



INTEGRATING DISASTER RISK REDUCTION INTO URBAN LAND USE PLANNING:  
A RESILIENCE FRAMEWORK FOR FLOOD-PRONE PERI-URBAN AREAS  
IN LAHORE, PAKISTAN

Muhammad Sultan Mahmood <sup>1</sup>, Faraz Ahmed <sup>2</sup>

**Affiliations:**

<sup>1</sup> Department of City and Regional Planning, University of Engineering and Technology (UET), Lahore.

Email:  
bhuttasultan123@gmail.com

<sup>2</sup> Institute of Space Science, University of the Punjab, Lahore

**Corresponding Author(s)**

**Email:**

<sup>1</sup> bhuttasultan123@gmail.com

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**Abstract**

Rapid and unplanned urbanization in developing countries has significantly increased exposure of peri-urban communities to natural hazards, particularly flooding. Lahore, one of South Asia's fastest-growing megacities with a population exceeding 14 million, presents a critical case where the absence of disaster-sensitive land use planning has led to repeated flood disasters in low-lying and peri-urban zones, disproportionately affecting vulnerable populations. Despite advancements in both urban planning policy and disaster risk reduction (DRR) frameworks in Pakistan, significant institutional and spatial planning gaps persist in translating resilience principles into actionable land use decisions. This paper argues that achieving urban resilience in flood-prone peri-urban areas requires the systematic integration of DRR into land use planning frameworks, guided by sustainable development principles. Drawing upon the Sendai Framework for Disaster Risk Reduction 2015–2030, the Sustainable Development Goals (SDGs 11 and 13), and Pakistan's National Disaster Management Policy, the study employs a mixed-method approach combining multi-scale spatial risk mapping, policy document analysis of 23 documents, and semi-structured key informant interviews with 24 stakeholders. The spatial analysis operates at two complementary scales: a district-level land use and land cover (LULC) analysis for 1990–2020 documenting the loss of over 400 km<sup>2</sup> of vegetation and a fourfold expansion of built-up area across Lahore district (Amin, 2024), and a peri-urban fringe analysis for 2000–2022 revealing that wetlands contracted by 73 percent and 87 km<sup>2</sup> of natural flood attenuation capacity was converted to built-up use. Together, these scales of evidence establish that Lahore's flood vulnerability is the cumulative product of sustained, multi-decadal land cover transformation operating across the full urban system. The research identifies critical disconnects between the Urban Unit's development plans and NDMA's risk assessments, highlighting institutional silos as the primary barrier to integrated resilience planning. Qualitative thematic analysis reveals five dominant barrier themes: institutional silos, weak data-sharing mechanisms, regulatory enforcement gaps, community exclusion, and capacity deficits. The findings propose a context-specific Resilience Integration Framework (RIF) comprising four mutually reinforcing pillars: risk-informed spatial planning, institutional integration, green infrastructure embedding, and community-based risk knowledge integration. This research contributes original empirical insight to the emerging discourse on disaster-resilient urbanism in South Asian contexts, offering replicable policy recommendations for cities facing similar trajectories of climate risk and unregulated urban growth.

**Keywords:** Disaster Risk Reduction, Urban Land Use Planning, Flood Resilience, Peri-Urban Areas, Sustainable Development, Climate Adaptation, Pakistan

**Thematic Area:** Integrated Urban Planning and Local Resource Management



## 1. Introduction

Urbanization is one of the defining forces reshaping the built and natural environment of the twenty-first century. By 2050, an estimated 68 percent of the world's population is projected to reside in urban areas, with the most rapid growth occurring in cities across Asia and Africa (UN-Habitat, 2022). This demographic shift carries profound implications for disaster risk: as cities expand into peri-urban fringes that overlap with floodplains, wetlands, and ecologically sensitive zones, populations increasingly settle in areas that are inherently hazardous. In South Asia alone, flood events have cost millions of lives and billions of dollars in economic losses over the past two decades (World Bank, 2022).

