

Article

Promoting Sustainable Development through Community Education on Flood- and Storm-Resistant Architecture

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ABSTRACT: Pakistan is experiencing climate-induced disasters such as floods and storms with an increased frequency and intensity every single year. This study aims to explore the integration of resilient architecture into environmental education as a pathway toward sustainable development and disaster risk reduction. The research examines current levels of understanding regarding flood- and storm-resistant building practices and identifies key barriers to their adoption in high-risk regions of Pakistan. The study used a mixed-methods approach by administering surveys. These surveys were administered to 500 community members in different cities of Sindh and Punjab. The study also incorporated two in-depth case studies: the Heritage Foundation's low-cost housing initiative in Makli, Sindh, and the Aga Khan Agency for Habitat's Safe Housing Program in Chitral, Khyber Pakhtunkhwa. These cases provide valuable insights into effective, culturally appropriate, and scalable models of resilient construction in Pakistan. Findings of the present study reveal that public awareness of resilient architecture is below a satisfactory level, with common misconceptions. Challenges, including high costs, lack of technical knowledge, and minimal government support, were identified as significant obstacles. Despite these issues, communities showed strong interest in learning about safer building practices when exposed to practical examples and local success stories. The study recommends integrating resilient construction education into community outreach, school curricula, and builder training programs. It also advocates for greater government involvement, financial incentives, and replication of proven models to foster widespread adoption of resilient architecture for long-term sustainability.

Keywords: Resilient architecture; Flood-resistant buildings; Environmental education; Sustainable development; Climate change



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1. Introduction

1.1. Background of the Study

The world is going through a massive climate change that is causing extreme disasters and damage to its people and surroundings. Pakistan is one of the countries that is under the destruction of natural calamities such as earthquakes, storms, floods, and landslides. The intensity and frequency of these calamities have been constantly increasing due to climate change, deforestation, unplanned urbanisation, and inadequate infrastructure [1,2]. The devastating floods of 2010 and 2022 caused massive infrastructure damage and human loss. These natural calamities and their unbearable destruction call for urgent, resilient, and sustainable building practices across the country [3].

There is no doubt that government policies and international aid need to be strengthened in disaster response and infrastructure building, but some serious actions are also required to spread grassroots-level awareness for community participation. For this purpose, a community-based environmental education program is an effective tool, especially in flood-prone regions such as Sindh, Punjab, and Khyber Pakhtunkhwa. This education must consist of flood and storm-resistant construction practices to reduce the vulnerability of households and communities to climate-related disasters. This kind of educational program helps them save precious human lives, their homes, and hard-earned assets.

Resilient architecture refers to the planning and construction of buildings that can resist environmental stresses such as flooding, heavy rainfall, high winds, and earthquakes. Modern technologies and latest architectural designs in developed countries are now adapting strategies such as elevating structures, using water-resistant material, improving drainage systems, and modifying roofs and wall designs to withstand storm surges [4]. Unfortunately, these practices are almost unfamiliar to rural and underprivileged communities in Pakistan due to the lack of education, dependence on old strategies, financial constraints, and technical support.

Environmental education in the form of customised and practical guidelines can empower communities with the knowledge and skills to understand sustainable building practices. This education can be given at different levels through various platforms such as schools, community centres, government initiatives, and non-governmental organisations (NGOs). Visual aids, demonstrations, local case studies, and practical examples can be very helpful even for people with low literacy skills. Moreover, training programs on low-cost resilient construction techniques can create a culture of adapting modern technologies and preparedness for future disasters.

This is a common practice in Pakistan to build homes using traditional, non-engineered methods due to a lack of funds and resources [5]. This practice promotes the use of low-quality material and poor infrastructure that are easily damaged due to the rainfall. The environmental education and resilient construction literacy programs can also address these issues significantly. This approach aligns with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). These goals emphasise the need for inclusive, safe, resilient, and sustainable human settlements [6].

The purpose of community education is not limited to physical resilience to natural disasters, but it also promotes social cohesion and self-reliance amongst its people. The knowledge of resilient structure makes them mentally ready to implement practical initiatives in times of calamity. They play the role of active agents towards change rather than becoming passive victims of environmental disasters.

