

## **EVALUATING CLIMATE VULNERABILITY AND ADAPTATION IN COASTAL AGRICULTURE THROUGH THE PRESSURE AND RELEASE (PAR) MODEL**

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### **ABSTRACT**

The frequency and severity of natural disaster are rising worldwide, posing significant challenges to agriculture, particularly in developing countries. Coastal countries are highly vulnerable to climate change, with sea level rise and salt water intrusion threaten water resources. As a developing country, Bangladesh's coastal communities face high vulnerability due to their reliance on agriculture. This study examines the pressures exerted by climate change on farming communities in a coastal upazila of Khulna district, Bangladesh. It also evaluates the effectiveness, feasibility, and sustainability of various adaptation practices adopted by local households in response to these pressures. Data for this study were collected through a mixed-methods approach, including household surveys, focus group discussions (FGDs), and key informant interviews (KIIs). A total of 100 randomly selected farming households participated in the survey, supplemented by four FGDs and four KIIs conducted within the study area. The data facilitated the identification and assessment of locally practiced climate adaptation strategies. Findings reveal a disparity in climate change pressures and adaptive capacity between two unions: Pankhali and Tildanga. Farmers in Pankhali Union experience relatively lower climate-related stress in agriculture. This can be attributed to its proximity to the nearby pourashava (municipality), which enhances access to agricultural extension services, transportation networks, and training opportunities. Additionally, farmers in this union tend to follow crop calendars, contributing to more organized and resilient farming practices. In contrast, Tildanga Union faces significantly higher climate-related agricultural pressures. Geographically, it is more remote and bordered by a river, which makes it highly susceptible to saline water intrusion, especially during high tides and cyclones. The salinization of agricultural land has severely impacted crop yields and led local farmers to explore alternative farming practices. This study emphasizes the importance of location-specific adaptation strategies and institutional support in mitigating the adverse effects of climate change on coastal agriculture in Bangladesh. It further highlights the need for targeted interventions to strengthen the resilience of vulnerable farming communities, particularly those in high-risk areas like Tildanga. Strengthening adaptive capacity with targeted strategies and support is key sustaining coastal agriculture in Bangladesh.

**Keywords:** *Climate change, livelihood vulnerability, climate change adaptation, coastal agriculture, PAR model*

## **1. INTRODUCTION**

Bangladesh's coastal regions, particularly dacope upazila in khulna district, are highly exposed to the increasing impacts of climate logging, salinity intrusion etc. (awal, 2013). Bangladesh is a "beach country" so it is also vulnerable to oceanic tsunami (ddm, 2015) as other countries like thailand, indonesia, japan etc. Agriculture in this area serves as a major livelihood source, yet it remains extremely vulnerable to cyclones, tidal floods, and salinity intrusion. Bangladesh's economy is based on agriculture. The majority of bangladeshis (84%) live in rural areas and work in agriculture-related activities such as farming, production, and business. Agricultural employs around 40.6% of all workers (gazi, 2020). Over the past decades, dacope has witnessed several devastating cyclones such as sidr (2007), aila (2009), and amphan (2020) which have severely damaged farmlands, disrupted livelihoods, and accelerated land degradation through prolonged saline waterlogging. These recurrent disasters have not only reduced crop yields but also undermined the socio-economic stability of farming households, making recovery increasingly difficult. Disaster impact on supply chain management in the pankhali and tildanga union which is located in dacope upazila in the southwestern region of bangladesh (sharmin et.al., 2024). Bangladesh government utilizes various types of social safety net services (morshed, 2009; bds, 2006) to tackle the emergencies although these are not enough measure for releasing the pressure appropriately. Generally, climatic disaster can be explained with some conceptual frameworks like pressure and release (par) model (wisner, 2003; wisner, cannon, davis, & blaikie, 1994; santha & sreedharan, 2010)). Understanding such climate-induced vulnerabilities requires an analytical approach that connects environmental hazards with underlying social and economic conditions. The pressure and release (par) model, developed by wisner et al. (2004), provides a valuable framework to explore vulnerability as a progression from root causes to dynamic pressures and unsafe conditions. This model emphasizes that disasters are not merely natural phenomena but the result of socio-political and institutional weaknesses that limit people's capacity to cope and adapt. Applying the par model to coastal agriculture in dacope enables a deeper understanding of how land ownership patterns, poverty, inadequate infrastructure, and limited institutional support exacerbate exposure to climatic hazards. This paper evaluates the interactions among these factors to identify critical points where adaptation efforts can be strengthened. The findings aim to support policymakers and local institutions in designing evidence-based interventions to build agricultural resilience and reduce climate vulnerability in bangladesh's coastal zone.change. Entire southern parts of bangladesh now are facing multi-hazard because of the striking of a tropical cyclone with storm surge and salinity intrusion. Nevertheless, sea level rising is gradually appearing as a slow onset disaster as it creates some other perils like a flood, water