Pakistan exemplifies this vulnerability in acute form. The country is consistently ranked among the ten most climate-vulnerable nations globally, rooted in its exposure to monsoon-driven floods, glacial lake outburst floods (GLOFs), and the compounding effects of rapid, unplanned urban growth (NDMA, 2023; ND-GAIN, 2024). The catastrophic 2022 monsoon floods inundated one-third of the country, affected over 33 million people, and caused approximately USD 30 billion in damages, revealing the profound inadequacy of existing disaster risk governance structures (NDMA, 2023; OCHA, 2022).

Lahore, the cultural and economic capital of Punjab Province and Pakistan's second-largest city with a population estimated at over 14 million, has experienced dramatic spatial expansion over the past three decades. The city's built-up area grew from approximately 150 km<sup>2</sup> in 1990 to over 620 km<sup>2</sup> by 2022, with significant encroachment into floodplain zones along the River Ravi and its tributaries (Urban Unit, 2021; Ali & Mahmood, 2024). Lahore carries the largest settlement area exposed to both fluvial flooding (163 km<sup>2</sup>) and pluvial flooding (129 km<sup>2</sup>) among Pakistani cities (World Bank, 2022).

Despite a well-established global policy architecture for disaster risk reduction anchored by the Sendai Framework for Disaster Risk Reduction 2015-2030, the Paris Agreement, and the New Urban Agenda, the translation of DRR principles into local land use planning decisions remains deeply inadequate, especially in low- and middle-income countries (UNDRR, 2023; ISC, 2023). This paper intervenes in this gap by examining how disaster risk reduction can be systematically integrated into urban land by using Lahore's flood-prone peri-urban fringe as its empirical canvas. Three primary research questions guide the study:

- What are the key spatial and institutional barriers to integrating flood hazard data into land use planning in Lahore's peri-urban zones?
- How do existing zoning regulations, floodplain management policies, and green infrastructure provisions align with or diverge from DRR principles?
- What framework can guide the institutionalization of flood-resilient spatial planning in comparable South Asian urban contexts?

## 2. Literature Review

### ***2.1 Disaster Risk Reduction and Urban Planning: Conceptual Linkages***

The intersection of disaster risk reduction and urban planning has become one of the most productive conceptual frontiers in both disciplines. The shift toward a risk reduction paradigm associated with the Hyogo Framework for Action (2005-2015) and consolidated by the Sendai Framework (2015-2030) repositioned prevention and mitigation as primary objectives, recognizing that disaster losses result from underlying risk conditions rather than hazard magnitude alone (UNDRR, 2015; Wisner et al., 2004). The Sendai Framework's midterm review (2023) found that while progress has been made in establishing national DRR strategies, integration into subnational spatial planning remains critically weak, especially in developing country urban contexts (ISC, 2023).

The concept of risk-sensitive land use planning (RSLUP) has emerged as an operational bridge between DRR and urban planning. RSLUP involves the systematic incorporation of multi-hazard risk information into planning processes, including the mapping of flood hazard zones, regulation of floodplain encroachment, and protection of ecological buffers (Mitchell, 2012; UNDRR, 2022). In practice, RSLUP requires not only technical tools GIS-based risk mapping, hydrological modelling, scenario analysis but also



institutional mechanisms that enable hazard agencies and planning authorities to share data and coordinate decisions (Meerow et al., 2016).

### **2.2 Urban Resilience and the Role of Green Infrastructure**

Urban resilience broadly defined as the capacity of urban systems and their inhabitants to absorb, adapt to, and recover from shocks and stresses has emerged as a dominant framework for thinking about cities and disaster risk (Meerow et al., 2016; Folke et al., 2010). Green infrastructure (GI) encompasses a range of nature-based solutions riparian buffer zones, urban wetlands, retention ponds, permeable pavements, bioswales, and green roofs that attenuate storm runoff, enhance infiltration, reduce peak flows, and sequester water during flood events (Gupta & De, 2024; Liu & Zhang, 2025). A systematic review by Caroppi et al. (2023) found that green infrastructure consistently reduces urban flood risk across diverse contexts, though its effectiveness is strongly mediated by design integration, spatial coverage, and maintenance regimes.

