixed systems. These households grow **paddy rice as their main crop** and typically keep between **two and four livestock types**, most frequently poultry, goats, cows, ducks, fish or pigeons. Their farms resemble small agroecosystems: rice fields are complemented by vegetables, pulses, trees and multiple animals. These mixed systems are structurally diverse and tend to offer households a broader set of buffers against shocks.

Oilseed- and vegetable-based mixed farms with livestock

A second major group consists of oilseed- and vegetable-based mixed farms, representing about 31% of households. These households grow **peanuts, sunflower or vegetable crops** such as pumpkin or bitter melon as their primary agricultural activity, and they also maintain a moderate to high diversity of **livestock**. While not rice-dominated, these farms are still highly mixed systems, combining commercial crops with household-level food production and animal husbandry. Their practice of integrating crops, trees and livestock creates a farm structure that is ecologically robust and economically flexible.

Vegetable-focused, livestock-light farms

By contrast, a smaller share of households – around 7% – **operate vegetable-focused farms** with little or no livestock. These households often specialise in horticulture and maintain only a single livestock species or none at all, usually keeping only poultry. Their farming systems are less integrated and more specialised, relying on crop production rather than the broader ecological synergies that mixed farming provides. As such, they may have fewer internal buffers and depend more on market conditions to stabilise livelihoods.

Low-livestock cereal or pulse farms

A notable group of around 15% of households run low-livestock cereal or pulse farms. These farming systems are built around rice or pulses but have minimal animal integration. With none or only one livestock species, these households operate simpler and more linear systems. They **rely heavily on their primary crop and have fewer biological, nutritional or economic feedback loops**², which may limit their capacity to adapt or absorb shocks.

Social networks

Programme households also show stronger **social and financial networks**. They participated more frequently in NGO or government programmes, had better access to credit, and were far more likely to belong to savings groups.

Type of network or social safety net	Programme households	Non-programme households
Part of an NGO/government programme (%)	77	31
Access to credit (%)	82	60
Member of a savings group (%)	94	40
Frequency of advice on farming (0-3 scale)	2.66	0.32
Member of a farmers' group (%)	98	5
Degree of community collaboration (0-3 scale)	2.28	0.48
Degree of participation in decision making processes (0-3 scale)	2.29	0.46

TABLE 3. Networks and social safety nets of programme and non-programme participants

2. Feedback loops here refer to the internal flows and circular exchanges between farm system components. These can include nutrient transfers between crops and livestock, manure returning to soils, or diversified income streams which help buffer production losses. Systems with tighter feedback loops tend to exhibit greater resilience, since they can absorb short- and long-term stress without alterations to the overall system structure and function (Carswell et al, 2025). Meuwissen et al. (2019) identify the tightness of feedback loops – measured through the number of connections and exchanges among farm components – as one of the five core determinants of farming-system resilience.

In terms of farming advice, the differences were even more pronounced. Most programme respondents reported receiving regular agricultural advice and were engaged in farmer groups or FFSs. At the community level, they also reported higher collaboration and more active participation in local decision-making processes.

These patterns suggest that programme households operate within denser support networks and have more resources to draw upon in times of need.

Programme households were better connected to **social and financial safety nets**. They were more likely to be part of an NGO or a local government programme, have access to credit, and belong to a saving group – all factors indicating that support might be available in case of emergency.

Access to **advice on farming and social networks** was more available among programme households (see Table 3). Advice was received more often, and nearly all were members of farmer groups/co-operatives/FFSs. At the community level, programme households reported much stronger collaboration and level of participation in decision-making processes.

Geography

Observations on site indicated that **households' distance to rivers or canals and the sea** shape exposure to cyclones and other hazards. We therefore complemented the survey data with spatial analysis using ArcGIS Pro. We calculated each study households' closest distance to a waterbody (river, canal or the sea) and added these distances to our data frame³. Figure 6 (below) shows household locations within the delta, and their proximity to waterbodies.

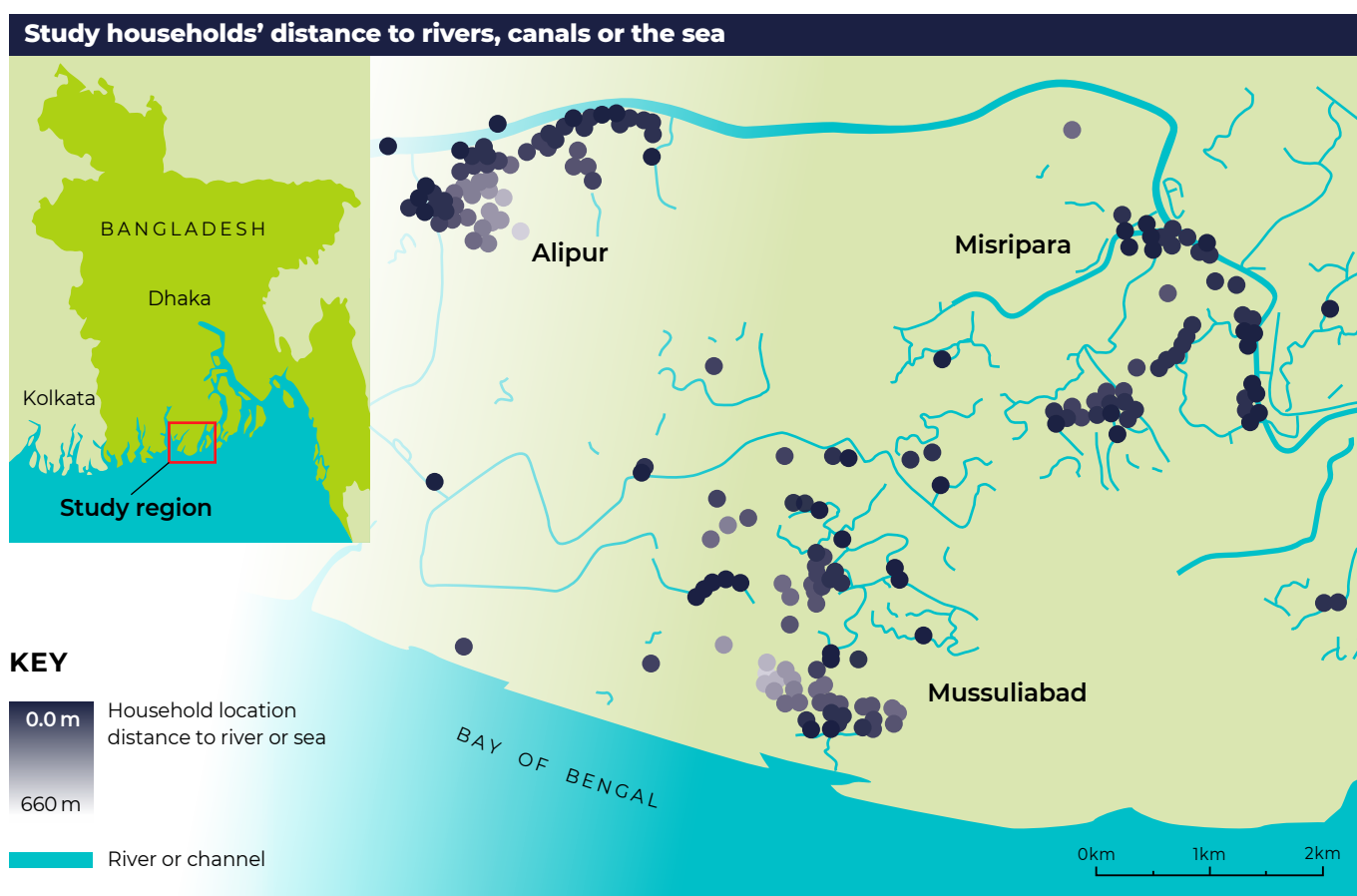


FIGURE 6. Inset left map shows the study region in Bangladesh (red box). The main map displays locations of the study households together with rivers/canals and the sea. Only water bodies within 500m of households were mapped. Colours of the household locations indicate the smallest distance to the nearest river/canal or the sea. Source: Own elaboration on 10/09/2025.

3. Note: Calculated distances to the nearest water bodies should be interpreted with precaution, as the household coordinates extracted from Kobo Toolbox may contain inaccuracies.

On average, households were 164.8 m ($\pm$ 138) from the next waterbody, with distances ranging from 5.7 m to 666 meters. There was no statistically significant difference in these distances between programme and non-programme participants.

We included distance measures into our model as a control when analysing differences in resilience outcomes.

KEY FINDINGS CHAPTER 1

- + Programme and non-programme households live in the **same fragile landscape** of the delta, farm similarly small plots and face the same looming cyclone risk.
- + The two groups (programme and non-programme participants) share **similar socio-demographic characteristics**, making them comparable.
- + Before any storm, **programme households are more diversified** in their livelihoods, focused on farming, more **connected** to markets (especially organic ones), and more deeply embedded in social and financial networks. Non-programme households rely more on wage labour and have thinner safety nets.
- + Because geography and basic hazard exposure of households are similar, later differences in how households withstand, cope with and recover from Cyclone Remal cannot be explained by location alone.
- + The different **configurations of livelihoods, market integration and social networks** described in this chapter are likely to be **central** to understanding resilience outcomes



Rice cultivation in Latachapli, the coastal region of Barishal.

2. Preparing for the storm

Chapter 2 takes a closer look at what households were already doing before Cyclone Remal hit: how they farmed, how they prepared, and what they believed about their own future. We first describe the agroecological status of farms based on the 10 Elements of Agroecology. We then look more closely at concrete farming practices, asking which types of households have adopted agroecology-aligned practices. Finally, we examine households' anticipatory capacity: how they invested in long-term risk reduction, accessed early warning and shelters, and translated training and experience into early action. Together, these two sections show that programme participation, social networks and mindset shifts are key in shaping how prepared households were when Remal arrived.

The agroecological status of the farms

In this section, we describe the agroecological status of surveyed farms, looking at programme and non-programme participants. We organise the analysis along nine of the ten FAO Elements of Agroecology, omitting the element “Resilience”, which underpins the report as a whole. A description of the Agroecological Elements is not provided in this section but can be found in [Annex 3](#). Analysis of the agroecological status is based on the construction of an Agroecology Composite Index (see [Methodology](#) and [Annex 2](#) for details).

We found that programme households were **more closely aligned with the Elements of Agroecology than non-programme participants**, with particularly large differences in efficiency, recycling, co-creation and sharing of knowledge, and human and social values (see [Figure 7](#)).

In the **agroecology composite index**, programme households scored on average 3.11, compared to 0.96 among non-programme participants, a difference of 2.15 points on a 0–4 scale.

This very large gap indicates that participation in the Proyash programme enabled farmers to **embrace a new model of farming**. This model is not simply about adding a bit more diversity or adopting a few additional practices. Instead, the package of programme participation and engagement in agroecology supports a comprehensive conversion of the farming system. The degree of this conversion becomes clear when comparing programme participants with non-participants.



Raised beds protect crops from flooding. Sack cultivation mitigates against salinity and allows plants to be moved in adverse weather.

The majority of households cluster at the high end of the composite scale, with only a small part showing low scores. This suggests that among programme households, **high adoption of practices aligned with agroecology elements is the norm**. The much smaller subgroup at the lower end of the distribution may represent newly trained farmers or households operating in more challenging contexts where full adoption of agroecology is not yet possible (see Figure 7, below).

