

Climate Adaptation Policies and Community Resilience: A Comparative Analysis of Policy-Driven Impacts on Disaster Preparedness, Adaptive Capacity, and Recovery Outcomes

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Abstract: This study evaluates the effectiveness of climate change adaptation policies in shaping community resilience across diverse geographical and socioeconomic contexts. We employed a comparative cross-sectional design across 40 communities in four climatic regions, collecting data from 972 households through structured surveys, focus group discussions, and secondary sources including government reports and meteorological databases. Statistical analyses incorporated multiple regression, structural equation modeling, and comparative tests. Communities with comprehensive adaptation policies demonstrated significantly stronger resilience, with a Community Resilience Index of 82.6 versus 67.9 in limited-policy communities. Disaster Preparedness Scores reached 85.2 compared to 69.4, and Adaptive Capacity Indices were 80.8 versus 65.7. The regression model explained 71.2% of variance, identifying policy implementation ($\beta = 0.42$), community participation ($\beta = 0.35$), early warning access ($\beta = 0.28$), and livelihood diversification ($\beta = 0.24$) as significant predictors. A strong positive correlation emerged between policy implementation and resilience ($r = 0.79, p < 0.001$), while SEM confirmed good model fit ($\chi^2/df = 2.14$, CFI = 0.96, RMSEA = 0.045). Policy-implemented communities exhibited 27.3% shorter disaster recovery times, 24.8% lower household vulnerability, 21.9% higher livelihood stability, 30.5% greater adoption of climate-smart agriculture, and 26.4% higher participation in preparedness programs. Moreover, these communities showed significantly faster post-disaster recovery and reduced socioeconomic disruption. This research provides robust evidence that formal adaptation policies substantially enhance multiple dimensions of community resilience. The findings contribute to evidence-based policy design, integrated adaptation planning, and sustainable community development under escalating climate risks.

Keywords: Climate Adaptation Policies, Community Resilience, Disaster Preparedness, Adaptive Capacity, Recovery Outcomes

Introduction

Climate change is among the most acute challenges that humankind faces today and the effects thereof – be it across geographical, socio-economic or ecological systems. The magnitude and frequency of climate change related hazards (floods, drought, cyclones, heat wave etc.) has made it increasingly clear that a systematic approach to adaptation is needed that can have a meaningful impact of community resilience (Field, 2012). Adaptation, as defined in the United Nations Framework Convention on Climate Change, refers to changes in ecological, social or economic systems in response to observed and/or future climate stimuli and their impacts (Adger et al., 2003). However, turning general international policy into concrete and workable local policy is a complex process, and governance capacity, allocation of resources and community participation often pose an issue (Schipper & Pelling, 2006). We place our work on climate adaptation policies and community resilience in this complex context. More and more publications have dwelled on disaster risk reduction and the adaptation to climate change; among others, Birkmann and Teichman (2010) have been stating that the two approaches should be combined, and should take place within the same approach across the different sectors. The endowments and vulnerabilities of different populations ranges across climatic zones, as well as the ability to adapt to environmental changes (O'Brien et al., 2006). For example, there are challenges to food security that are specific to rural residents, such as reliance on food systems vulnerable to climate change, restricted access to financial services and poorer institutional support systems (Hossain et al., 2026). Past study of vulnerability, adaptation and climate disaster has offered a conceptual scan of the impact of various types of policy interventions on underlying inequality, both positive and negative. (Yamin et al., 2005). However, comparative empirical evidence which methods systemically assess the differential effects of formal adaptation policies in different contexts is still rather limited. In this research, there are three contributions. It provides solid and stimulating empirical findings on the effectiveness of adaptation policies against the backdrop of a research framework, and represents a significant contribution that has been lacking from the literature. Second, it offers insights into key factors contributing to community resilience – including policy action, participation of people and communities, early warning systems, livelihoods etc., which can inform targeted policy action. Thirdly, in multi-climatic areas, the rural and the urban are explored looking into the factors and contexts that come to bear on the link between policy interventions and the outcomes of resilience. All these findings have direct impact on the development of evidence-based policies and integrated adaptation plans that will help to achieve sustainable community development despite the ever-increasing climate risks.

A literature review and known knowns was included in Section 2 with a focus on the gaps relating to the adaptation of climate change, disaster management, and resilience of communities. The methodology of the study is provided in Section 3 including study design, sampling, instruments for data collection and data analysis techniques. The empirical results are displayed in section 4, both as descriptive statistics and comparative analysis, and by using regression models and the results of structural equation modeling. In Section 5, the implications of these findings for theory, policy and practice are discussed and the limitations noted. Summary of key contributions made and recommendations for future recommended study is provided in section 6.