## **2. METHODOLOGY**

The study area is under the no of 32 polder. The study area is situated in Dacope Upazila of Khulna district, which is located in the southwestern zone of Bangladesh. Its geographical coordinates are 22° 39' 30" North, 89° 30' 0" East. The study area is adjacent to the mangrove forest, the Sundarbans, and the Bay of Bengal.To achieve the specific objectives of the study. Primary data were collected by using qualitative and quantitative questionnaires. Data have been collected from different groups of people.

### **2.1 STUDY SITE**

In this study, two areas Pankhali and Tildanga Union in Dacope Upazila were selected for data collection. Both Union, Pankhali and Tildanga is situated along the banks of the Pasur and Jhaki Rivers. The population density of this area is 159 people per square kilometer (Annual Report 2020-2021, 2021). Map of the study area shows in the Figure 1. According to the respondents, the transportation mode was chosen based on some factors such as distance, road conditions, and the availability of vehicles. The respondents in Pankhali Union used only on-road vehicles like trucks, pickups, and mini-pickups for transporting their agricultural goods into the central market (small and large vehicles). The respondents in Tildanga Union used both on-road and non-road (water vehicles)

vehicles like barges, engine boat, pickups, and mini-pickups for transporting their agricultural goods into the central market (small and large vehicles).

### 2.1.1 Pankhali Union

Pankhali Union, located in Dacope Upazila of Khulna District, lies along the Pasur River near the Sundarbans and is highly vulnerable to cyclones, tidal surges, and salinity intrusion. The devastating impacts of Cyclones Sidr (2007), Aila (2009), and Amphan (2020) have repeatedly damaged embankments, inundated farmlands, and reduced agricultural productivity. Many farmers have shifted from rice cultivation to shrimp farming due to soil salinization. Despite these challenges, local communities practice rainwater harvesting, floating gardens, and salt-tolerant crop cultivation as adaptive strategies. These characteristics make Pankhali a critical site for analyzing vulnerability and resilience using the Pressure and Release (PAR) Model.

### 2.2.2 Tildanga Union

Tildanga Union, also part of Dacope Upazila, is located between the Pasur and Sibsa rivers, bordering the Sundarbans. It faces severe salinity intrusion, tidal flooding, and cyclone impacts, with Aila (2009) and Amphan (2020) causing long-term agricultural losses. Traditional farmlands have increasingly converted to shrimp and crab ponds, altering livelihoods. However, local communities continue adapting through raised homesteads, mixed cropping, and salt-tolerant rice varieties. These adaptive responses, coupled with socio-economic pressures and environmental risks, make Tildanga a representative coastal area for applying the Pressure and Release (PAR) Model to assess climate vulnerability and adaptation dynamics.

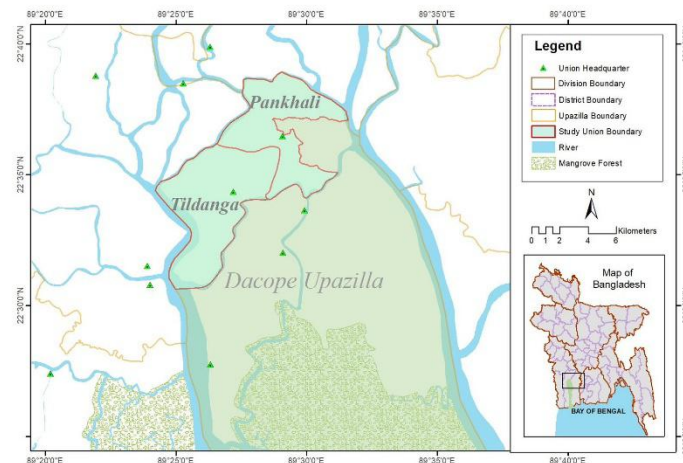


Figure 1: Map of the Study Area

## 2.2 METHODOLOGY

This study employed a mixed-method approach to evaluate climate vulnerability and adaptation in coastal agriculture through the Pressure and Release (PAR) Model. The research was conducted in Dacope Upazila, a cyclone-prone coastal region of Khulna District, Bangladesh, where agriculture is highly exposed to salinity intrusion, tidal flooding, and storm surges. The PAR framework guided the assessment by examining the progression of vulnerability from root causes to dynamic pressures and unsafe conditions.