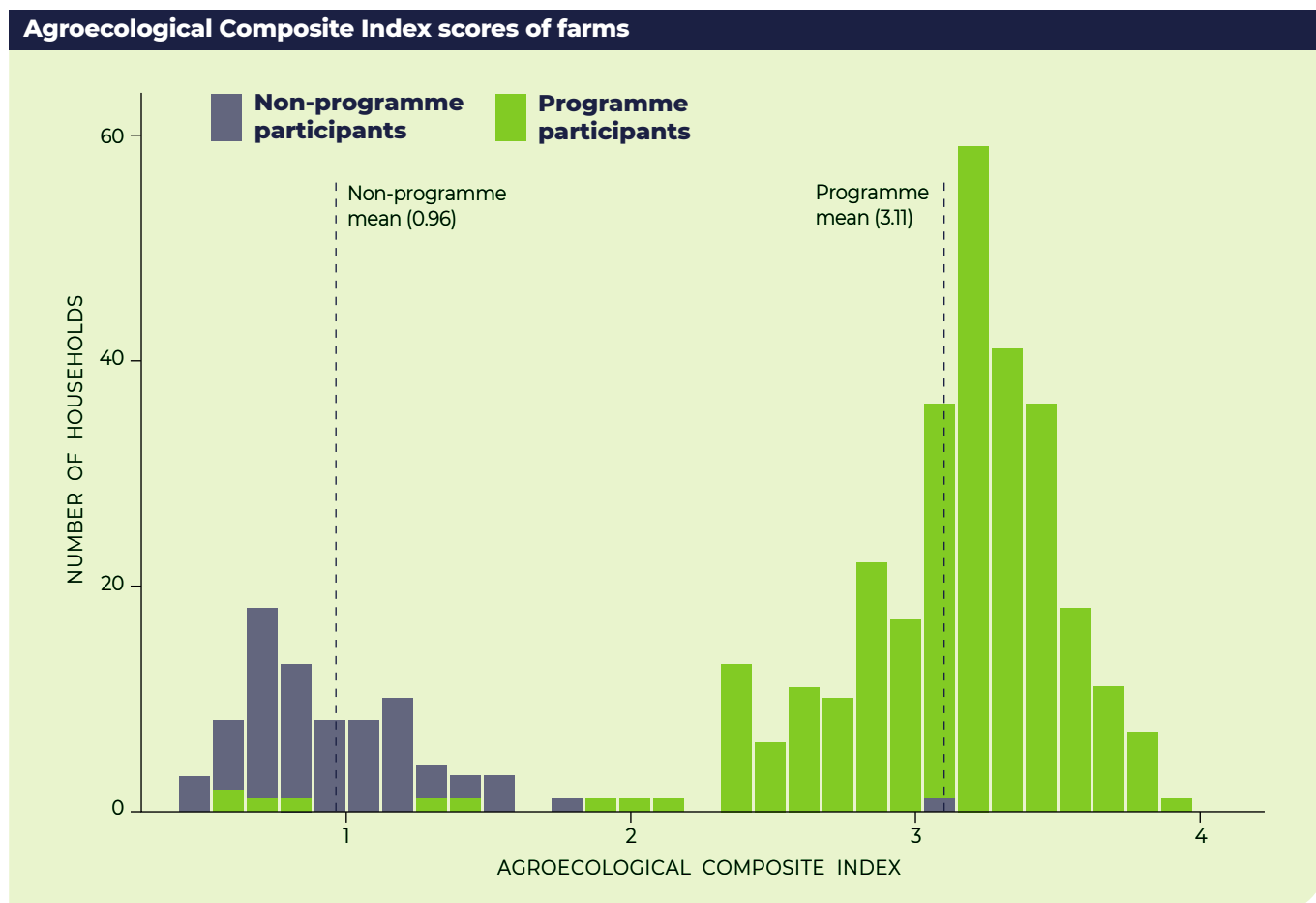


FIGURE 7. Distribution of the calculated Agroecological Composite Index scores (0–4 scale) reflecting the alignment of farms with the 10 Elements of Agroecology.

Findings are shown for programme and non-programme participants. Bars show the number of households in each score class; dashed vertical lines indicate group means, illustrating that trained households cluster at much higher agroecological transition levels than non-programme households.

One of the largest gaps we observe appears in the element called Co-creation and sharing of knowledge (3.73 vs. 1.11) (Figure 8). Programme activities such as **FFSs, women's groups and cooperatives** create **new social spaces** where farmers meet, experiment and exchange experiences. These spaces challenge traditional, hierarchical knowledge structures and can particularly empower women, who often lack formal roles in farming and decision-making. Farmers who participate in such groups become important local hubs, spreading information and reducing long-standing knowledge asymmetries within communities.

Alignment of farms with the 10 Elements of Agroecology



FIGURE 8. Radar chart of average scores (0-4) for each FAO Agroecological Element, except Element 6 “Resilience”, see [Methodology](#).

Households without some form of training or access to the programme remain more atomised, relying heavily on traditional networks that tend to exclude women and poorer farmers. **The programme intervention seems to have strengthened social capital** – something badly needed to withstand environmental stresses and market volatility. We find that **programme activities that encourage labour exchange, elevate women’s participation, reduce social marginalisation, and strengthen mutual responsibility are especially valuable.**

Differences in agroecological farming practices

To specifically understand the degree to which households had adopted agroecology-aligned farming practices before Cyclone Remal, we took a closer look at the farming practices present in the Agroecological elements. Within the following five elements these were:

- **Diversity:** diversity of minor crops, tree integration, livestock diversity, type of production system (monoculture, polyculture, integration of livestock/trees/fish)
- **Synergies and Recycling:** crop diversity, use of specific cultivation practices such as sack and surjan methods, mulching, raised beds, saline-tolerant crops, tree planting, soil bunds or drainage, raised livestock shelters, drip irrigation, greenhouses, vermicomposting, reuse of crop or kitchen residues or animal manure, seed bank access and seed saving practices
- **Efficiency:** utilisation of organic fertilisers, application of ecological products or mechanical weed control, seed bank access and seed saving practices, reuse of crop or kitchen residues or animal manure
- **Culture and Food traditions:** presence of a kitchen garden and diversity of minor crops.

As in the overall index, programme households scored much higher than non-programme participants across all five agroecology practice dimensions (see Figure 9). This indicates far broader and deeper adoption of agroecology-aligned farming.

For the element **Diversity** – capturing diversity of crops, livestock, income sources and market channels – programme farms averaged about 2.6 on the 0–4 scale compared to 1.1 among non-programme farms. The index capturing the element **Synergies** shows an even sharper contrast (3.05 vs 0.68).

Differences are largest for **Efficiency** and **Recycling**: programme households reached mean scores of 3.37 and 3.13 respectively, while non-programme participants remained close to zero (0.32 and 0.40), suggesting that programme participants are much more likely to use seed saving, organic inputs, and circular resource flows. Also, for **culture and food traditions**, measured through kitchen gardens and minor-crop diversity, programme households score more than twice as high as non-programme participants (2.22 vs 0.99).

Overall, these results point to a consistent pattern: **programme participants have moved towards more diversified, synergistic, resource-efficient and circular production systems**, while non-programme participants apply such practices only to a limited extent.

At the same time, even among programme households, scores rarely reach the maximum, suggesting that although participants are substantially further advanced in the agroecological transition, there is still room to deepen and broaden the implementation of practices.

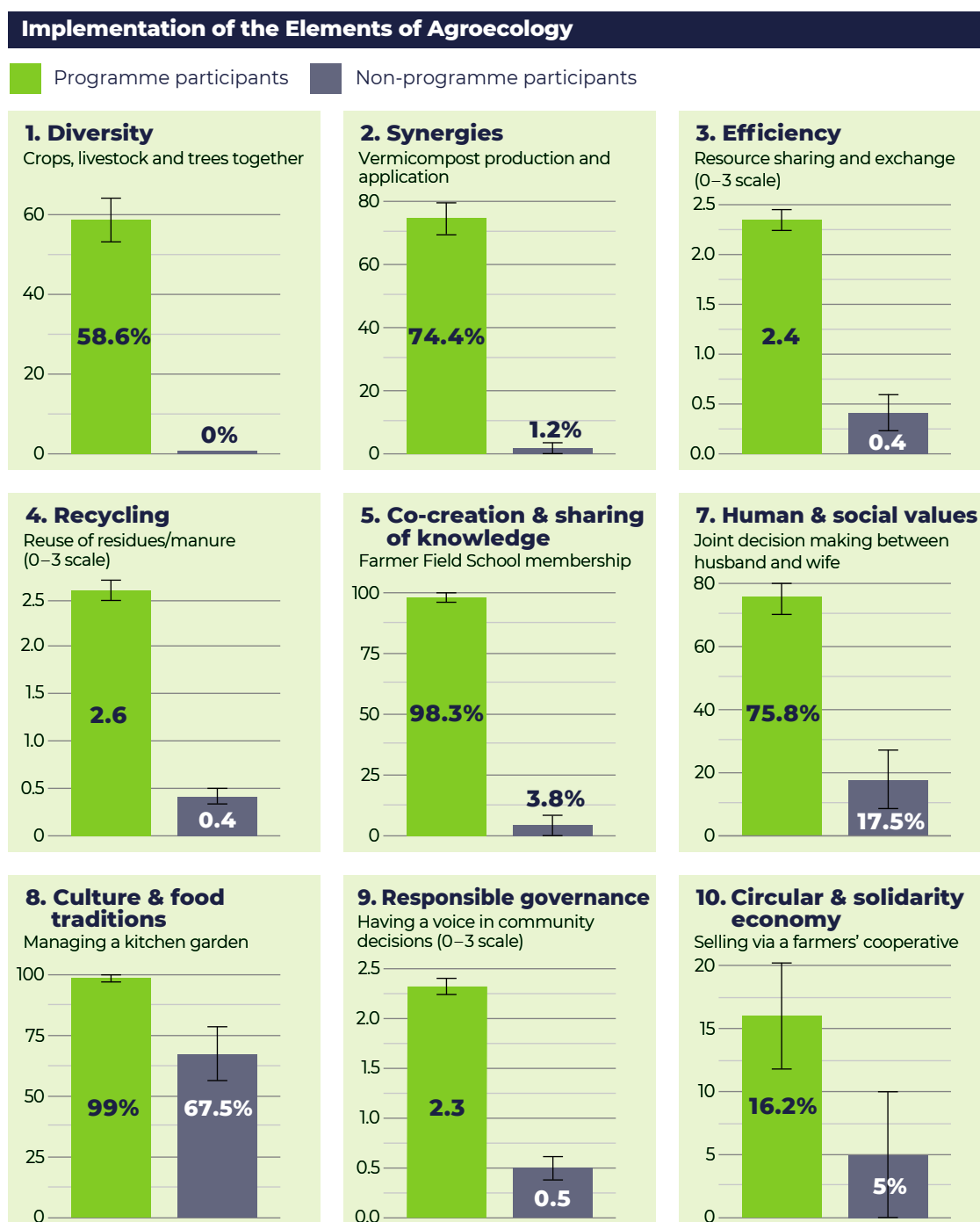


FIGURE 9. Bars show results for representative aspects for nine of the ten dimensions. The element “Resilience” was intentionally left out.

What shapes the degree of the agroecological transition?

In trying to understand which types of households are more likely to be further advanced in the agroecology transition, we assessed which pathways explain the calculated Agroecology Composite. We found that **programme participation, and access to financial and basic services** explain the degree of agroecological transition to different extents:

The agroecological status of households is shaped above all by their **involvement in the Proyash programme**. In the SEM, the programme variable is by far the strongest predictor of the agroecology composite index. Households that participated in the programme score substantially higher on the index than comparable non-participant households. The large effect of the programme ($\beta \approx 0.79$, $p < 0.001$) indicates that programme participation is closely associated with the adoption of a broader set of agroecological practices.

Access to **financial services** (social safety net programme, own savings, access to credit) and **basic services** (water, electricity, phone network) also supports the uptake of agroecological practices, though to a lesser extent. Households with higher levels of financial inclusion tend to have higher agroecology scores ($\beta \approx 0.16$, $p < 0.001$), suggesting that **the ability to save, borrow or use formal financial products may help them invest in or maintain more diversified and sustainable farming systems**. Similarly, better access to services is positively associated with the agroecology index, albeit with a smaller effect size ($\beta \approx 0.07$, $p < 0.05$). These factors likely ease some of the practical and transaction-cost barriers to implementing agroecological practices.

By contrast, **land size** plays only a minor role. The association between landholding and the agroecology composite index is weak and only **marginally significant** ($\beta \approx 0.04$, $p \approx 0.06$), indicating that **larger farms are only slightly more likely** to score higher on the index.

Demographic variables i.e. education level, age, gender, household size and market orientation, did not explain the differences observed in the agroecological status of farms.

Anticipatory capacities of households

In the following section we describe how households prepared for the cyclone, both in the short- and long-term. What processes facilitated or hindered them in doing so? We refer to these preparatory processes as the households' 'anticipatory capacity'. We also included questions on the respondents' aspirations, purpose and future orientation since these subjective aspects are important drivers of respondents' motivation and agency in acting for change and explain drivers of households' anticipatory capacity.

Preparedness

Programme households mainly reported having made multiple **permanent improvements** to their **farm to reduce cyclone-related risks**, while non-programme participants most often made no changes. Among those reporting change, programme respondents overwhelmingly credited disaster training/**programme participation**, with smaller numbers citing personal experience and advice from others. Non-programme respondents primarily pointed to **personal experience**, with far fewer mentioning training.