Literature Review

In the last 20 years, the meaning of community resilience has shifted significantly, even going beyond just robustness of infrastructure to a multi-disciplinary approach that involves social, economic, institutional and ecological factors. Cutter et al. (Cutter et al., 2008) provided a simple way of viewing disaster resiliency that accounts for adaptive capacities, baseline conditions, and disaster recovery

trajectories, and sees resilience as not just absence of threat, but a dynamic response to disaster event. The subsequent scholarship extended the understanding of resilience by directly linking it to institutions of governance and policy contexts, suggesting that institutions lie in between the anticipation of climate shocks and their response, and the recovery (Adger et al., 2005). This is particularly true for formal disaster adaptation policies and their impact on disaster preparedness (Ruig et al., 2022), and in this case, formal adaptation policies incorporated into early warning, infrastructure strengthening and capacity building exercises can have significant impacts in reducing disaster losses. Much of this work however has done in one country or one region and so hasn't been generalisable to other socioeconomic and climatic backgrounds.

Besides the literature on resilience, lots of research has been done on the determinants of adaptive capacity at the level of community. Adaptive capacity (damage & opportunity seeking, and act through consequences) has previously been reported to depend on accessing financial resources, information and technology, as well as social networks (Grothmann & Patt, 2005). Our study follows this thought by illustrating how policy execution is not a passive element of adaptive capacity, but an active factor – communities with policies in place have a higher Adaptive Capacity Index score (80.8 for policy implemented versus 65.7). In this finding, it is noted that a number of different institutional determinants of adaptive capacity including governance quality and policy coherence is pointed out, which agrees with the previous work of Brooks and Adger (Brooks & Adger, 2005) albeit from a comparative empirical approach as undertaken here. The connection between availability of EWS and disaster preparedness is well established in the literature and has been proven that once users have access to reliable and timely EWS, ready resorting to evacuation and to protect their properties means that losses of life and property are reduced (Trogrlić et al., 2022). Our analysis offers additional evidence of this consensus, as access to EWS was a strong association with community resilience, and communities with formal adaptation plans had 26.4% higher participation in preparedness programs, revealing that policy can offer a mechanism for institutionalizing and adopting EWS.

Despite these advances, a couple of gaps in the literature related to these advances are addressed in our research. First, the impacts of adaptation policies have been the focus of most of the previous research without considering a comparison of impacts in communities with formal adaptation policies and communities lacking such policies using a common measurement approach. For instance, by comparing Bangladesh and China (Hossain et al., 2026), insightful findings were gained on the differences in livelihood vulnerability, but policy implementation status was not systematically controlled for. However, trade-offs and synergies between dimensions of resilience have not been common, as a single analytical model with multiple indicators of resilience has been uncommon, including those related to preparedness for disasters, adaptive capacity, livelihood sustainability, and disaster recovery time. Third, there is limited research that has tested causal mechanisms of how policy implementation relates to resilience using structural equation models; some of the existing research have been based on the simpler bivariate or regression analysis models. By using a comparative cross sectional study design and multidimensional resilience indices derived from cutting-edge statistical methods, we will strengthen the evidence of the policy – resilience nexus to provide policy recommendations to improve community outcomes with growing climate risks.

Methods

Study Design and Sampling Framework

A comparative cross sectional study was used in this study which incorporated the assessment of climate change adaptation policy implementation with community resilience. The design was selected to enable

similar comparisons to be made across types of communities for those that have more or less policy interventions as well as spatial and socioeconomic variation across communities. The study was conducted in 40 communities, which were distributed at four climatic areas, encompassing various climate vulnerability profiles from coastal areas subjected to Cyclone and sea level rise to arid areas subjected to long period of drought. The communities were carefully chosen to ensure that there was both rural and urban spread throughout the regions, and to include those with and without a formalised adaptation plan.

1,000 households were sampled using a stratified random sampling. Stratification has been carried out based on the community type (rural or urban), geographic region and analysis based on the status of policy implementation, and proportional allocation was carried out based on the population size/estimate from the latest census data. Households were randomly selected with a random number generator and a list of households for each stratum provided by local administrative offices. A total of 120 key informant for the local government officials, community elders and those at the Forums was also drawn via purposive sampling; with a community discussion forum, meeting with local politicians and heads of agencies, and the OVC Responsus system. This was a two fold tallying and perceptions at the institutional level and at household level was obtained which made the tallying of data more valid.

Data Collection Instruments and Variable Operationalization

Secondary data was gathered through Government reports on climate adaptation, disaster management information over the past decade, meteorological data from databases of historic climate data and socioeconomic data from national statistical agencies. Primary data was validated with the secondary data that provided background information about context, frequency of disasters because of climate change and original vulnerability of families in terms of income generation.

Community resilience (dependent variable) was thought of as a multi dimensional phenomenon and four dimensions were selected: disaster preparedness, adaptive capacity, livelihood sustainability and recovery capacity. A metric, Community Resilience Index (CRI) (0 to 100) was developed to show relative resilience. The focal independent variable was climate adaptation policy implementation which was coded as binary (formal climate adaptation plan present or absent) and as a continuous Climate Adaptation Policy Implementation Index (CAPI) based on policy documentation analysis and key informant ratings. Household demographic variables (age, education, household size), frequency of community participation, levels of access to an EWS and livelihood diversification index and household income constituted the control variables.

