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URBAN FLOODING IN LAHORE, PAKISTAN: ASSESSING RESIDENTS' PERCEPTIONS AND MITIGATION RESPONSES

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Abstract
The increasing frequency of urban flooding in Lahore could be attributed to inadequate drainage and excessive runoff. Urban resilience can offset the impact of climate change and increase inundation. Residents' resilience can be assessed based on their knowledge, attitudes, and practices. The Knowledge–Attitude–Practice (KAP) framework was used to investigate the three dimensions through which residents' viewpoints in Lahore's urban flooding-prone districts were examined, aiming to better understand the demographic and socioeconomic factors that impact this problem. We used Ridit analysis to rank the questionnaire responses, and a regression model identified key demographic and socioeconomic predictors of KAP outcomes. According to the results, people in Samnabad were more receptive to flood warnings and had better KAP ratings than people in other towns. This study highlights sustainable and data-driven techniques for improving urban flooding resilience by combining nature-based solutions with a spatial risk framework.

INTRODUCTION
Rapid urbanization, insufficient infrastructure, and the increasing consequences of climate change have contributed to the recurrence and severity of urban flooding, a problem that affects numerous cities worldwide. Not only do these floods pose severe health and safety hazards to impacted communities, but they also cause extensive property damage, disrupt daily life, and cause significant economic losses. In addition to the obvious physical damage, urban flooding highlights the shortcomings of city planning, especially in heavily populated regions where unchecked buildings and poorly planned drainage systems worsen the situation.

Urban flooding occurs when heavy rainfall generates runoff that cannot infiltrate poorly permeable soils (Aladelokun & Ajayi, 2014). In developed catchments, urbanization can increase peak flows by up to 1.8-fold and total flood volumes by as much as six-fold compared with rural areas (Ahmed et al., 2013). Urban flooding occurs rapidly and causes harm and fatalities in vulnerable areas. The global population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050, and 10.4 billion by 2100, per UN forecast

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(Nations, 2022). The variance in urban flood impacts is due to the structural solutions used by wealthier nations, such as the UK, the Netherlands, and Germany, which afford costly flood defenses. Developing countries that are less capable of implementing these measures are more vulnerable. Flood intensity is influenced by the weather, human activities, and socioeconomic status, all of which affect community responses and impacts (Zia, 2007). Mitigation approaches aim to prevent or reduce environmental damage via replacement, restoration, and compensation (Côté Gold Project, 2015). Urban floods disproportionately affect vulnerable low-lying communities and cause immediate and long-term damage. With 55% of the global population living in cities, severe weather events are worsening their effects and increasing their risk (Agonafir et al., 2023). Rapid urbanization and climate change have intensified urban flooding in developing nations such as Pakistan. Urban flooding is more severe in developing nations because of their weak infrastructure and unplanned development (Zia et al., 2023). In developing countries, inadequate planning, mismanaged drainage, and illegal dumping exacerbate this issue. In advanced economies, flooding is often caused by excessive rainfall, climate variations, and flash floods (Tarasova et al., 2023). Urban or pluvial flooding, which causes large ponds, can lead to property damage, traffic issues, and health problems. This continuum of flooding, from minor to severe, is a growing environmental concern in developing nations, affecting residents, authorities, insurance firms, and governments (Zia & Shirazi, 2019).

Pakistan is a developing country that is facing several challenges. Lahore is a developing region with thriving culture and academia. Urban Flooding is a serious environmental problem in Lahore, Pakistan's largest city (Rana & Routray, 2018). Climate change, which causes large-scale weather shifts, leads to increasingly unpredictable and frequent urban flooding in Pakistan with significant implications for the future (Akhtar, 2023). Lahore, in Punjab, Pakistan, is bordered by Sheikhupura, Wagah, and Kasur, with the Ravi River to the north. It is Punjab's capital and the second-fastest-growing city after Karachi. The Lahore Metropolitan Area (LMA) covers 2306 sq km, including parts of Kasur and Ferozwala (Ghous et al., 2015; Rana & Bhatti, 2018). Lahore, the provincial capital and the second most populous city in Pakistan has a population of 11.3 million, growing annually at a rate of 3.32%. Of the total population, two million live in towns and cities (Affairs & Social, 2019; Nadeem et al., 2021). Urban flooding in Lahore worsens during the monsoon months, with increasing severity each year. In June 2023, the Water and Sanitation Agency (WASA) recorded 260 mm of rainfall in just six hours, resulting in severe traffic congestion, power outages, and prolonged road blockages (Dawn News, 2023). Stagnant water causes significant disruptions, with residents being stranded in traffic for hours. Urbanization in Lahore creates water-repellent surfaces that hinder rainwater absorption. Poor stormwater drainage and waste management worsen flooding. Socioeconomic factors further increase vulnerability, making urban flooding a result of both heavy rain and population pressure on drainage systems (Manzoor et al., 2022). This study examined residents' views on urban flooding and highlighted the impacts of socioeconomic and demographic factors. The issue, driven by human activity and poor sanitation, cannot be fully eradicated, but can be managed. In underdeveloped countries, such as Pakistan, costly and time-consuming measures often lead to short-term solutions that may cause future challenges. Non-structured measures depend on effective management and community resources (Szöllösi-Nagy & Zevenbergen, 2018). Technical solutions, including better infrastructure and drainage systems, and adaptive policies that consider long-term environmental changes, are necessary for an effective comprehensive strategy to solve urban floods.

This study aims to assess urban residents' perspectives on flood prevention and response

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strategies. Capturing the perspectives, experiences, and needs of urban residents, those directly affected, is essential yet often overlooked. Their insights are invaluable for developing equitable and effective policies and identifying gaps in the current mitigation strategies. The findings of this study can inform efforts to enhance urban resilience and sustainability by highlighting the residents' challenges and recommendations.

Material and Methods

This section outlines the study's overall approach, including the criteria for selecting the case study areas, the design of the data collection instruments, and the sampling techniques employed. By integrating qualitative and quantitative data, this methodology provides a nuanced understanding of residents' perceptions and the socio-environmental dynamics that contribute to urban flooding in Lahore.

Selection of Case Study Area

Lahore is the second-largest city in Pakistan. Lahore is divided into nine towns. A case study was conducted in three municipalities: Gunj Baksh Town, Allama Iqbal Town, and Samnabad Town, as shown in Figure 1. Gunj Bakhsh is an administrative zone characterized by high activity, featuring concentrated retail and wholesale centers, shopping malls, hotels, restaurants, public and historical structures, offices, recreational places, schools, colleges, and universities (Mahmood et al., 2022). Allama Iqbal Town, also known as Iqbal Town, is a mixed-use area located in the southwest of Lahore, Pakistan, and is among the neighborhoods in the city that are susceptible to urban flooding. Due to its high population density, understanding the perspectives of residents on urban flooding is essential (Iftikhar, 2024). Samnabad Town is situated in Lahore's Samnabad Tehsil, Punjab, Pakistan. Notable climate variations in precipitation and temperature characterize this region (Ashfaq et al., 2023).