Early warning

On average, respondents **heard the day before or on the same day about the approaching cyclone**. A surprising finding was that almost all respondents reported to have access to local early warning systems and shelter, however access to shelters was slightly lower for non-programme participants. The same pattern was observed for a functioning embankment. A comparison of these indicators of anticipatory capacity is also provided in [Table 4](#).

Sub-module	Variable	Programme participants	Non-programme participants
Household structural/long-term preparedness	Implementation of permanent risk-reduction measures at farm-scale (0-3 scale)	2.1	0.14
	Drivers of these measures: Training/programmes (%)	91	18
	Drivers of these measures: Personal experience (%)	17	91
	Drivers of these measures: Advice from others (%)	11	-
Community structures, risk reduction & quality of governance	Early warning received (%)	99	99
	Shelter access (%)	99	91
	Functioning embankment (%)	89	76

TABLE 4. Comparison of the results for selected variables comprising the anticipatory capacity of programme and non-programme participants.

Early action

In the hours before landfall of Remal, **early harvest was the dominant action** for programme participants (70%) while for non-programme participants it was preparing food reserves (31%). Further steps taken were **moving livestock** to safe places (5% programme; 18% non-programme), **covering tools or seeds**, and preparing food reserves (8% programme; 31% non-programme). 19% of non-programme participants reported to have taken no preparatory actions.

Among the three most important aspects that enabled households to take these preparatory actions, programme participants most often selected **timely alerts, prior planning**, and **support from NGO/farmer platforms**. Non-programme participants relied primarily on past-shock experiences and support from family or neighbours (see Figure 10).



FIGURE 10. Comparison of most important sources of disaster knowledge or support received to prepare for Cyclone Remal among programme and non-programme participants. Answered by 377 out of 377.

The two main factors mentioned by all respondents in **limiting their ability to prepare** for the cyclone were **lack of money/tools** (88% programme vs 63% non-programme) and time (81% programme vs 70% non-programme). However, programme households rarely cited that they did not know what to do in comparison to non-programme participants (2% vs 68%). Consistently, programme households rated their actions as being effective (2.61 vs 0.38 on a 0-3 scale).

When asked what kind of support would **most help them to prepare better in future**, programme and non-programme participants expressed broadly similar needs. Both groups stressed the importance of earlier and clearer warnings (74% programme vs 73% non-programme) and **additional training** (74% vs. 64%). **Access to finance and insurance** was another central demand (48% vs. 37%), along with **better community-level preparedness plans** (38% vs 35%) and more hazard-proof farm redesign (33% in both groups) (see also Figure 11).



FIGURE 11. Perceived priorities for improving preparedness before future cyclones among programme and non-programme participants. Answered by 377 out of 377.

Aspirations and purpose of households

Finally, responses on **aspirations and purpose** indicated **differences in how respondents think about their future** and their role in shaping it. Programme participants were much more likely to prioritise their own **long-term goals over immediate needs** (85% vs. 23%), emphasise **personal fulfilment** (83% vs. 25%), and to identify primarily with their work (85% vs. 23%). They also strongly highlighted “working together” as being important (95% vs. 41%). By contrast, non-programme participants more often focused on covering immediate needs (55%) and “making it alone” (39%).

What shapes anticipatory capacity before the storm?

As with the agroecological status of farms, we also analysed **which factors predict households’ anticipatory capacity**, since these help us explain differences in how households withstand and recover from the shock.

Households' anticipatory capacity before the cyclone is strongly shaped by their participation in the Proyash programme. In the SEM, the programme has by far the largest standardised effect on the Anticipatory Capacity index ($\beta \approx 0.76$, $p < 0.001$), and the model explains a substantial share of the variance in this index ($R^2 = 0.72$). This aligns with the underlying components: compared to non-participants, programme households report many **more permanent risk-reduction changes** on their farms, far higher **exposure to climate and disaster-related training**, and a much stronger role of **external drivers such as advice and programme support** in motivating these changes, while also having slightly better access to local risk-reduction infrastructure (shelters, embankments, early-warning systems). **Financial inclusion and access to services** show smaller but still positive associations with anticipatory capacity, suggesting that being connected to formal institutions and services helps households translate training and experience into concrete preparedness actions. Land size, by contrast, does not significantly influence anticipatory capacity, indicating that it is the **quality of engagement with training, information and services** that differentiates households' ability to prepare in advance of cyclones.

KEY FINDINGS CHAPTER 2

- + **Programme households show a substantially higher degree of agroecological transition** across all FAO Agroecological Elements. There are especially large differences in **co-creation and sharing of knowledge, recycling, efficiency, and human and social values**. The gap in the agroecology composite index is substantial.
- + **Participation in the Proyash programme is the strongest predictor of agroecological practice uptake**, even after controlling for land size, financial inclusion, and service access. Farm size plays only a minor role in the uptake. The integration of farms into financial and service networks additionally supports but does not drive the transition.
- + **Agroecological transition is associated with stronger social capital, collaboration, and future-oriented aspirations**. Programme participants more frequently emphasised collective action, long-term goals, and personal agency.
- + **Programme households exhibit significantly stronger anticipatory capacity**, they also invest more in long-term, permanent risk-reduction measures on their farms and took more early actions before Cyclone Remal.
- + **Disaster risk reduction measures among programme households are primarily knowledge driven**. Almost all programme participants attribute their actions to training and programme engagement. Non-programme households rely predominantly on past shock experience.
- + Results indicate that **material resources as well as social relations and mindset** shape anticipatory capacity of households.

Exposure to and impacts of Cyclone Remal

While all surveyed households live in the same cyclone-prone coastal context and reported similar prior exposure to cyclones, the extent of damage experienced during Remal varied considerably. In Chapter 3, we examine the exposure of households to Cyclone Remal and the immediate impacts experienced during and shortly after the event. Distinguishing between exposure and impact is critical. This is because households face similar hazards but experience different outcomes depending on their preparedness, farming systems, and protective measures.

Exposure

Exposure to **cyclones was similar** across all respondents – both groups reported experiencing a cyclone more than three times in the past five years (2.92 vs 2.75 on a 0–3 scale) and reported a duration of ~24–36 hours for Cyclone Remal.

We then constructed an exposure intensity index (INT) (see [Methodology](#) and [Annex 2](#)) that combines perceived severity of Cyclone Remal, duration of the storm, and the number of days with standing water into a 0–4 scale. We found that variation in exposure **intensity is explained only weakly by the location** i.e. distance to water bodies. More protected locations showed only a slightly lower exposure intensity (standardised $\beta \approx -0.12$, $p = 0.018$; $R^2 \approx 0.01$). Further, the exposure intensity has only a small association with the reported cyclone damage ($\beta \approx 0.06$, $p \approx 0.05$). Taken together, these findings suggest that while households reported severe and sometimes prolonged exposure to Remal, differences in the impact and subsequent resilience outcomes are driven less by different levels of exposure to the cyclone.

Hazard impact

Overall, non-programme participants reported hazard impacts twice as severe as programme participants (2.65 vs. 1.36 on a 0–3 scale). Table 5 (below) provides a closer look at the immediate impacts of Cyclone Remal for the two groups.

Impact Type		Programme participants mean	Non-programme participants mean
Damage to housing (%)	No	5.1	0
	Partially	92.9	25
	Heavily	2	75
Standing crops lost		0.4 (1-25% crops lost)	2.11 (5-200% crops lost)
Livestock losses (#)		1.49	7.3
Persistence of floodwater		1.79 (1=1-3 days/2=4-10 days)	2.34 (2=4-10 days/3=more than 10 days)
Damage to farming infrastructure		1.03 (Minor – quick repairs at low cost)	2.34 (Moderate damage – repairs take several weeks)
Income loss in the following cropping season		0.65 (1-25 % lost/ 25-50% lost)	1.96 (25-50% lost/ 75-100% lost)
Psychological impact		1.12 Worried but it did not affect my sleep and work)	2.38 (Often felt anxious or it sometimes affected sleep and work)

TABLE 5. Immediate impacts of Cyclone Remal among programme ($n=297$) and non-programme participants ($n=80$). Results represent the mean across the respondents.

To synthesise these multiple impact dimensions, we constructed a composite index that was based on the immediate impacts of the cyclone (crop loss, livestock losses, infrastructure damage, income loss) (SHI_B, see [Methodology](#) and [Annex 2](#) for details).

In the model, the observed cyclone damage at household level is strongly shaped by pre-existing agroecological practices and anticipatory capacity. Households with **higher scores on the agroecological composite index experienced substantially lower damage** (standardised coefficient -0.34), and those with **stronger anticipatory capacity also reported less damage** (-0.33).

Additionally, Proyash programme participation has a further protective effect even after accounting for agroecological status and anticipatory capacity: households that participated in the programme show significantly lower cyclone impact scores (-0.26), suggesting that aspects such as **practical preparedness skills or social support also helped limit losses**.

The influence of **cyclone intensity** (INT, see section above) on the damage was relatively small (0.06). More intense or prolonged exposure is associated with slightly higher damage. Yet both effects are low compared to the influence of households' anticipatory capacities and the agroecological status of farms.

Other structural characteristics, such as financial inclusion, land size and access to services, do not show significant direct effects once agroecology, anticipatory capacity and programme status are taken into account.

Overall, the model explains around 72% of the variation of the cyclone impact, underscoring that the observed **differences in damage were largely driven by households' pre-cyclone practices and preparedness rather than by exposure alone**.

KEY FINDINGS CHAPTER 3

- + Programme and non-programme households reported similar cyclone exposure. Even when including comparable frequency of past cyclones and duration of Cyclone Remal, both groups face broadly similar hazard conditions.
- + **Despite similar exposure, non-programme households experienced substantially higher negative impacts across all material and non-material dimensions.**
- + **The composite damage index confirms a large gap in cyclone impacts.** Non-programme households experienced roughly double the damage of programme households.
- + **Programme participation is the strongest and most consistent predictor of lower damage.** This result does not change even after statistically controlling for village location, distance to water bodies, farm size and household size.
- + **Commonly assumed risk factors such as proximity to water and farm size explain little additional variation in damage** once programme participation and village context are accounted for.

Typically, households respond to cyclone impacts with immediate coping actions, followed by the sequencing of recovery measures. The speed at which households restore core activities such as farming and household functioning is crucial for shaping recovery trajectories. In this chapter, we examine how households coped with and recovered from the impacts of Cyclone Remal, analysing recovery as a multi-stage process. We focus on how different responses influence the depth and type of recovery achieved, comparing how programme and non-programme participants mobilised resources, prioritised actions, and adapted their livelihoods after the cyclone.

Immediate coping strategies

Immediately after a disaster strikes, households and individuals go into coping mode. Coping means doing the most essential things to stay alive and stabilise. In our sample, meal reduction was a common strategy for households in the wake of Cyclone Remal. **Thus, the cyclone had an immediate food security impact** for all.

However, there are differences between programme and non-programme participants in how they coped with the immediate aftermath of Cyclone Remal. Meal reduction was a common strategy across both groups, reported by 74% of programme households and 55% of non-programme participants. We have not fully resolved this paradox.

Financial coping strategies differed markedly. **Programme households relied predominantly on their own savings**, with 73% reporting the use of savings compared to only 28% of non-programme participants. In contrast, non-programme participants were much more likely to rely on loans or credit (54% vs. 26%).

Non-programme participants were also substantially more likely to adopt coping strategies that involved liquidating assets or disrupting household stability. Thirty percent reported **selling household items** (compared to 6% among programme households), 26% sold major production assets such as livestock or farm equipment (vs. 13%), and 16% temporarily relocated (vs. 3%).

In addition, many households sought to increase income through extra wage labour, reported by 64% of programme households and 43% of non-programme participants.

These patterns indicate that programme households were more able to cope with the shock using internal financial resources, whereas non-programme participants more often relied on borrowing or asset sales during the immediate recovery period.



Minara Begum uses vermicompost to improve soil quality after the cyclone.

Predictors of the coping behaviour

We now take a closer look at processes that explain the observed differences in coping strategies. The construction of the index to assess the coping behaviour is detailed in the [Methodology](#) and [Annex 2](#).

Based on our SEM, we found that coping quality (i.e. the combination of the concrete coping actions taken and their perceived downstream quality) is negatively associated with both cyclone impact and cyclone intensity. Households that experienced greater damage (SHI_B) or higher perceived intensity (INT) reported poorer coping quality ($\beta \approx -0.33$ and $\beta \approx -0.15$ respectively). This indicates that **more severe shocks constrain households' ability to respond without resorting to erosive strategies**.