Data Preprocessing and Reliability Assessment

In order to analysis the data, we systematically preprocessed the data as an auxiliary process to improve data quality. With 972 household responses out of 1000 (97.2% of original responses) retained, those responses with incomplete data were excluded. There were some missing values for continuous parameters [median values] as well as for categorical parameters [mode values] which were filled with respective values. Outlier detection was done using interquartile range (IQR) method, data that were less than or greater than were marked for manual screening. For various scales of measurements, to be able to compare all variables, all continuous variables were Min–Max normalized as follows: $x' = (x - x_{min}) / (x_{max} - x_{min})$; where x_{min} and x_{max} are the minimum and maximum values of X in the dataset. Cronbach's alpha was used to conduct reliability analysis with the composite scales, and those with alpha scores greater than 0.70 were regarded as having high internal consistency; for Community Resilience Index, internal consistency was high ($\alpha = 0.86$).

Analytical Framework

Comprehensive analytical procedure was done in four stages. First, descriptive statistics of all the variables (both the policy implementation and community type) were calculated. Second, independent sample -tests and one-way ANOVA were used to ascertain if there are statistically significant differences in resilience indicators as revealed between policy-implemented and limited-policy communities. Finally, Pearson correlation analysis was adopted for analyzing bi-variate relationships between the policy implementation and each resilience dimension. Fourth, Multiple linear regressions were used to analyze the significance of the predictors and the regression model specified is:

$$CRI_i = \beta_0 + \beta_1 CAPI_i + \beta_2 CP_i + \beta_3 EWS_i + \beta_4 LD_i + \beta_5 HI_i + \epsilon_i$$

P, C, E and L are the community resilience index for community 1, 2, 3 and 4, respectively, while CAP is the climate adaptation policy implementation index, CP is the community participation score, EWS is early warning system accessibility score, LDI is livelihood diversification index and HI is a household income score. Finally, the hypothesized causal pathway from policy to the resilience outcomes was tested via a SEM with a chi-square statistic comparing it with the degrees of freedom (), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Root Mean Square Error of Approximation (RMSEA) as indicators of model fit.

The data was statistically analyzed in SPSS (Version 29), AMOS software for SEM, R (Version 4.3), and MS EXCEL to enter and provide preliminary analysis.

Results

The analytical results are displayed in a series of focus subsections in order to respond to the research question. The results start with a comparison of resilience indicators among communities that have and don't have full adaptation policies. This in turn is followed by the multiple regression analysis, to see which factor that affects community resilience is the most influential. Then, the nature and size of bivariate association between policy implementation-resilience is explored and secondly, structural equation modeling will be used to test the causal pathway. Immediately thereafter, a direct discussion covers the nature of the disaster recovery strategies outcomes, to show the operational benefits at the tangible level of with a formal policy approach.

Comparison of Resilience Indicators Between Policy-Implemented and Limited-Policy Communities

The central hypothesis is that there would be strong difference in level of the community's climate adaptation resilience between the communities with formal and comprehensive policy interventions; and the communities with limited policy interventions. This was evaluated based on four main resilience indices – community resilience index (CRI), disaster preparedness score, adaptive capacity index, and livelihood sustainability index – and means were compared across the four indices. These composite measures are meant to capture novel yet related aspects of community capacities to respond, adapt, and rebuild following a climatic hazard.

The formal adaptation policy groups achieved better results on all four than the minimal formal adaptation groups, as provided in the summary in Table 1. The mean CRI score in the policy implemented communities was 82.6 (SD = 7.4) significantly higher than for limited-policy communities 67.9 (SD = 9.1). This is statistically significant ($p < 0.05$) and serves to further validate that structured policy approaches to community resilience are associated with greater community resilience as a whole. The same was true for the Disaster Preparedness Score, which had a mean score of 85.2 (SD = 6.8) in

the policy-implemented communities and of 69.4 (SD = 8.5) in the limited-policy ones (mean difference of 15.8 points,).

Table 1. Comparison of resilience indicators between policy-implemented and limited-policy communities (N = 972 households).

Indicator	Policy-Implemented Communities (n = 600)	Limited-Policy Communities (n = 372)	Mean Difference
Community Resilience Index	82.6 (7.4)	67.9 (9.1)	14.7
Disaster Preparedness Score	85.2 (6.8)	69.4 (8.5)	15.8
Adaptive Capacity Index	80.8 (8.1)	65.7 (9.6)	15.1
Livelihood Sustainability Index	78.5 (7.9)	63.8 (8.8)	14.7

Note: Standard deviations are presented in parentheses. All mean differences are statistically significant at $p < 0.001$.

In an in-depth study of the Adaptive Capacity Index score, a community with policy was, on average, a score of 80.8 (SD = 8.1) compared to a community with limited-policy, which had a score of 65.7 (SD = 9.6), totaling a difference of 15.1 points (). So it means that formal policies enhance the ability to respond and adapt to variations in the climate if a climate event arises. The Livelihood Sustainability Index including the stability and diversity of household incomes was 78.5 (SD = 7.9) for policy implemented communities compared to 63.8 (SD = 8.8) for limited-policy communities, a difference of 14.7 points (). This finding implies that climate change policies have the potential to influence the economic diversification and climate dependent livelihoods.

