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Research article

Assessment of Livelihood Resilience in Hazard-prone Areas of Southwestern Bangladesh

Md. Obydur Rahman and Sazia Ahmed*

Economics Discipline, Social Science School, Khulna University, Khulna – 9208, Bangladesh

A B S T R A C T

This study examined the resilience of two unions (*Uttar Bedkashi* and *Koyra*) in Bangladesh's Khulna district to climate change-induced disasters concerning their livelihood sustainability. This study employed the Resilience Index Measurement and Analysis II (RIMA-II) methodology to assess the livelihood resilience of vulnerable populations in the southwest coastal region. A survey of 150 households in each union assessed their income, food accessibility, socio-demographics, agricultural and non-agricultural assets, farming practices and technologies, adaptability, sensitivity, and access to essential services. We conducted this study to determine their resilience capacities, encompassing their ability to adapt, absorb, and transform. After the data were merged, a composite index was used to compare the resilience scores. The findings of this study showed that *Koyra* was the most resilient in terms of income and food access, while *Uttar Bedkashi* may be resilient in terms of social safety nets. Overall, LRI revealed that *Koyra* union exhibited the highest resilience (0.46), while *Uttar Bedkashi* union demonstrated the lowest resilience (0.36). Providing loans, raising livestock, employing irrigation machinery, utilizing boats, applying fertilizers to agricultural fields, and relying on agriculture as the primary income source were recognized as key markers of resilience in the research area. To strengthen southwest coastal residents' resilience, local government, NGO, and public-private capacity-building programs should be developed. This study may help develop viable programs, adaptation strategies, and methods to improve southwestern coastal homes.

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Introduction

Climate-related disasters are becoming a significant global problem. Various hazardous occurrences are occurring with greater frequency, jeopardizing the socioeconomic stability of local populations, and climate variability is considered the primary factor contributing to the escalation of these hazardous events (Azam et al., 2021; Didar-UL Islam et al., 2020). Experts agree that there is no way to slow climate change (IPCC, 2007). According to Hoegh-Guldberg and Bruno (2010) and Wheeler and Braun (2013), a major disaster can affect people's livelihoods by causing deaths and environmental damage, which are necessary for oneself and one's dependents to survive. The incidence and intensity of these natural disasters have escalated due to human activities on the environment, including settlement, urbanization, and resource exploitation (FAO, 2016; Jang and Wang, 2009; Sina et al., 2019; IPCC, 2015). Consequently, governments, societies, and the scientific community are all concerned about the impacts of climate change on ethnic groups (Zhang et al., 2019).

Moreover, extreme weather occurrences are known for disrupting individuals' daily lives by damaging their homes, possessions, and other assets, in addition to affecting their income and stock valuations. This results in persons experiencing poverty and enduring prolonged shocks and stresses. Numerous livelihood changes might exacerbate vulnerability when coupled with alterations in the ecosystem (Sallu et al., 2010; Zhang et al., 2019). Consequently, the daily lives of impoverished individuals in numerous developing nations are disproportionately vulnerable to various shocks and pressures (Hirons et al., 2018). Specifically, these severe weather occurrences present a significant threat to local livelihoods and asset foundations in coastal regions of developing areas.

Bangladesh, as a developing nation, is regarded as one of the most vulnerable countries to natural disasters due to its coastal proximity, physical characteristics, high population density, insufficient awareness, and sluggish

*Corresponding author: <sazia.ahmed@econ.ku.ac.bd>

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economy (Rahman et al., 2019). Bangladesh has numerous natural disasters and climate-related events annually, including floods, cyclones, droughts, and riverbank erosion (Azad et al., 2013). On average, the nation experiences highly intense tropical cyclones every three years, resulting in 70% of the population being homeless. Moreover, as much as 80% of the population is adversely affected by annual flooding, which inundates between 25 and 60% of the total land area. Consequently, floods and cyclones are regarded as the most catastrophic climate disasters in Bangladesh (Bank, 2018; Tajrin and Hossain, 2017). This situation adversely impacted the livelihoods of impoverished rural communities in Bangladesh (Bhuiyan et al., 2017).

The southwest coastal region of Bangladesh, encompassing the districts of *Satkhira*, *Khulna*, *Bagerhat*, and *Jashore*, is significantly more vulnerable to climate-induced disasters, such as severe cyclones, which have resulted in extensive property damage, loss of human and animal life, inundation of low-lying areas, failure of embankments, uprooting of trees, and displacement of numerous families (Afroz et al., 2021; Aid, 2019; IFRC, 2021; Kabir et al., 2016). Cyclones are responsible for the incursion of saline water, freshwater scarcity, alterations to living conditions, difficulties in accessing healthcare, inadequate sanitation, and famine. All of these intensify other problematic circumstances, including migration and evolving livelihood trends (Tajrin and Hossain, 2017). In addition to these intense cyclones, additional calamities such as tidal waves, floods, riverbank erosion, and waterlogging are commonly documented in this region of Bangladesh. Consequently, various socio-economic factors, including age, gender, education, income, housing type, sanitary facilities, and savings, function as influential determinants that enhance susceptibility to the impacts of natural disasters (Chang, 2007). Due to the damage to life, property, and agricultural yields, affected households have become increasingly susceptible to sustaining their living standards. Simultaneously, most coastal households lack the financial resources to integrate adaptation measures into long-term adjustment strategies (Houqe et al., 2019; Mudassar et al., 2020).

The present condition of livelihood activities in the southwest coastal regions of Bangladesh reveals that individuals are under significant stress due to climatic variability, with these pressures intensifying daily (Awal et al., 2013; Amin et al., 2018). Assessing livelihood resilience is essential for advancing their livelihoods while enhancing resilience. Thus, they are equipped to address the adverse effects of natural catastrophes. The prior literature has focused on the regional vulnerability, with fewer quantitative indicators to compare the micro-level differences in resilience within the high-risk zone, and this study tried to fill this research gap. The primary objective of the study is to evaluate the resilience of households' livelihoods in response to climate-related risks in *Koyra Upazila*.

Materials and Methods

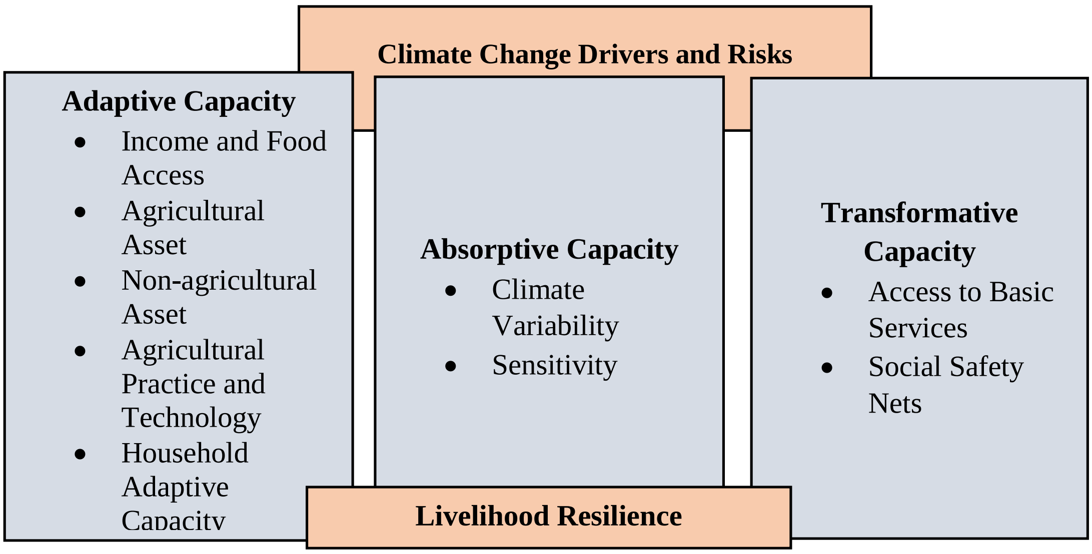

Figure 1: Framework on Livelihood Resilience to Climate-Related Disasters

This research utilized a purposive sampling technique to examine the effects of coastal catastrophes in *Koyra Upazila*, Khulna, Bangladesh. The study location was selected because of its susceptibility to cyclones, tidal surges, and saline intrusion. The selection of the study area is purposive because of its geographic exposure to continuous natural disasters. This sampling technique has been selected over random sampling to ensure the inclusion of people most affected by climatic hazards. Primary data have been collected via household surveys performed from March to April (2023), utilizing a scheduled interview schedule. A total of 300 household heads (both male and female) from two randomly selected unions (due to minimize the sampling bias), *Uttar Bedkashi* (150) and *Koyra* (150), participated in the survey. In cases where the household head was unavailable, the eldest adult member was interviewed. The enumerators, after receiving prior training, used a random walk approach to select households and reduce study area-based selection bias and obtain consent from community leaders before data collection. Secondary data were gathered from published literature, official records, and relevant sources to support the study's analysis. Ethical approval for this study has been obtained from Khulna University, and all respondents were informed about the purpose of the research. No personal information has been collected in this study interview, and their voluntary participation was the major priority. It has been ensured to the respondents that the data will be used only for academic purposes.