These areas were identified based on their distinct socioeconomic characteristics and past experiences with urban flooding. Data from Gunj Baksh Town, which is characterized by its high population density, suggests considerable obstacles faced by low-income households in flood-prone areas. Allama Iqbal Town offers unique insight into the efficacy of municipal flood management programs in a middle-income setting, whereas Samnabad Town implemented successful proactive flood mitigation techniques. These areas collectively provide a broad perspective on flood control technology, stakeholder perspectives, and policy implications, thereby expanding the global discussion on effective urban flooding management. Furthermore, the Water and Sanitation Agency (WASA) selected areas vulnerable to flooding using secondary data, ensuring that the research was confined to the city's most susceptible neighborhoods.

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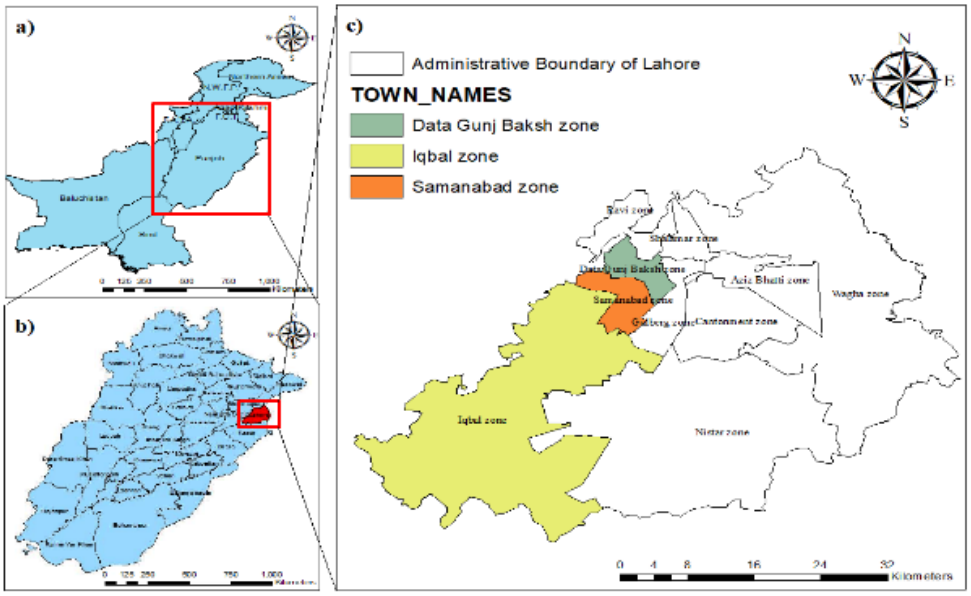


Figure 1: Study area map, (a): The administrative boundaries map of Pakistan, (b): The administrative boundaries map of Punjab, (c): The administrative tehsil map of Lahore Source: Prepared by Researcher

Design of Questionnaire and Data Collection

This study employed a mixed-methods design that integrates quantitative and qualitative techniques to examine urban flooding in Lahore. Field surveys and interviews were conducted, relevant literature was reviewed, and Water and Sanitation Agency (WASA) data were analyzed to characterize the area's water supply, sewer networks, and stormwater drainage systems. Data on flood-prone regions, water depth, and drainage network capacity were collected in areas prone to flooding, particularly after heavy monsoon rains. A comprehensive field study was conducted to assess the socioeconomic impacts of urban flooding. The survey questionnaire collected demographic data and assessed respondents' knowledge, attitudes, and practices (KAP) regarding urban flooding and its mitigation measures. This technique offers valuable insights into the various impacts of flooding in cities. A stratified proportional sampling approach was employed to ensure a representative sample of Lahore's population, facilitating a thorough understanding of this issue.

Calculation of the Sample Size

Sampling was conducted in selected neighborhoods of Lahore, with a focus on areas recognized as significant by the Water and Sanitation Agency (WASA) during the monsoon season. The populations of Data Gunj Baksh Town, Allama Iqbal Town, and Samnabad Town were recorded as 156,250, 156,250, and 159,375, respectively (Masood & Barlow, 2013). The sample sizes were computed using stratified sampling, yielding 127 for Data Gunj Baksh Town, 127 for Allama Iqbal Town, and 130 for Samnabad Town, all with a 5% margin of error. Stratified Proportionate Sampling was employed to ensure representative samples by segmenting the population into strata and randomly selecting samples from each stratum, thereby providing thorough coverage without exclusion. The equation for stratified sampling was: nh = (Nh/N) n.

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Analysis of the Data

Perception of Residents

As shown in Figure 2, 41%, 45%, and 36% of the respondents attributed urban floods to heavy rainfall, while 30% of Data Gunj Bakhsh, 25% of Allama Iqbal, and 32% of respondents in Samnabad attributed urban floods to climate change. This study proposes the enhancement of drainage systems, implementation of climate-resilient urban designs, and augmentation of flood risk awareness, particularly in areas with low awareness, such as Data Gunj Bakhsh. It is also advisable to implement nature-based solutions, including the restoration of natural water bodies and development of green infrastructure.