Primary data were collected through Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). A total of 10 KIIs were conducted with Upazila-level agricultural officers, local government representatives, NGO personnel, and experienced farmers. Additionally, five FGDs, each involving 8–10 participants from different unions, were organized to capture farmers' perceptions of climate impacts, traditional coping mechanisms, and adaptation challenges. These participatory discussions provided in-depth insights into the socio-economic and institutional factors influencing agricultural vulnerability.

### 3. RESULTS AND DISCUSSION

Among the unions of Dacope upazila, the agricultural practices are higher in Pankhali and Tildanga unions. Besides, the level of salinity intrusion is also less compared to other unions of the upazila which makes these two unions more suitable for agricultural production. As a result, the amount of uncultivated land is less in the study area. To achieve the objectives of this study, the Pressure and Release (PAR) Model is applied. This is a framework used in disaster risk reduction to understand how disasters occur and how risks can be minimized. It explains disasters as the result of two main factors: vulnerability and hazards. The model suggests that disasters happen when pressure builds up from increasing vulnerability and a triggering hazard. To prevent disasters, this pressure needs to be released by reducing vulnerability. In Figure 2 shows the pressure and release model for tildanga union

#### 3.1 Field observation

Due to education, this union has been improved. They share cultivation idea. They do field test going to NGO and Krishi office. Soil tolerant vegetables, rice are produced and they take idea from agriculture office. Farmers are influenced by another farmers. The farmers share idea, use youtube and techniques from the krishhi office. Tildanga union is good than previous.

In Mojamnagor, watermelon production is more. They earn 3 lakh taka from 2.5 acre land. They dig pond, cultivate seasonal vegetable near pond . They meet their demands and others as well. New farmers take new techniques. The young generation are influenced more. After Aila and Sidor, the farmers become more poor. The govt. tried to save them more. But in time, they take agriculture as their alternated profession keeping away fishing. After 16 years, they overcome all problems. Education and livelihood is becoming increased.

Due to cyclone and river erosion, the transportation system becomes more vulnerable and so the products can not be reached another place. They can not market vegetables. The transportation system becomes vulnerable and so the vegetables selling cost becomes high. So it is urgent needed to improve transportation system to improve capacity. Heavy rain causes destroy of vegetables. So it is needed to improve dike side. The govt also should apply strict rules.

#### 3.2 Root Causes

These are deep structural and socio-economic factors that make Dacope highly exposed to climate stressors: Dependence on limited livelihoods (shrimp aquaculture and agriculture as the only income sources due to poor transportation and market access). Extreme poverty after Cyclones Sidr (2007) and Aila (2009), which collapsed the shrimp economy following government bans on saline-water aquaculture. Weak infrastructure and governance, including fragile embankments (e.g., Polder 32 vulnerability), poor roads, and slow repair of water bodies. Low institutional capacity for irrigation support, soil testing, and new agricultural technologies. Limited diversification of income, making households highly sensitive to climate shocks. Gender inequality, where women carry greater psychological stress but show higher adaptive capacity. Low organic matter and soil degradation, especially in saline-prone and river-eroded lands.

### **3.2.1 Drought**

The Atel soil is found in Tildanga. Drought is mostly seen here. The natural calamities are more in February March month. There are four farmers group in every ward who are provided PRA technique to give solution. Problem identifying, sorting analysis, priority-based solutions are given here. Awareness is raised among the farmers before the disasters. The name of the face book group is “Farm awareness” where the farmers discuss all their conditions, precautions, measures, future preservation of rice seed. The govt. office gives these seeds without amount. All the precautions are taken here to keep these safe. The govt. as well as the NGO provide agriculture related target training. The NGO arranges group meeting in every month consulting with agriculture officer. And provide finance as well as valuable information to the farmers as well as the field officers.

After any disaster, the govt. offers the NGOs for fund to recover the hazardous situation of farmers. After disaster analyzing the hazardous situation, the NGO and govt collaborately help the farmers and give the other facilities. The aid is provided more in Tildanga as it is more hazardous region. The provided fund by the ministry of disaster is very low than the hazard. So, the NGO’s play a vital role in this aid. The remarkable NGOs are Dolith, Sushilon, Brac, World Vision, Locoth. They are providing support along with the govt. The fund is provided considering the amount of land. Also, fund is provided according to the priority-based land. After disaster, the farmers also follow their own indigenous way.