Floodplain management represents another critical spatial planning tool. In high-income countries, floodplain zoning has demonstrated significant risk reduction benefits. However, in developing country contexts, floodplain encroachment continues because of weak enforcement capacity, politicized planning decisions, and the absence of affordable alternative settlement options for low-income households (Dodman et al., 2019; UN-Habitat, 2022). Recent scholarship highlights the vulnerability of peri-urban areas, which are characterized by rapid and often unplanned spatial change, incomplete infrastructure provision, contested land governance, and variable adaptive capacity (Salem et al., 2025).

### **2.3 Institutional Barriers to DRR-Planning Integration in South Asia**

A growing body of empirical research has documented the institutional barriers preventing effective integration of DRR into urban spatial planning in South Asian contexts. These barriers operate at multiple levels political, administrative, technical, and financial and collectively produce what Revi et al. (2014) describe as institutional silos between hazard management agencies and planning authorities. In Pakistan, the vertical structure of the National Disaster Management Act (2010) creates a three-tiered disaster management system lacking explicit horizontal linkages to urban planning authorities (NDMA, 2023). Capacity constraints compound institutional fragmentation: municipal planning departments in Pakistani cities typically lack the technical expertise and computational infrastructure to interpret and apply spatial risk data (NDMA, 2023; Ahmed et al., 2023).

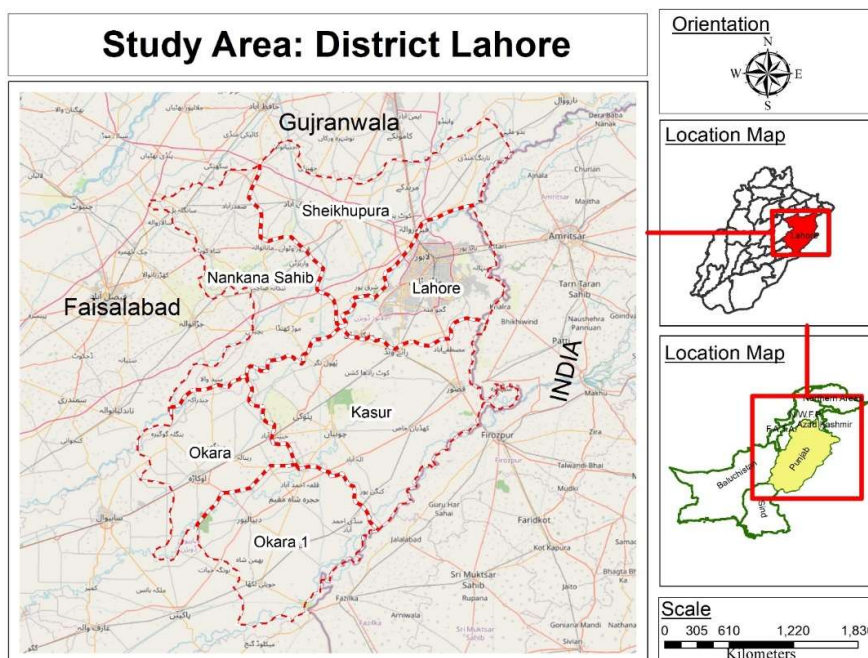
## **3. Methodology**

### **3.1 Research Design**

This study employs a mixed-method research design combining spatial analysis, policy document review, and qualitative data collection through key informant interviews. The mixed-method approach is appropriate for research that seeks to understand both the biophysical dimensions of flood risk and the institutional and political dimensions of governance responses. The case study method using Lahore's peri-urban fringe as the primary empirical site enables in-depth contextual analysis while generating transferable findings (Yin, 2018). The analytical framework integrates three theoretical perspectives: risk-sensitive land use planning (Mitchell, 2012); urban resilience theory (Meerow et al., 2016); and institutional analysis drawing on Ostrom's (1990) principles for governance of common pool resources.

### **3.2 Study Area**

The study area encompasses Lahore's peri-urban fringe, defined as the belt of rapidly urbanizing settlements within a 10-to-30-kilometer radius of the historic urban core. This zone includes areas administered by Lahore Development Authority (LDA), Cantonment Boards, and various Town Committees, as well as large, unplanned settlement clusters outside formal administrative jurisdictions. The study focuses specifically on low-lying sub-districts along the River Ravi's left bank and its tributary streams areas repeatedly inundated during monsoon seasons (2010, 2014, 2020, 2022). Table 1 presents key characteristics of the principal sub-zones within the study area.