To determine livelihood resilience to climate-related disasters, several research frameworks have been introduced over the decades (FAO, 2016; Sarker et al., 2020; Al-Maruf et al., 2021; Mallick, 2019; Uddin et al., 2021). Besides, theoretical frameworks specify certain environmental management directions and suggest methodologies for estimating livelihood resilience to climate change (Campbell, 2021). The important elements of livelihood resilience are often indicated by these frameworks: i) adaptive, ii) absorptive, and iii) transformative capacity (Bene et al., 2012). However, in this framework, there are some sub-indicators. Authors have expanded the livelihood resilience framework by using four more variables, like Non-agricultural Asset, Household Adaptive Capacity, Sensitivity, and Access to Basic Services.

The livelihood Resilience Index was employed to achieve the objective of this study. The author utilized the sustainable livelihood framework and converted it into a composite index based on 9 distinct indicators proposed by FAO (2016) to measure livelihood resilience (Sarker et al., 2020). According to FAO (2016), resilience depends on the following three dimensions:

Resilience = *f* (adaptive, absorptive, transformative capacity)

These nine components: Income and Food Access, Agricultural Asset, Non-agricultural Asset, Agricultural Practice and Technology, Household Adaptive Capacity, Sensitivity, Access to Basic Services, Climate Variability as well as Social Safety Nets were assessed by equally weighting each of the three main components, such as adaptive, absorptive, and transformative capacity to calculate the Livelihood Resilience of each study site.

Using an aggregated standard mean, this approach creates a resilience index for a collection of indicators. This enables the identification of parameters or drivers that may be used to evaluate participation and monitoring systems. Since each sub-component is not measured on the same scale, Equation (i) was used to standardize each indicator. For an indication, standardized values ranged from 0 to 1.

$$Index_{S_i} = \frac{S_i - S_{min}}{S_{max} - S_{min}} \quad \ldots\ldots\ldots (i)$$

Where, $Index_{S_i}$ is a standardized value of an indicator for a household (HH); S_i is the actual value of the same indicator, and S_{min} and S_{max} are the minimum and maximum values, respectively, of the same indicator.

After each indicator was standardized, the sub-components were averaged using Equation (ii) to determine the value of each main component, including Income and Food Access (IFA), Agricultural Asset (AA), Non-agricultural Asset (NAA), Agricultural Practice and Technology (APT), Household Adaptive Capacity (AC), Climate Variability (CC), Sensitivity (S), Access to Basic Services (ABS), and Social Safety Nets (SSN).

$$M_u = \frac{\sum_{i=1}^{n} Index_{S_{u^i}}}{n} \quad \ldots\ldots\ldots (ii)$$

Wherein, M_u = one of the nine major components for union u [Income and Food Access, Agricultural Asset, Non-agricultural Asset, Agricultural Practice and Technology, Household Adaptive Capacity, Sensitivity, Climate Variability, Access to Basic Services and Social Safety Nets], $Index_{S_{u^i}}$ represents the sub-components, indexed by i that comprise each vital element, and n is the number of sub-components in each element.

Once values were determined for each of the nine principal components of a union, Equation (iii) was used to calculate the average to develop the union level LRI:

$$LRI_u = \frac{\sum_{i=1}^{9} W_{M_i} M_{ui}}{\sum_{i=1}^{9} W_{M_i}} \quad \ldots\ldots\ldots (iii)$$

That can also be written as

$$LRIv = \frac{W_{IFA}IFAv + W_{ABS}ABSv + W_{WAA}AAv + W_{NAA}NAAv + W_{APT}APTv + W_{SSN}SSNv + W_{CC}CCv + W_{S}Sv + W_{AC}ACv}{W_{IFA} + W_{ABS} + W_{WAA} + W_{NAA} + W_{APT} + W_{SNN} + W_{CC} + W_{S} + W_{AC}} \quad \ldots\ldots (iv)$$

where LRI_u, the Livelihood Resilience Index for each union u, equals the weighted average of the nine major components. The weights of each W_{M_i}, major components, which were determined by the number of sub-components that made up each vital component and were included to assure that all sub-components contribute evenly to the overall LRI (Sullivan et al., 2002).

The index for Adaptive Capacity (AdaCap) includes Income and Food access, Agricultural Asset, Non-agricultural Asset, Agricultural Practice and Technology, and Household Adaptive Capacity were measured in equation no. (v) as follows,

$$IndexAdaCap = \frac{W_{ad1}IFA + W_{ad2}AA + W_{ad3}NAA + W_{ad4}APT + W_{ad5}AC}{W_{ad1} + W_{ad2} + W_{ad3} + W_{ad4} + W_{ad5}} \quad \ldots\ldots\ldots (v)$$

Wherever, $W_{ad1}, W_{ad2}, W_{ad3}, W_{ad4}, W_{ad5}$ represents the weightage for the household's Income and Food Access (IFA), Household's Agricultural Asset (AA), Household's Non-agricultural Asset (NAA), Household's Agricultural Practice and Technology (APT), and Household's Adaptive Capacity (AC) for a particular area correspondingly.

The Absorptive Capacity (AbsCap) index includes Sensitivity and Climatic Variability and was measured as follows: equation no. (vi):

$$IndexAbsCap = \frac{W_{abs1}S + W_{abs2}CC}{W_{abs1} + W_{abs2}} \quad \ldots\ldots\ldots (vi)$$

Where, W_{abs1}, W_{abs2} represent the weightage for Household's Sensitivity (S), and Household's perception of Climatic Variability (CC), respectively.

The index of Transformative Capacity (TC) was calculated from Access to Basic Services and Social Safety Nets, as follows: equation no. (vii):

$$IndexTransCap = \frac{W_{tr1}ABS + W_{tr2}SSN}{W_{tr1} + W_{tr2}} \quad \ldots\ldots\ldots (vii)$$

Where, W_{tr1}, W_{tr2} denote weightage for Household's Access to Basic Services (ABS), and Household's Social Safety Nets (SSN) respectively.

In this study, the LRI was scaled from 0 (low resilience) to 1 (high resilience) to show the resilience status of inter and intra-groups of respondents.

Results

Socio-economic Characteristics of the Households

Socio-demographic Profile

The most important socio-demographic characteristics of the respondent households in this study area are listed in Table 1. With an average age of 46.20 (± 10.20) years in *Koyra* and 43.77 (± 11.213) years in *Uttar Bedkashi*, the respondents indicate having seen significant changes in climatic trends and have been more severely affected by climate-related calamities during the past ten years. The majority of the respondents' households were headed by males, as the percentage of male respondents in *Koyra* is 74% and 82% in *Uttar Bedkashi*, and the rest of the percentage is female. In this study, the average family member of the respondent is 4.85 (± 1.48) in *Koyra* and 4.76 (± 1.398) in *Uttar Bedkashi*. The results also indicated that the percentage of the working age population (> 14 and < 65 years) of the respondent's household is higher in *Koyra* than *Uttar Bedkashi*, with an average of 1.32 (± .468) compared to 1.31 (± .533).

Table 1: Socio-demographic Profile Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Socio-demographic profile	Age of the HH heads	Mean ± SD (years)	46.20 ± 10.20 (66 – 26)	43.77 ± 11.213 (70 – 25)
	% of male-headed HHs	Percent	74 (100 - 0)	82 (100 - 0)
	% of HHs Family member	Mean ± SD (individuals)	4.85 ± 1.48 (8 – 2)	4.76 ± 1.398 (9 – 2)
	% of HHs Working age population	Mean ± SD (individuals)	1.32 ± .468 (2 – 1)	1.31 ± .533 (3 – 1)

Note: Max = Maximum; Min = Minimum; SD = Standard Deviation

Income and Food Access

At the same time, the percentage of the two union households that lend money to others is 45% in *Koyra* and 20% in *Uttar Bedkashi*. In *Koyra*, the percentage of not borrowing money from other relatives is 53% while in *Uttar Bedkashi*, it is 50%. Along with, 59% of people in *Uttar Bedkasi* and 65% of people in *Koyra* reported not borrowing money from their neighbors. Additionally, about 56% of households in *Koyra* and 33% *Uttar Bedkashi* did not borrow money from NGOs or commercial banks in the last 12 months. Besides, this study found that about 53% of the households in *Koyra* and 28% of the households in *Uttar Bedkashi* were not worried about the lack of sufficient food during the previous three months. Findings also showed that 42% of people in *Uttar Bedkashi* and 61% of those in *Koyra* reported eating fewer than three meals a day owing to food shortages over the past three months. Furthermore, about 69% of the households in *Koyra* did not go to bed hungry during the past three months due to a lack of sufficient food and the percentage in *Uttar Bedkashi* is 67%.