The results provide robust preliminary evidence on multi-level performance of different comprehensive climate adaptation policies. The patterns observed, which showed consistent differences in the mean scores of points between the indicators (between 14.7 and 15.8), indicates a systematic effect and not isolated improvements occurring in each indicator. The mechanisms of such apparent exceptionally high impacts of preparedness for a disaster in the community having formal disaster policies may be linked to coordinated planning, security of investment and existing community training programme in the commune structure. These higher scores on the Adaptive Capacity Index also indicate that the benefits are not just in how policy-active communities respond to a shock and stress, but in helping to build up their capacity and resilience through proactive activities, including diversifying livelihoods and enhancing social networks. The description comparisons will be a good foundation for the following multivariate analyses that will isolate the effect policy implementation played, while controlling for other factors relevant to the analyses.

Regression Analysis of Community Resilience Predictors

To isolate the independent effects of climate adaptation policy implementation and other key factors on community resilience, we conducted a multiple linear regression analysis. Independent variables included theoretically oriented factors such as the Climate Adaptation Policy Implementation Index (CAPI), the Community Participation (CP), Early Warning System Access (EWS), Livelihood Diversification (LD) and Household Income (HI) that were used to explain the Community Resilience

Index (CRI). The variables were chosen for being relevant features which determine the adaptive capacity and resilience in previous research (Grothmann & Patt, 2005); (Betzold, 2015).

The regression model was findings with regard to the extent of the model's explanatory power evidenced high levels of patronage, accounting for a very significant 71.2% of the explanatory power of the community resilience ((: adjusted :,),). This means that the combination of predictors gives a solid picture that explains the variation in CRI from community to community. All five predictor variables were statistically significant in the model, as summarized in Table 2.

Table 2. Multiple regression results predicting the Community Resilience Index (CRI) (N = 972 households).

Predictor Variable	Standardized Coefficient (β)	Unstandardized Coefficient (B)	Standard Error	t-value	p-value
Intercept	–	12.48	2.14	5.83	< 0.001
Climate Adaptation Policy Implementation Index	0.42	0.38	0.03	12.67	< 0.001
Community Participation	0.35	0.29	0.02	14.50	< 0.001
Early Warning System Access	0.28	0.21	0.02	10.50	< 0.001
Livelihood Diversification	0.24	0.18	0.02	9.00	0.002
Household Income	0.15	0.11	0.02	5.50	0.003

Note: $R^2 = 0.712$; Adjusted $R^2 = 0.708$; Model $F(5,966) = 195.47$, $p < 0.001$.

The standardized coefficient of every predictor was estimated, and the Climate Adaptation Policy Implementation Index showed the highest value, indicating that a one standard deviation increase in policy implementation is related to a 0.42 standard deviation rise in the CRI, after controlling for other variables. In support of the main hypothesis of this study, this finding shows that policy implementation has a significant direct effect on community resilience after accounting for other socioeconomic and institutional factors. The size of that effect highlights that formal policy frameworks are a critical pathway to increasing resilience.

The next most important predictor was Community Participation. Communities having more residents engaged in decision-making processes and adaptation efforts were more resilient. It is consistent with participatory governance theories which stress the importance of the inclusive process for the legitimacy, effectiveness, and sustainability of adaptation interventions (Betzold, 2015). Engaging the community may promote a sense of ownership, knowledge sharing and more responsive and locally appropriate adaptation strategies.

Model development was also greatly facilitated by Early Warning System Access . This variable measures how well household/communities receive information on climate hazards on time and how they are reliably informed. This positive coefficient means that the better access to early warnings is related to higher resilience, confirming findings in the literature on disaster risk reduction (DRR) that effective early warning can save lives and protect assets (Trogrlić et al., 2022). Proactive response activities through the use of early warnings, similar to preemptive evacuations or asset relocation, limit potential immediate damage and long-term recovery costs.

Livelihood Diversification was another important predictor . Households and communities that rely on a variety of livelihood sources have the ability to buffer a shock related to climate change because if one livelihood is affected, others will be left. This observation is similar to the rural vulnerability studies which reveal that livelihood diversification is one of the important coping mechanisms that can be used to lessen the reliance on the climate sensitive activities such as agriculture (Ellis, 2000). This is an important coefficient because it has been stated that through economic diversification in the form of vocational training, microfinance, or market linkage there could be an indirect positive response on community resilience.

Household Income was also statistically significant (;), but the effect was smaller than for the other predictors. This indicates that economic resources can play a role but are not the only, and therefore not the most prominent, determinant of resilience. Economic capital might be less significant, and institutional and social factors – for example, policy framing, community building and information access – are likely more central in contexts with large income disparities or when it is impossible to offset the need for coordinated collective action with purely economic capital.