**Table 1**  
*Study Area Sub-Zone Characteristics and Flood Risk Classification*

Sub-District / Zone	Area (km <sup>2</sup> )	Population (est.)	Flood Risk Level
Shahdara – Head Islam Corridor	38.4	~420,000	<b>High (Fluvial)</b>
Babu Sabu – Gajjumatta	22.7	~290,000	<b>High (Fluvial + Pluvial)</b>
Lahore-Sheikhupura Corridor	31.2	~510,000	<b>High (Pluvial)</b>
Main Canal Transitional Zone	18.9	~195,000	<b>Medium</b>
Eastern Fringe (Former Agri Depressions)	27.5	~360,000	<b>High (Pluvial)</b>
DHA Newer Phases (Gated Developments)	24.3	~140,000	<b>Low (Private Infra)</b>

Source: Urban Unit (2021); PDMA Punjab (2022); World Bank (2022); Authors' spatial analysis. Population figures are 2022 estimates.

**3.3 Spatial Analysis**

The spatial analysis component involved the compilation and analysis of multiple geospatial datasets to produce a composite flood risk assessment. Datasets included: (a) 30-meter resolution Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM); (b) Land Use/Land Cover (LULC) change data derived from Landsat 8 OLI satellite imagery for 2000, 2010, and 2022, processed using the Random Forest classification algorithm in Google Earth Engine; (c) historical flood inundation records from NDMA and PDMA for the 2010, 2014, 2020, and 2022 flood events; (d) drainage network data from the Water and Sanitation Agency (WASA) Lahore; and (e) settlement boundary and density data from the Urban Unit's spatial database. These were integrated in QGIS to produce flood hazard zone maps, settlement exposure maps, and land use change analysis.

**3.4 Policy Document Analysis**

Policy document analysis involved the systematic review of 23 documents including the Lahore Master Plan 2021-2041, the National Disaster Management Act (2010), the National Disaster Risk Reduction Policy, the Punjab Local Government Act (2022), the Sendai Framework for Disaster Risk Reduction 2015-2030, SDG progress reports for Pakistan (2022, 2023), and relevant World Bank and UN-Habitat reports. Documents were analysed using a structured coding framework based on six dimensions: presence of flood



hazard data; linkages to DRR frameworks; provisions for floodplain management; green infrastructure requirements; inter-agency coordination mechanisms; and community participation requirements.

3.5 Key Informant Interviews (KII)

A total of 24 semi-structured key informant interviews were conducted between April and May 2026 with three categories of stakeholders. Participants were selected through purposive and snowball sampling to ensure representation of different institutional roles, geographic sub-areas, and socioeconomic positions.

Table 2

Key Informant Interview Sample Profile

Table with 4 columns: Stakeholder Category, n, Institutional Affiliation, and Primary Theme Contribution. Rows include Urban Planners & Spatial Planning Professionals, DRR & Disaster Management Professionals, Community Leaders & Civil Society, and a TOTAL row.

Source: Authors' primary data (2024). Snowball and purposive sampling; interviews conducted April-May 2026.

4. Findings

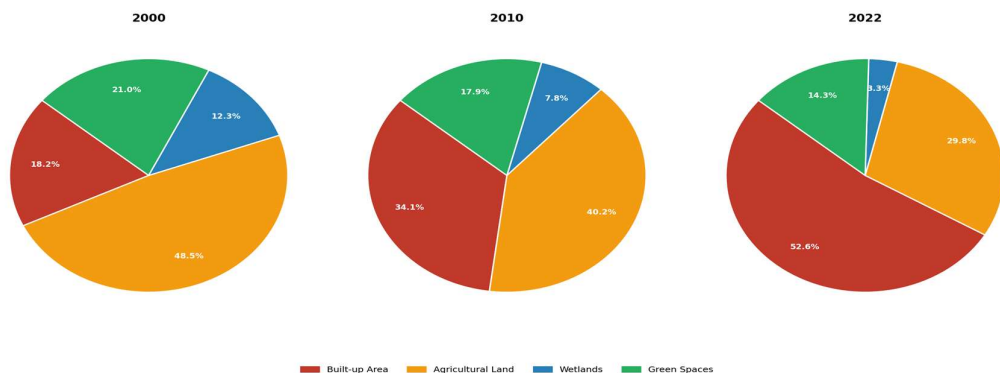
4.1 Spatial Analysis: The Geography of Flood Risk