Table 2: Income and Food Access Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Income and Food Access (IFA)	% of HHs lending money to others	Percent	45 (100 - 0)	20 (100 - 0)
	% of HHs not borrowing money from other relatives	Percent	53 (100 - 0)	50 (150 - 0)
	% of HHs not taking out loans from other neighbors	Percent	65 (100 - 0)	59 (100 - 0)
	% of HHs not borrowing money from NGOs or commercial banks	Percent	56 (100 - 0)	33 (100 - 0)
	% of HHs not worry about the lack of sufficient food	Percent	53 (100 - 0)	28 (100 - 0)
	% of not eating fewer than three meals per day due to the unavailability of food	Percent	61 (100 - 0)	42 (100 - 0)
	% of HHs not going to bed in hunger due to a lack of sufficient food	Percent	69 (100 - 0)	67 (100 - 0)

Note: Max = Maximum; Min = Minimum

Agricultural Asset

Then, the result found that a substantial number of households had livestock (agricultural assets) like cows including 57% in *Koyra* and 38% in *Uttar Bedkashi*. It also showed the percentage of rearing goats in *Koyra* is 49% and *Uttar Bedkashi* is 38%. Moreover, about 60% of the households have Poultry in *Koyra* and 30% in *Uttar Bedkashi.*

Table 3: Agricultural Asset Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Agricultural Asset (AA)	% of HHs having Cows	Percent	57 (100 - 0)	38 (100 - 0)
	% of HHs having Goats	Percent	49 (100 - 0)	38 (100 - 0)
	% of HHs having Poultry	Percent	60 (100 - 0)	30 (100 - 0)

Note: Max = Maximum; Min = Minimum

Non-agricultural Asset

In a similar vein, the results showed that many households, notably 51% in *Koyra* and 39% in *Uttar Bedkashi*, owned assets unrelated to agriculture, such as motorcycles, vans, or bicycles. Additionally, it revealed the percentage of households who have irrigation machines and the percentage in *Koyra* is 39% and *Uttar Bedkashi* is 13%. Moreover, 58% of households in *Uttar Bedkashi* and 43% of households in *Koyra* have boats, respectively.

Table 4: Non-agricultural Asset Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Non-agricultural Asset (NAA)	% of HHs having durable assets (Motorbike, Van, Bicycle)	Percent	51 (100 - 0)	39 (100 - 0)
	% of HHs having machines for irrigation	Percent	39 (100 - 0)	13 (100 - 0)
	% of HHs having boat	Percent	43 (100 - 0)	58 (100 - 0)

Note: Max = Maximum; Min = Minimum

Agricultural Practice and Technology

Then again, this study indicated that approximately 61% of households in *Koyra* and 51% of households in *Uttar Bedkashi* used fertilizer or insecticides on their agricultural fields. Along with receiving recommendations on better flood prevention measures, 58% of households in *Koyra* and 35% of households in *Uttar Bedkashi*. Additionally, this study revealed that 34% of *Koyra's* farmers used improved farming technology to control disasters, and 17% of *Uttar Bedkashi* farmers did the same.

Table 5: Agricultural Practice and Technology Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Agricultural Practice and Technology (APT)	% of HHs using any fertilizers or pesticides on their crop field	Percent	61 (100 - 0)	51 (100 - 0)
	% of HHs getting any recommendations for better flood-prevention strategies	Percent	58 (100 - 0)	35 (100 - 0)
	% of HHs using enhanced farming technologies to manage disasters	Percent	34 (100 - 0)	17 (100 - 0)

Note: Max = Maximum; Min = Minimum

Household Adaptive Capacity

Similarly, households headed by individuals with formal education made up 40% of respondents in *Uttar Bedkashi* and 51% of respondents in *Koyra*. According to the findings, 45% of respondents in *Uttar Bedkashi* and 58% of respondents in *Koyra* had finished their primary education. In addition, agriculture does not provide the primary source of income for 49% of households in *Koyra* and 41% of households in *Uttar Bedkashi*. Along with, 34% of respondents in *Koyra* and 27% in *Uttar Bedkashi* reported not going fishing during the flood season. In terms of participation in non-farm activities, 55% of the households in *Koyra* and 57% of the households in *Uttar Bedkashi*. The findings of this study also showed that 20% of households in *Uttar Bedkashi* and 28% of households in *Koyra* did not experience unemployment during the flood season. Moreover, in *Koyra*, 25% of households have not had to deal with floods or other natural calamities, compared to 18% in *Uttar Bedkashi*. Furthermore, about 43% of households in *Koyra* and 41% of those in *Uttar Bedkashi* permit their female members to work outside the home according to this study. In addition, this study also includes the percentage of respondents who work for nonprofit organizations, which in *Koyra* is 45%, and in *Uttar Bedkashi* is 36%, and 23% of the household's home in *Uttar Bedkashi* and 30% of the households' house in *Koyra* were not affected by the natural disasters.

Table 6: Household Adaptive Capacity Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Household Adaptive Capacity (AC)	% of HHs where the head of the HHs is not illiterate	Percent	51 (100 - 0)	40 (100 - 0)
	% of HHs where the head of the HHs has completed primary school	Percent	58 (100 - 0)	45 (100 - 0)
	% of HHs where agriculture is not the major source of income	Percent	49 (100 - 0)	41 (100 - 0)
	% of HHs not going fishing during the flood season	Percent	34 (100 - 0)	27 (100 - 0)
	% of HHs with family members participated in non-farm activities	Percent	55 (100 - 0)	57 (100 - 0)
	% of HHs not unemployed during the disaster period	Percent	28 (100 - 0)	20 (100 - 0)
	% of HHs with family members have any experience to deal with floods and other natural disasters	Percent	25 (100 - 0)	18 (100 - 0)
	% of HHs allowed female members of their family to work outside the home	Percent	43 (100 - 0)	41 (100 - 0)
	% of HHs working for a non-profit organization	Percent	45 (100 - 00)	36 (100 - 0)
	% of HHs whose home is not affected by the natural disasters	Percent	30 (100 - 00)	23 (100 - 0)

Note: Max = Maximum; Min = Minimum

Climate Variability

Likewise, households were not affected by the gradual increase of various disasters over the past ten years, as shown in this study. According to these findings, in *Koyra*, 13%, 53%, 48%, and 35% of households were not impacted by the flood, riverbank erosion, monsoon rains, or cyclones, whereas in *Uttar Bedkashi*, these percentages were, 11%, 49%, 45% and 32% of the households. This survey also revealed that in *Koyra*, 20%, 33%, and *Uttar Bedkashi*, 20%, and 32%, respectively, there hasn't been a rise in summer temperatures or a lengthening of the summer season over the past 10 years.

Table 7: Climate Variability Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Climate Variability (CC)	% of HHs not affected by the gradual increase of flood	Percent	13 (100 - 0)	11 (100 - 0)
	% of HHs not affected by the gradual increase of riverbank erosion	Percent	53 (100 - 0)	49 (100 - 0)
	% of HHs not affected by the gradual increase of monsoon rainfall	Percent	48 (100 - 0)	45 (100 - 0)
	% of HHs not affected by the gradual increase of cyclone	Percent	35 (100 - 0)	32 (100 - 0)
	% of HHs did not notice the gradual rise in summer temperature	Percent	20 (100 - 0)	20 (100 - 0)
	% of HHs have not seen the progressive increase in the length of the summer season	Percent	33 (100 - 0)	32 (100 - 0)

Note: Max = Maximum; Min = Minimum

Sensitivity

By this study's findings, a significant number of households did not experience any difficulties because of numerous disasters, most particularly 27% of respondents in *Uttar Bedkashi* and 46% of households in *Koyra* reported not experiencing a food problem, respectively. Along with, 31% of respondents in *Uttar Bedkashi* and 42% of respondents in *Koyra* reported that their access to sanitary facilities had not been interrupted. Further, 13% of respondents in *Uttar Bedkashi* and 25% of respondents in *Koyra*, respectively, did not experience water logging problems. Moreover, the percentage of households in *Koyra* did not experience a lack of fresh water, salinity intrusion, or access to healthcare services. is 47%, 33%, 57%, and 41%, 23%, and 29% in *Uttar Bedkashi*. In addition, based on the findings, 35% of livestock owned by households in *Koyra* and *Uttar Bedkashi* are not affected by natural calamities.

Table 8: Sensitivity Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Sensitivity (S)	% of HHs did not experience the difficulties of food crisis because of various disasters	Percent	46 (100 - 0)	27 (100 - 0)
	% of HHs did not experience the difficulties of disruption of sanitation facilities because of various disasters	Percent	42 (100 - 0)	31 (100 - 0)
	% of HHs did not experience the difficulties of water logging because of various disasters	Percent	25 (100 - 0)	13 (100 - 0)
	% of HHs did not experience the difficulties of the lack of access to health care services because of various disasters	Percent	57 (100 - 0)	29 (100 - 0)
	% of HHs did not experience the difficulties of salinity intrusion because of various disasters	Percent	33 (100 - 00)	23 (100 - 0)
	% of HHs did not experience the difficulties of fresh water shortage because of various disasters	Percent	47 (100 - 0)	41 (100 - 0)
	% of livestock not affected by natural disasters	Percent	35 (100-0)	35 (100-0)

Note: Max = Maximum; Min = Minimum

<u>*Access to Basic Services*</u>

Correspondingly, Table 9 exhibits the percentage of households that have access to the same basic services during the disasters. According to this, 39% of households in *Koyra* and 27% of households in *Uttar Bedkashi* have access to educational facilities, 59% of households in *Koyra* and 40% of households in *Uttar Bedkashi* have access to health care facilities, 69% of the households in *Koyra* and 49% of households in *Uttar Bedkashi* have access to drinking water, 53% of households in *Koyra* and 35% households in *Uttar Bedkashi* have access to sanitation facilities, 29% of households in *Koyra* and 15% of the households in *Uttar Bedkashi* have access to electricity facilities.