At the same time, **programme and access to services show positive associations with the coping quality** ($\beta \approx 0.24$ and $\beta \approx 0.10$ respectively). These results suggest that households connected to training and service networks are better able to cope with the immediate aftermath of the cyclone, even when facing similar levels of impact. Overall, the model explains a moderate share of variation in coping quality ($R^2 \approx 0.27$; [Figure 14](#)).

Importantly, anticipatory capacity is associated with less intensive coping. This reflects that **households who were better prepared before the cyclone often required fewer coping actions** after the shock, as preparatory measures reduced losses and immediate needs.

Recovery time

In this study, recovery time refers to how quickly and how fully households were able to resume key household and farm activities after Cyclone Remal. Recovery time captures the speed and the extent of recovery, using two short ordinal indicators (*Speed of resuming basic household activities*; *Recovery of farming and livelihood activities*).

In short, programme households restarted their livelihood activities earlier after the cyclone. Also, programme households had a shorter recovery timeline after the cyclone:

It took programme households on average ~15 days to restart farming and ~7-15 days for household routines. For non-programme participants the timespan for both activities was ~30 days for farming and 15-30 days for household activities.

These recovery times reflect how effectively a household can move from immediate disruption and related coping to functional stability and, eventually, back to farming and livelihood activities. It is influenced by multiple factors such as damage levels, household resources, preparedness, social support, and farming practices informed through agroecology.

Sequencing of recovery

A central question for building safety nets and strengthening disaster support services in the delta is how households behave following coping. Respective information directly determines how disaster recovery could be designed in future.

To examine how households prioritised recovery after Cyclone Remal, respondents were asked what they restored first, second, and third in the aftermath of the cyclone. The comparison between programme and non-programme participants reveals clear differences in the sequencing of recovery activities ([Figure 12](#)).

Programme households restored **farming as their first recovery activity** (68%), whereas non-programme participants primarily prioritised repairing housing (52.5%) and securing food supply (29%). This indicates distinct recovery pathways across the two groups. Programme households entered recovery from a position where they **could invest forward** (restart farming). In contrast, **non-programme participants were in a stabilisation phase** with an emphasis on losses that had to be resolved **before** livelihood recovery was possible.

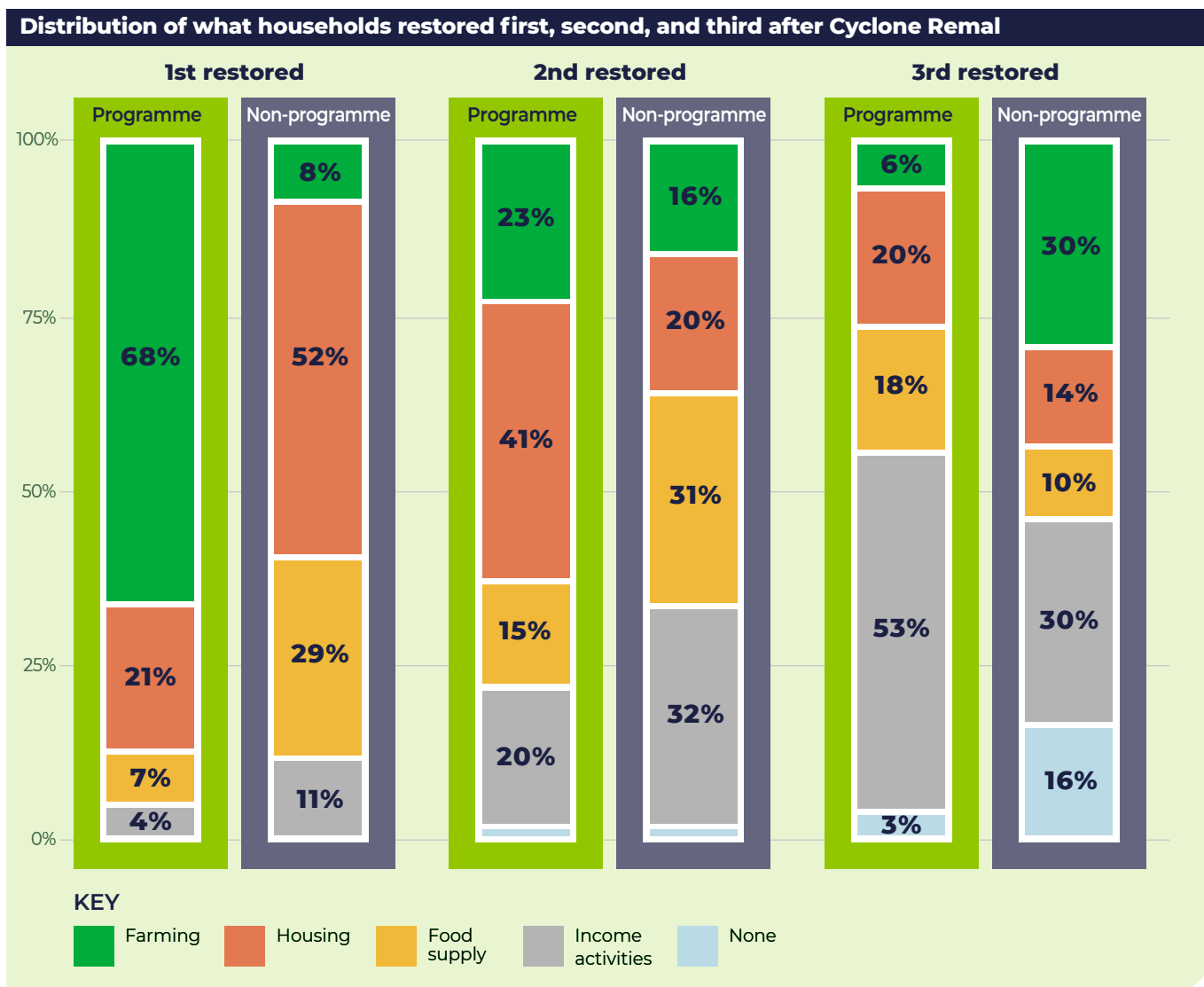


FIGURE 12. Distribution of what households restored first, second, and third after Cyclone Remal, by programme participation (n=297 programme; n=80 non-programme).

Differences persist in subsequent recovery stages. After restoring farming, programme households most often prioritised income-generating activities, while non-programme participants continued to focus on basic needs such as food and housing in the second stage of recovery. By the third stage, programme households mainly reported income activities and housing, whereas non-programme participants still showed a higher share of unmet basic needs.

These differences in recovery sequencing are reflected in overall recovery status at the time of the survey, 14 months after the cyclone. Seventy-two percent of programme households reported that everything had returned to normal, compared to 12.5% of non-programme participants. Only 5% of programme households reported that farming activities had not yet returned to normal, compared to 45% of non-programme participants.

The data show that **programme households were able to resume farming and income-related activities earlier** in the recovery process, while non-programme participants remained focused on restoring basic shelter and food security for a longer period following Cyclone Remal.

Drivers of the recovery process

To examine what supported households' recovery after Cyclone Remal, respondents were asked to rank the three most important drivers of their recovery (Figure 13). Clear differences emerge between programme and non-programme participants.

Among programme households, the most frequently reported recovery drivers were own savings (35%), NGO support (31%), and farming practices (27%). These drivers also appear consistently across first, second, and third choices, indicating that programme households relied on a combination of financial resources, external support, and on-farm practices during recovery. Access to markets and services further supported recovery among programme households, with higher average scores compared to non-programme participants.

In contrast, non-programme participants most often identified credit, loans, or remittances as their main recovery driver (35%), followed by own savings (30%). NGO support and farming practices were reported far less frequently. Notably, non-programme participants much more often reported having no third helpful recovery factor (42.5%), suggesting a narrower set of identified recovery drivers.

Across the ranking, programme households consistently reported a broader range of recovery drivers, while non-programme participants relied more heavily on financial borrowing and were more likely to report limited or no additional sources of support beyond their primary coping strategy.

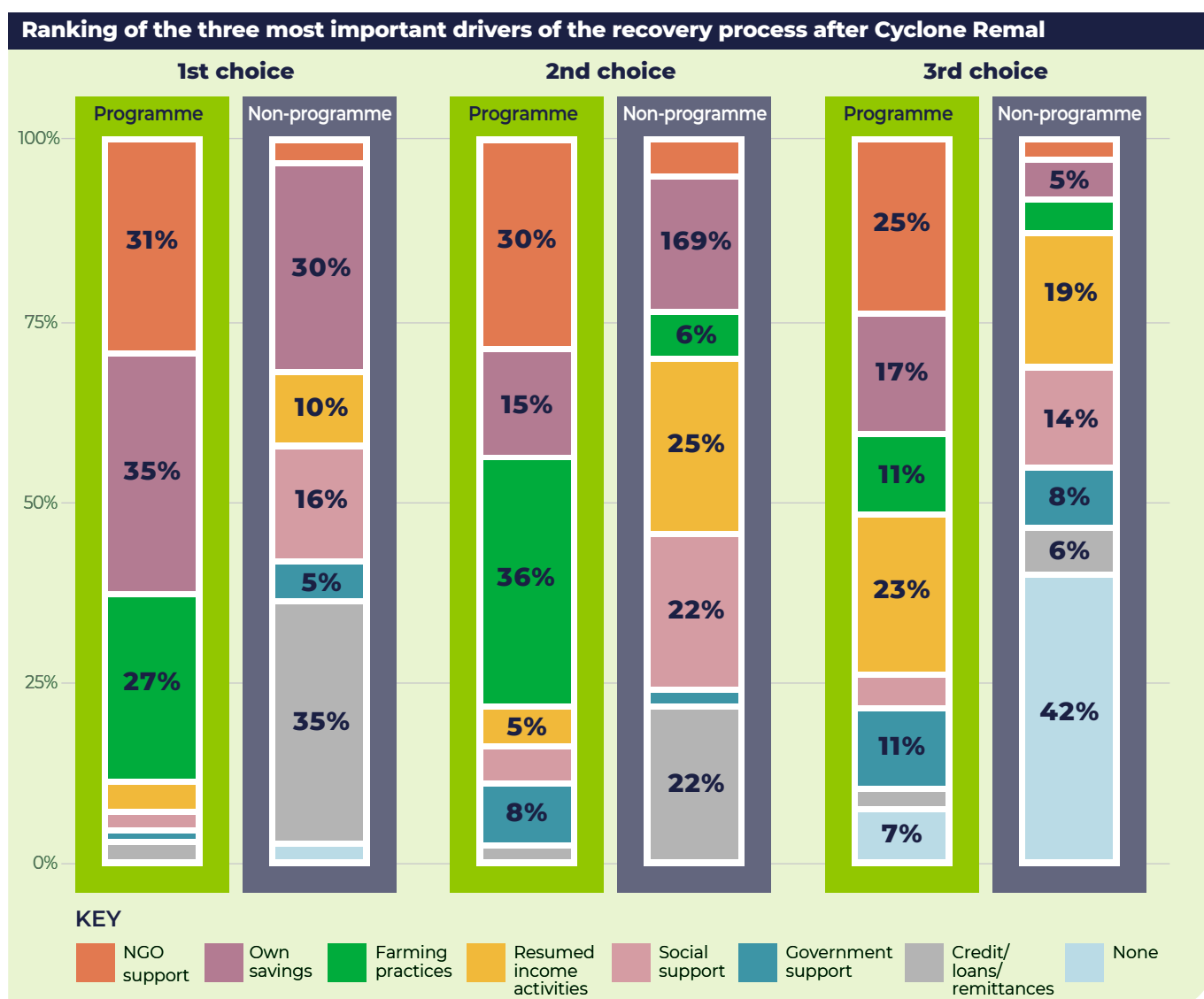


FIGURE 13. Ranking of the three most important drivers of the recovery process after Cyclone Remal by programme participation (n=297 programme; n=80 non-programme).

Depth of recovery

Programme households were more likely than non-programme participants to report adaptive or transformative changes following Cyclone Remal, rather than only restoring pre-cyclone conditions. On a 0–3 scale, programme households reported substantially greater changes in farming systems (mean 2.04 vs. 0.16) and income activities (1.67 vs. 0.19).

Programme households also reported higher **perceived preparedness for a future cyclone** (2.29 vs. 0.40). Self-reported confidence in managing another cyclone (2.32 vs. 0.48) and optimism about improving livelihood conditions (2.27 vs. 0.59) were likewise higher among programme households.