The LULC change analysis reveals a dramatic transformation of Lahore's peri-urban landscape over the 2000-2022 period. Built-up area increased from 18.2% to 52.6% of the study area, while agricultural land declined from 48.5% to 29.8%, wetlands contracted from 12.3% to just 3.3%, and green spaces fell from 21.0% to 14.3%.

Figure 1

Land Use/Land Cover Change in Lahore Peri-Urban Fringe (2000–2022).

Figure 1: Land Use / Land Cover Change in Lahore Peri-Urban Fringe (2000–2022)



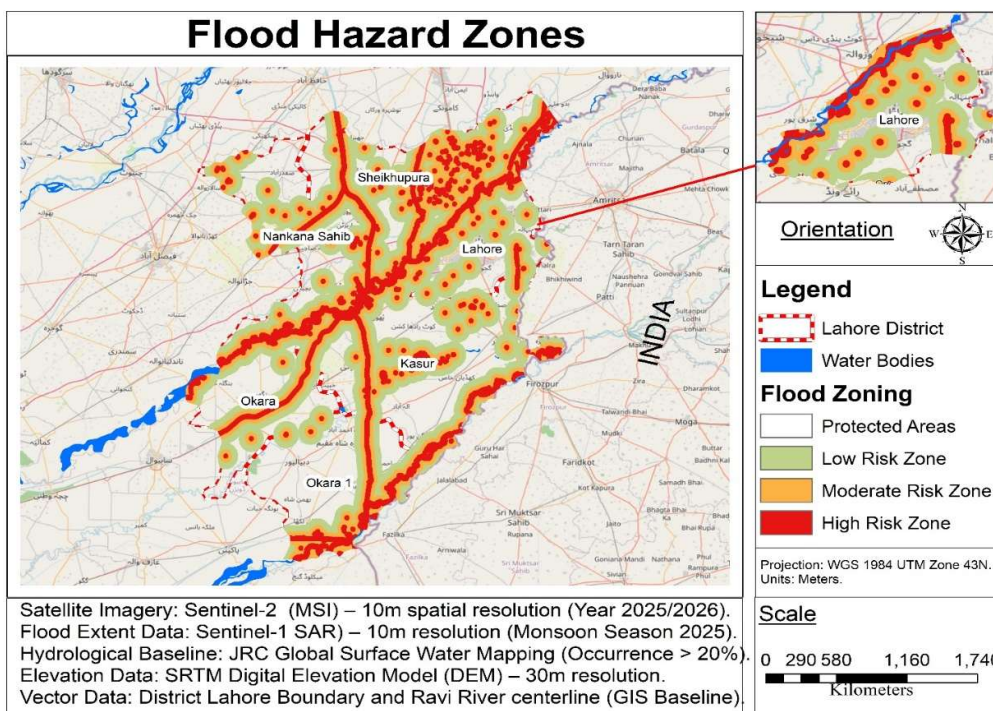
Source: Landsat 8 OLI, Google Earth Engine, Random Forest Classification; Author's analysis. Built-up area grew from 18.2% to 52.6%, wetlands contracted by 73% (2000–2022).