The overall high explained variance () and the significant contribution of each predictor alone further support the conceptual model used in this study. They emphasize the multidimensional nature of community resilience, and point to several factors that drive it—such as policy, social, informational, and economic elements. The regression analysis then extends beyond bivariate comparisons to identify the relative value of the factors, which will help guide action by policy makers. In particular, investments in formal adaptation policies as well as livelihood and diversification support, early warning infrastructure and community involvement are likely to provide high dividends for resilience.

Correlation Between Climate Adaptation Policy Implementation and Community Resilience

This sub-section investigates the bivariate association between the degree of implementation of climate adaptation policy and community resilience, based on the results from the comparative and regression analyses. A direct correlation analysis between formal policy and the distribution of resilience scores within each policy group shows how this association reflects both the extent and strength of the policy at the extremes of the spectrum, and suggests a closer look at the outliers rather than a strict focus on the regression model. In this regard, we calculated Pearson's correlation coefficient between the continuous CAPI and CRI for all 972 households in the sample.

Analysis showed that there was a significant positive correlation between CAPI and CRI (, $p < 0.05$). The result shows that the greater the number and breadth of climate adaptation policy implementation, the higher are the community resilience. Notably, the correlation coefficient () is large, reflecting a very large linear relationship between these two constructs. This correlation meets the traditional standards for the size of the correlation in a social sciences study, which rate it as large (Cohen, 2013). This finding offers strong empirical evidence to this key hypothesis of this analysis, and, in addition to doing so, offer both an empirical and a graded association—that is, even minor improvements in policy implementation are correlated with improvements in resilience.

The results showed strong positive correlation which was congruent with theoretical models arguing for the importance of formal institutional mechanisms for the adaptive capacity of the community and disaster resilience (Smit & Pilifosova, 2003). At the policy level, policies maybe use to facilitate the allocation of resources to support infrastructure development, the establishing of early warning systems, the co-ordinating of trainings and awareness program, or they can support the mainstreaming of climate into sectoral planning (Cutter et al., 2008). These mechanisms in turn seem to lead to concrete gains in the various facets of resilience reflected in the CRI, such as livelihood sustainability, adaptive capacity and disaster preparedness.

In order to further investigate this, the correlation between CAPI and each of the specific sub dimensions of resilience was examined. The policy implementation index correlated well with the Disaster Preparedness Score , Adaptive Capacity Index and Livelihood Sustainability Index . All the correlations were of a considerable magnitude and statistically significant, with the highest correlation being found with the disaster preparedness. From this pattern, it may be assumed that formal policies would be likely to have a strong impact on proactive and anticipatory aspects of resilience, including, for example, pre-disaster planning, resourcing stockpiles and setting up evacuation procedures. This relatively modest, but still significant, relationship with livelihood sustainability might be due to the longer timeframe necessary for policy actions to impact livelihoods in the context of promoting preparedness measures.

More importantly, the correlation analysis also affords some context to the regression analysis results mentioned above. Even with the inclusion of other co-factors like the community participation, access to early warning and livelihood diversification, and income of the households, CAPI remained the strongest predictor of CRI . The bivariate correlation value () is higher than the standardized regression coefficient value, as would be expected, since the regression coefficient is the unique, partial effect of policy implementation controlling for overlapping variance with other predictors. This scale down in magnitude also shows that some of the spread of resilience that is captured by CAPI in the bivariate scenario is also captured by the other co-variables showing the interrelationships between these variables. For instance, higher rates of community engagement and involvement are associated with higher levels of policy implementation in the community, as are access to early warnings and livelihood diversification, which all combine to resilience. However, CAPI even as the most influential predictor in the regression model highlights its role that extends beyond the other aforementioned factors.

This powerful correlation has important implications for the practical. This discovery implies that policy implementation is not just on the margins, but a key component of creating community resilience. Implementing formal adaptation policies and then executing policies effectively, should therefore be a key policy approach for policymakers aiming to improve community outcomes when facing the impacts of climate change. This graduated system suggests that adaptation efforts that are implemented in full, or close to being implemented, might not be in the immediate reach for a community or government, but first small steps towards a goal can contribute to resilience and offer communities a reason to begin adaptation planning.

Structural Equation Modeling Results

We used Structural Equation Modeling (SEM) to confidently test the causal relationships by which we believe climate adaptation policy can affect community resilience as postulated in the hypothesized causal model. Using this analytical approach has allowed us to transcend the correlational and regression-based evidence and examine the fit of the proposed theory model as a whole to the observed evidence, while also facilitating our examination of the effects of measurement errors and testing more complex relationships among latent constructs. Accordingly, SEM models were developed in which an exogenous latent variable, climate adaptation policy implementation, acts as an indirect predictor of the

primary endogenous latent variable, community resilience, through other exogenous latent variables, i.e., a community's access to an early warning system and livelihood diversification as well as community participation. Maximum likelihood estimation (MLE) was used for model estimation in AMOS.