### **3.2.2 Mental and Physical adaptation**

The water scarcity is seen in February to May. Farming is almost impossible in that month due to lack of geographical condition. The salinity is increased then. The mental state becomes vulnerable then. Roads become so vulnerable that even the patient can not be reached to the hospital. Even the dead body can not be buried. In that situation, the mental situation becomes vulnerable. Mental support is provided at that time. The counseling is provided considering age of the people. After a long observation, the adaptation power is more in women and their adaptation capacity is more. The young generation accept technology more than adaptation. The stress capacity of young generation is more. They cultivate Sorisha in 40 bigha land. After rice production, they start sorisha cultivation.

### **3.2.3 Pest**

Due to more vegetation, pests are high in Pankhali and Tildanga. The pests are high due to temperate weather and so agricultural production is slightly hampered. After identifying types of pests, at first, they try to apply bio-ingredients. If it is not useful to the crops, then they apply chemicals to ave crops from these harmful pests considering environmental balance.

### **3.2.4 Salinity**

Depending on months, salinity rate is changed in Pankhali and Tildanga union. Salinity test is freely provided in the govt. agricultural office. Salinity is 14~16 psu in Tildanga and it is 6~8 psu in Pankhali union. No salinity is found in rainy season. The Water Development board continuously monitor the river bank erosion and takes effective initiatives. Agricultural adaptative initiatives are taken previous or after the disaster. No initiatives would be possible to take during disaster.

### **3.3 Dynamic Pressure**

These factors transmit the root causes into direct pressures on local livelihoods:

Seasonal patterns change drastically each year; strategies that worked last year fail this year. Increasing salinity and recurring drought (February–May), especially on Atel soil in Tildanga. Riverbank erosion, particularly along the Shibsha River, destroying agricultural land and infrastructure. Inadequate extension services and climate education farmers rely heavily on officers but receive inconsistent support. Weak irrigation systems and dependence on mini-ponds, deep-water

pumping, and indigenous techniques. Pest outbreaks due to increased vegetation and moderate temperature conditions. Poor transportation networks, restricting market access, raising input costs, and increasing post-harvest losses. Limited access to agricultural tools, finance, and technology—especially in Tildanga due to distance from town. Communication and infrastructure failures after disasters, delaying recovery.