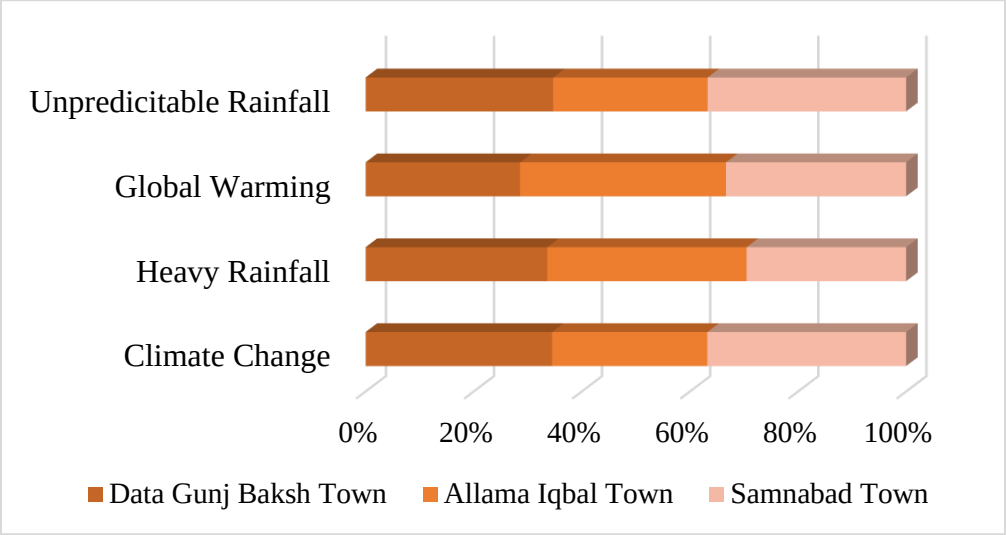


Figure 2: Environmental Factors Source: Field Survey, 2023

Samnabad exhibited the highest urbanization rate at 26%, whereas Data Gunj Bakhsh faced the most significant planning and maintenance issues at 35%. Poor drainage and sewage systems were significant issues in Allama Iqbal (39%), Samnabad (38%), and Data Gunj Bakhsh (30%), with the latter exhibiting the most substantial governance challenges (21%) (Figure 3). These findings underscore infrastructure deficiencies as principal catalysts of urban flooding. The proposed solutions encompass enhancing drainage systems, emphasizing governance reforms in Data Gunj Bakhsh, implementing nature-based solutions, and utilizing a vulnerability-oriented geospatial framework.

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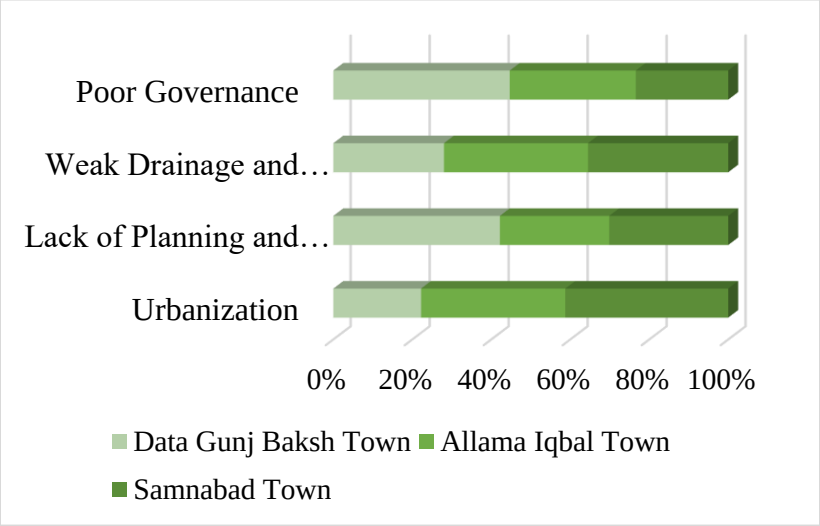


Figure 3: Anthropogenic Factors Source: Field Survey, 2023

Knowledge of Residents

A 5-point Likert scale, spanning from "very low" to "very high," was employed to evaluate knowledge. Nine knowledge-based elements were employed to assess public comprehension of urban flooding in the three municipalities. Figure 4 illustrates the diverse levels of knowledge across the nine areas associated with urban flooding. The majority of responders exhibited poor to neutral comprehension of critical subjects, including helpline numbers, warning systems, and financial assistance, with "Very Low" knowledge prevailing across several categories. Despite the high awareness of the causes and consequences of flooding, there are deficiencies in understanding essential elements, such as power outages and warning notifications, underscoring the necessity for improved information dissemination in these domains.

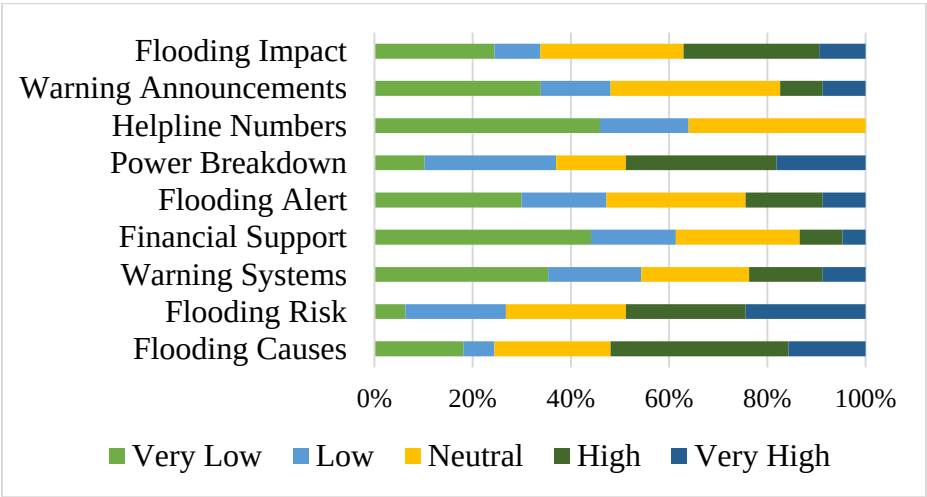


Figure 4: Level of Knowledge at Allama Iqbal Town Source: Field Survey, 2023

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Figure 5 illustrates that the majority of respondents possessed "Neutral" or "Low" knowledge, particularly on helpline numbers, power outages, and financial aid, indicating insufficient information availability. Awareness of the causes of floods is notably robust, with a considerable proportion of respondents indicating "High" or "Very High" levels of knowledge. Nevertheless, critical domains such as warning systems and notifications exhibit deficiencies in awareness, underscoring the necessity for enhanced public education and communication regarding flood preparedness and disaster response.