The primary aim of this study is to explore how community education on flood and storm-resistant architecture can be integrated into environmental education frameworks in Pakistan. It seeks to identify effective educational strategies and propose implementable recommendations to enhance resilient construction knowledge at the grassroots level. The study contributes to the broader discourse on disaster risk reduction and sustainable development in Pakistan's climate-vulnerable regions.

1.2. Literature Review

1.2.1. Climate Change in Pakistan and Disaster Resilience

According to the Global Climate Risk Index (2021), Pakistan is one of the top ten countries most impacted by climate change [7]. The intensity, frequency, and impact of natural disasters have become unbearable in rural areas of Pakistan. Rapid urbanisation, deforestation, and uncontrolled building methods have all contributed to the increased susceptibility of urban and rural people to storms and flooding. These disasters often result in large-scale displacement, infrastructure damage, and long-term socio-economic setbacks. Ahmad & Saeed [8] emphasise how urgently adaptive infrastructure is needed to reduce the risk of disasters. Research shows that building resilience through community awareness and local education is key to minimising disaster risk and achieving sustainable development (UNDRR, 2020).

1.2.2. Function of Environmental Education in Disaster Preparedness

The importance of environmental education in fostering climate resilience has long been acknowledged. According to UNESCO (2018), disaster preparedness can be greatly increased by including climate adaptation techniques in academic curricula and career training programs [8]. Research from Nepal and Bangladesh has shown that practical instruction in resilient building methods boosts community adoption rates and safer housing [9]. Similarly, it was found that community-led initiatives in the Philippines encouraged the adoption of elevated foundations and reinforced roofing among vulnerable populations [10]. These studies suggest that communities are more likely to adopt resilient building practices when they understand the risks and are prepared with practical, affordable solutions.

1.2.3. Storms and Floods Resistant Buildings Practices

The resilient architecture uses architectural strategies appropriate to a certain region to reduce damage from harsh weather. Traditional flood-resistant construction in Pakistan has successfully reduced the danger of disasters. Examples include reinforced concrete buildings in Punjab and raised residences in Sindh [11,12]. However, knowledge of such

practices is still limited to technical experts and engineers, which is rarely transferred to community members who construct their homes using local materials.

Sardar and Phil [13] studied the significance of post-disaster reconstruction efforts in Sindh. They reported that houses built with community training and input on disaster-resistance techniques performed significantly better during floods. The Heritage Foundation of Pakistan has introduced “zero-carbon” and flood-resistant mud homes in rural Sindh by combining local materials with disaster-resilient designs. This integration documented improved safety and community satisfaction [14]. However, such initiatives are localised and lack systematic implementation across the country.

1.2.4. Government Initiatives and Policy

Programs encouraging climate-resilient building have been introduced by the National Disaster Management Authority (NDMA) [15,16]. These tactics aren't often included in official education and community awareness initiatives. More emphasis on environmental education in policy can improve sustainable development and community readiness. The practical component in environmental education is lacking in the national curriculum. Imran [7] argues that environmental education in schools tends to be theoretical and fails to address community-specific challenges such as flooding or poor housing infrastructure. There is a critical need to integrate locally relevant and action-oriented content into formal and informal educational settings.

The literature emphasises that education is a powerful tool bridging the gap between vulnerability and resilience. The planning and implementation of curriculum and training programs is not enough in this endeavour. Its success is highly dependent on the customised content according to the socio-economic realities of the target population. These programs must consist of local language, culturally relevant materials, and community participation. It suggests that sustainable development is not only about environmental conservation but also about empowering communities to protect themselves and thrive despite increasing environmental risks.

1.3. Theoretical Framework

This study is grounded in social-ecological resilience theory, which depicts resilience as growing from interactions between social systems (knowledge, governance, cultural norms) and ecological systems (flood risks, local materials). Moreover, the diffusion of innovations theory is employed to explain the adoption dynamics of resilient architectural practices to complement this view. This theory highlights how awareness, cultural compatibility, and communication channels shape adoption rates. Additionally, the Health Belief Model informs the analysis of individual motivations and barriers to adoption. By merging these concepts and theories, it can be said that these frameworks provide a robust lens to interpret both community-level resilience and individual decision-making in adopting resilient architecture in Pakistan.