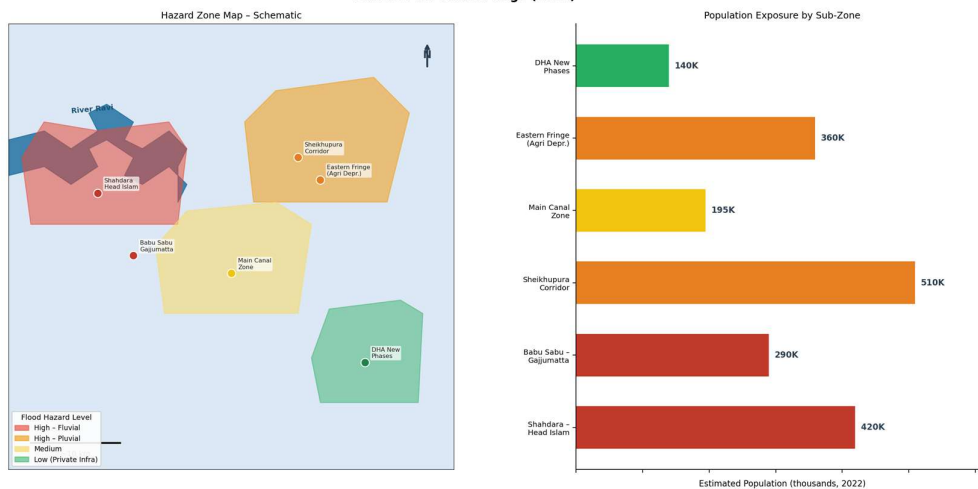
Pie charts show the proportion of built-up areas, agricultural land, wetlands, and green spaces for each period. Built-up cover expanded from 18.2% to 52.6%; wetlands contracted from 12.3% to 3.3% (-73%).  
 Source: Landsat 8 OLI; Google Earth Engine Random Forest Classification; Authors' analysis.

The spatial analysis reveals a stark geography of flood risk across Lahore's peri-urban zone. Approximately 163 km<sup>2</sup> of the city's settled area is exposed to fluvial flooding from the River Ravi and its tributaries, with an additional 129 km<sup>2</sup> exposed to pluvial (rainfall-induced) flooding from the degraded urban drainage network (World Bank, 2022). Figure 2 presents the hazard zone classification by affected settlement area.

**Figure 2**  
 Flood Hazard Zone Classification and Affected Settlement Areas – Lahore Peri-Urban Fringe (2022)



**Figure 2: Flood Hazard Zone Classification & Affected Settlement Areas Lahore Peri-Urban Fringe (2022)**



Source: NDMA; PDMA Punjab; World Bank (2022); Authors' spatial analysis in QGIS. 163 km<sup>2</sup> exposed to fluvial flooding; 129 km<sup>2</sup> to pluvial flooding.

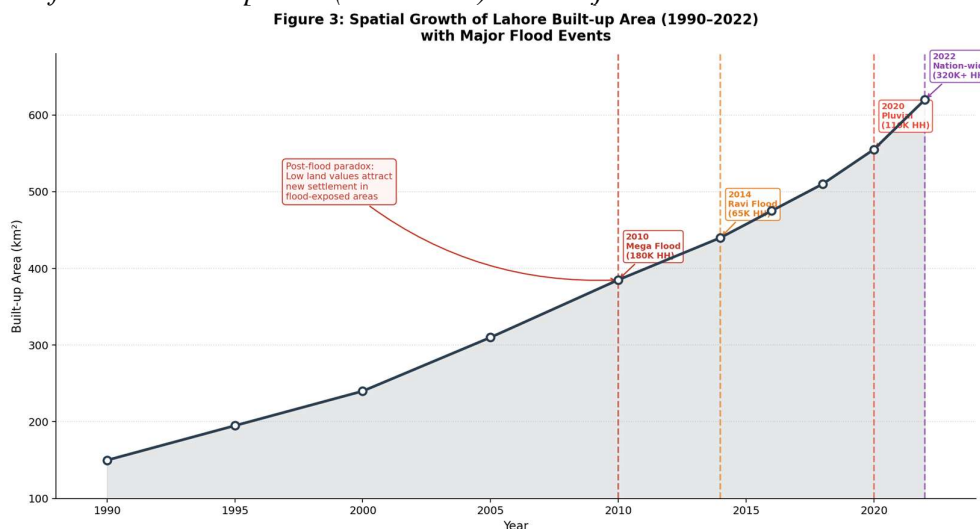


Left: schematic hazard zone map showing fluvial (red) and pluviial (orange) high-risk areas, medium and low-risk zones, and key sub-district locations. Right: horizontal bar chart of population exposure by sub-zone. Source: NDMA; PDMA Punjab; World Bank (2022); Authors' spatial analysis in QGIS.