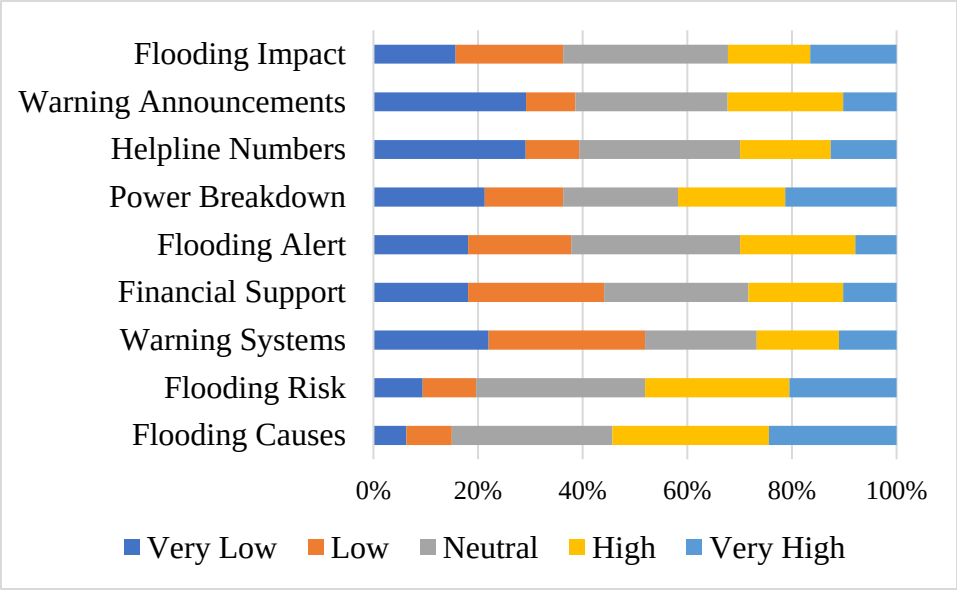


Figure 5: Level of Knowledge at Data Gunj Bakash Town Source: Field Survey, 2023

Figure 6 indicates that numerous respondents recognized the causes and dangers of floods and expressed considerable concern regarding them. Nevertheless, most respondents expressed dissatisfaction with the effectiveness of warning systems, helplines, and financial assistance. Power outages and flooding alerts have highlighted the need for improved infrastructure and communication during flood emergencies.

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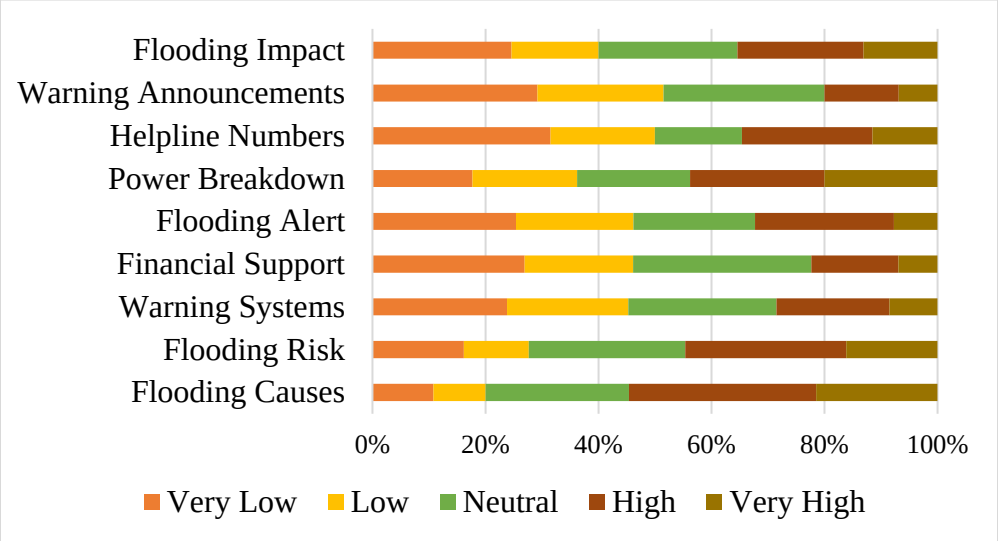


Figure 6: Level of Knowledge at Samnabad Town Source: Field Survey, 2023

Attitude of Residents

Citizens' attitudes were assessed on a 5-point scale. The bar chart illustrates respondents' perceptions of many facets of urban flooding management, including satisfaction levels, government trust, public awareness, mitigation effectiveness, municipal policies, community involvement, authority support, and drainage conditions. Significantly, the data presented in Figure 7 indicate that the populace is discontented with urban flood management, particularly regarding drainage conditions, government support, and effectiveness of mitigation efforts. A significant majority vehemently contest the sufficiency of drainage and efficacy of assistance provided by authorities, with several individuals expressing skepticism towards municipal programs and governmental trust. Perceptions of community participation differed, although there was a significant deficiency in public awareness and satisfaction with current flood control measures, highlighting the urgent need for enhanced infrastructure and increased community involvement.

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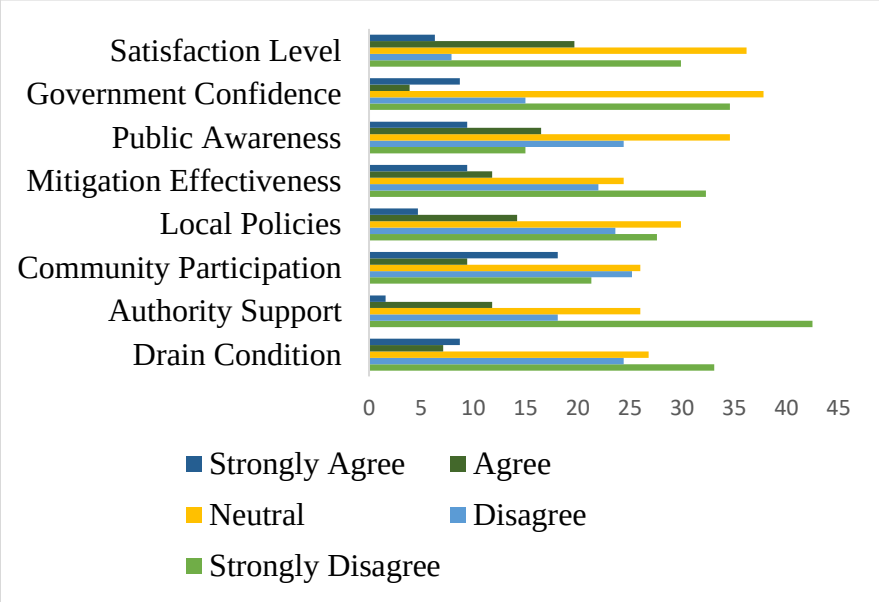


Figure 7: Attitude of Residents at Allama Iqbal Town Source: Field Survey, 2023

The public expressed significant concern regarding urban flood control, particularly in relation to inadequate drainage conditions (40.9% strongly disagree) and insufficient support from authorities (33.9% strongly disagree). Despite community interaction being seen favorably (26% strongly agree), as illustrated in figure 8, skepticism persists over the efficacy of local restrictions and mitigation efforts. Public understanding and trust in government efforts are minimal, leading to ambivalent satisfaction with flood management and highlighting areas of enhancement.