Table 9: Access to Basic Services Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Access to Basic Services (ABS)	% of HHs have the same access to education facilities during a disaster	Percent	39 (100 - 0)	27 (100 - 0)
	% of HHs have the same access to health care services during a disaster	Percent	59 (100 - 0)	40 (100 - 0)
	% of HHs have the same access to the availability of drinking water during a disaster	Percent	69 (100 - 0)	49 (100 - 0)
	% of HHs have the same access to sanitation facilities during a disaster	Percent	53 (100 - 0)	35 (100 - 0)
	% of HHs have the same access to electricity facilities during a disaster	Percent	29 (100 - 0)	15 (100 - 0)

Note: Max = Maximum; Min = Minimum

<u>*Social Safety Nets*</u>

However, the findings of this study found that the percentage of the respondents who participate in an NGO or GO program in *Koyra* is 60% and in *Uttar Bedkashi* is 48%. It also includes the Percentage of households helped by NGOs or GO during a disaster in *Koyra* is 36% and in *Uttar Bedkashi* is 46%. Moreover, in *Koyra*, 41% of households received financial aid from an NGO or GO in the event of a calamity, whereas in *Uttar Bedkashi*, 53% did. In addition, the percent of households receiving skill development training from an NGO or GO in *Koyra* is 45% while in *Uttar Bedkashi* is 42%.

Table 10: Social Safety Nets Values

Major Components	Sub-components	Unit	*Koyra* (Max – Min)	*Uttar Bedkashi* (Max – Min)
Social Safety Nets (SSN)	% of HHs with family members participated in an NGO or GO program	Percent	60 (100 - 0)	48 (100 - 0)
	% of HHs who were helped by NGO or GO during a disaster	Percent	36 (100 - 0)	46 (100 - 0)
	% of HHs received financial assistance from NGO or GO in the event of a disaster	Percent	41 (100 - 0)	53 (100 -0)
	% of HHs with family members received skill development training from an NGO or GO	Percent	45 (100 - 0)	42 (100 - 0)

Note: Max = Maximum; Min = Minimum; GO = Governmental Organization; NGO = Non-governmental Organization

Household's Livelihood Resilience Index

Income and Food Access

With a weighted average score of 0.58, *Koyra* union was found to have the highest resilience score for income and food access, while *Uttar Bedkashi* union was found to have the lowest level of resilience 0.43 (Table 11). Having the standardized score for two unions, the sub-components in terms of lending money to others demonstrated that, the *Koyra* union is most resilient with a normalized score of 0.45 following the normalized score of 0.20 for *Uttar Bedkashi* union. At the same time, *Uttar Bedkashi* was the least resilient in terms of not borrowing money from other relatives, with a normalized score of 0.50 following the normalized score of 0.53 for *Koyra*. Likewise, in terms of not taking out loans from other neighbors, *Koyra* was found most resilient with a normalized score of 0.65, whereas *Uttar Bedkashi* was found least resilient with a normalized score of 0.59. Similarly, *Koyra* was found most resilient in terms of not borrowing money from NGOs or commercial banks with a normalized score of 0.56 while the normalized score of 0.33 indicated *Uttar Bedkashi* as the least resilient union. Besides, in terms of not worrying about the lack of sufficient food during the last 3 months, revealed that the highest standardized score (0.53) was recorded in *Koyra*, while the minimum standardized score was reported in *Uttar Bedkashi* (0.33). Further in terms of not eating fewer than three meals per day due to the unavailability of food during the last 3 months, the highest score was noted in *Koyra* (0.61) while the lowest standardized score was documented in *Uttar Bedkasi* (0.42). Moreover, based on the standardized score (0.69) *Koyra* is the most resilient union whereas *Uttar Bedkashi* is the least resilient Union with a standardized score (0.67).

Table 11: LRI Index Value of Income and Food Access

Sub-components	***Koyra***	***Uttar Bedkashi***	**Major Components**	***Koyra***	***Uttar Bedkashi***
% of HHs lending money to others	0.45	0.20	Income and Food Access (IFA)	0.58	0.43
% of HHs not borrowing money from other relatives	0.53	0.50			
% of HHs not taking out loans from other neighbors	0.65	0.59			
% of HHs not borrowing money from NGOs or commercial banks	0.56	0.33			
% of HHs not worry about the lack of sufficient food	0.53	0.28			
% of not eating fewer than three meals per day due to the unavailability of food	0.61	0.42			
% of HHs not going to bed in hunger due to a lack of sufficient food	0.69	0.67			

Agricultural Asset

Koyra union was found to have the highest resilience score for the agricultural asset, with a weighted average score of 0.55, while *Uttar Bedkashi* union was found to have the lowest resilience level with a weighted average score of 0.35 (Table 12). The sub-components score demonstrated that *Koyra* was the most resilient in terms of having cows, with a normalized score of 0.57, while the normalized score of 0.38 indicated *Uttar Bedkashi* least resilient. Similarly, in terms of having goats demonstrated *Koyra* was the most resilient, with a normalized score of 0.49, following the normalized score of 0.38 for *Uttar Bedkashi*. Likewise, *Koyra* was found as the most resilient in terms of having poultry assets with a normalized score of 0.60, while the normalized score of 0.30 for *Uttar Bedkashi* demonstrated its least resilience.

Table 12: LRI Index Value of Agricultural Asset

Sub-components	***Koyra***	***Uttar Bedkashi***	**Major Components**	***Koyra***	***Uttar Bedkashi***
% of HHs having Cows	0.57	0.38	Agricultural Asset (AA)	0.55	0.35
% of HHs having Goats	0.49	0.38			
% of HHs having Poultry	0.60	0.30			

Non-agricultural Asset

With a weighted average score of 0.44, *Koyra* union was identified to have the maximum resilient score for its non-agricultural asset, while the *Uttar Bedkashi* union was determined to have the lowest resilient union with a score of 0.37 (Table 13). The sub-components comprising households having durable assets (motorbike, van, and bicycle) that aren't related to agriculture demonstrated that *Koyra* was the most resilient with a normalized score of 0.51, while the normalized score of 0.39 for *Uttar Bedkashi* union was found to be the least resilient. Likewise, the highest standardized score (0.39) was noted in *Koyra* and the lowest standardized score (0.13) in *Uttar Bedkashi* in terms of having the machine for irrigation with a normalized score of 0.39. Similarly, *Koyra* was the least resilient in terms of having a boat with a normalized score of 0.43, while the normalized score of 0.13 for *Uttar Bedkashi* demonstrated it is the most resilient.

Table 13: LRI Index Value of Non-agricultural Asset

Sub-components	*Koyra*	*Uttar Bedkashi*	Major Components	*Koyra*	*Uttar Bedkashi*
% of HHs having Durable assets (Motorbike, Van, Bicycle)	0.51	0.39	Non-Agricultural Asset (NAA)	0.44	0.37
% of HHs having machines for irrigation	0.39	0.13			
% of HHs having boat	0.43	0.58			

<u>*Agricultural Practice and Technology*</u>

Koyra union was found to have the highest resilient score for agricultural practice and technology, with a weighted average score of 0.51, while *Uttar Bedkashi* union was found to have the lowest resilient level with a weighted average score of 0.34 (Table 14). The sub-components score demonstrated that *Koyra* was the most resilient in terms of using any fertilizers or pesticides on their crop field, with a normalized score of 0.61, whereas *Uttar Bedkashi* was found to be the least resilient union with a normalized score of 0.51. Similarly, *Koyra* was determined to be the most resilient in terms of getting any recommendations for better flood-prevention strategies, with a normalized score of 0.58, and *Uttar Bedkashi* with a normalized score of 0.35. Likewise, the highest standardized score was reported in *Koyra* in terms of using enhanced farming technologies to manage disasters, with a normalized score of (0.34) for *Koyra* whereas the lowest standardized score (0.17) was documented in *Uttar Bedkashi.*

Table 14: LRI Index Value of Agricultural Practice and Technology

Sub-components	*Koyra*	*Uttar Bedkashi*	Major Components	*Koyra*	*Uttar Bedkashi*
% of HHs using any fertilizers or pesticides on their crop field	0.61	0.51	Agricultural Practice and Technology (APT)	0.51	0.34
% of HHs getting any recommendations for better flood-prevention strategies	0.58	0.35			
% of HHs using enhanced farming technologies to manage disasters	0.34	0.17			