1.4. Objectives of the Study

This study aims:

1. To assess the current level of community awareness regarding flood and storm resilient building practices in disaster-prone areas of Pakistan.
2. To assess the role of environmental education in promoting sustainable construction practices at the community level.
3. To identify challenges and barriers to adapting resilient construction practices in vulnerable communities in Pakistan.
4. To propose practical recommendations and strategies to integrate education on resilient architecture.
5. To contribute to the National Sustainable Development Goals by combining community education, disaster risk education, and climate adaptation initiatives in Pakistan.

1.5. Significance of the Study

The study findings are crucial for community leaders, educators, and development organisations. The program promotes long-term disaster risk reduction by educating and training residents in resilient design. The study supports sustainable urban development and climate adaptation in Pakistan by being in line with the Sustainable Development Goals (SDGs) of the UN, especially Goal 11 (Sustainable Cities and Communities) and Goal 13 (Climate Action). This study highlights the importance of customised environmental education in empowering communities to take preventive actions against climate-related hazards. This study aims to foster long-term safety, reduce disaster-related loss, and minimise dependence on external aids by focusing on the integration of resilient architecture and community education.

Finally, the study desires to empower vulnerable populations not just as recipients of aid but as active participants in building safer, more resilient futures for themselves and their communities.

2. Methodology

2.1. Research Design

A mixed-methods research design is used in this study, focusing on survey research and case studies to examine the efficacy of community education in adopting flood- and storm-resistant architectural practices in disaster-prone areas of Pakistan.

2.2. Sampling Method

The study was conducted in Sindh and Punjab, as these two regions are highly prone to being affected by floods. The population consisted of local residents, especially affected by previous floods, local builders involved in reconstruction, and community educators associated with community awareness programs.

A survey was conducted by using a purposive sampling method by selecting 200 members from the community, 150 individuals from local institutes, particularly associated with training programs, 100 local architects, and 50 government officials who especially belonged to the construction and development sector.

The research will examine two specific local projects for case studies:

1. The Heritage Foundation's Post-Flooding Housing Projects in Makli, Sindh: This is a model of zero-carbon and low-cost flood-resistant housing buildings built using lime-stabilised mud and bamboo. Community participation and training local constructors were the main forces behind this model.
2. Aga Khan Agency for Habitat (AKAH)'s Safe Housing Program in Chitral and Gilgit Baltistan: This project is based on disaster resilient structures using hazard maps, local materials, and inclusive education. This project is a clear example of how AKAH-trained communities successfully build resilient structures for their people.

2.3. Data Collection

A survey questionnaire was used to collect information on awareness of climate risk and safe building techniques. Experience with past disasters and reconstruction efforts, knowledge gained through local educational programs, and barriers to adopting flood-storm resilient buildings. The questionnaire consisted of 20 items and was conducted in a local language with the help of a trained researcher.

Each case study included site visits to observe architectural techniques and community involvement. The researcher also reviewed documents related to the project, training manuals and media reports.

Data analysis was done using descriptive statistics to determine patterns in awareness, behaviour, and community needs. Case studies were analysed by using thematic analysis focusing on themes such as knowledge transfer, local innovation, and community participation.

2.4. Ethical Consideration

All participants provided their informed consent, and the study complied with ethical research guidelines. Respondents' anonymity and confidentiality were preserved, and the data were used only for research purposes. In order to guarantee that the results directly support local capacity building, community participation was promoted.

3. Results and Discussion

The demographic profile (Table A1) showed a balanced mix of genders, age groups, and occupations that represent diverse perspectives across communities and professionals. Sources of information (Table A2) were dominated by NGO/community trainings, while government and formal channels played a limited role that is revealing gaps in institutional outreach. Participants identified reduced flood risk and long-term cost savings as the most important benefits of resilient architecture (Table A3). Adoption of practices (Table A4) was moderate, with elevated foundations and reinforced roofing more common than flood-resistant materials or drainage systems, which points to cost and technical barriers. Willingness to adopt in the future (Table A5) was encouragingly high but often conditional on affordability. Participation in awareness programs (Table A6) was generally low, particularly in government and school-led initiatives, which suggests the need for stronger outreach. Subgroup comparisons (Table A7) found no significant

demographic differences in adoption, though educators and NGO-trained participants showed slightly higher uptake. Correlation analysis (Table A8) indicated weak but positive links between perceived benefits and adoption, which suggests that awareness contributes but is insufficient without supportive measures. Lessons from Makli and Chitral (Table A9) reinforced the value of community-led construction, local materials, hazard mapping, and technical training. It highlights that resilience requires both cultural acceptance and institutional support for effective replication.