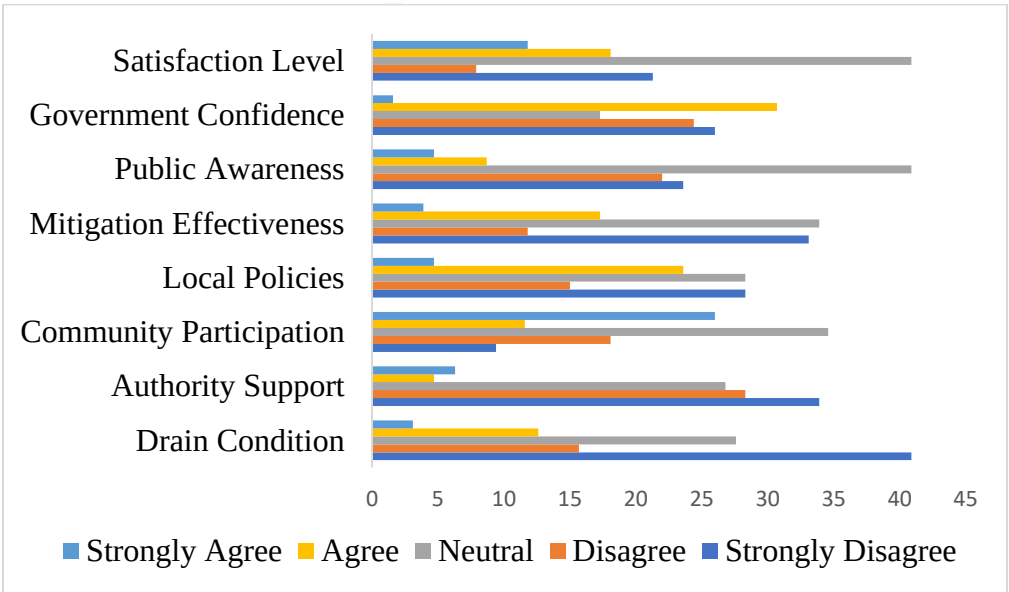


Figure 8: Attitude of Residents at Data Gunj Bakhsh Town Source: Field Survey, 2023

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Figure 9 indicates significant public apprehension regarding urban flood control, particularly concerning inadequate drainage conditions (37.7% disagree) and a deficit of trust in governmental support (23.1% strongly disagree). Of the respondents, 30.8% expressed skepticism about the efficacy of municipal policies and mitigation efforts. Public awareness is perceived as inadequate, and overall contentment with flood management is unsatisfactory, underscoring the necessity for enhanced infrastructure, legislation, and civic engagement.

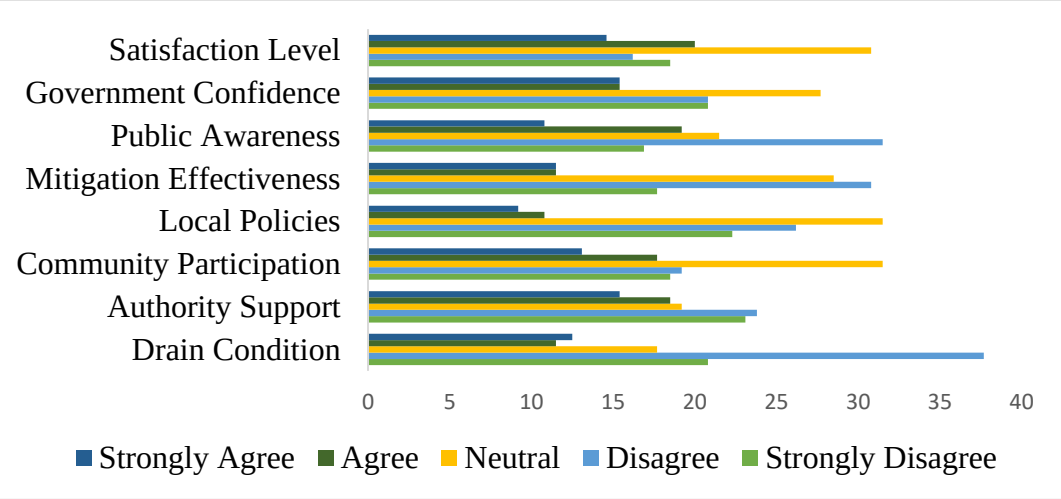


Figure 9: Attitude of Residents at Samnabad Town Source: Field Survey, 2023

Practice Adopted

Figure 10 illustrates the primary issues related to urban flood management, with 40.9% categorizing financial support as exceedingly inadequate and 35.4% rating government aid as insufficient. Coping mechanisms were perceived as diverse, with 37.8% neutral and 31.5% low perceptions. These findings underscore the importance of augmented financial resources, government support, and efficient coping strategies to address flooding.

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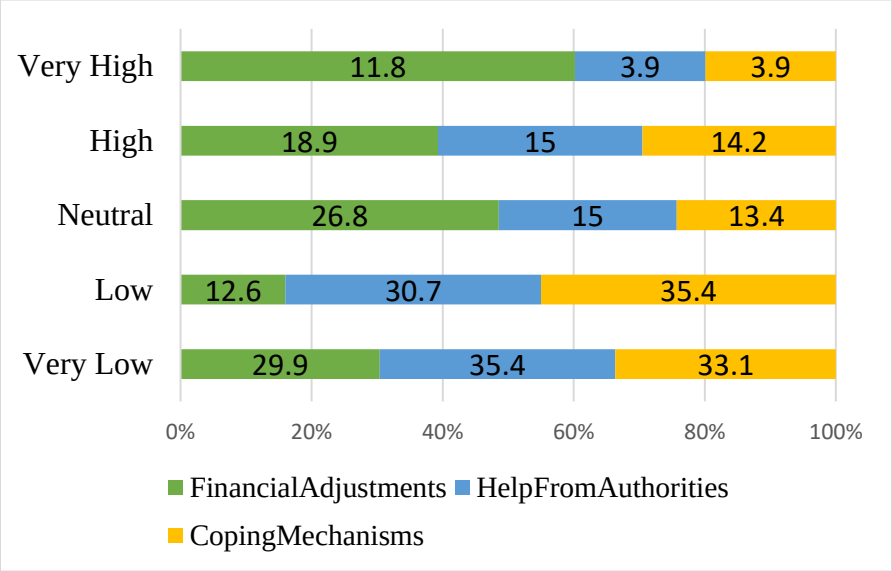


Figure 10: Practice Adopted at Allama Iqbal Town Source: Field Survey, 2023

The poll results indicated significant apprehensions over urban flooding management, with 29.9% of respondents categorizing financial adjustments as very low and 35.4% evaluating aid from authorities as very low, reflecting pervasive dissatisfaction with the support provided. Coping tactics received varied evaluations, with 33.1% categorizing them as very low and 35.4% as low, suggesting that a significant number of individuals perceived these strategies to be unsuccessful (figure 11). These findings underscore the urgent need for augmented financial resources, improved government assistance, and efficient strategies to address flooding.