<u>*Household Adaptive Capacity*</u>

Koyra union was found to have the highest resilient score for household adaptive capacity, with a weighted average score of 0.42, while *Uttar Bedkashi* union was specified to have the lowest resilience score with a value of 0.35 (Table 15). Having a standardized score for the sub-components in terms of not having an illiterate head of household, with a normalized score of 0.51 for *Koyra* union, while the normalized score of 0.40 for *Uttar Bedkashi* union. Likewise, *Koyra* was found to be the highest resilient in the position of the households head who have completed primary school, family members participated in non-farm activities, family members have any experience to deal with natural disasters, and allowed any female members of their family to work outside the home and family member work for a non-profit organization with a normalized score of 0.58, 0.55, 0.25, 0.43 and 0.45 respectively, on the other hand, following the normalized score of 0.45, 0.57, 0.18, 0.41 and 0.36 respectively *Uttar Bedkashi* union was considered as least resilient. At the same time, the maximum standardized score in the case of not agricultural dependence as the principal source of income was recorded in *Koyra* (0.49), while the minimum standardized score was reported in *Uttar Bedkashi* (0.41). Along with, in the position of not going to fishing during the flood season, the highest standardized score was noted in *Koyra* (0.34), while the lowest standardized score was documented in *Uttar Bedkashi* (0.27). Similarly, *Koyra* was found to be the most resilient in the case of households that were not unemployed during the disaster with a normalized score, (0.28) whereas the normalized score for *Uttar Bedkashi* is (0.20). Further *Koyra* was noted as the maximum standardized score (0.30) in the case of households whose homes were not affected by the disaster, while the lowest standardized score (0.23) was reported in *Uttar Bedkashi*.

Table 15: LRI Index Value of Household Adaptive Capacity

Sub-components	*Koyra*	*Uttar Bedkashi*	Major Components	*Koyra*	*Uttar Bedkashi*
% of HHs where the head of the HHS is not illiterate	0.51	0.40	Household Adaptive Capacity (AC)	0.42	0.35
% of HHs where the head of the HHs has completed primary school	0.58	0.45			
% of HHs where agriculture is not the major source of income	0.49	0.41			
% of HHs not going fishing during the flood season	0.34	0.27			
% of HHs with family members participated in non-farm activities	0.55	0.57			
% of HHs not unemployed during the disaster period	0.28	0.20			

% of HHs with family members have any experience to deal with floods and other natural disasters	0.25	0.18			
% of HHs allowed female members of their family to work outside the home	0.43	0.41			
% of HHs working for a non-profit organization	0.45	0.36			
% of HHs whose home is not affected by the natural disasters	0.30	0.23			

<u>*Climate Variability*</u>

Koyra union was found to have the highest resilient score for climate variability, with a weighted average score of 0.34, while *Uttar Bedkashi* union was found to have the lowest resilient level with a weighted average score of 0.32 (Table 16). Having the standardized score for the sub-components in terms of households not affected by the gradual increase of disasters over the past ten years like a flood, with a normalized score (0.13), cyclone with a normalized score (0.35), riverbank erosion with a normalized score (0.53), monsoon rainfall with a normalized score (0.48), *Koyra* was found to be maximum resilient union, while the normalized score for flood (0.11), cyclone (0.32), riverbank erosion (0.49) and Monsoon rainfall (0.45) demonstrated the *Uttar Bedkashi* union as least resilient. At the same time, *Koyra* and *Uttar Bedkashi* were considered as a similar resilient union in terms of not rising in summer temperature over the previous ten years, with a normalized score of 0.20. Similarly, with a normalized score of 0.33, *Koyra* obtained the highest resilience in terms of households not seeing the progressive increase in summer length over the past ten years, while *Uttar Bedkasi* was reported as the least resilient with a normalized score of 0.32.

Table 16: LRI Index Value of Climate Variability

Sub-components	***Koyra***	***Uttar Bedkashi***	**Major Components**	***Koyra***	***Uttar Bedkashi***
% of HHs not affected by the gradual increase of flood	0.13	0.11	Climate Variability (CC)	0.34	0.32
% of HHs not affected by the gradual increase of riverbank erosion	0.53	0.49			
% of HHs not affected by the gradual increase of monsoon rainfall	0.48	0.45			
% of HHs not affected by the gradual increase of cyclone	0.35	0.32			
% of HHs did not notice the gradual rise in summer temperature	0.20	0.20			
% of HHs have not seen the progressive increase in the length of the summer season	0.33	0.32			

<u>*Sensitivity*</u>

With a weighted average score of 0.41, *Koyra* union was identified to have the highest resilience, while the *Uttar Bedkashi* union was found to have the lowest resilience with a weighted average score of 0.28 for sensitivity (Table 17). The sub-components score demonstrated that *Koyra* was considered the most resilient in case of households not experienced difficulties during various disasters such as the food crisis, disruption of sanitation facilities, water logging, and lack of access to healthcare services with a normalized score of 0.46, 0.42, 0.25 and 0.57 respectively, while the normalized score of 0.27, 0.31, 0.13 and 0.29 for *Uttar Bedkashi*., Similarly, *Koyra* obtained the highest standardized score for salinity intrusion (0.33) and freshwater shortage (0.47), while the lowest standardized score for salinity intrusion (0.23) and freshwater shortage (0.41) was reported in *Uttar Bedkashi*. Likewise, *Koyra* and *Uttar Bedkashi* was found to the similar resilient union in terms of household's livestock not affected by natural disasters.

Table 17: LRI Index Value of Sensitivity

Sub-components	***Koyra***	***Uttar Bedkashi***	**Major Components**	***Koyra***	***Uttar Bedkashi***
% of HHs did not experience the difficulties of food crisis because of various disasters	0.46	0.27	Sensitivity (S)	0.41	0.28
% of HHs did not experience the difficulties of disruption of sanitation facilities because of various disasters	0.42	0.31			
% of HHs did not experience the difficulties of water logging because of various disasters	0.25	0.13			
% of HHs did not experience the difficulties of the lack of access to health care services because of various disasters	0.57	0.29			
% of HHs did not experience the difficulties of salinity intrusion because of various disasters	0.33	0.23			

% of HHs did not experience the difficulties of freshwater shortage because of various disasters	0.47	0.41			
% of livestock not affected by natural disasters	0.35	0.35			

Access to Basic Services

Koyra union was found to have the highest resilient score for access to basic services, with a weighted average score of 0.50, while *Uttar Bedkashi* union was found to have the lowest resilient level with an average score of 0.33 (Table 18). The sub-components score demonstrated that *Koyra* was the most resilient in terms of households having the same access to basic services like education facilities, health care services, and availability of drinking water, sanitation facilities, and electricity facilities with a normalized score of 0.39, 0.59, 0.69, 0.53 and 0.29 while Uttar *Bedkasi* was considered least resilient with a normalized score of 0.27, 0.40, 0.49, 0.35 and 0.15.

Table 18: LRI Index Value of Access to Basic Services

Sub-components	*Koyra*	*Uttar Bedkashi*	Major Components	*Koyra*	*Uttar Bedkashi*
% of HHs have the same access to education facilities during a disaster	0.39	0.27	Access to Basic Services (ABS)	0.50	0.33
% of HHs have the same access to health care services during a disaster	0.59	0.40			
% of HHs have the same access to the availability of drinking water during a disaster	0.69	0.49			
% of HHs have the same access to sanitation facilities during a disaster	0.53	0.35			
% of HHs have the same access to electricity facilities during a disaster	0.29	0.15			

Social Safety Nets

With a weighted average score of 0.47, *Uttar Bedkashi* union was identified to have the highest resilient score for its social safety nets, while *Koyra* was found to have the lowest resilient with a weighted average score of 0.46 (Table 19). The sub-components score demonstrated that in the case of households that participated in NGO or GO programs, the highest standardized score was obtained in *Koyra* (0.60), while the lowest standardized score was documented in *Uttar Bedkashi*.

Table 19: LRI Index Value of Social Safety Nets

Sub-components	*Koyra*	*Uttar Bedkashi*	Major Components	*Koyra*	*Uttar Bedkashi*
% of HHs with family members participated in an NGO or GO program	0.60	0.48	Social safety nets (SSN)	0.46	0.47
% of HHs who were helped by NGO or GO during a disaster	0.36	0.46			
% of HHs received financial assistance from NGO or GO in the event of a disaster	0.41	0.53			
% of HHs with family members received skill development training from an NGO or GO	0.45	0.42			

Similarly, *Uttar Bedkashi* was found to be the most resilient in terms of households helped by NGO or GO during a disaster and received financial assistance from NGO or GO in the event of a disaster with a normalized score of 0.46 and 0.53 while following the normalized score of 0.36 and 0.41 for *Koyra* was considered least resilient. Likewise, in the position of households receiving skill development training from an NGO or GO, the highest standardized score was obtained in *Koyra* (0.45) and the lowest standardized score was reported in *Uttar Bedkashi*.

Overall Livelihood Resilience Index

Overall Livelihood Resilience Index demonstrated that *Koyra* was the most resilient union with a weighted score of 0.46 whereas the *Uttar Bedkashi* union was found as the least resilient union with a weighted score of 0.36 (Figure 2).