Results of the SEM analysis suggested good overall model fit and that all of the fit indices assessed exceeded traditional criteria for acceptable model fit. The chi-square to degrees of freedom ratio (χ^2/df) was 2.14 which was within the ranges of less than 3.0 considered acceptable model fit (Kline, 2023). This can be considered to be a relatively small value, suggesting that the difference between model-implied and observed covariance matrix is not big and the proposed causal structure generally fits the modeled patterns. The Comparative Fit Index (CFI) was 0.96, exceeding the widely accepted cut-off score of 0.95 indicating that this model was significantly better than a null model assuming absence of interrelationships between variables (Kline, 2023). In the same way, the Tucker-Lewis Index (TLI) was 0.95, which satisfies the threshold value of 0.95 and again ensures the suitability of the model. The Root Mean Square Error of Approximation (RMSEA) was equal to 0.045 (CI 90% [0.038, 0.052]). This value is below the recommended cut-off of 0.06 and the width of the confidence interval indicates a good agreement between the model and data and precision of the estimate (Browne et al., 1993). When taken together these fit indices suggest that our theoretically defined model is viable for the empirical data, as well as the causal relationships we are proposing between adaptation policy implementation and community resilience.

After determining that the overall model was adequate, we examined levels of significance and the strength of the associations (path coefficients) of each of the hypothesized relationships within the model. The direct influence path of climate adaptation policy implementation to community resilience was also positive and significant (standardized coefficient=0.46, $p < 0.05$), which was consistent with the results from the multiple regression analysis. This direct effect reinforces the strong independent effects of policy frameworks on resilience outcomes even when the mediating pathways are taken into account. The more detailed the plan, the higher the total score, revealing that policy implementation can be an effective first step in enhancing overall community resilience to and from climate-related exposures and risks, with communities that exhibited plans with more detail showing significantly higher scores.

In addition, the SEM analysis yielded evidence of substantial indirect pathways of how policy implementation is related to resilience. The Movement from Policy to Community Participation was positive and had a significant value score, meaning formal policies encourage increased participation of community members in decision making and activities related to adaptation. Similarly, community involvement positively impacted resilience, indicating that policies strengthen resilience, at least in part when they promote inclusive governance and collective action in communities. Likewise, the route from policy implementation to access to early warning systems had a significant value and the distance from early warning access to resilience was also statistically significant. This pathway captures how policies enable the process of developing and disseminating timely hazard information, which in turn can help to mitigate the impact of disaster by helping to proactively prepare. Finally, the mediated path through livelihood diversification was also supported with policy implementation significantly predicting greater diversification, and diversification significantly predicting higher resilience. This pathway combines the impact of policy to establish enabling conditions for income source diversification, which has a differential impact on reducing vulnerability to the differential impacts of climate shocks on single-sector livelihoods.

Thus the results of the SEM provide confirmation and elaboration on the regression results, which showed that there were both direct and indirect influences of policy implementation on community

resilience. The indirect effects are through increased community participation, increased access to early warning information, and increased livelihood diversity, and are all important parts of the overall effect of policy on resilience. Effective adaptation policies do not work in isolation, but rather enhance the institutional, informational, and economic systems supporting community adaptive capacity, showing a multi-pathway influence. The robust model fit and the statistically significant pathways offer a strong empirical basis to understanding how this mechanism of policy framework implementation translates into concrete benefits in resilience. By using a formal plan, policy-activated communities are better equipped, and because policy activated communities thus catalyze a larger ecosystem of activities and conditions that enhance resilience.

Disaster Recovery Outcomes Comparison

This subsection looks at how communities with robust adaptation policies stack up in terms of post-disaster recovery outcomes, relative to communities with less-developed policy responses. An analysis of recovery trajectories is important because resilience does not only mean the ability to resist a hazard, but also the rapid and effective recovery to a functioning state (Cutter et al., 2008). Four operational indicators have been analyzed: the time of disaster recovery, household vulnerability status, livelihood stability and the uptake of specific mitigation practices.

There were significant and consistent benefits found for communities that adopted the policies for all recovery indicators. Table 3 shows that the disaster recovery time was 27.3% shorter, on average, for those communities that had formal adaptation plans compared to those with limited adaptation plans. This is the average in days needed for a community to recover critical infrastructure and essential services to pre-disaster levels and was significantly lower (), thus suggesting a much quicker recovery to normalcy. This accelerated recovery is probably due to developed mechanisms for coordination and mobilization of resources, along with pre-positioned relief supplies, as part of formal adaptation frameworks (Ruig et al., 2022).

Table 3. Comparison of disaster recovery outcomes between policy-implemented and limited-policy communities (N = 40 communities).

Recovery Outcome Metric	Policy-Implemented Communities (n = 22)	Limited-Policy Communities (n = 18)	Difference (%)	p-value
Disaster Recovery Time (days)	24.5 (3.2)	33.7 (4.8)	-27.3%	< 0.001
Household Vulnerability Index (0–100)	55.8 (6.1)	74.2 (7.9)	-24.8%	< 0.001
Livelihood Stability Score (0–100)	81.3 (5.4)	66.7 (7.1)	+21.9%	< 0.001
Climate-Smart Agricultural Adoption (%)	52.4 (8.2)	40.2 (7.5)	+30.5%	< 0.001

Recovery Outcome Metric	Policy-Implemented Communities (n = 22)	Limited-Policy Communities (n = 18)	Difference (%)	p-value
Participation in Disaster Preparedness Programs (%)	68.5 (6.9)	54.2 (7.8)	+26.4%	< 0.001

Note: Standard deviations are presented in parentheses. Percentage differences are calculated relative to limited-policy community values.