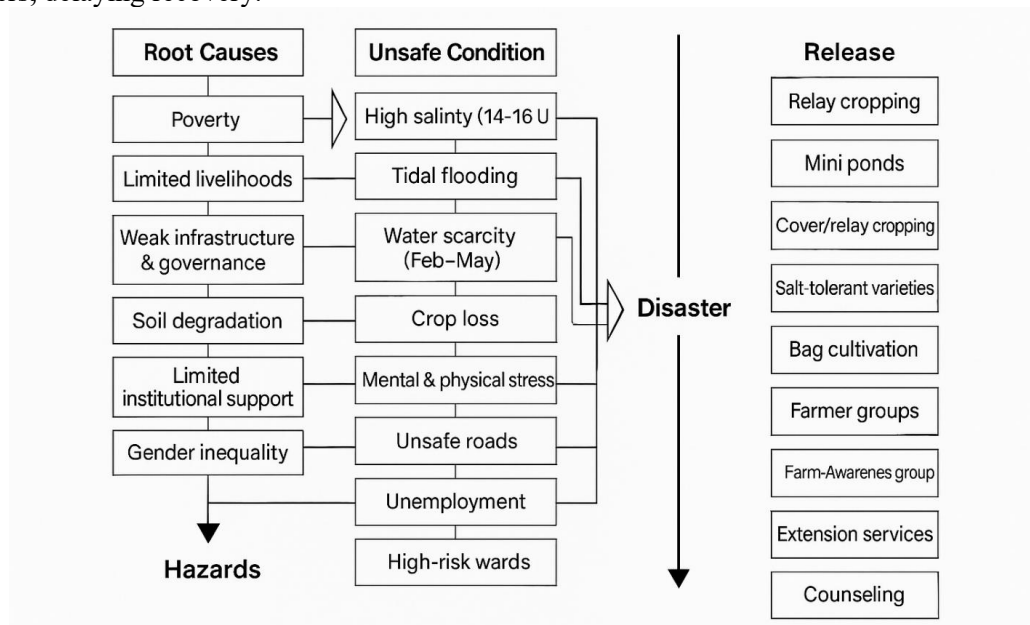


Figure 2: Pressure and Release Model for Tildanga Union

### 3.4 Unsafe Conditions

High salinity (14–16 PSU in Tildanga; 6–8 PSU in Pankhali) in dry months. Tidal flooding, cyclones, and embankment breaches (e.g., Jaloshas events). Crop destruction from heavy rainfall, waterlogging, and river erosion. Stressful dry season (Feb–May) water scarcity, soil moisture loss, and halted agriculture. Mental and physical stress, caused by poor access to hospitals, unsafe roads, and isolation. Decline in winter crops due to shortened winter period and high humidity. Unemployment in fisheries after the ban on saline aquaculture. High vulnerability in Tildanga’s 9 wards, where disasters hit hardest and fertile land is limited. Comparison of pressures for disaster between Tildanga Union and Pankhali Union are shown in Table.1.

Table.1 Comparison of pressures for disaster between Tildanga Union and Pankhali Union

Category of Pressure Factors	Tildanga Union	Pankhali Union
1. Population Pressure	Higher population density in several villages increases pressure on limited agricultural land.	Slightly lower density but rapid migration from embankment-eroded areas increases settlement pressure.
2. Livelihood Stress	Agriculture heavily dependent on brackish water; high reliance on shrimp–rice mixed farming. Income fluctuates.	Strong dependence on seasonal labour, fishing, and sharecropping. High income instability after cyclones.
3. Soil Degradation	Severe salinity intrusion after every cyclone; soil recovery is slow.	Moderate to high salinity; some pockets recover faster due to proximity to river channels.
4. Weak Infrastructure	Embankments are old and frequently breached; internal roads often collapse	Embankments moderately maintained but vulnerable. Road connections to

	during tidal floods.	Dacope sadar often submerged.
5. Limited Access to Services	Limited agricultural extension services; farmers receive irregular support.	Better NGO coverage, but government extension services are still insufficient.
6. Market & Supply Chain Gaps	Farmers depend on local middlemen; after disasters, product prices drop sharply.	Slightly better market access due to closer link with local bazaars; still unstable during cyclone season.
7. Institutional Weaknesses	Union Parishad disaster committees not fully functional; early warning dissemination inconsistent.	Disaster committees active but lack resources; coordination improves mainly when NGOs intervene.
8. Education & Awareness Gaps	Low awareness on climate-resilient farming; training sessions not frequent.	Better participation in community meetings but adoption of climate-smart techniques remains slow.
9. Health & WASH Pressure	Waterlogging after storms contaminates drinking water; low access to safe sanitation.	Similar issues, but some villages have improved latrines and piped water pilots.
10. Migration Pressure	Out-migration of youth for work reduces agricultural labour availability.	In-migration after embankment breaches in adjacent unions increases local stress.

### 3.5 Release

To reduce vulnerability and break the pressure chain, communities and institutions have adopted multiple adaptation practices:

While the Pressure and Release (PAR) Model effectively captures the socio-economic and environmental dimensions of vulnerability, the effectiveness of the identified “release” strategies is strongly conditioned by irrigation infrastructure and seasonal water availability in coastal agriculture. Field evidence from Tildanga and Pankhali indicates that adaptation measures such as relay cropping, mini-pond irrigation, and stress-tolerant crop varieties are highly sensitive to freshwater access during the dry season (February–May), when salinity intrusion and surface water scarcity peak. In Tildanga Union, limited canal connectivity, high soil salinity (14–16 PSU), and dependence on shallow groundwater restrict the scalability of these strategies, even when farmers are willing to adopt them. Conversely, in Pankhali Union, relatively better access to freshwater sources, proximity to extension services, and functional embankments enhance the practical effectiveness of similar adaptation measures. This comparison demonstrates that PAR “release” mechanisms are not universally transferable but must be evaluated within the hydrological and irrigation context of each locality.

#### 3.5.1 Relay cropping

Relay cropping means sowing a second crop into a standing main crop before harvesting. The idea is to save time, use residual soil moisture, and reduce the crop-gap between harvests. They cultivate relay crops. In coastal Bangladesh (like Dacope, Khulna), it's especially important because agricultural land is limited, Salinity intrusion and waterlogging shorten the growing season, Cyclones/floods often damage standing crops. Relay cropping helps maximize land use in the narrow "safe window" between harvest and salinity rise.