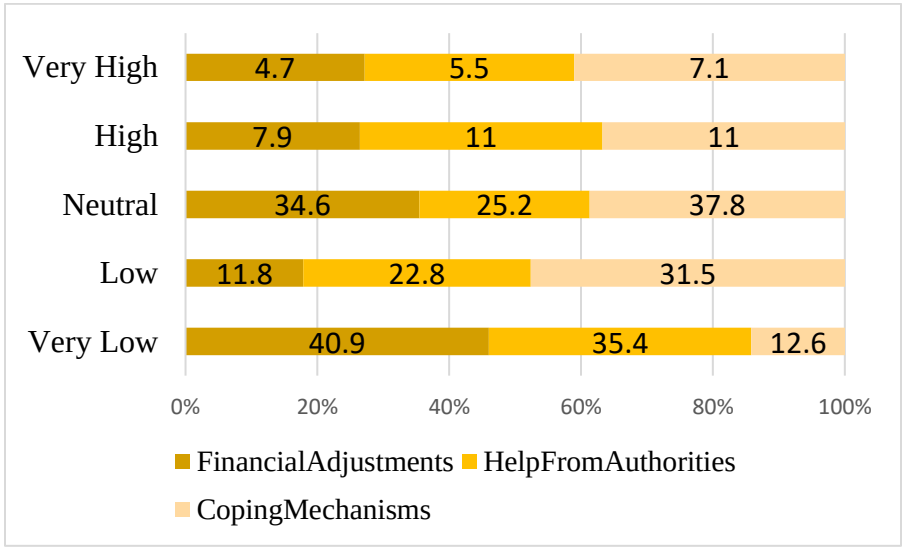


Figure 11: Practice Adopted at Data Gunj Bakash Town Source: Field Survey, 2023

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Figure 12 underscores the significant issues pertaining to urban flood management, with 20% and 19.2% assessing financial modifications to be severely inadequate and inadequate, respectively. Assistance from authorities was similarly seen unfavorably, with 25.4% categorizing it as poor. Coping skills garnered varied evaluations, with 20% categorizing them as low. These findings underscore the necessity for augmented financial resources, enhanced authority support, and more efficient coping strategies to address flooding.

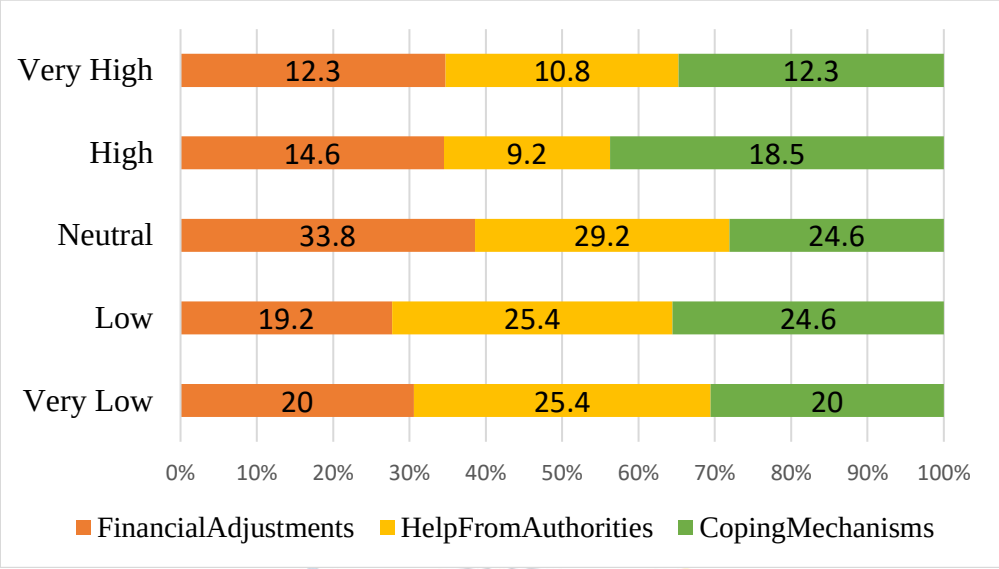


Figure 12: Practice Adopted at Samnabad Town Source: Field Survey, 2023

Modeling and Ranking of the Data

Regression analysis elucidated the relationships between residents' perceptions and socio-economic and demographic factors, while RIDIT analysis ranked groups according to cumulative probability. This integrated methodology yields valuable insights into the flood risk and mitigation efficacy.

Urban Flooding: The Influence of Socio-Economic and Demographic Variables

The regression analysis indicated that demographic factors, such as age and household size, exerted no significant influence on residents' practices and attitudes in Gunj Bakhsh and Samnabad Towns. In contrast in Allama Iqbal Town, demographic factors significantly affected residents' flood-associated knowledge, attitudes, and practices, underscoring the interplay between these variables and flooding risk perception and behavior, as shown in Tables 1, 2, and 3.

Age

Every decade people perceive, react, and deal with the risks associated with urban flooding in different ways. Attitudes towards preventive measures, such as emergency and urban planning, vary by age group. These perspectives are shaped by factors such as education, media exposure, poverty, and unemployment. Table 1 depicts the relationship between age and Knowledge, Attitudes, Practices (KAP), determining how age influences people's perspectives and responses to flooding difficulties. These findings highlight the importance of considering age-related factors when developing flood management strategies.

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Table 1: Age as a Causation of Knowledge, Attitudes, and Practices in Urban Flooding in Lahore Towns. (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R2	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	AGE	Knowledge	0.62	0.270	1.190	0.026	.040	.014
		Attitude					.332	.026
		Practice					.189	.053
Allama Iqbal		Knowledge	0.59	0.624	0.963	0.022	.489	.028
		Attitude					.142	.031
		Practice					.317	.053
Samnabad		Knowledge	0.52	0.270	0.193	0.035	.083	.051
		Attitude					.252	.020
		Practice					.113	.052

Source: Field Survey, 2023

Household Size

This study highlights how household size governs the knowledge, attitudes, and practices (KAP) of flooding. More substantial families may exhibit distinct dynamics to relay information and organize preliminary actions. Table 2 demonstrates the relationship between household size and KAP, emphasizing how family structure influences the risk of flooding awareness and response strategies.