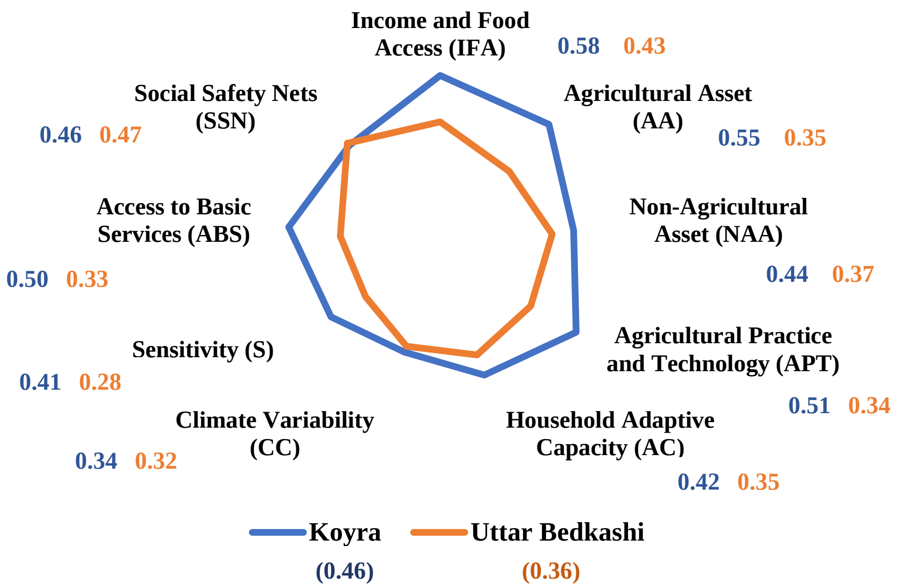

Figure 2: Resilience Spider Diagram of the Major Components of the Livelihood Resilience Index (LRI)

Household's Livelihood Resilience Capacities

The livelihood resilience index (LRI) was classified into three major components: adaptive, absorptive, and transformative capacity. According to the LRI score, households in *Uttar Bedkashi* are more susceptible to different climatic-related disasters (Figure 2). The scores of the major dimensions of LRI are shown in Figure 2. The value of the adaptive, absorptive, and transformative capacity of the households of *Koyra* union was moderately higher than the households of *Uttar Bedkashi* (Figure 3). The values indicated that households of *Uttar Bedkashi* union are more vulnerable and sensitive to climate-related hazards than households of *Koyra* union. Similarly, the adaptive, absorptive, transformative capacity of households of *Uttar Bedkashi* is less than the households of *Koyra*. The value of LRI also indicates that households of *Uttar Bedkashi* are least resilient than the *Koyra* union (Alam et al., 2018; Sarker et al., 2020).

Adaptive Capacity

The adaptive capacity was included in the components such as income and food access, agricultural assets, non-agricultural assets, agricultural practice and technology, and household adaptive capacity, as well as their sub-components. To deal with this dimension, the author conducted the relevant adjustment. With a weighted score of 0.50, *Koyra* union has the highest adaptive capacity, followed by the *Uttar Bedkshi* union with a weighted score of 0.37 (Figure 3). At the same time, *Koyra* union was assessed to have the maximum adaptive capacity score for income and food access, with a weighted score of 0.58, while *Uttar Bedkashi* union was identified to have the minimum score with a weighted value of 0.43. Similarly, *Koyra* union was identified to have the highest adaptive capacity score for the agricultural asset, with a weighted value of 0.55 while *Uttar Bedkashi* was found to have the lowest adaptive capacity, with a weighted score of 0.35. Likewise, *Koyra* Union, with a weighted score of 0.44, was determined to have the greatest adaptive capacity score for non-agricultural assets whereas *Uttar Bedkashi* revealed the least adaptive capacity with a weighted average score of 0.37. The *Koyra* union obtained the highest adaptive capacity score for agricultural practice and technology, with a weighted average score of 0.51, while *Uttar Bedkashi* Union was listed to have the lowest adaptive capacity level, with a value of 0.34. Just as, *Koyra* was considered to have the highest adaptive capacity score for household adaptive capacity, with a weighted average score of 0.42, while *Uttar Bedkashi* union was specified to have the lowest adaptive capacity score, with a value of 0.35.

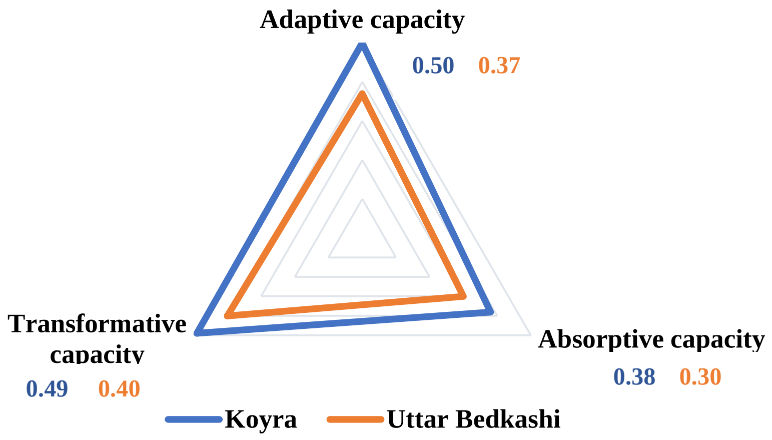

Figure 3: Livelihood Resilience Capacities Triangle Diagram

Absorptive Capacity

The components, including climate variability and sensitivity as well as their sub-components, incorporated the absorptive capacity**.** With a weighted score of 0.38, *Koyra* union was found to have the highest absorptive capacity, followed by the *Uttar Bedkshi* union with a weighted score of 0.30 (Figure 3). At the same time, *Koyra* union was assessed to have the maximum absorptive capacity score for climate variability, with a weighted score of 0.34, while *Uttar Bedkashi* union was identified to have the minimum score with a weighted value of 0.32. Similarly, *Koyra* union was identified to have the highest absorptive capacity score for the sensitivity, with a weighted value of 0.41 while *Uttar Bedkashi* was found to have the lowest adaptive capacity, with a weighted score of 0.28.

Transformative Capacity

Transformative capacity consists of access to basic service and social safety nets components, including the sub-components of this component. The outcomes indicated that the *Koyra* union has the highest transformative capacity, with a weighted score of 0.49, followed by the *Uttar Bedkshi* union with a weighted score of 0.40 (Figure 3). Likewise, *Koyra* Union, with a weighted score of 0.50, was determined to have the greatest transformative capacity score for access to basic service whereas *Uttar Bedkashi* revealed the least transformative capacity with a weighted average score of 0.33. *Uttar Bedkashi* was considered to have the highest transformative capacity score for social safety nets, with a weighted average score of 0.47, while *Koyra* union was specified to have the lowest transformative capacity score, with a value of 0.46.

Livelihood Resilience at the Household Level

In this study, livelihood resilience at the household level was categorized into three categories, which are 0 = low resilience (≤0.40), 1 = medium resilience (0.41 to 0.60), and 2 = high resilience (>0.60). According to this scale, both *Koyra* and *Uttar Bedkashi* Union were rated as having medium resilience at the household level, but the *Koyra* Union percentage is moderately higher (73.3) than *Uttar Bedkashi* (68.0). Besides, the percentage of low resilience at the household level in *Koyra* is (12.7) and in *Uttar Bedkashi* is (20.7) whereas the percentage of high resilience at the household level in *Koyra* is (14.0) and in *Uttar Bedkashi* is (11.3).

Table 20: Livelihood Resilience at the Households Level

Koyra		*Uttar Bedkashi*	
Level	**Percent**	**Level**	**Percent**
Low (≤0.40)	12.7	Low (≤0.40)	20.7
Medium (0.41-0.60)	73.3	Medium (0.41-0.60)	68.0
High (>0.60)	14.0	High (>0.60)	11.3

Discussion

This study was conducted by various unions in the Koyra Upazila of the Khulna district in Bangladesh's southwestern coastal region to assess the livelihood resilience of households in response to climate-related disasters. Severe climate-related phenomena have transpired in the region situated on the southwest coast, encompassing tropical cyclones, tidal waves, flooding, intense rainfall, coastal erosion, salinization, and waterlogging. Two successive strong cyclones, *Aila* in 2009 and *Amphan* in 2020, adversely affected the *Upazilla* (Roy, 2019; Sadik et al., 2018). This study employed a Resilience Index Measurement and Analysis approach created by FAO to evaluate Livelihood Resilience for each union. This index was formulated utilizing nine components: Income and Food Access, Agricultural