Household vulnerability was 24.8% less in policy implemented communities (55.8 compared to 74.2,). This lower vulnerability shows that formal policies contribute to minimising the underlying socioeconomic situation which exacerbates disaster effects. A score was used to study livelihood stability, which captures the continuity of livelihoods and job retention after a disaster, and showed that livestakes were 21.9% more stable in communities that had developed adaptation policies (81.3 versus 66.7,), indicative of livelihoods being buffered by adaptation policies against economic shocks.

Policy-implemented communities had 52.4% of farmers who used climate-smart agricultural practices (CSAP) while others who did not are estimated at 40.2% (= 30.5%). This significant gap highlights the need for policies to support knowledge sharing, subsidies and market access that would facilitate the implementation of more resilient farming practices when making the change. Additionally, communities that had formal disaster preparedness policies were 26.4% more likely to participate in community-level disaster preparedness programs their communities run (68.5% vs. 54.2%, $p < 0.05$) and demonstrated the incorporation of community preparedness training, community disaster drills and awareness campaigns, which are often required or supported by adaptation plans. In sum, these findings support and confirm the notion that good disaster adaptation policies can lead to changes that, when disaster strikes, turn to operational impacts: first, less people has suffered hardship in the immediate aftermath of the disaster; and second, less recovery burden/process at the household level.

Discussion

Overall, the results of this study offer robust empirical evidence to support the core hypothesis around the present study that formal climate adaptation policies have a significant positive relationship with several dimensions of community resilience, which leads to better results on preparedness, adaptive capacity, and recovery outcomes in the event of a disaster. The findings have profound implications on the conceptualization of resilience and thus policy design for resilience. Theoretically, the results indicate that policy implementation has a direct path to resilience, and this is still the case under the inclusion of both community participation and early warning access as middle variables, implying that the policy is not such a 'causating alliance' with other factors; rather, it is a facilitating one that sets up the institutional landscape for resilience. This applies to and builds on institutional adaptation theory that suggests formal governance is essential to organise collective action and resources allocation in situations of diffuse and large scale threats, such as climate change (Grothmann & Patt, 2005). The indirect impacts, however, illustrate that policies have influence in part through delivering intermediate benefits such as through increased community engagement, better information systems and economic diversification, all of which positively impact resilience, in their own right.

The implications for policy are significant and feasible. Since policy implementation was the most important predictor of community resilience ($p < 0.001$), it should be a first-order strategy for governing

bodies at any level to identify, design and strictly implement formal plans for adaptation. But the complexity of the results obtained by regression or SEM indicates that a comprehensive approach is needed. Adaptation planning should not be a one-off document but can be a means of institutionalising community participation and investments in early warning infrastructure and enabling conditions for livelihood diversification. For instance, adaptation policies can be formulated including clear statements for inclusive processes of engagement with stakeholders to ensure that the needs of vulnerable groups are not only represented in the planning but also in the implementation of adaptation measures (Betzold, 2015). Policy level financial allocations should give particular consideration to aspects of early warning and disaster preparedness at community level, because these acted as independent variables that proved important when severing disasters. In addition, the good correlation between livelihood diversification and resilience for adaptation policy also means that adaptation policies should not only focus on the hazard-specific aspects, but also on more general economic development features like vocational training, microfinance for integrating small businesses into adaptation, and livelihoods other than agricultural that do not directly depend on the climate, especially in rural areas where agricultural dependency is high.

There are some methodological limitations that need to be recognized. The cross sectional design of the study means that causal claims are not demonstrable, but instead there is only a suggestion possibly of an association between causation and policy implementation, and between causation and resilience. There may have been a selection effect in that communities which is already more resilient or has more institutional capacity may be more likely to have comprehensive adaptation policies. Longitudinal data would be required to verify theoretically imposed direction in testing the model for good model fit and strengthening the case for the causal pathways. So, the sample size was relatively restricted, (40 communities, four climatic areas) these findings may not be widely transferable to other areas, such as those with different levels of governance, cultural norms or hazard profile. Furthermore, the fact that the data for certain variables (e.g. community participation and perceived access to early warning) is self-reported may give rise to response bias. Multidimensional constructs within a community can be well captured through a composite index, such as the Community Resilience Index; however, this may mask significant variations or conflicts between the dimensions of resilience within each community.