Qualitative responses illustrate how some households linked changes in farming practices to their recovery experience. For example, during data collection one respondent described how vermicomposting supported the resumption of crop production after the cyclone, noting that earthworm reproduction helped restore soil fertility and enabled farming activities to restart.

Hence, results suggest differences between programme and non-programme participants in the extent of post-cyclone changes to farming and livelihood activities, as well as in reported preparedness, confidence, and optimism following Cyclone Remal.

What shapes the recovery of households from the storm?

Moving further along the disaster cycle, we trace the different pathways households followed and examine which factors explain the variation in their recovery after the shock.

In the SEM, we captured household recovery as a latent index that reflects how quickly households restarted farming and household activities and how far they “bounced forward” rather than simply restoring pre-cyclone conditions. This latent Recovery factor is measured by the speed of restarting activities and the degree of adaptation or transformation in farm and income activities, and remaining deficits (see [Methodology](#) and [Annex 2](#) for details).

The strongest driver of better recovery is the agroecological composite index. Programme households recover substantially faster and in a more adaptive way (standardised $\beta \approx 0.48$), even after controlling for damage, anticipatory capacity, support, and other structural factors.

Anticipatory capacity and the quality of support during and after the cyclone further enhance recovery ($\beta \approx 0.25$ and 0.24 respectively), indicating that households who had already implemented risk-reduction measures, received preparedness training, and had access to broad and useful support networks were better able to restart activities and adjust their livelihoods.

Not surprisingly, higher damage levels (SHI_B) significantly undermine recovery ($\beta \approx -0.25$), and households relying more strongly on erosive coping strategies – captured in the coping quality index – also show somewhat weaker recovery once other factors are taken into account ($\beta \approx -0.11$).

The impact of the Proyash programme on the recovery process is realised through the capacities it builds (agroecology, anticipatory capacity, access to social networks) rather than as a single effect.

Lipi Begum runs a community Business and Information Hub through which farmers can sell their organic produce.



Other structural characteristics, such as financial inclusion, land size and service access, do not have significant effects.

Overall, the model explains about 91% of the variation in the Recovery index, indicating that differences in pre-cyclone agroecological status and preparedness, the extent of damage, and the ways households coped and were supported after the storm together account for most of the observed differences in how households recovered from Cyclone Remal.

When estimating the model only for Proyash programme households, these mechanisms appear particularly coherent. Programme participation is very strongly associated with both the agroecological composite index ($\beta \approx 0.79$) and anticipatory capacity ($\beta \approx 0.76$), both of which substantially reduce cyclone damage ($\beta \approx -0.34$ and -0.33) and contribute to faster and more adaptive recovery (e.g. $\beta \approx 0.48$ from agroecology to recovery). In this group, the perceived quality of support becomes an additional major driver ($\beta \approx 0.44$), and financial inclusion and access to services work in synergy with programme participation, reinforcing agroecological practice adoption and anticipatory capacity rather than acting as stand-alone factors.

By contrast, the SEM for non-programme participants points to a much more fragmented and fragile resilience pathway.

Anticipatory capacity is only weakly explained ($R^2 \approx 0.04$), exposure intensity remains largely unbuffered ($R^2 \approx 0.13$), and coping patterns account for only part of the variation in recovery ($R^2 \approx 0.30$), with relatively few households fully recovering. In this group, existing agroecological practices are only modestly and not significantly associated with lower damage ($\beta \approx -0.23$, $p \approx 0.08$), support quality (defined as the number of support channels available and perceived helpfulness) does not show a clear positive effect, and financial inclusion is strongly negatively associated with recovery ($\beta \approx -0.58$), consistent with households relying on debt in erosive ways. Storm intensity also weighs more heavily on recovery ($\beta \approx -0.40$), indicating that, without the reinforcing effects of programme and structured support, non-programme participants are more fully exposed to the hazard and have fewer effective levers to translate damage into adaptive, “bounce-forward” recovery.

KEY FINDINGS CHAPTER 4

- + **Programme households coped with the immediate shock using less erosive strategies**, relying mainly on savings and wage labour, while non-programme households depended more on loans, asset sales, and temporary relocation.
- + **Recovery was significantly faster among programme households**, with earlier resumption of farming and household routines, compared to substantially longer recovery timelines for non-programme households.
- + **Distinct recovery sequences emerged across groups**. Programme households prioritised restoring farming and income generation, whereas non-programme households focused first on housing repair and food security, remaining in a stabilisation phase for longer.
- + **These differences translated into unequal recovery outcomes**. Most programme households reported full recovery at the time of the survey, while many non-programme households continued to face unresolved deficits, particularly in farming activities.
- + **Programme households drew on a broader and more diverse set of recovery drivers**, combining savings, farming practices, NGO support, and service access, whereas non-programme households relied mainly on borrowing and had fewer supportive recovery factors.
- + **Agroecological practices and anticipatory capacity are the strongest drivers of adaptive recovery**, mediating cyclone impacts and enabling households to recover faster and “bounce forward,” while higher damage levels and erosive coping strategies undermine recovery.

Chapter 5 integrates findings across the disaster risk management cycle to explain how households' agroecological orientation, anticipatory capacity, and support systems interact to shape resilience to Cyclone Remal. Building on the findings presented in Chapters 1–4, we first describe resilience as a multifactorial, socially constructed phenomenon, and then present key levers for actions within each phase of the disaster risk management cycle.

Resilience is multifactorial

What happens if we now bring all the data presented in Chapter 1- 4 together into one perspective? **A core finding of this research is that participation in the Proyash programme, anticipatory capacity, agroecology and social support jointly shape households' ability to recover from tropical storms like Cyclone Remal.**

Even though storms such as cyclones are meteorological events that affect people equally, the impacts are strongly shaped by social factors. Communities and households with greater skills, better information, higher levels of preparedness, and stronger social networks pass through the storm event much more safely than others. The highest level conclusion we can therefore draw is that **vulnerability to storms – and resilience – are shaped by social and structural conditions.**



This community seed bank contains over 220 varieties of indigenous seed deposited by local farmers as a community resource.

These interlinked relations are summarised in Figure 14, which visualises the SEM across all three phases of the disaster risk management cycle.

From the data we see that training and capacity development multiply and **increase social capital**. Programme participation shows the strongest effect across the model and appears to be the single most important driver of disaster resilience in the study area. However, it is a specific form of training that matters here. It must be a **structured intervention that strengthens the technical, cognitive, social, and economic capacities of households**. In this regard, NGO projects play a critical role because they help distribute power and agency, thereby reducing inequalities in disaster recovery.

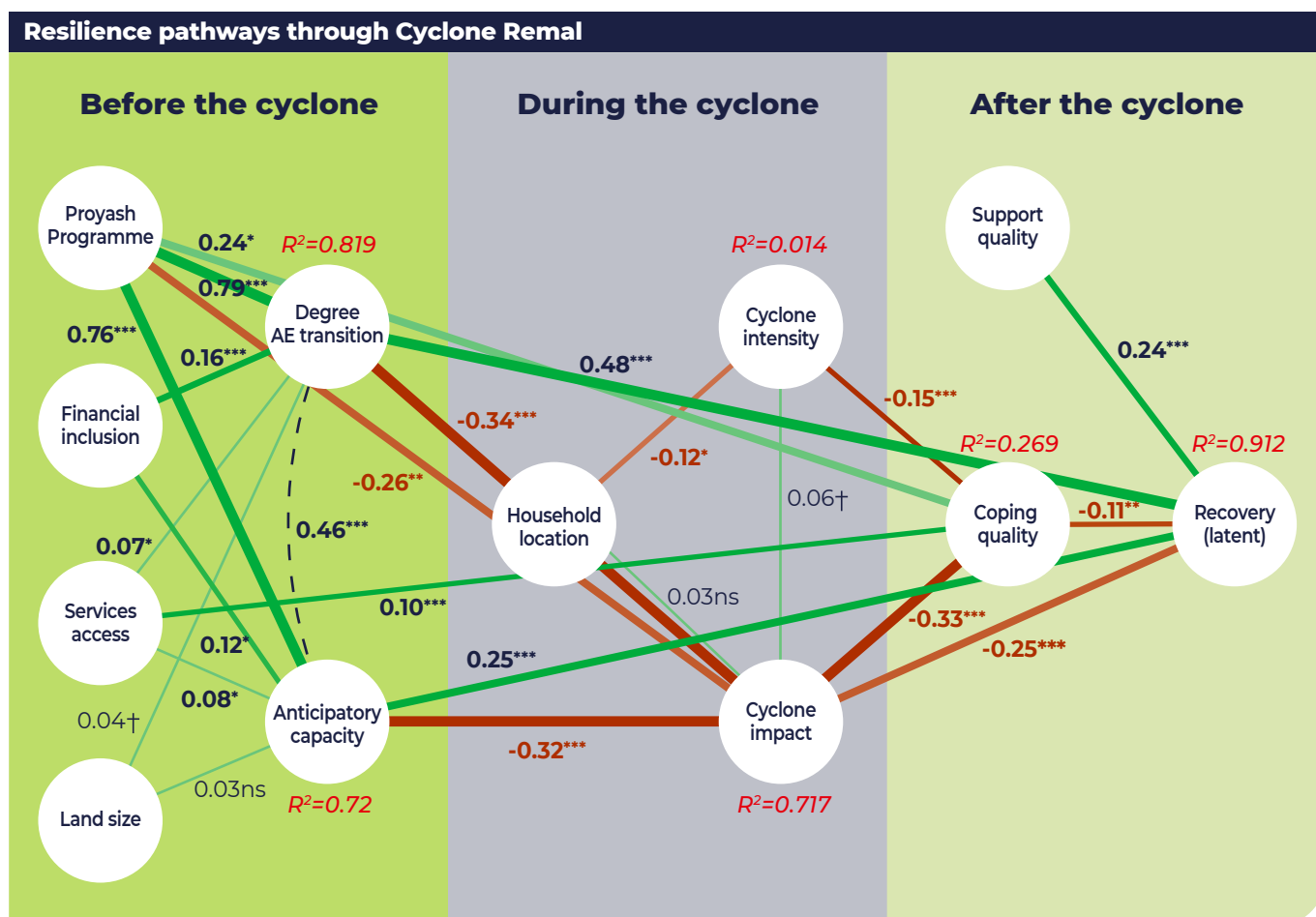


FIGURE 14. Structural equation model (SEM) for testing pathways to household resilience to Cyclone Remal. Green and red arrows indicate positive or negative standardised path coefficients (β), respectively. The line thickness is proportional to the effect size. R^2 values are shown in red for endogenous variables. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$, ns not significant.

Anticipatory capacity is central in all regards. It reflects a household's ability to plan, foresee, and coordinate activities in relation to emerging cyclones. A precondition for this, however, is that **communities are able to develop a culture of preparedness**. We argue that this culture of preparedness is a **defining property of disaster resilience in the delta**. This capacity stems from social networks, social learning through FFSs, and shared norms that communities develop around disaster management. That said, the **social networks through which disaster management occurs have potentially game-changing functions**.

When we began this research, we hypothesised that location matters and that geography would be a key determinant of observed resilience outcomes. But this is not the case here. The location of a household matters far less than its social position within the community. The fact that **asset and location variables explain almost none of the variation** in intensity of impact is striking. Our results suggest instead that **people experience the same storm differently because of their differences in resources, access to institutions, and capabilities** throughout the disaster risk management cycle.

We can clearly see that the impacts households experience in the week of the cyclone cascade through the social system i.e. connected households and communities. This, in turn, erodes households' coping capacity when shocks are widespread and not buffered by anticipatory measures. Shared resources are quickly overwhelmed, weakening the very support networks that families usually depend on during recovery.

We argue that this pattern reflects a kind of stress-process phenomena: **shocks erode the ability to cope and subsequently prolong the recovery deficit**. In other words, a disaster like a cyclone creates an increasing disadvantage for some households with weak social buffers (e.g. access to social networks, cyclone shelter, etc). This phenomenon is well documented in the disaster literature. Early harm compounds, and this effect is intensified in households with limited institutional or social support. This means reducing initial impact is not only about limiting immediate damage within households, but about preventing a downward spiral in which early losses undermine coping options and lock households into slower, weaker recovery trajectories.

A key variable appears to be the quality of support offered by state, civil society organisations and community members to households before the cyclone hits. This factor (representing the number of available support channels but also their perceived helpfulness) substantially affects recovery and almost functions as a kind of recovery accelerator.