Table 2: Household as a Determinant of Knowledge, Attitudes, and Practices in Urban Flooding (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R-Square	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	Household	Knowledge	0.52	0.2704	0.193	0.031	.138	.027
		Attitude					.120	.052
		Practice					.108	.026
Allama Iqbal		Knowledge	0.50	0.3969	1.196	0.002	-.496	.021
		Attitude					.678	.003
		Practice					-.113	.035
Samnabad		Knowledge	0.56	0.7744	1.390	0.033	.251	.033
		Attitude					.208	.013
		Practice					.142	.023

Source: Field Survey, 2023

Living period

This study focuses on how people's Knowledge, Attitudes, and Practices (KAP) regarding urban floods are affected by how long they reside in a certain area. Long-term residents are often more aware of local flood patterns and have developed better coping strategies through their experience. Table 3 demonstrates the association between the period of residency and KAP, indicating how long-term exposure to flood warnings can affect preparedness and reaction strategies. These findings emphasize the significance of local experience in developing community resilience to urban flooding.

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Table 3: Living Period as a Determinant of Knowledge, Attitudes, and Practices in Urban Flooding (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R-Square	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	**Living Period**	Knowledge	0.56	0.5776	1.107	0.019	.206	.013
		Attitude					.298	.041
		Practice					.027	.025
Allama Iqbal		Knowledge	0.58	0.6084	1.570	0.008	.443	.023
		Attitude					.363	.038
		Practice					.074	.042
Samnabad		Knowledge	0.55	0.3025	0.193	0.031	.236	.004
		Attitude					.209	.041
		Practice					.019	.007

Source: Field Survey, 2023

Tables 4, 5, 6, and 7 demonstrate that socioeconomic characteristics including occupation, education, income, and property ownership had a substantial impact on residents' knowledge, attitudes, and actions in all three towns. These factors greatly impacted how people perceived and responded to flooding warnings, highlighting the intricate relationship between socioeconomic features and flooding attitude and behaviors. The findings emphasize the need to use these features to develop effective flood risk mitigation approaches.

Occupation

This study examined how occupation affects Knowledge, Attitudes, and Practices (KAP) regarding urban flooding. Individuals in specific occupations may develop more proactive attitudes and behaviors, such as participating in community preparation activities or advocating secure workplace standards. Table 4 shows the relationship between work and KAP, focusing on how professional experience might influence residents' flood awareness and reaction methods. These findings demonstrate the need to incorporate occupational factors when establishing flood risk-mitigation techniques.

Table 4: Occupation as a Determinant of Knowledge, Attitudes, and Practices in Urban Flooding (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R-Square	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	**Occupation**	Knowledge	0.63	0.8649	9.643	0.034	.268	.047
		Attitude					.281	.035
		Practice					.349	.034
Allama Iqbal		Knowledge	0.66	0.4356	2.234	0.036	.247	.046
		Attitude					.227	.027
		Practice					.110	.032
Samnabad		Knowledge	0.69	0.4761	19.71	0.019	.300	.019
		Attitude					.256	.012
		Practice					.198	.010

Source: Field Survey, 2023

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Education Level

This study emphasized the relationship between knowledge, attitudes, and practices (KAP) and education regarding urban flooding. Higher knowledge of flood risks and mitigation strategies correlated with higher education levels, which led to more proactive measures such as sustainable planning and preparedness for emergencies. The correlation between education level and KAP is displayed in Table 5, underscoring the role of education in promoting improved flood management and resilience. These results lent credence to educational initiatives as a crucial part of equitable and long-term urban flood mitigation measures.

Table 5: Level of Education as a Determinant of Knowledge, Attitudes, and Practices in Urban Flooding (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R-Square	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	Level of Education	Knowledge	0.71	0.5041	1.164	0.037	.376	.037
		Attitude					.281	.055
		Practice					.265	.051
Allama Iqbal		Knowledge	0.72	0.5184	0.172	0.028	.435	.030
		Attitude					.536	.026
		Practice					.286	.029
Samnabad		Knowledge	0.67	0.4489	2.065	0.005	.218	.009
		Attitude					.438	.002
		Practice					.376	.005

Source: Field Survey, 2023

Ownership

This study focuses on how property ownership, whether owned, rented, or leased, influences Knowledge, Attitudes, and Practices (KAP) in urban flooding. Because proprietors have an affinity for protecting their property, they are more likely to be vigilant and prepared. To increase community resilience, inclusive flood management strategies that address the problems faced by renters and lessees are crucial, as Table 6 shows the strong correlation between ownership status and KAP.

Table 6: Ownership as a Determinant of Knowledge, Attitudes, and Practices in Urban Flooding (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R-Square	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	Ownership	Knowledge	0.65	0.4225	1.559	0.024	.172	.020
		Attitude					.117	.041
		Practice					.019	.004
Allama Iqbal		Knowledge	0.77	0.7569	2.207	0.018	.200	.044
		Attitude					.609	.008
		Practice					-.238	.005
Samnabad		Knowledge	0.76	0.5776	1.903	0.016	.050	.012
		Attitude					.335	.016
		Practice					.267	.017

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Source: Field Survey, 2023

Level of Income

This study focused on the relationship between income levels and knowledge, attitudes, and practices (KAP) regarding urban flooding, and emphasized how financial resources influence people's awareness, perceptions, and reactions to flood dangers. Wealthier families often have better access to knowledge, resources, and infrastructure, resulting in greater preparedness for resistance to urban floods. The statistics, as displayed in Table 7, demonstrate a consistent relationship between income levels and KAP and emphasize the disparities in flood awareness and readiness among socioeconomic groups. These results emphasize the value of focused interventions to address gaps in knowledge and preparedness, especially for low-income groups, and support equitable and efficient flood risk management strategies.

Table 7: Level of Income as a Determinant of Knowledge, Attitudes, and Practices in Urban Flooding (Regression Analysis)

Towns	D.V	I.V	Model Summary		ANOVA		Coefficients	
			R	R-Square	F-Value	P-Value	B	Sig
Data Gunj Bakhsh	Level of Income	Knowledge	0.77	0.5929	1.559	0.024	.231	.015
		Attitude					.354	.024
		Practice					.205	.017
Allama Iqbal		Knowledge	0.75	0.5625	0.748	0.052	-.345	.004
		Attitude					-.480	.013
		Practice					.375	.003
Samnabad		Knowledge	0.69	0.4761	2.234	0.014	.324	.011
		Attitude					.289	.014
		Practice					.244	.005

Source: Field Survey, 2023

Several socioeconomic and demographic factors influence community preparation for urban flooding, and successful flood mitigation methods should consider these. Addressing these variables through specialized educational campaigns and community engagement projects has the potential to significantly increase public knowledge and participation in flood risk mitigation. Furthermore, establishing forward-inclusive policies that include these factors would result in fairer and more successful flood management techniques, ensuring that those in the greatest need are not overlooked. Filling these gaps and aiding communities to become more prepared and resilient will result in a more comprehensive and long-term plan for controlling urban floods. These findings are consistent with international initiatives to promote community-based and flexible ways to reduce flooding risk.