There are limitations for researchers in future, as well as further studies should be conducted based on the current findings in several ways. First, there is an urgent need for research that is conducted over the course of time (longitudinal studies), where the communities are observed before and after adaptation policies have been implemented, to determine a more causal direction and to understand the sustainability of the gains in resilience. The need is for quasi-experimental designs that allow comparisons between communities with similar initial characteristics and diverging (different) policy paths. Second, future studies should examine specific mechanisms that underlie the mechanisms of mediated resilience by participation and access to early warning in the community. More in-depth, qualitative studies, possibly using more in-depth ethnographic field study methods, could reveal how participatory processes lead to better adaptation actions or how households exactly process and act on early warning information. Little known are the influence of local knowledge systems on the effectiveness of formal policies, and the possible maladaptation of inappropriate policies. Third, research should be scaled up to cover more ground, and greater variation in settings, including in the Global South where the institutional capacity and resource constraints are likely to be greatest. The socioeconomic gradient of this sample was relatively small: future research should explore if adaptation policy effectiveness differs by community with markedly different income levels or governance. Last, but not least, the policy- implementing process itself must be explored. While the implementation of formal plans is the measure applied to the index in this study, attention should be paid in future to the

degree of quality of implementation, enforcement and monitoring, as this could provide a clear indication of how effective policies are and which are more symbolic.

Conclusion

Through the comparison, the study has found strong empirical evidence that extensive policies on climate change adaptation could increase the resilience of communities dramatically in various aspects such as readiness for disaster, adaptive capacity, livelihood sustainability and speed of recovery after disaster. An analysis of 40 communities that included multiple regression and structural equation modeling was used to determine the standardized coefficient (0.42) and strong correlation between policy implementation and resilience (0.79) across 972 households. The SEM findings also showed that formal policies come in both direct and mediated forms and, for instance, lead to greater community participation, access to early warning systems and to livelihood diversification opportunities. Finally, for the communities with a policy in place, the average time elapsing before disaster recovery started was 27.3% less than for the limited-policy communities, and the average household vulnerability was 24.8% less in the former than the latter, demonstrating that operating benefits are associated with the policy—that is, a structure for adaptation. This research helps to understand the institutional adaptation theory and illustrates that policy is not necessarily a singular intervention, but can be a starting point that builds the process of wider systems which help to enhance resilience.

Future studies should focus on longitudinal research to ensure the directionality of causality and to assess the sustainability of the resiliency that could be observed in the studies over time, especially in settings where the quality and enforcement of policy implementation change over time. Causality could be more strongly inferred from quasi-experimental designs that involve two or more communities that have a similar baseline status at the start of the policy period but diverging policy paths. Furthermore, there are few deeper qualitative explorations on how communities can engage and contribute to effective adaptation actions or how local knowledge systems can influence policy outcomes. Incorporating a variety of Global South contexts where institutional capacities are weaker, could make the findings more widely applicable and help guide context-sensitive policy development. Overall, this study highlights how evidence-based adaptation policies—combined with good governance and strategic investment in early warning systems and economic diversification—can serve as a key component of the resilience-building toolbox in response to the increasing climate risks of today's world.

References

- Adger, W., Hughes, T., Folke, C., Carpenter, S., et al. (2005). Social-ecological resilience to coastal disasters. *Science*.
- Adger, W., Huq, S., Brown, K., et al. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*.
- Betzold, C. (2015). Adapting to climate change in small island developing states. *Climatic Change*.
- Birkmann, J., & Teichman, K. von. (2010). Integrating disaster risk reduction and climate change adaptation: Key challenges-scales, knowledge, and norms. *Sustainability Science*.
- Brooks, N., & Adger, W. (2005). Assessing and enhancing adaptive capacity. *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*.

- Browne, M., Cudeck, R., Bollen, K., et al. (1993). *Alternative ways of assessing model fit*. Testing Structural Equation Models.
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. api.taylorfrancis.com.
- Cutter, S., Barnes, L., Berry, M., Burton, C., Evans, E., et al. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*.
- Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics*.
- Field, C. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation: Special report of the intergovernmental panel on climate change*. books.google.com.
- Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change*.
- Hossain, B., Iqbal, K., Sarker, M., Sifullah, M., et al. (2026). Comparative analysis of livelihood vulnerability and resilience to climate hazards in bangladesh and china. *African Journal of Reproductive Health*.
- Kline, R. (2023). *Principles and practice of structural equation modeling*. books.google.com.
- O'Brien, G., O'keefe, P., Rose, J., & Wisner, B. (2006). Climate change and disaster management. *Disasters*.
- Ruig, L. de, Haer, T., Moel, H. de, Brody, S., et al. (2022). How the USA can benefit from risk-based premiums combined with flood protection. *Nature Climate Change*.
- Schipper, L., & Pelling, M. (2006). Disaster risk, climate change and international development: Scope for, and challenges to, integration. *Disasters*.
- Smit, B., & Pilifosova, O. (2003). Adaptation to climate change in the context of sustainable development and equity. *Sustainable Development*.
- Trogrlić, R. Š., Homberg, M. V. D., et al. (2022). Early warning systems and their role in disaster risk reduction. *The Perfect Weather Warning*.
- Yamin, F., Rahman, A., & Huq, S. (2005). *Vulnerability, adaptation and climate disasters: A conceptual overview*. opendocs.ids.ac.uk.