Community networks, aid organisations, and the networks emerging through FFSs all matter, often more than physical infrastructure. For the households we interviewed, **recovery seems to be a collective social process** and is not an effort undertaken by a single household alone. This becomes clear, for example, when FFSs share seeds for early planting during the recovery phase. We interpret this as a form of collective efficacy. Efficient support reduces uncertainty, likely lowers psychological stress, and helps households protect their resources during a structured recovery period.

What we see in the data resembles a kind of **capability stack**; a layered system in which **different capacities build on one another**. It appears that resilience is constructed by stacking programme participation, anticipatory capacity, coping strategies, and recovery capacities, each reinforcing the next.

Summary of levers along the disaster risk management cycle

The SEM results help identify **levers along the disaster risk management cycle**. These **levers indicate where interventions can most effectively strengthen resilience**. In this context, a lever refers to a strategic point of intervention within the disaster risk management cycle where a targeted investment or action produces disproportionate effects on overall resilience outcomes.

1. Before the storm: building foundations for resilience

The strongest lever for building resilience clearly lies in the pre-shock phase. Our analysis points to **participation in the Proyash programme** as a key entry point, because its **systemic approach simultaneously supports the agroecological transition of farms and strengthens households' anticipatory capacity**.

The **systemic approach of agroecology** offers a next, interrelated lever for building resilience. Agroecological farming **practices** such as sack and surjan methods, raised beds, saline-tolerant crops, vermicompost and mulch application, together with diversified cropping, integration of trees and livestock, access to **seed banks** or own seed saving, but also closer links to **local markets** and diversified income activities (for example producing and marketing vermicompost), jointly create multiple layers of protection. FFSs, cooperatives or other knowledge-exchange platforms can help to spread and deepen these practices. Hence, **supporting a holistic agroecological transition**, combined with the other points specified in this section, before the storm is a **strategic way of reducing later impacts and shortening recovery time**.

Anticipatory capacity marks another lever. Our constructed anticipatory index brings together farm-level **risk-reduction measures, climate and disaster preparedness training**, access to external advice and programmes, and **the existence of embankments, flood barriers and access to shelters and early warning**. Improving any of these components, for example by widespread access to early warning, improvement of physical protection measures, or ensuring that disaster risk training leads to concrete preparedness plans, helps households in shifting from reactive to anticipatory disaster management.

Lastly, **financial inclusion and access to services** are further supporting levers. Both factors show positive effects in supporting both agroecology and the anticipatory capacity of households. When combined with trainings and other group-based approaches, **savings mechanisms or small credits** can further strengthen the pre-storm capability stack. Without those connections, as we saw for some non-programme participants, financial tools risk increasing vulnerability.

2. During the storm: buffering exposure and limiting impact

Our **exposure intensity index (INT)** shows that all households experienced a strong exposure to Remal, but that differences in exposure intensity are only weakly explained by location-based measures such as distance to water. Although **the intensity and duration of the exposure** to the cyclone is slightly associated with level of damage, this effect is much **smaller than the influence of agroecology and anticipatory capacity**.

This suggests that, during the cyclone, the main entry point is **how well households can activate their already existing anticipatory capacities**. Early warning systems, preparedness plans and on-farm protective measures (such as elevated structures, drainage, moving crops, early harvest and protecting seeds) help households to translate hazard warnings into timely action. **Social networks** can provide last-minute support with the protection of livestock, inputs and equipment. Strengthening the links between early warning, concrete protective actions and collective organisation is therefore a critical mid-cycle entry point.

3. After the storm: supporting recovery and transformation

In the post-shock phase, we can identify three main levers: **damage reduction, support quality and the nature of coping strategies**.

Experiencing lower impact, driven by the agroecological status of farms and their anticipatory capacity, helps households to recover faster. Yet, **where damage is high, recovery becomes much more dependent on A. the quality of support** (defined as the number of support channels available and perceived helpfulness of the support) and **B. the strategies households use to cope**.

A. Quality of support:

For programme households, support quality is one of the strongest predictors of the recovery, suggesting that **timely, relevant and well-coordinated support for affected households is key**. This support includes **material assistance** (seeds, tools, small financial support), **practical help** (labour sharing, access to services) and **psychosocial support**. It is most effective when it is embedded in existing group structures such as FFSs or savings groups, rather than provided to individuals.

B. Quality of coping:

Our model showed that higher damage is linked to poorer **coping quality** and, in turn, to weaker recovery. Households that are forced into **erosive coping** (selling productive assets, taking high-interest loans, reducing essential consumption), face a **longer recovery trajectory**. Interventions that protect assets or provide liquidity without creating debt traps therefore help prevent negative coping spirals and support a more transformative recovery.

Overall, the post-storm entry points underline that recovery is not only a matter of “bouncing back”, but of how pre-existing capacities, support systems and coping choices interact once the cyclone has passed.

Recommendations

Evidence from our study (377 households affected by Cyclone Remal) shows that **farm resilience is built through connected support systems**. Households with access to holistic **agroecological training, a good anticipatory capacity before the disaster, and good-quality post-disaster support** experienced lower damage, relied less on erosive coping strategies that drain assets, and recovered faster and more fully within a reasonable time.

THE MAIN MESSAGES BASED ON THE FINDINGS OF THIS STUDY

- + **Agroecology supports resilience.** Higher adoption of agroecological practices aligned with the FAO Agroecology Elements is linked to lower damage, better coping, and faster recovery.
- + **Agroecological programmes matter most upstream.** Participation in such programmes was strongly associated with a higher alignment with the FAO Agroecological Elements and stronger anticipatory capacity, which together reduce cyclone impact and improve recovery.
- + **Preparedness reduces losses and the need for erosive coping.** Households with stronger anticipatory capacity experience less damage and rely less on asset sales or debt.
- + **Support quality is decisive after the shock.** Timely, relevant NGO and service support is a strong predictor of recovery.
- + **Location explains little on its own.** Proximity to water bodies explains little variation in impact compared to household capacities.
- + **Debt-based recovery undermines outcomes.** Non-programme participants rely more on loans and asset sales and recover more slowly.

Based on this evidence base, we here synthesise two types of recommendations: First, we formulate recommendations that will be of relevance to NGOs, donors, and implementers and secondly, we highlight key implications that are of interest to policy makers.

Lutfa Begum was able to restore her livelihood quickly after Cyclone Remal using vermicompost and sack farming.



Programming recommendations for implementers

Rather than prescribing a fixed set of activities, in this section we translate findings into a set of high-level programming recommendations for implementers. These could be relevant beyond the immediate project context of the study. The recommendations that follow point to a shift in programming logic from short-term, activity-based approaches toward systems-oriented designs. These designs potentially strengthen capacities before shocks, reduce reliance on harmful coping strategies during crises, and enable adaptive recovery afterwards.

- **Place agroecological programmes at the centre of resilience programming.**

The evidence from this study shows that the programme is the strongest upstream factor associated with both agroecological adoption and anticipatory capacity. Programmes that treat training as a peripheral activity risk missing this leverage point. Instead, continuous learning should be designed as the backbone of resilience interventions, providing households with the knowledge, skills, and confidence needed to prepare for, withstand, and recover from cyclones. Programmes should be iterative and sustained, rather than delivered as one-off sessions.

- **Explicitly connect agroecology to disaster preparedness.**

Agroecology is most effective when farmers understand how it influences exposure, impact, and recovery across the disaster cycle. Programmes could therefore go beyond the promotion of individual techniques and explicitly link practices such as soil management, diversification, and on-farm integration to concrete resilience outcomes i.e. reducing crop losses, protecting productive assets, and enabling faster recovery after floods or storm surges. Making these links visible to households could help them prioritise practices that matter most under disaster risk.

- **Build anticipatory capacity alongside changes in farming practices.**

Preparedness plays a critical role in reducing damage and limiting the need for erosive coping strategies after a cyclone. Programming could consider integrating short-term preparedness actions, and long-term risk reduction measures into routine farm and household planning. Rather than treating preparedness as a separate disaster-focused activity, programmes could embed it within agricultural decision-making, so that they become a normal part of how households manage their farms and livelihoods.

- **Strengthen social and institutional linkages as part of resilience building.**

Recovery outcomes are consistently stronger for households that are embedded in supportive networks. Programmes should therefore invest in strengthening farmer groups, local platforms for knowledge exchange, and connections to extension services, markets, and NGOs. These linkages enhance access to information and resources before a shock and improve the quality of support available afterwards. Building and maintaining these relationships should be seen as a core component of resilience programming.

- **Reduce reliance on erosive coping strategies.**

Non-programme participants in this study relied more heavily on asset sales, borrowing, and temporary relocation, strategies that are associated with slower and weaker recovery. Programmes can help households avoid these outcomes by promoting savings mechanisms, supporting income diversification, and aligning post-disaster assistance with the protection of productive assets. Interventions that strengthen households' ability to cope without liquidating assets or accumulating debt are critical for sustaining livelihoods in cyclone-prone areas.

- **Support adaptive recovery rather than simple restoration.**

Recovery is not uniform. While some households focus on restoring pre-cyclone conditions, others use the recovery phase to adapt or transform their farming and livelihood practices. Programmes should allow flexibility in recovery support so that households can adjust farming systems, diversify income sources, and strengthen preparedness for future shocks. Supporting adaptive recovery can help households move beyond repeated cycles of loss and replacement toward more durable resilience in the face of recurring cyclones.

Policy recommendations

In this final section, we outline policy-relevant implications of the study's findings. We hope our findings offer insights for national policy frameworks that already support household resilience in cyclone-prone areas. As all recommendations in this chapter, we consider these as a basket of options for consideration.

- **Adopt a systems-based approach to climate resilience in cyclone-prone regions.**

The findings of this study show that household resilience is shaped by how capacities, practices, and support mechanisms are connected across the disaster cycle. Isolated interventions supporting disaster risk infrastructure, or farming practices, or post-disaster relief alone are less effective than integrated approaches. National policies under the National Adaptation Plan (NAP), the Bangladesh Delta Plan 2100, and the Disaster Risk Reduction (DRR) framework could put resilience into practice by understanding and treating it as a connected system: agroecology-informed farming, better preparedness and safer coping strategies, leading to faster recovery after shocks.

- **Balance investments in physical protection with sustained capacity building.**

While embankments, cyclone shelters, and other protective infrastructure remain essential in coastal Bangladesh, the evidence shows that differences in cyclone impact and recovery are more strongly associated with household-level capacities than with simple location or exposure indicators. Policy frameworks could complement structural measures with long-term investment in farmer training focusing on agroecology, preparedness planning, and strengthening local knowledge systems that strengthen households' ability to reduce damage and recover from shocks.

- **Embed agroecology within national climate adaptation and agricultural strategies.**

In our study, the degree of the agroecological transition is consistently associated with reduced cyclone impact and improved recovery outcomes. This evidence supports the integration of agroecology into national adaptation plans and agricultural policies as a pathway for building farm resilience in the vulnerable delta region. Agricultural extension mandates, climate adaptation strategies, and coastal development plans could explicitly recognise agroecology as relevant to disaster resilience.

- **Strengthen the quality and coordination of post-disaster support.**

The quality of support households receive after a cyclone is a strong predictor of recovery outcomes. Policies governing disaster response, including the Standing Orders on Disaster, should place greater emphasis on coordination between NGOs, extension services, and local government, and on ensuring that assistance is timely and appropriate.

- **Align financial inclusion and social protection with resilience objectives.**

Financial inclusion supports preparedness and recovery when it enables savings and flexible responses, while reliance on loans during recovery can undermine resilience. Social protection and financial inclusion policies should promote tools that help households manage shocks without falling into debt, such as savings mechanisms, emergency funds, and recovery-sensitive financial products. Post-disaster assistance should be designed to prevent the erosion of productive assets.

- **Recognise recovery as an opportunity for adaptation and building back better.**

Instead of only restoring what was lost, recovery programmes should support households to improve farm practices, diversify livelihoods, and strengthen preparedness for future cyclones. Such an approach recognises that those who adapt during recovery, tend to become more resilient in the long run.