Urban Flooding: Knowledge, Attitudes, and Practices Survey (KAP) Rankings in Lahore Towns

The Knowledge, Attitudes, and Practices (KAP) Survey (Tables 8, 9, and 10) revealed considerable differences in public awareness, attitudes, and behaviors regarding urban flooding among the three areas. Samnabad Town demonstrated the highest level of knowledge, positive attitudes, and proactive flooding control methods, showcasing exceptional community participation and preparedness. Gunj Bakhsh Town, on the other

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hand, had the lowest levels of all parameters, emphasizing the critical importance of enhanced flood awareness, preparedness, and community engagement. Allama Iqbal Town was ranked in the middle, with average knowledge, attitudes, and behaviors, indicating both strengths in flood control and opportunities for development. These findings underscore the importance of measures to enhance community understanding, promote participation, and foster resilience in urban flood management, thereby contributing to the global discourse on reducing fatal risks.

Table 8: Ranking of Knowledge Variables Across Town

	Knowledge Variables	Data Gunj Bakhsh Town	Allama Iqbal Town	Samnabad Town
K1	Flooding Causes	5	3	4
K2	Flooding Risk	4	5	4
K3	Warning Systems	2	1	5
K4	Financial Support	3	2	3
K5	Flooding Alert	3	3	4
K6	Power Breakdown	3	4	4
K7	Helpline Numbers	3	1	1
K8	Warning Announcements	3	3	2
K9	Flooding Impact	1	3	4
1= Very Low 2= Low 3=Neutral 4= High 5= Very High				

Source: Field Survey, 2023

Table 9: Ranking of Attitude Variables Across Town

	Attitude Variables	Data Gunj Bakash Town	Allama Iqbal Town	Samnabad Town
A1	Drain Condition	1	1	2
A2	Authority Support	1	1	3
A3	Community Participation	3	3	3
A4	Local Policies	2	3	2
A5	Mitigation Effectiveness	3	1	4
A6	Public Awareness	2	2	2
A7	Government Confidence	1	1	4
A8	Satisfaction Level	3	3	4
1= Strongly disagree 2= Disagree 3= Neutral 4= Agree 5= Strongly Agree				

Source: Field Survey, 2023

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Table 10: Ranking of Practice Variables Across Town

	Practice Variables	Data Gunj Bakash Town	Allama Iqbal Town	Samnabad Town
P1	Financial Adjustments	**1**	1	3
P2	Help From Authorities	**1**	3	1
P3	Coping Mechanisms	**1**	3	4
1= Very Low 2= Low 3=Neutral 4= High 5= Very High				

Source: Field Survey, 2023

Maintenance and extension of effective flood mitigation projects in Samnabad Town and their use as models for other communities. To increase flood awareness and involvement, targeted education efforts and community workshops were conducted in Gunj Bakhsh Town. Enhance education and public involvement in Allama Iqbal Town to support current programs. The implementation of early warning systems and GIS technologies in all municipalities has increased flood preparedness and resilience.

Conclusion

A multi-method approach was utilized to fulfill the research objectives, incorporating a survey to evaluate residents' knowledge, attitudes, and practices (KAP) concerning urban flooding; regression analysis to investigate the correlation between socio-economic and demographic factors and flood-related behaviors; and interviews with officials from the Water and Sanitation Agency (WASA) to assess current flood mitigation strategies.

This study provides insights into the urban flooding problem experienced by various areas in Lahore, focusing on people's perspectives and responses to recurring calamities. Socioeconomic and demographic factors, age, household composition, education, employment status, property ownership, and income significantly influenced residents' knowledge, attitudes, and practices. These effects were examined across three townships: Data Gunj Bakhsh Town, Allama Iqbal Town, and Samnabad Town. Environmental circumstances differed across these municipalities, with Gunj Bakhsh Town having the highest rate of severe flooding (24%), Allama Iqbal Town (28%), and Samnabad Town (25%). Regardless of meteorological and socioeconomic conditions, individuals in all locations displayed resilience and a proactive approach to handling urban flooding.

Evaluation of Mitigation Strategies/Governmental Perspective

Interviews with the WASA staff provided insights into current preventive methods. The WASA's initiatives to sustain and enhance the area's drainage and sewerage systems include scheduled desilting of sewers and drains, increased pumping capacity at wastewater pumping stations, and the replacement of outdated pumps. The WASA has constructed underground stormwater storage tanks that are highly vulnerable to floods in Lahore, with three operating tanks and eight connected pipes. Additionally, gully gratings have been constructed to prevent water accumulation in low-lying road areas, and interim relief measures, including the mobilization of machinery to stagnant water zones, have been enacted to tackle immediate flood issues.

Implications of Urban Flood Management

This study substantiates that urban flooding in Lahore is caused by a complex interaction between natural and human-induced variables, with significant disparities in the perceived importance of these factors. The results indicate that a comprehensive urban flood control strategy

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is required to monitor environmental and infrastructural vulnerabilities. Municipal authorities should upgrade drainage and sewerage networks, reinforce urban planning frameworks, refine maintenance protocols, and rectify the existing governance deficiencies. Furthermore, the systematic solicitation of community feedback and experiential accounts is essential, and public concerns should guide the prioritization of interventions to bolster urban infrastructure resilience. These outcomes will enhance the worldwide conversation on urban flooding management and provide substantial ideas for creating more adaptable and sustainable cities in the face of growing environmental challenges.

Moreover, the analysis reveals differences in preparedness and response mechanisms among municipalities. Samnabad Town was prominent for its significant early warning systems, financial aid programs, and urban flood reporting hotlines, which represented improved infrastructure and support mechanisms. Residents of Samnabad were also more satisfied with mitigation efforts and trusted local officials than those in Gunj Bakhsh and Allama Iqbal Towns. Moreover, it highlights the importance of focused activities to increase public education and improve mitigation techniques according to the concerns of each area. Comprehensive urban planning, infrastructure enhancements, and good governance are critical for mitigating urban flooding. Thus, specific actions, such as upgrading drainage infrastructure, responding promptly to public concerns, and disseminating information about alternatives, can help mitigate the financial and social costs of floods.

This study recommends a comprehensive plan that involves local bodies, community members, and stakeholders to develop resilient and sustainable communities. By incorporating these outcomes into urban flood management plans, cities can better prepare for and respond to the increasing threat of urban flooding. Furthermore, this study contributes to the worldwide efforts to create an adaptive and inclusive urban environment

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