Assets, Non-Agricultural Assets, Agricultural Practices and Technology, Household Adaptive Capacity, Climate Variability, Sensitivity, Access to Basic Services, and Social Safety Nets (Sarker et al., 2020). This study compares the livelihood resilience of two households that responded to the union. Despite both unions being situated in the same climate, the literature indicates that the distinct landscapes and socio-economic circumstances of each region lead to differing environmental and hazard risks (Nguyen et al., 2021). Consequently, the *Uttar Bedkashi* union, encircled by the *Kopotakkho* and *Shakbaria* rivers, exhibited the lowest livelihood resilience to numerous natural disasters in the livelihood resilience index when compared to the *Koyra* Union. Moreover, the contributing factors, such as Income and Food Access, Agricultural Assets, Non-Agricultural Assets, Agricultural Practices and Technology, Household Adaptive Capacity, Climate Variability, Sensitivity, and Access to Basic Services, are poorly indexed in the *Uttar Bedkashi* Union of this study. These outcomes closely resemble a recent study that evaluated household resilience to cyclones and storms in nine coastal unions of Bangladesh, revealing inadequate livelihood resilience associated with borrowing, liquidating assets, and reducing food consumption, which adversely affected the livelihood resilience dimension (Al-Maruf et al., 2021). The geographical positioning of *Uttar Bedkashi* between two rivers enhanced its vulnerability to floods, salinity, tidal surges and complicated infrastructure development, and natural calamities response efforts. A further study indicated that agriculture and aquaculture are the principal income sources, but livestock rearing, intense rainfall, flooding, waterlogging, and salinity challenges significantly diminish the resilience of livelihoods in the southern coastal region of Bangladesh (Mallick, 2019). Furthermore, regarding food, water, and health, the households of the *Munda* community in *Symnagar* Upazila, *Sathkhira* district, Bangladesh, demonstrated a decline in livelihood resilience due to the prolonged impacts of climate disasters such as tropical cyclones, floods, salinity intrusion, famine, and heat waves (Roy, 2018). Furthermore, a prior study demonstrated that the resilience capacity of riverine mainland households is markedly superior to that of char (island) families, indicating that livelihood resilience can differ geographically (Sarker et al., 2020). It demonstrated that availability of food, water, healthcare facilities, educational attainment, and livelihood strategies are the principal predictors of resilience capacity (Alam et al., 2018). In terms of income and food availability, household adaptive capacity, climate variability, and sensitivity, the prevalence of limited access to basic services and the lowest levels of resilience are more pronounced in *Uttar Bedkashi* than in *Koyra*. Excessive dependence on agriculture and aquaculture without considering climate-resilient strategies and insurance systems is the reason for facing significant risk. Salinity, waterlogging, and floods in this area can undermine the livelihood of people when income diversification is not available. This study revealed that social safety nets in *Uttar Bedkashi* exhibited the highest degree of livelihood resilience compared to the other examined unions. However, the other institutional support systems like finance facilities, early warning system, and agricultural extension services are unattainable. This study identified livelihood resilience by classifying it into three components: adaptive ability, absorptive capacity, and transformative capacity. *Uttar Bedkashi* exhibits the lowest adaptable, absorptive, and transformative capacities in comparison to *Koyra* union. A study in Bangladesh assessed the adaptability of coastal agricultural systems, quantitatively evaluating resilience through capacities such as absorptive, adaptive, and transformative. The findings indicated a mixed ability to recover, restructure, and evolve in response to shocks (e.g., flash floods) and pressures (e.g., water logging) (Roy et al., 2019). Moreover, a study indicated that a livelihood might exhibit greater resilience by absorbing, tolerating, and recovering from vulnerabilities induced by alterations in the natural resource system (Sadik et al., 2009). The lower transformative capacity indicates a disjunction between immediate assistance and sustainable adaptive development. Though the higher score of social safety net, the paradox may arise due to the features and constraints of these safety net programs. These may provide short-term relief rather than long-term investments in infrastructure development, skill, and innovation. So, the community cannot be enabled to transform its livelihood sustainability. Moreover, the geographical limitations, absence of quality education, vocational training, and robust agricultural technologies further restrict them from shifting to more climate-resilient income-generating activities. Furthermore, institutional deficiencies, including inadequate coordination among local government, NGOs, and development agencies, may obstruct the integration of safety net programs into comprehensive development strategies. These findings of this research may aid in assessing the resilience of household livelihoods to climate-related disasters and the effective execution of adaptation plans and policies to mitigate the adverse effects of climate change on Bangladesh's southwestern coastline.

Although this study provides useful insights, the authors acknowledged some limitations of the research. Firstly, the application of the self-reported data may introduce response bias. Because respondents may either overestimate or underestimate their resilience due to recall errors or social desirability biases. Furthermore, when the nature of the data is cross-sectional, then it has the restriction of capability to detect temporal changes. Sometimes, it is limited to establishing the causal relationships between livelihood resilience and climate-related events. Despite ensuring most suffering households by the purposive sampling, it may inhibit the generalizability of the results to other coastal regions with various socio-economic or environmental circumstances.

Conclusion and Recommendations

This study focused on two unions of *Koyra Upazila* in Khulna district, which is located on Bangladesh's southwest coast and is particularly vulnerable to climate-related disasters. Using the livelihood resilience index (LRI), this study evaluated households' capacity to recover from climate-related disasters. The main components of LRI were then categorized using the terms adaptive, absorptive, and transformative capacities. This method can be used to offer a complete picture of livelihood resilience in a particular union. Households in the *Uttar B*edkashi union were more susceptible to climate-related disasters than those in the *Koyra* union across all livelihood resilience indices. Additionally, the study discovered that the *Uttar B*edkashi union was less able to absorb, transform, and adapt than *Koyra*. Numerous issues with household adaptability, sensitivity, income and food access, agricultural practices and technology, non-agricultural assets, basic service accessibility, and agricultural assets were found in *Uttar B*edkashi Union. Issuing loans, borrowing money from NGOs or banks, going to bed hungry, raising livestock (cows, goats, and poultry), owning an irrigation machine, a boat, motorcycle, van, or cycle, fertilizing the crop field, having a household head who completed primary school, having agriculture as the primary source of income, being unemployed during the disaster period, having experience dealing with natural disasters, having a family member working for an NGO, and having a home affected by disasters are some important sub-indicators that determine the resilience of the study area. Since these areas are thought to be the most hazard-prone, it is important to do in-depth research there, paying particular attention to their livelihood condition, susceptibility, and resilience. Until then, it is impossible to plan for future development that will benefit the people living on the south shore. The findings of this study may also help create adaptation plans, projects, and practices to improve the welfare of southwest coastal households.

It is imperative to prioritize the implementation of a long-term development program to enhance the capabilities of vulnerable populations. This effort aims to enhance agricultural and rural development, generate income, and improve food accessibility through collaboration with local governments (Rahman et al., 2019). The research revealed that livelihood decisions, educational levels, and the availability of resources such as food, water, livestock, and agricultural methods primarily influence resilience. Consequently, the most susceptible households in Bangladesh's southwest coastal region require access to education, alternative livelihoods, agricultural markets, agricultural training, and livestock management to enhance their resilience to climate change. These amenities will assist coastal residents in maintaining their livelihoods and enduring future natural disasters (Rahman et al., 2019; Sarker, 2020; Alam, 2018).

It is recommended to implement specific interventions in *Uttar Bedkashi* like climate-resilient agricultural training programs, expanded access to microfinance and crop insurance, and the introduction of salt- and flood-tolerant crop varieties to enhance the low adaptive capacity. These interventions should be supported by the local government, community-based extension services, and government livelihood diversification programs to introduce long-term adaptive resilience. A comprehensive development strategy should be implemented to enhance communication infrastructure, seasonal transportation, and the lives of coastal communities. Financial institutions eschew the shore owing to its geographical position and several complications. The government must regulate banks and non-banking financial institutions that proliferate in coastal regions to provide financial resources to disadvantaged individuals. Coastal households depend on agriculture, so research groups need to come up with coastal-specific crop varieties (salt-tolerant - BRRI Dhan47 and 67, flood or waterlogging-tolerant – BRRI Dhan52, 61, and 71, short duration or early maturing rice, etc.) and ways to transfer technology to make coastal livelihoods more stable (Sarker et al., 2020). Through collaborative research by BRRI and BARI; field trials, participatory breeding initiatives by local farmers, saline-prone seed distribution, farmers' training programs, and crop varieties technology adaptation can be ensured. The communities of Bangladesh coastal areas can enhance their resilience to abrupt, incremental, and spatial climatic changes by utilizing the sub-indicators of adaptive capacity that characterize resilience.

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References

Afroz, S., Cramb, R., and Grünbühel, C. (2021). Vulnerability and Response to Cyclones in Coastal Bangladesh: A Political Ecology Perspective. *Asian Journal of Social Science*, *46*(6), pp. 601-637.

Aid, C (2019). Cyclone Bulbul a Month on: the Impact on Bangladesh’s Coastal Communities. Relief web. Retried December 9 from https://reliefweb.int/report/bangladesh/cyclone-bulbul-month-impact-bangladesh-s-coastal-communities.

Alam, G. M., Alam, K., Mushtaq, S., Khatun, M. N., and Leal Filho, W. (2018). Strategies and Barriers to Adaptation of Hazard-Prone Rural Households in Bangladesh, In *Limits to Climate Change Adaptation,* 12, pp. 11-24

Al-Maruf, A., Craig Jenkins, J., Bernzen, A., and Braun, B. (2021). Measuring Household Resilience to Cyclone Disasters in Coastal Bangladesh. *Climate*, *9*(6), pp. 1–19.