Typical Crops in Relay System, T. Aman rice (monsoon, Aug–Nov) → Relay with mustard, lentil, or grasspea (khesari). T. Aman rice → Relay with mungbean (March–April) before salinity peak. Relay sunflower, sesame, maize also tested in some Dacope polders by NGOs (WorldFish, Blue Gold,

BRAC). Vegetables (spinach, pumpkin, tomato, okra) grown on dykes or raised beds as part of relay/relay-mixed systems. The farmers rely on govt office for this full process.

### 3.5.2 Mini pond adaptation

For the Kaminibashi and Mojamnagar region people, the govt has taken mini pond adaptation for the maintenance of water in 20 hector land. Their reliance is acceptance on agricultural officers. Most people follow the previous adaptation processes which are practiced from the past (indigenous). Approx. 10 people maintain the new process told by the Krishi officers and they become successful. Following their success, there is an increased number of 20 people in that case. Thus, the number increases. When the salinity increases, they use irrigation of the deep water. Poly mulching, cover cropping, dike side monthly based cultivation. These are off seasoned cultivation.

### 3.5.3 Cultivation

There are 14 to16 variant sunflower tolerant crop are cultivated. They follow strategy considering land position. The water holding capacity is more in Tildanga union as the Atel soil exists there. So, they use dike land to get more crops in less land. To increase water holding capacity, they do cover cropping, inter cropping to resist vapor. over cropping means growing plants mainly to protect and improve soil, not always for harvest. They cover the land to reduce erosion, maintain fertility, and suppress weeds. Dacope is a brand of watermelon. According to Dacope Krishi officer (Md. Shafikul Islam), the production of watermelon is controlled by field monitoring. The ingredients for watermelon production are provided free by the govt. This production is high in Pankhali union which is not good in Tildanga. Figure 3 shows the presuure and release model for Pnkhal Union and their comparison of pressure release between Tildanga Union and Pankhali Union are mentioned in Table2.

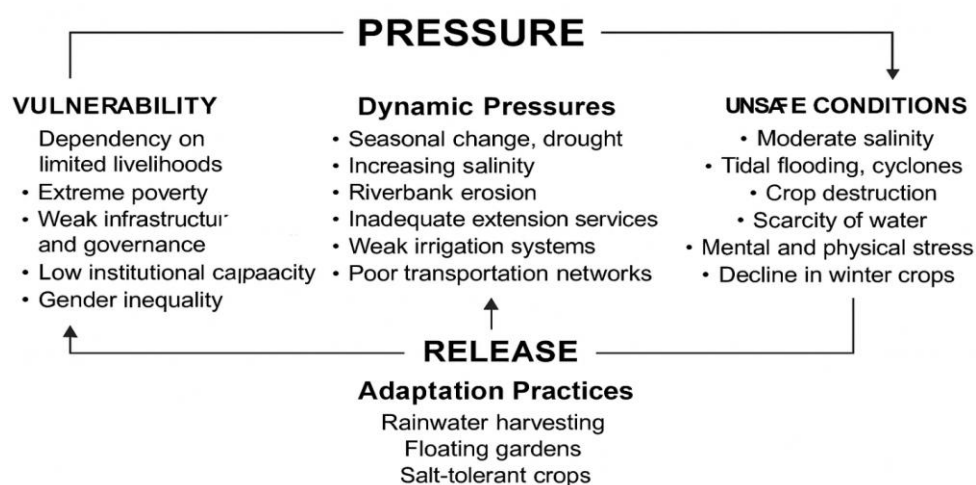


Figure 3: Presuure and Release Model for Pankhali Union

Table.2 Comparison of Pressure Release between Tildanga Union and Pankhali Union

Category of Pressure Release Factors	Tildanga Union	Pankhali Union
1. Local Adaptation Practices	Farmers use mixed shrimp–rice cultivation and salt-tolerant rice varieties. Some adopt raised-bed vegetable farming.	Stronger adoption of homestead gardening, floating agriculture trials, and salt-tolerant rice.
2. Community Organization & Social Networks	Moderate level of community groups; participation increases during cyclone season.	More active community groups and women-led savings groups; better coordination during emergencies.
3. Disaster Preparedness & Early	Early warning messages reach most villages but response varies. Shelter use is	Early warning dissemination stronger due to NGO support; households respond