The findings from this study provide valuable insights into the current awareness, attitudes, and challenges in the relevance of the adoption of resilient architectural practices in Pakistan. The data was gathered from a diverse population sample and supported by case study analysis. Several critical themes emerged as a result of this study, which are given below:

1. **Diverse Demographic and Relevance of Results:** The demographic data of participants reveal a balanced representation of gender, age, profession, and region. The inclusion of community members, local developers, architects, trainers, and policy makers ensures that the survey findings are not limited to a single stakeholder. The external validity of the study was also strengthened by selecting flood-prone regions in Pakistan. Chi-square analysis further confirmed that adoption patterns did not significantly vary by gender ($\chi^2 = 3.12, p = 0.374$), age ($\chi^2 = 6.85, p = 0.654$), occupation ($\chi^2 = 14.27, p = 0.285$), or region ($\chi^2 = 10.94, p = 0.534$). This highlights that demographic factors alone are not strong determinants of resilient practice adoption.
2. **Limited Baseline Awareness and Prevalent Misconceptions:** The survey indicated that only 35% of respondents were fully aware of resilient architectural practices, while a larger proportion of the population was only partially aware. A notable population (25%) was unaware that it was alarming. They associate resilience construction solely with urban development or believe that traditional methods are ineffective due to their misconceptions. These misconceptions were the greatest hindrance to adopting cost-effective local solutions. Chi-square results showed that adoption did not differ significantly by awareness level ($\chi^2 = 18.64, p = 0.229$), although participants trained by NGOs and community programs trended toward higher adoption.
3. **Positive Impact of Educational Interventions:** A positive response was achieved towards the idea of gaining education regarding resilient architecture by community members. The loss of assets, physical damage, and lack of governmental support encouraged members to receive training to help themselves in calamities. They believed that different sources, such as NGOs, workshops, and community events, can play a pivotal role in demystifying resilient architecture and correcting misinformation. It also implies that communities are receptive when content is relevant and accessible.
4. **Limited Adoption of Resilient Practices:** Participants with some awareness identified existing resilient measures, such as elevated foundations and improved drainage systems. However, adoption remains limited in rural and semi-urban areas due to cost and accessibility issues. Correlation analysis revealed that perceived benefits of these practices were weakly associated with actual adoption choices ($r = 0.02\text{--}0.09$). For instance, flood-resistant materials correlated most with reduced risk ($r = 0.09$) while reinforced roofing showed a slight association with health and safety ($r = 0.06$). These weak relationships suggest that this does not translate into practice, although communities conceptually recognise benefits.
5. **Financial and Technical Barriers:** There are many hurdles and barriers that were identified by community members that stop them from working on resilient structures in their areas, such as high construction costs, lack of technical expertise, lack of government support, and cultural resistance. These findings align with past studies that have emphasised the critical role of subsidies, community-based training, and locally available materials in overcoming these barriers. Regression analysis confirmed this: financial barriers significantly reduced the likelihood of adoption ($\beta = -0.42, p < 0.01$), making them the most influential factor in explaining non-adoption. In contrast, awareness ($\beta = 0.18, p = 0.09$) and training ($\beta = 0.14, p = 0.12$) showed only marginal, non-significant effects.
6. **Fragmented Information Sources:** The data revealed that NGOs and community-based education programs are currently the leading sources of information on resilient architecture. This highlights the need for structured government-supported awareness campaigns, especially through schools, local municipalities, and digital platforms.
7. **Perceived Benefits:** Due to the lack of knowledge and old mindset, community members are not fully aware of the benefits of resilient structures. They believe that developing resilient buildings and adopting resilient methods can protect them only from flood damage. Few of them appreciated the idea of cost savings and improved health and safety. Correlation analysis supported this perception gap, showing only weak associations across benefits. For example, resilient materials correlated most strongly with reduced risk ($r = 0.09$), but still far from a meaningful relationship.
8. **Low participation in Awareness Programs:** The results of the study suggested limited community participation in awareness programs because of a lack of understanding of their benefits and practical implementations. Regression

results also confirmed that training and awareness did not significantly predict adoption behaviours, which suggests that outreach efforts must be restructured to be more context-specific, incentivised, and participatory. This gap creates an opportunity to integrate environmental education into school curriculum, technical training centres, and municipal programs. Small incentives can also be used to maximize the participation of community members.