Amin, M. N., Solayman, H. M., Snigdha, S. S., and Sultana, J. (2018). Climate Resilient Livelihood Activity in the South-Central Coastal Region of Bangladesh. *Journal of Science Technology and Environment Informatics*, *6*(1), pp. 421–430.

Awal, M. A., Rashid, M. H. A., Islam, A. F. M. T., and Imam, M. F. (2013). Adapting Social Safety Net Programs to Climate Change Shocks: Issues and Options for Bangladesh. *Mymensingh: Bangladesh Agricultural University*, PP. 20-60.

Azam, G., Huda, M. E., Bhuiyan, M. A. H., Mohinuzzaman, M., Bodrud-Doza, M., and Islam, S. M. (2021). Climate Change and Natural Hazards Vulnerability of Char Land (Bar Land) Communities of Bangladesh: Application of the Livelihood Vulnerability Index (LVI). *Global Social Welfare*, *8*(1), pp. 93-105.

Azad, A. K., Hossain, K. M., and Nasreen, M. (2013). Flood-Induced Vulnerabilities and Problems Encountered by Women in Northern Bangladesh. *International Journal of Disaster Risk Science*, *4*(4), pp. 190-199.

Bank, W (2018). Bangladesh Disaster Risk and Climate Resilience Program. Retried July 25

Béné, C., Wood, R. G., Newsham, A., and Davies, M. (2012). Resilience: New Utopia or New Tyranny? Reflection about the Potentials and Limits of the Concept of Resilience in Relation to Vulnerability Reduction Programmes. *IDS Working Papers*, *2012*(405), pp. 1-61.

Bhuiyan, M. A. H., Islam, S. M., and Azam, G. (2017). Exploring Impacts and Livelihood Vulnerability of Riverbank Erosion Hazard among Rural Household along the River Padma of Bangladesh. *Environmental Systems Research*, *6*(1), pp. 1-15.

Campbell, D. (2021). Environmental Change and the Livelihood Resilience of Coffee Farmers in Jamaica: A Case Study of the Cedar Valley Farming Region. *Journal of Rural Studies*, *81*, pp. 220–234.

Chang, I. C. (2007). Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press, Cambridge, UK*, pp. 7–22.

Didar-Ul Islam, S. M., Bhuiyan, M. A., and Ramanathan, A. L. (2015). Climate Change Impacts and Vulnerability Assessment in Coastal Region of Bangladesh: A Case Study on Shyamnagar Upazila of Satkhira District. *Journal of Climate Change*, *1*(1-2), pp. 37-45.

FAO. (2016). *Analysing Resilience for Better Targeting and Action*. Food and Agricultural Organization of the United Nations, Rome, Italy.

Hirons, M., Boyd, E., McDermott, C., Asare, R., Morel, A., Mason, J., Malhi, Y., and Norris, K. (2018). Understanding Climate Resilience in Ghanaian Cocoa Communities – Advancing a Biocultural Perspective. *Journal of Rural Studies*, *63*(January), 120–129.

Hoegh-Guldberg, O., and Bruno, J. F. (2010). The Impact of Climate Change on the World's Marine Ecosystems. *Science*, *328*(5985), pp. 1523-1528.

Hoque, M. Z., Cui, S., Xu, L., Islam, I., Tang, J., and Ding, S. (2019). Assessing Agricultural Livelihood Vulnerability to Climate Change in Coastal Bangladesh. *International Journal of Environmental Research and Public Health*, *16*(22), pp. 4552.

IFRC. (2021). Bangladesh: Cyclone YAAS – Operation Update Report, DREF Operation n^0 1. Reliefweb. Retrived 25 July from https://reliefweb.int/report/bangladesh/bangladesh-cyclone-yass-operation-update-report-dref-operation-n-mdrbd027-update-n

IPCC. (2007). *Climate Change 2007:* Synthesis Report. Contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Challenge. *Cambridge University Press.*

IPCC. (2015). *Climate Chang 2014:* Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Chang *[Core writing team, R.K. Pachauri and L.A. Meyer (eds)]. Intergovernmental Panel on Climate Change* (IPCC), Geneva, Switzerland.

Islam, T., Md, A. R., Rahman, M. S., Khatun, R., and Hu, Z. (2020). Spatiotemporal Trends in the Frequency of Daily Rainfall in Bangladesh during 1975–2017. *Theoretical and Applied Climatology*, *141*(3–4), pp. 869–887.

Jang, L. J., and Wang, J. J. (2009). Disaster Resilience in a Hakka Community in Taiwan. *Journal of Pacific Rim Psychology*, *3*(2), pp. 55-65.

Kabir, R., Khan, H. T., Ball, E., and Caldwell, K. (2016). Climate Change Impact: the Experience of the Coastal Areas of Bangladesh Affected by Cyclones Sidr and Aila. *Journal of Environmental and Public Health*, *9*.

Mallick, B. (2019). The Nexus between Socio-Ecological System, Livelihood Resilience, and Migration Decisions: Empirical Evidence from Bangladesh. *Sustainability*, *11*(12), pp. 3332.

Mudasser, M., Hossain, M. Z., Rahaman, K. R., and Ha-Mim, N. M. (2020). Investigating the Climate-Induced Livelihood Vulnerability Index in Coastal Areas of Bangladesh. *World*, *1*(2), pp. 12.

Nguyen, T. A., Nguyen, B. T., Van Ta, H., Nguyen, N. T. P., Hoang, H. T., Nguyen, Q. P., and Hens, L. (2021). Livelihood Vulnerability to Climate Change in the Mountains of Northern Vietnam: Comparing the Hmong and the Dzao Ethnic Minority Populations. *Environment, Development and Sustainability*, *23*(9), pp. 13469-13489.

Rahman, S., Islam, M. S., Khan, M. N. H., and Touhiduzzaman, M. (2019). Climate Change Adaptation and Disaster Risk Reduction (DRR) through Coastal Afforestation in South-Central Coast of Bangladesh. *Management of Environmental Quality: An International Journal*, PP. 110-125

Roy, R., Gain, A. K., Samat, N., Hurlbert, M., Tan, M. L., and Chan, N. W. (2019). Resilience of Coastal Agricultural Systems in Bangladesh: Assessment for Agroecosystem Stewardship Strategies. *Ecological Indicators*, *106*, pp. 105525.

Sadik, M., Nakagawa, H., Rahman, R., Shaw, R., Kawaike, K., and Fujita, K. (2018). A Study on Cyclone Aila Recovery in Koyra, Bangladesh: Evaluating the Inclusiveness of Recovery with Respect to Pre-Disaster Vulnerability Reduction. *International Journal of Disaster Risk Science*, *9*(1), pp. 28-43.

Sallu, S. M., Twyman, C., and Stringer, L. C. (2010). Resilient or Vulnerable Livelihoods? Assessing Livelihood Dynamics and Trajectories in Rural Botswana. *Ecology and Society*, *15*(4).

Sarker, M. N. I., Wu, M., Alam, G. M. M., and Shouse, R. C. (2020). Life in Riverine Islands in Bangladesh: Local Adaptation Strategies of Climate Vulnerable Riverine Island Dwellers for Livelihood Resilience. *Land Use Policy*, *94*, pp. 104574.

Sina, D., Chang-Richards, A. Y., Wilkinson, S., and Potangaroa, R. (2019). What Does the Future Hold for Relocated Communities' Post-Disaster? Factors Affecting Livelihood Resilience. *International Journal of Disaster Risk Reduction*, *34*, pp. 173-183.

Sina, D., Chang-Richards, A. Y., Wilkinson, S., and Potangaroa, R. (2019). A Conceptual Framework for Measuring Livelihood Resilience: Relocation Experience from Aceh, Indonesia. *World Development*, *117*, pp. 253–265.

Sullivan, C. A., Meigh, J. R., and Fediw, T. S. (2002). Derivation and Testing of the Water Poverty Index Phase 1. Final Report May 2002. D.f.I. Development.

Tajrin, S., and Hossain, B. (2017). The Socio-Economic Impact Due to Cyclone Aila in the Coastal Zone of Bangladesh. *Inter J Law Human Soc Sci*, *1*, pp. 60-7.

Uddin, M. S., Haque, C. E., Khan, M. N., Doberstein, B., and Cox, R. S. (2021). "Disasters Threaten Livelihoods, and People Cope, Adapt and Make Transformational Changes": Community Resilience and Livelihoods Reconstruction in Coastal Communities of Bangladesh. *International Journal of Disaster Risk Reduction*, *63*, pp. 102444.

Wheeler, T., and Von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science*, *341*(6145), pp. 508-513.

Zhang, Q., Zhao, X., and Tang, H. (2019). Vulnerability of Communities to Climate Change: Application of the Livelihood Vulnerability Index to an Environmentally Sensitive Region of China. *Climate and Development*, *11*(6), pp. 525–542.