ANNEX 1 Villages, sampling frame and sampling steps

The following three villages in the Latachapli Union were selected for the study in consultation with Caritas Bangladesh, based on their geographical differences and because some of their inhabitants had participated in the Proyash programme:

- **Mussuliabad** beside the sea, embankment, heavy sandy soils, saline
- **Misripara** river, canal, salinity, drought, waterlogged
- **Alipur** beside a river, outside embankment

First, all surveys with programme participants were completed within the three villages. In the next step, non-programme participants were selected for study participation based on the following inclusion criteria:

- non Proyash-programme participant
- same / similar livelihood activities
- same / similar economic status
- same average land size
- same average family size
- same location

Among non-programme participants, the steps for the data collection were:

1. Identification of eligible households for each village
2. Selection of households using above criteria (as per sample, see above)
3. Ensuring that households are equally distributed across the villages
4. Conducting the survey

ANNEX 2 Composite indices construction

1. Agroecological composite index

The agroecological composite index summarises multiple dimensions of agroecological practice on a 0–4 scale (higher = stronger performance). We first constructed nine element indices (for the elements and their respective variables see [Annex 3](#)).

Within each element the survey items were rescaled to 0–4. The overall agroecological transition score (ae_composite_index) was then calculated as the mean of all available element indices for each household, if at least half of the element scores are present. The [Table A1](#) on the next page explains the index in detail.

2. Anticipatory Capacity index

We constructed a composite anticipatory capacity index on a 0–4 scale. It aggregates several pre-cyclone preparedness dimensions.

First, we constructed four 0–4 sub-indices:

- a. **Permanent farm** risk-reduction changes (C1.1).
- b. Participation in climate/disaster-related **training** (C3.1).
- c. The externality of **reasons** for **making farm changes**, coded as a weighted mean of reported drivers (personal experience=0, advice from others=2, training/programmes=4; C1.2.2–C1.2.4).
- d. We further derived a 0–4 measure of **access to local risk-reduction infrastructure and services** (mean of binary access to embankments/barriers, cyclone shelters and early warning systems, C5.1–C5.3).

Each of the sub-indicators was first normalised to a 0–4 scale and then combined into a single summary measure, so that higher values reflect actions taken before the cyclone that were done in a more structural, better-informed and/or institutionally supported way.

Agroecological Element	Question ID	Construction	Scale information	Logic
1. Diversity	A2.1.1; B1.1; B1.4; A2.3.1; B1.5.3–B1.5.11; B1.6	Composite of: (i) # of household income activities (A2.1.1) capped & rescaled; (ii) production system type scored (B1.1); (iii) count of minor crops capped & rescaled (B1.4); (iv) market channel scored (A2.3.1); (v) livestock checklist proportion (B1.5.3–B1.5.11); (vi) crop diversity/intensity (B1.6). Mean of components $\times 4$.	0–4 (higher = more diverse farm, activities, and products).	Captures ecological/economic diversity supporting resilience.
2. Synergies	B1.6; B1.7; B4.1; B2.2.2–B2.2.15 (excl. B2.2.13)	Composite of: tree diversity (B1.6), soil/water management (B1.7), ecosystem services emphasis (B4.1), and proportion of AE practices adopted (B2.2.* excluding 'None'). Mean $\times 4$.	0–4 (higher = stronger beneficial interactions on-farm).	Measures stacking/practice combinations that create positive synergies.
3. Efficiency	B2.1; B3.1; B3.2; B3.3; B4.1; B5.2	Rescale or bin: resource-use efficiency (B2.1), seed saving/banking (B3.1, B3.2), soil fertility/inputs (B3.3), ecosystem services (B4.1), and market access frequency (B5.2). Mean of 0–1 components $\times 4$.	0–4 (higher = more efficient use of on-farm/off-farm resources).	Captures input-use efficiency, self-provisioning and stable flows.
4. Recycling	B2.2.2–B2.2.15 (excl. B2.2.13); B3.1; B3.2; B4.1; B5.2	Proportion of recycling/circular practices used (B2.2.* excl. 'None'), plus seed bank access (B3.1, B3.2), ecosystem services (B4.1), and marketing regularity (B5.2). Mean $\times 4$.	0–4 (higher = more internal recycling and circular flows).	Assesses nutrient/biomass recycling and circularity on farm.
5. Co-creation and sharing of knowledge		Components: programme exposure (A5.1), info channels (A5.3, A5.4), provider quality (A5.5.1), extension intensity (A6.1), and weighted disaster-knowledge sources from C3.2.* (0 only none; 1/3 only input dealer/own experience; 2/3 input dealer/own experience + family/neighbour; 1 if includes institutions). Mean of 0–1 parts $\times 4$.	0–4 (higher = stronger co-creation and knowledge exchange).	Reflects participatory learning, quality of sources, and extension links.
6. Human and social values		Decision-making scored: joint husband/wife=1; men/women alone=0; other=NA. Average of the three domains $\times 4$.	0–4 (higher = more inclusive/shared governance within household).	Proxy for equity, participation and social cohesion in decisions.
7. Culture and food traditions	B1.3; B1.4	Kitchen garden presence (B1.3: Yes=1/No=0) and minor crop count rescaled (B1.4): 0–1.	0–4 (higher = stronger food culture/diversity on farm).	Indicates traditions linked to dietary diversity and local foods.
8. Responsible Governance	A5.5.1; A6.2	Provider quality (A5.5.1: NGO/Gov/extension>farmer/peers>input dealer) and engagement level with organisations/training (A6.2) rescaled; mean $\times 4$.	0–4 (higher = stronger, more accountable support/governance).	Captures quality of institutions and farmer interface with them.
9. Circular and solidarity economy	A2.3.1; A5.2; A6.1	Market channel scored (A2.3.1), group/association membership (A5.2: Yes/No), and extension intensity (A6.1) rescaled; mean $\times 4$.	0–4 (higher = more embedded in circular/solidarity economy).	Signals short value chains, collective action and service linkages.
Composite index	All ae1, ae2, ae3, ae4, ae5, ae7, ae8, ae9, ae10	Row-mean of available AE element indices (0–4 each); set to NA if fewer than half of element scores are present for a household.	0–4 (higher = stronger overall agroecological performance).	Balanced summary of AE elements for SEM (robust to partial nonresponse).

TABLE A1. Construction of indices for each agroecological element and the overall agroecological composite index. The element “Resilience” was intentionally left out.

3. Hazard exposure and impact indices

Shock exposure and impact were captured using several indices:

- Shock exposure (SHI_B)** is a multi-domain loss composite on a 0–4 scale: households reporting no exposure to Cyclone Remal are coded 0; exposed households receive a summed score (0–12) for crop loss, livestock loss (0, 1–2, 3–10, >10 animals), infrastructure damage, and income loss, which is then linearly rescaled to 0–4 (higher = greater overall loss severity).
- The **exposure intensity index (INT)** measured how **strong and long-lasting** a household's exposure to Cyclone Remal was. It was calculated by rescaling three items to a 0–1 range – perceived severity (D1.2), shock duration (D1.3), and number of days with standing water (E1.5) – taking their mean, and multiplying it by 4. This yielded a score from 0 to 4, where higher values indicate more intense and/or prolonged exposure.
- The (unscaled) distance from the homestead to the nearest water body was included as a geographic exposure proxy (**LBE**).

4. Coping quality overall

This index coping quality overall consists of a combination of two sub-indices; coping actions and coping quality and was constructed as follows:

a. Coping actions

We weighed coping actions that households took in response to the cyclone impact according to their effect on the households' long-term functioning and well-being (Question E2.1).

The assumption was that erosive coping actions potentially undermine households' resilience to future shocks and livelihoods. Scoring of coping actions was done according to Anwar et al. (2024) and IndiKit's Coping Strategy Index (n.d.).

Category	Score	Variables (Coping actions)	Justification
None	3	None (no coping action taken)	
Neutral/ Recoverable	2	- Did extra wage labour - Consumed livestock - Took a loan or bought on credit	Little or no long-term impact.
Erosive coping	1	- Sold household items - Reduced number or size of meals - Used savings	May undermine future capacity of households to respond to shocks.
Highly erosive coping	0	- Sold major production assets (livestock, tools) - Relocated temporarily for shelter or to look for work - Relocated permanently	High likelihood of undermining future capacity of households to respond to shocks.

TABLE A2. Categorisation and scoring of coping actions taken by households in response to the impact of Cyclone Remal. The mean of the scores was taken and converted to a scale ranging from 0–4.

b. Coping quality

The second sub-index was constructed based on the perceived downstream quality of the coping actions in relation to farming (Question E2.2., “Did these coping actions make it harder to farm in the following season?”). The answers were scaled from 0–4, where a higher score indicates that coping did not hinder farming in the next season.

c. Combination of a. and b. into an index representing **overall coping quality**

Means of index a. and b. were combined into a composite index reflecting the households' coping actions and their perceived consequences. Means of each sub-index were used and scaled from 0–4, where a higher score meant a better overall coping quality.

5. Resilience outcomes and recovery indices

We here looked at the tangible results observed after the cyclone. We assume that the observed outcomes are (partly) a result of the processes that happened before and during the cyclone.

Recovery indices and resilience outcomes were assessed along the following categories:

- a. Support quality** combines the breadth of available support sources and how helpful they were perceived to be (higher = broader and more useful support) (E3.1.2–E3.1.6; E3.2).
- b. Speed of recovery** presents the mean of the reported speed of restarting farming and household activities (higher = faster overall recovery) (F1.1; F1.2).
- c. Deficits** counts how many key livelihood domains had not yet returned to pre-cyclone levels (mapped to 0–4; higher = more remaining gaps) (F1.4.2; F1.4.3; F1.4.4; F1.4.5 (excluding F1.4.6 “None”)).
- d. Type of recovery overall** averages the degree of adaptation or transformation in farm and income activities (higher = more “bounce forward” rather than simple restoration) (F3.1 After Cyclone Remal did you change anything in your farming system; F3.2 Did your household change the activities it relies on for income after the cyclone).
- e. Subjective resilience overall** is the mean of confidence, optimism, and perceived preparedness for future cyclones (higher = stronger subjective resilience) (F4.1; F4.2; F3.3).

ANNEX 3 Mapping of the survey variables to the 10 Elements of Agroecology

Agroecological Element	Aspects of the AE Element covered in question	Description of the Element and potential effect on household resilience
1. Diversity	A2.1, A2.3, B1.1, B1.4, B1.5, B1.6	Species diversity (trees, animals, crops) and a diversity for income generating activities buffers against shocks, enhances food and income options over time. Income diversity/diversity of activities helps to buffer a shock if one income source fails.
2. Synergies	B1.6, B1.7, B2.2, B4.1	Residues and by-products from animals, trees or crops are used for example as animal feed or manure and not bought from outside. Intercropping and residues are used to cover the soil. Synergistic interactions (e.g. agroforestry, soil bunds) stabilise production and reduce losses.
3. Efficiency	B2.1, B2.2, B3.1, B3.2, B3.3, B4.1, B5.2	Covers aspects related to use of external inputs, soil fertility, pest and disease management, productivity and household needs. Input efficiency lowers costs, reduces dependency, and helps buffer input shortages.
4. Recycling	B2.2, B3.1, B3.2, B4.1, B5.2	Covers aspects related to recycling of biomass and nutrients, water saving practices, management of seeds and energy use. Waste reuse enhances nutrient cycling, input security, and environmental stability.
5. Co-creation and sharing of knowledge	A5.1, A5.3, A5.4, A5.5, A6.1, C3.2	Access to platforms for knowledge exchange and good practices exist, access to agroecological knowledge, participation of producers in networks or farmers organisations. Farmer learning and experimentation improve preparedness and uptake of resilient practices.
6. Resilience	Cross-cutting	The outcome supported by integration of all elements; resilience is both means and end; but avoid tautology as covered.
7. Human and social values	A4.1, A4.2, A4.3, A4.4	Covers aspects related to gender equality, labour conditions, inclusion of youth. Farmer identity, values, and autonomy influence readiness and innovation in risk contexts.
8. Culture and food traditions	B1.3, B1.4	Includes healthy, diversified diets, use of local varieties, traditional knowledge for food preparation. Traditional crops and practices support cultural integrity and food security in recovery
9. Responsible Governance	A6.2, A5.5	Includes recognition of producers' rights, the capacity of producers to develop their skills, the provision of market access, access to producers' organisations and the possibility to participate in decisions around land and resource governance. Collective rule-setting and participation enable early warning, resource control, and joint coping.
10. Circular and solidarity economy	A2.3, A6.1, B5.2	Includes aspects related to local marketing of products/degree of self-sufficiency of the community, networks of producers, consumer relations, self-sufficiency of communities in terms of food production. (=products marketed locally, producer networks exist, consumer relations, how local is the food system). Local markets, mutual aid, and cooperatives reduce disruption impacts and support recovery.