9. Community Focused and Context Specific Approaches in Case Studies: The case studies from the Heritage Foundation in Makli and the AKAH Safe Housing Program in Chitral underline the fact that localised, culturally sensitive, and community-driven approaches are effective. The use of vernacular architecture of mud and lime for flood resistance demonstrates the traditional method in a modern way. The significance of hazard mapping and participatory design in Chitral shows that flood-resistant structures can be developed by community integration.

3.1. Case Study 1: Heritage Foundation Pakistan and Resistant Housing in Makli

3.1.1. Background

The Heritage Foundation of Pakistan pioneered the use of vernacular techniques under the supervision of Yasmeen Lari. This technique is a low-cost building method to create climate-resilient housing in flood-prone rural areas. The town of Makli, located near Thatta in Sindh, has been at the centre of these interventions [14].

3.1.2. Resilient Features

- Use of mud and lime plaster along with bamboo and local bricks
- Raised stands to protect against flooding
- Cross-ventilation for temperature regulation
- Water-resistant plinths and thatched or bamboo roofs to allow for flexibility and low replacement cost

3.1.3. Community Engagement

- The project follows a barefoot architect model where community members, both males and females, were trained in the building process
- Focus was placed on empowering local communities, especially women, by teaching them to construct their own homes
- Educational materials and hands-on training were part of the awareness intervention

3.1.4. Outcomes

- Over 50,000 resilient shelters have been constructed since 2010
- The project demonstrated that traditional low-carbon methods can offer high resilience against climate-induced disasters
- Cultural acceptability and cost-effectiveness were major factors for success

3.2. Case Study 2: Aga Khan Agency for Habitat (AKAH) and Safe Housing Program in Chitral, KP

3.2.1. Background

The Northern region of Pakistan is highly vulnerable to flash floods and seismic activity. The AKAH launched a comprehensive Safe Housing Program that integrates hazard mapping, community education, and structural retrofitting [17].

3.2.2. Resilient Features

- Community-driven vulnerability and risk assessments.
- Development of “safe site” maps to guide future construction away from high-risk zones
- Use of reinforced concrete, stone masonry, and seismic-resistant designs
- Implementation of early warning systems in collaboration with local government and NGOs

3.2.3. Community Engagement

- Conducted over 800 awareness sessions and training programs for builders and community leaders
- Built model homes in selected high-risk areas as educational tools
- Engaged local builders and engineers in adapting traditional construction with modern fortification

3.2.4. Outcomes

- Over 6000 households trained in safe construction practices
- Strengthened community preparedness and reduced disaster vulnerability
- The AKAH model is now being scaled to other mountainous regions of Gilgit-Baltistan and Azad Jammu & Kashmir.

3.3. Proposed Framework

As shown in Table 1, replication framework that distinguishes between universal elements of resilient housing interventions and those that require local adaptation. The universal elements, such as hazard screening, participatory design, and low-carbon material use, can be replicated across diverse contexts without modification. Context-specific elements such as local construction materials, cultural acceptability, and tenure arrangements must be tailored to the socio-environmental setting of each community. The diagnostic questions provide a practical guide for practitioners and policymakers to assess local readiness before scaling up so that resilience strategies remain both technically sound and socially acceptable.

Table 1. Replication Framework: Universal vs. Context-Specific Elements Caption.

Layer	Universal (Replicate as-Is)	Context-Specific (Adapt Locally)	Diagnostic Questions before Scale-Up
Risk intelligence	Multi-hazard screening; no-build/low-risk siting principles; basic DRR education	Detailed hazard & micro-siting (local flood heights, scour, debris paths)	Are high-resolution hazard maps and historical flood levels available and trusted?
Technical standards	Principles: elevated plinths, drainage paths, bracing; “build back safer” checklists	Section sizes, joinery, mortar mixes, roof pitch per climate/materials	Do local soils/materials meet minimum performance? What adaptations are needed?
Materials & supply	Preference for low-carbon, locally sourced materials; cost-transparency	Specific species (bamboo), lime quality, curing times, and transport logistics	Are supply chains reliable year-round? Who quality-assures inputs?
Skills & delivery	Cascade training model; competency-based certification; on-site coaching	Training duration, language, gender inclusion, and stipend design	Who trains trainers? How to retain artisans and avoid attrition?
Community governance	Participatory design; user maintenance manuals; grievance redress	Land tenure solutions, community savings, O&M norms	Are tenure/permissions clear? What community institutions exist?
Finance & incentives	Targeted subsidies for the poorest; results-based disbursement; transparency	Subsidy size, eligibility, local financing partners, and micro-insurance	What is the willingness/ability to pay? Which subsidy lever closes the gap?
Policy & permitting	Fast-track approvals for resilient typologies; standard drawings	Local code alignment; district-level by-laws and inspections	Who signs off? Are inspectors trained on these typologies?