Warning	moderate.	quickly and shelter attendance is higher.
4. Infrastructure Strengthening	Some embankment rehabilitation under government projects; repairs often delayed.	Better progress in small-scale embankment repairs and raised roads through LGED/NGOs.
5. Access to External Support (NGOs/Govt)	Limited long-term NGO projects; support increases mainly after major cyclones.	More consistent NGO presence (WASH, agriculture, livelihood programs) which boosts resilience.
6. Livelihood Diversification	Limited diversification; most households rely on aquaculture or agriculture.	More households engage in fishing, small trade, transport work, and services, reducing sole dependence on farming.
7. Education & Training	Occasional training on climate-resilient agriculture but low follow-up.	Better participation in training, especially for women and youth.
8. Water & Sanitation Improvements	Rainwater harvesting systems exist but many are damaged; pond-sand filters poorly maintained.	Greater number of functional rainwater tanks, pond-sand filters, and NGO-supported WASH facilities.
9. Health Services & Emergency Support	Limited emergency medical services; cyclone shelters lack medical kits.	Slightly better access to mobile clinics and first-aid support through NGOs.
10. Migration as a Coping Strategy	Out-migration of youth reduces local labour but increases household income through remittances.	Seasonal migration for work is common and supports families during post-disaster periods.

### 3.5.4 Stress Mitigation

There are secure polynet culture to preserve seedling tree for future to release the stress of seedling tress. They prepare more policy but implementation is so tough.

When the rain is low and salinity increase, there is a cultivation in bag which is more economic and profitable. Ginger cultivation is common. For example, 1 kg of ginger production cost is 100 taka and sell value is 200 taka per kg. The farmers can get more profit. The NGOs supply seed in rainy season. New variant has been invented named Agni to mitigate stress. Due to transportation system problem as well as infrastructure problem there is less impletion. They give some agro tools so that the farmers can use. But they cannot provide to all them. All of them are not provided fully with demonstration. The communication system in Tildanga is very poor. So, it is tough to provide all these equipments to all the people of this union. Space for training is not enough. For example, there is a problem to reach all the equipment's due to transportation to about 1000 farmers. As a result, they cannot get technological infrastructure. There is also problem in agricultural tools and fund. In pankhali, there is fertile land, low stress, easy access, good maketing which is not in Tildanga. In Tildanga, there is poor transportation system. So good infrastructure is needed badly. In Tildanga, there is less fertile land and so why vegetation is low. The top soil tests are not provided well due to flood. But poly soil can be added due to flood sometimes. To change of soil structure, bio equipment are needed. There is not any software analysis for soil improvement. There is dynamic process under project to get adaptation to give training among the farmers. In future there needs some training for more technology. In this study the proposed model of Pressure and Release (PAR) are shown in Figure 4.

### 3.6 Limits of Farmer Perception & Technical Blind Spots

Although farmers possess rich experiential knowledge of climatic stress, field surveys and FGDs reveal that their perceptions often emphasize immediate and visible impacts such as crop failure, salinity, or market disruption while underrepresenting underlying technical constraints related to irrigation efficiency, groundwater sustainability, and embankment hydraulics. For instance, water scarcity is frequently described as a seasonal problem, yet discussions rarely account for long-term changes in river flow regimes, sedimentation of canals, or declining freshwater recharge. This gap suggests that perception-based data, while essential for understanding lived vulnerability, may

overlook systemic water management challenges that critically shape agricultural resilience in coastal polders.