TABLE A3. Mapping of the survey questions to nine of the ten Elements of Agroecology and description of the elements.

ANNEX 4 Detailed description of the agroecological status of farms

1. Diversity	Programme households were more diverse in different aspects: they kept a greater diversity of animal species (poultry, cow, duck, fish, pigeon), they grew a greater diversity of main crops while among non-programme participants monocropping was significantly more widespread (1% programme HHs vs 51% non-programme HHs). Programme households grew a greater diversity of minor crops (5 vs 2) and kitchen gardens were almost universal (99% vs 67.5%). Additionally, livelihood activities of programme households were slightly more diverse (1.32 vs 1.14 activities).
2. Synergies	Synergistic features were more common among programme households: trees were more widespread in the farm landscape (2.60 vs 0.80 on a 0–3 scale) and more synergistic soil, residue and water management practices were applied: raised beds (90.2% vs 68.8%), mulching (91.2% vs 6.2%), sack method (97.3% vs 15.0%), vegetable pools (27.3% vs 0%), saline-tolerant crops (82.8% vs 46.2%), drip irrigation (57.2% vs 1.2%).
3. Efficiency	Programme households were less dependent on external inputs : Soil fertility was predominantly maintained with organic inputs, the same was the case for pest and weed control. Seeds were mainly exchanged and 97% of the programme households had access to a seed bank (vs. 3.8% of non-programme participants) and often exchanged other resources such as labour or tools.
4. Recycling	Consistent with the above-described aspects, residue and manure management, water saving cultivation practices as well as seed exchange and seed saving were common among programme households.
5. Co-creation and sharing of knowledge	Programme households received agricultural advice far more frequently (2.66 vs 0.32 on a 0–3 scale) and were well connected : cooperative membership 98% vs 5%; Farmer Field School membership 98.3% vs 3.8%. The main sources of advice differed among the two groups: FFS/NGOs dominated for programme households (FFS 71% vs 1.2%; NGO 18.2% vs 3.8%), while non-programme households relied on peer exchange and own trials (other-farmer exchange 45% vs 1%; own trials 31.2% vs 0.7%).
7. Human and social values	Decision-making and control of farm income were done more collaboratively in programme households (joint decisions 75.8% vs 17.5%; joint income management 66.0% vs 15.0%), with men-only decision shares much lower (15.5% vs 70.0%). Joint implementation of farm activities was also higher (planting, weeding, harvesting and marketing).
8. Culture and food traditions	This aspect was covered indirectly by asking about the presence of a kitchen garden and the diversity of minor crops grown. The large presence of gardens in programme households (99% vs 67.5%) and a higher diversity of minor crops (5.19 vs 2.08) suggest stronger household-level food diversity and culinary traditions in the programme group.
9. Responsible Governance	Programme respondents generally reported stronger local governance and higher levels of participation : voice in community decisions (2.29 vs 0.46 on a 0–3 scale), higher quality of collaboration (2.28 vs 0.48 on a 0–3 scale) and less resistance to changing practices within their surroundings (2.25 vs 0.78 on a 0–3 scale).
10. Circular and solidarity economy	Programme households were embedded in alternative, local food networks : 72.4% sold at organic markets (vs 1.2%), or through a cooperative (16.2% vs 5%), far fewer relied on middlemen (1.3% vs 23.8%). Resource sharing was more frequent (2.37 vs 0.42 on a 0–3 scale).

TABLE A4. Study findings on the agroecological status of farms structured along nine of the ten Elements of Agroecology comparing programme (n=297) and non-programme participants (n=80).

ANNEX 5 Variables of the Structural Equation Model (SEM)

SEM Category	Index	Question ID	Construction	Scale information	Logic
1. Control Variables	resp_gender_female	A1.2	Gender of respondent recoded: Female=1, Male=0.	Binary (0/1).	Gender of respondent for heterogeneity and control.
2. Control Variables	resp_age	A1.3	Age in years computed as 2025 – year of birth.	Continuous (years; higher = older).	Respondent age control.
3. Control Variables	edu01	A1.4	Education mapped ordinally: None=0; Primary=1; Secondary=2; College=3; University=4.	Ordinal 0–4 (higher = more education).	Human capital proxy.
4. Control Variables	hh_size	A1.5	Household size as reported.	Count (persons).	Household scale/needs control.
5. Control Variables	female_adults_ratio	A1.6.2 over (A1.6.1 + A1.6.2)	Share of adult women among all adults: female adults / (male adults + female adults); 0 if no women; NA if no adults.	Proportion 0–1.	Gender composition of adult labour/decision-makers.
6. Control Variables	labor_share	A1.6.1; A1.6.2; A1.5	Share of potential labour: (adults + youth) / household size.	Proportion 0–1.	Availability of household labour capacity.
7. Control Variables	fin_inclusion4	A2.5; A2.7; A2.8	Financial inclusion mini index: mean of {SSN, credit, savings} (each Yes=1, No=0) × 4.	0–4 (higher = more instruments available).	Access to formal/semi-formal financial safety nets.
8. Control Variables	land_log	A3.1.2–A3.1.7	Log(1 + total_land).	Continuous (log scale).	Mitigates skew in land distribution for modelling.
9. Control Variables	services_access4	A5.6; A5.7; A5.8	Access to basic services index: mean of {water, electricity, mobile} (Yes=1, No=0) × 4.	0–4 (higher = better basic services access).	Household-level infrastructure/connectivity.
10. AE Transition	ae_composite_index	All ae1, ae2, ae3, ae4, ae5, ae7, ae8, ae9, ae10	Row-mean of available AE element indices (0–4 each); set to NA if fewer than half of element scores are present for a household.	0–4 (higher = stronger overall agroecological performance).	Balanced summary of AE elements for SEM (robust to partial non response).
11. Resilience outcomes	SpeedOf Recovery_0_4	F1.1; F1.2	Mean of SpeedRestart_Farming_0_4 and SpeedRestart_HH_0_4.	0–4 (higher = faster overall recovery).	Overall pace of post-cyclone recovery.
12. Resilience outcomes	Deficits_0_4	F1.4.2; F1.4.3; F1.4.4; F1.4.5 (exclude F1.4.6 “None”)	Count of domains not yet returned (0–4) mapped to 0–4.	0–4 (higher = more outstanding deficits; worse).	Remaining recovery gaps.

TABLE A5. Continued on next page

SEM Category	Index	Question ID	Construction	Scale information	Logic
13. Resilience outcomes	TypeOfRecovery_overall_0_4	F3.1; F3.2	Mean of TypeOfRecovery_Farm_0_4 and TypeOfRecovery_Income_0_4.	0–4 (higher = greater adaptive/transformation response).	Overall “bounce back vs forward” orientation.
14. Resilience outcomes	SubjectiveResilience_overall_0_4	F4.1; F4.2; F3.3	Mean of confidence, optimism, and preparedness indicators.	0–4 (higher = stronger subjective resilience).	Composite perception of resilience and preparedness.
15. Resilience outcomes	SupportQuality_0_4	E3.1.2–E3.1.6; E3.2	Mean of SupportAvailability_0_4 and SupportHelpfulness_0_4 (both on 0–4; computed with na.rm = TRUE).	0–4 (higher = broader availability AND greater helpfulness).	Overall quality of received support combining breadth of sources and perceived usefulness.
16. Coping Actions	CopingQuality_overall_0_4	CopingActions_0_4; CopingQuality_E22_0_4	Mean of CopingActions_0_4 and CopingQuality_E22_0_4.	0–4 (higher = better overall coping quality).	Composite of coping choices and their perceived consequences.
17. Hazard Exposure	INT	D1.2; D1.3; E1.5	Exposure intensity. Compute mean of normalised inputs: perceived severity D1.2 (0–3 → 0–1), shock duration D1.3 (1–5 → 0–1), standing-water days E1.5 (0–3 → 0–1); then multiply the mean by 4.	0–4 (higher = more intense/longer-lasting exposure).	Severity-focused intensity signal; tends to align strongly with SHI_B.
18. Hazard Exposure	LBE	dist_water	Location-based exposure proxy using distance to nearest water body.	Metres (unbounded, kept as-is; larger distance typically implies lower flood exposure).	Geographic exposure gradient; expected weak negative correlation with severity indices.
19. Hazard Impact	SHI_B	A0.5; E1.3; E1.4; E1.6; E1.7	Severity-aware composite. If not exposed (A0.5 = No) → 0. Else sum four 0–3 components: crop loss (E1.3), animals lost recoded: 0 none; 1 = 1–2; 2 = 3–10; 3 = >10 (from E1.4), infrastructure damage (E1.6), income loss (E1.7). Sum (0–12) linearly rescaled to 0–4; cap at 4.	0–4 (higher = greater multi-domain severity).	Captures severity gradients across loss domains.
20. Anticipatory Capacity	AnticipatoryCapacity_0_4	C1.1; C3.1; C1.2.2–C1.2.4; C5.1–C5.3	Mean of {Mean of {ChangeFarm_0_4, TrainingReceived_0_4, ChangeDrivers_externality_0_4}, risk_reduction_access4}.	0–4 (higher = stronger anticipatory capacity).	Aggregate of structural change, training, externality of drivers, and access to risk-reduction services

TABLE A5. Variables and composite indices included in the structural equation model, showing SEM category, underlying survey questions, construction steps and the logic of inclusion.

List of figures, tables and acronyms

Figures

Figure 1.	Conceptual framework for assessing household resilience to cyclones and the role of agroecology, showing hypothesised pathway through which household characteristics, agroecology, and anticipatory capacity shape cyclone impact and post-shock recovery	7
Figure 2.	Distribution of respondents by programme or non-programme participation and village.	9
Figure 3.	Gender of the respondents by programme and non-programme members.	12
Figure 4.	Age distribution of the household members by programme and non-programme participation.	12
Figure 5.	Distribution of respondent's highest level of education by programme and non-programme participants.	13
Figure 6.	Map showing study households' distance to rivers, canals or the sea with inset overview map showing the study region in Bangladesh.	16
Figure 7.	Distribution of the calculated Agroecological Composite Index scores (0–4 scale) reflecting the alignment of farms with the Ten FAO elements of agroecology.	19
Figure 8.	Radar chart of average scores (0-4) for each FAO Agroecological Element.	20
Figure 9.	Implementation of the Elements of Agroecology for non-programme and programme households.	21
Figure 10.	Comparison of most important sources of disaster knowledge or support received to prepare for Cyclone Remal among programme and non-programme participants.	23
Figure 11.	Perceived priorities for improving preparedness before future cyclones among programme and non-programme participants.	24
Figure 12.	Distribution of what households restored first, second, and third after Cyclone Remal, by programme participation.	30
Figure 13.	Ranking of the three most important drivers of the recovery process after Cyclone Remal by programme participation.	31
Figure 14.	Structural equation model (SEM) for testing pathways to household resilience to Cyclone Remal.	35

Tables

Table 1.	First and second largest household income sources of programme and non-programme participants before Remal.	13
Table 2.	Comparison of agricultural market integration for programme and non-programme participants.	14
Table 3.	Networks and social safety nets of programme and non-programme participants.	15
Table 4.	Comparison of the results for selected variables comprising the anticipatory capacity of programme and non-programme participants.	23
Table 5.	Immediate impacts of Cyclone Remal among programme and non-programme participants. Results represent the mean across the respondents.	26

Acronyms

AE	Agroecological Element
AI	Artificial Intelligence
BRACE	Building Resilience through Agroecology for Coastal Emergencies
CAFOD	Catholic Agency for Overseas Development
DRR	Disaster Risk Reduction
FAO	Food and Agriculture Organisation of the United Nations
FFS / FFSs	Farmer Field School / Farmer Field Schools
FIML	Full Information Maximum Likelihood
GIS	Geographic Information System
GPS	Global Positioning System
HLPE	High Level Panel of Experts on Food Security and Nutrition
HH / HHs	Household / Households
INT	Exposure Intensity Index
IPCC	Intergovernmental Panel on Climate Change
LBE	Location-Based Exposure
MLR	Maximum Likelihood Robust
NAP	National Adaptation Plan
NGO	Non-Governmental Organisation
SEM	Structural Equation Model
SHI_B	Shock and Hazard Impact Index
SSN	Social Safety Net
TAPE	Tool for Agroecology Performance Evaluation

Declaration of the use of generative AI tools

Coding in R was performed with assistance from ChatGPT (OpenAI), and manuscript editing was supported by ChatGPT and Grammarly Pro. All AI-generated outputs were reviewed.

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