3.4. Stepwise Scale-Up Roadmap (12–18 Months)

- Context scan (6–8 weeks): Rapid hazard, market, and governance appraisal; populate the table above.
- Design sprints (4–6 weeks): Co-create 2–3 localised variants (e.g., mud–lime + raised plinth; stone–mortar + ring beams).
- Pilot cells (3–4 months): 50–100 units across contrasting micro-contexts; randomise training intensity and incentive size to learn what sticks.
- Implementation protocol: Lock minimum standards (non-negotiables) and adaptation menu (negotiables) based on pilot evidence.
- Capacity & supply: Certify local trainers, pre-qualify suppliers, set simple QA checklists (plinth height, drainage slope, connections).
- Policy hooks: MoUs with district authorities for expedited approvals and community-led inspections.
- Scale tranche (6–9 months): Expand to 1000–2000 units with continuous monitoring and adaptive management.

3.5. Recommendations

- It is recommended that community awareness workshops and training modules be designed using local languages and visual aids. Training local builders and community members using successful models from Makli and Chitral can add value to these training objectives. However, these case studies should not be idealised as universally replicable. Instead, a scaling framework is recommended that distinguishes between universally applicable practices (e.g., hazard mapping, participatory design) and context-specific elements (e.g., vernacular materials, cultural acceptance).
- Promoting low-cost and local materials can encourage the use of affordable and culturally acceptable construction in high-risk areas. The use of mud, lime, and bamboo can be done in these structures as it is a low-cost and easily accessible materials. It aligns with community expectations identified in the correlation analysis, where financial barriers were strongly associated with low adoption rates.
- Engagement of local authorities and government support can promote resilient architecture. Subsidies or incentives for adopting flood- and storm-resistant building practices can encourage communities to adopt this modern technique. The chi-square results indicated that awareness levels did not differ significantly across gender, age, or region. This reinforces the importance of structural government intervention to reach all demographic groups equally, rather than assuming certain groups will adopt more readily.
- Integrating resilient building concepts in schools and vocational training curricula can enhance the long-term knowledge and skills of community members.
- Effective use of communication channels such as TV, radio, social media, and mobile apps can be used to raise public awareness and correct misconceptions.
- Participatory risk mapping can be encouraged by involving local communities in identifying safe construction zones through risk mapping and hazard assessments.
- Fostering partnerships with NGOs, universities, and construction firms to scale up model housing projects and spread technical expertise is also highly recommended. Importantly, replication of success stories must be paired with critical monitoring of scalability challenges to avoid one-size-fits-all solutions.
- A system of continuous tracking and evaluation of educational interventions should be institutionalised. Lessons learned from successful models should be replicated in other flood-prone regions of Pakistan, while failed attempts must also be documented to refine strategies.
- To ensure consistent policy implementation, establish coordination between NDMA (National Disaster Management Authority), provincial disaster agencies, local governments, and municipal bodies. Align disaster management, housing, and urban development policies to remove overlaps and contradictions, ensuring resilience is mainstreamed rather than treated as a stand-alone initiative.

4. Conclusions

This study highlights that although awareness of resilient architecture exists, actual adoption remains limited and uneven across demographic groups. The awareness is mostly present in groups largely driven by NGO training rather than systemic support. Case studies of the Makli Heritage Foundation and the AKAH Safe Housing Program in Chitral demonstrate how culturally grounded community-driven approaches can successfully integrate vernacular techniques into modern resilience practices. These insights reinforce the study's objectives and are best framed through social-ecological resilience theory and the diffusion of innovations model. These theories explain why some practices diffuse successfully while others face resistance. Nonetheless, gaps in understanding gendered adoption patterns, urban–rural contrasts, and cost-benefit trade-offs require further research. Policy recommendations emphasise multi-level governance with accountability, integration of resilience into education and training, and financial incentives to replicate and scale such models across flood-prone regions of Pakistan.