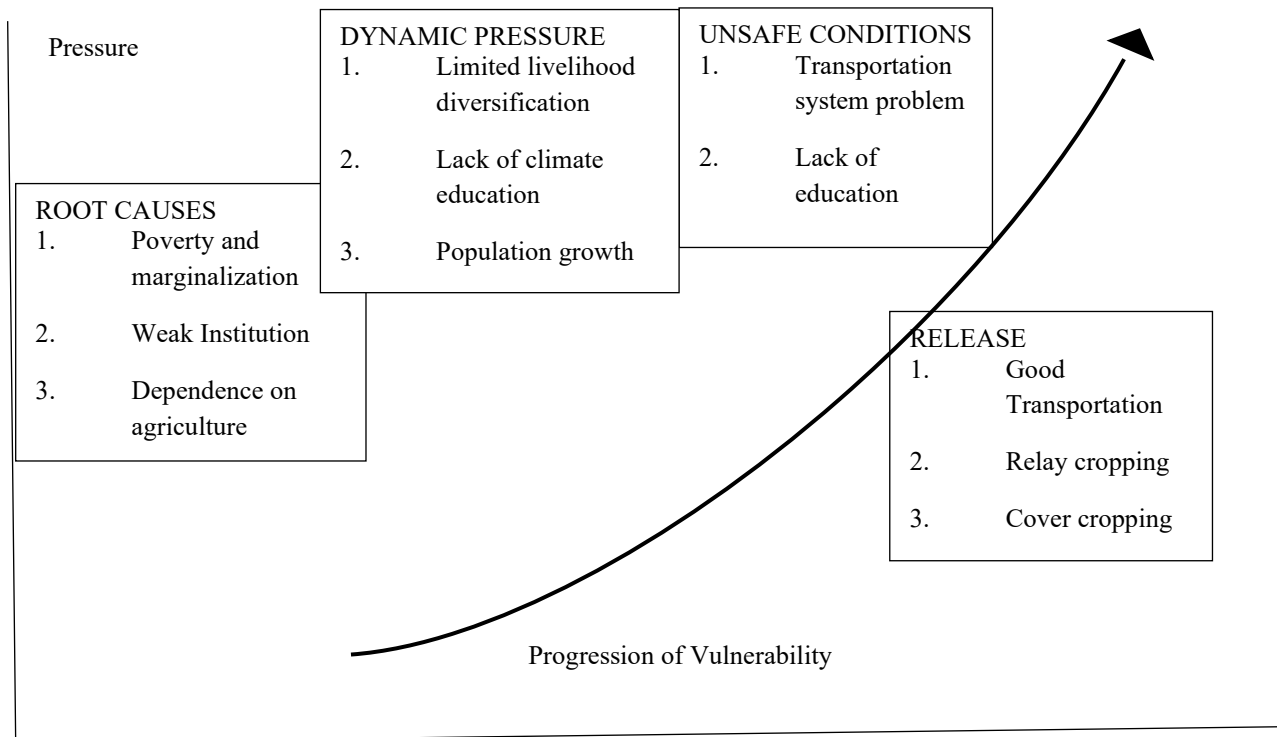


Figure 4: Proposed Pressure and Release (PAR) Model

### 3.7 Critical Reflection on Field Survey Findings

A critical examination of the field survey data indicates that while household surveys and FGDs effectively capture adaptive practices and perceived risks, they have limitations in fully diagnosing structural constraints. Respondents' reliance on agricultural officers and NGOs for technical guidance suggests partial dependency on external expertise, which may influence reported adaptation success. Moreover, variations in education, age, and exposure to training affect how farmers articulate climate risks, potentially biasing responses toward short-term coping rather than long-term adaptation. Despite these limitations, triangulation through KIIs, FGDs, and direct field observation strengthens the validity of the findings by cross-checking farmer narratives with institutional perspectives. This reflective analysis enhances the robustness of the PAR application by situating local perceptions within broader environmental and infrastructural realities.

## 4. CONCLUSION

This study applied the Pressure and Release (PAR) Model to examine the complex drivers of climate vulnerability in the coastal agricultural systems of Dacope Upazila, with particular focus on Pankhali and Tildanga unions. The findings show that vulnerability in the region is shaped not only by exposure to environmental hazards but also by deep-rooted socio-economic and institutional factors. Pankhali, with relatively better transportation, stronger irrigation facilities, and more educated farmers, demonstrates lower vulnerability and higher adaptive capacity. In contrast, Tildanga remains more exposed due to poor infrastructure, higher salinity levels, riverbank erosion, and limited access to agricultural services. The PAR analysis reveals that the root causes—such as dependence on limited livelihoods, weak governance, soil degradation, and inadequate institutional support—intensify through dynamic pressures including erratic rainfall, seasonal droughts, pest attacks, and

market isolation. These pressures translate into unsafe conditions such as water scarcity, crop losses, and mental stress during peak stress months. Despite these challenges, farmers employ a wide range of adaptive strategies, including relay cropping, mini pond irrigation, stress-tolerant crop varieties, bag cultivation, and community-based knowledge sharing. The strong role of NGOs and agricultural offices, particularly in Pankhali, highlights the importance of coordinated institutional support in enhancing resilience. Overall, the study demonstrates that reducing climate vulnerability in coastal Bangladesh requires interventions that address both structural constraints and localized environmental pressures. Strengthening infrastructure, improving transportation networks, expanding irrigation coverage, and enhancing extension services can significantly reduce risk. Supporting farmer-led innovations and scaling up successful adaptive practices will be essential for building long-term agricultural resilience in cyclone-prone coastal areas. The PAR Model thus provides a valuable framework for guiding policy, planning, and community-based adaptation to safeguard livelihoods under a changing climate.

#### **DECLARATION OF USE OF AI**

To describe the Pressure and Release (PAR) Model AI has been used in this paper. AI simplified the components of the model to elaborate in this study.

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