Appendix A

Table A1. Demographic Profile of Participants.

Category	Subcategory	Frequency (n)	Percentage (%)
Gender	Male	275	55%
	Female	225	45%
Age Group	18–30 years	150	30%

	31–45 years	200	40%
	46–60 years	100	20%
	Above 60 years	50	10%
	Community members	100	20%
	Builders/Contractors	100	20%
Occupation	Educators	150	30%
	Architects/Urban Planners	100	20%
	Policymakers/Govt. Officials	50	10%
Location	Sindh1	125	25%
	Punjab 1	100	20%
	Punjab 2	75	15%
	Sindh 2	100	20%
	Punjab 3	100	20%

Table A2. Sources of Information About Resilient Architecture.

Source	Percentage of Respondents (%)
NGO/Community Trainings	30%
Television/Radio	20%
Social Media/Internet	15%
Local Government Programs	10%
Word of Mouth/Community Elders	15%
No Source	10%

Table A3. Perceived Benefits of Resilient Architecture.

Perceived Benefit	Percentage of Respondents (%)
Reduced Risk of Flood Damage	40%
Long-Term Cost Savings	25%
Improved Health and Safety	15%
Increased Property Value	10%
Environmental Sustainability	10%

Table A4. Adoption of Resilient Building Practices.

Practice Adopted	Percentage of Respondents (%)
Elevated Foundations	30%
Reinforced Roofing	25%
Flood-Resistant Materials	20%
Improved Drainage Systems	25%

Table A5. Willingness to Adopt Resilient Practices in the Future.

Response	Percentage of Respondents (%)
Yes, definitely	50%
Maybe, depending on cost	30%
No, not interested	10%
Already adopted	10%

Table A6. Participation in Awareness or Training Programs.

Program Type	Participated (%)	Did Not Participate (%)
NGO-led construction workshops	25%	75%
Government awareness campaigns	15%	85%
School/community education sessions	10%	90%

Table A7. Part Subgroup Comparisons Between Demographics and Adoption of Resilient Practices.

Comparisons	χ^2 (Chi-Square)	df	p-Value	Interpretation
Gender $\times$ Adoption	3.12	3	0.374	No significant difference in adoption between men and women.
Age Group $\times$ Adoption	6.85	9	0.654	Adoption patterns do not differ significantly across age groups.
Occupation $\times$ Adoption	14.27	12	0.285	No strong occupational differences, though educators showed slightly higher adoption.
Location $\times$ Adoption	10.94	12	0.534	Adoption does not vary significantly across regions.
Awareness $\times$ Adoption	18.64	15	0.229	No statistically significant difference, though NGO/Community trained participants trended toward higher adoption.

Table A8. Correlations Between Perceived Benefits and Adoption of Practices.

Variable	Reduced Risk	Cost Savings	Health & Safety	Property Value	Sustainability
Elevated Foundations	0.08	0.04	0.02	0.05	0.03
Reinforced Roofing	0.05	0.03	0.06	0.02	0.04
Flood-Resistant Materials	0.09	0.07	0.04	0.06	0.05
Improved Drainage Systems	0.04	0.05	0.03	0.04	0.02

Table A9. Key Lessons from Case Studies.

Case Study	Lesson Learned
Heritage Foundation—Makli, Sindh	Community-led construction and local materials can offer low-cost flood resilience.
AKAH Safe Housing Program—Chitral	Hazard mapping, technical training, and inclusive planning improve resilience.

Author Contributions

Conceptualisation, A.U. and D.I.E.; Methodology, A.U., A.N.B. and M.W.S.; Software, A.N.B. and M.W.S.; Validation, S.A.Q. and A.N.B.; Formal Analysis, M.W.S.; Investigation, A.U. and S.A.Q.; Resources, D.I.E.; Data Curation, S.A.Q., M.W.S.; Writing—Original Draft Preparation, A.U. and M.W.S.; Writing—Review & Editing, All authors; Visualization, A.N.B.; Supervision, A.U. and D.I.E.; Project Administration, A.U., D.I.E.

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Informed Consent Statement

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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