Figure 3 illustrates the trajectory of urban spatial growth alongside major flood events. The paradoxical pattern of post-flood settlement expansion where areas severely inundated in 2010 subsequently attracted new settlement due to low land values is clearly visible in the steepening of the growth curve after 2010.

**Figure 3**

*Spatial Growth of Lahore Built-up Area (1990–2022) with Major Flood Events.*



**Figure 3: Spatial Growth of Lahore Built-up Area (1990-2022) with Major Flood Events**

The steepening growth trajectory after 2010 reflects the post-flood paradox: low land values in flood-exposed areas continue to attract new settlement. Built-up area expanded from ~150 km<sup>2</sup> (1990) to >620 km<sup>2</sup> (2022). Source: SRTM DEM; Landsat Imagery; Urban Unit (2021); NDMA (2023); Authors' analysis.

Table 3 documents the major flood events in the study area between 2010 and 2022, illustrating the escalating pattern of exposure and loss.

**Table 3**

*Major Flood Events in Lahore Peri-Urban Fringe (2010–2022)*

Flood Event	Primary Cause	Peri-Urban Impact (Lahore)	Estimated Damages (PKR bn)	Households Affected
2010	Extreme monsoon + Ravi overtopping	Inundation of Shahdara, Babu Sabu, Gajjumatta zones	~320	~180,000
2014	Ravi flood peak + blocked drains	Recurrence in riverside settlements	~85	~65,000
2020	Urban pluviial flooding + drainage failure	New Western fringe housing schemes inundated	~140	~110,000
2022	Mega-monsoon (1/3 of Pakistan inundated)	All five high-risk clusters affected; 37.4 km <sup>2</sup> of built-up area inundated	~USD 30bn (national)	~320,000+



*Source: NDMA (2023); PDMA Punjab Annual Reports; OCHA (2022); World Bank (2022). Damage figures are approximate and may include broader Lahore district impacts.*

#### **4.2 District-Level LULC Change in Lahore (1990–2020): Green Space Loss and Urban Expansion**

To contextualize the peri-urban LULC change analysis presented in Section 4.1, it is instructive to situate those findings within the broader, district-wide pattern of urban expansion and green space loss documented for Lahore over the three decades from 1990 to 2020. Amin (2024) conducted a Landsat-based spatiotemporal analysis of land use and land cover change across the full Lahore district using four satellite images Landsat 5 TM scenes for 1990, 2000, and 2010, and a Landsat 8 OLI/TIRS scene for 2020 with supervised classification accuracies ranging from 82 to 92 percent. Four land cover classes were mapped: urban/built-up land, vegetation cover, barren land, and water bodies. The findings reveal a trajectory of sustained urbanization and vegetation loss that directly amplifies the district's flood vulnerability.

Between 1990 and 2000, vegetation cover across the Lahore district declined from 1,205 km<sup>2</sup> to 870 km<sup>2</sup> a loss of 335 km<sup>2</sup> in a single decade while built-up area more than doubled from 218 km<sup>2</sup> to 460 km<sup>2</sup>. This first decade corresponds to the rapid intensification of urbanization centered on the Walled City and its immediate hinterland. Between 2000 and 2010, urban expansion continued at pace: vegetation declined further to 671 km<sup>2</sup> and built-up area reached 582 km<sup>2</sup>, with Shalimar, Cantonment, Gulberg, Samanabad, and Iqbal Town recording the highest rates of built-up expansion (Amin, 2024). The cumulative vegetation loss over these two decades 534 km<sup>2</sup> relative to the 1990 baseline represents a dramatic contraction of the district's natural water retention and infiltration capacity. By 2020, a partial recovery in vegetation to 812 km<sup>2</sup> was recorded, attributable to the incorporation of landscaped parks and green amenities in newer housing societies developed on former barren land. Critically, however, built-up area had by this point reached 846 km<sup>2</sup> nearly a fourfold increase from the 1990 baseline of 218 km<sup>2</sup> and the partial vegetation recovery did not offset the loss of ecologically functional, permeable natural surfaces (Amin, 2024).

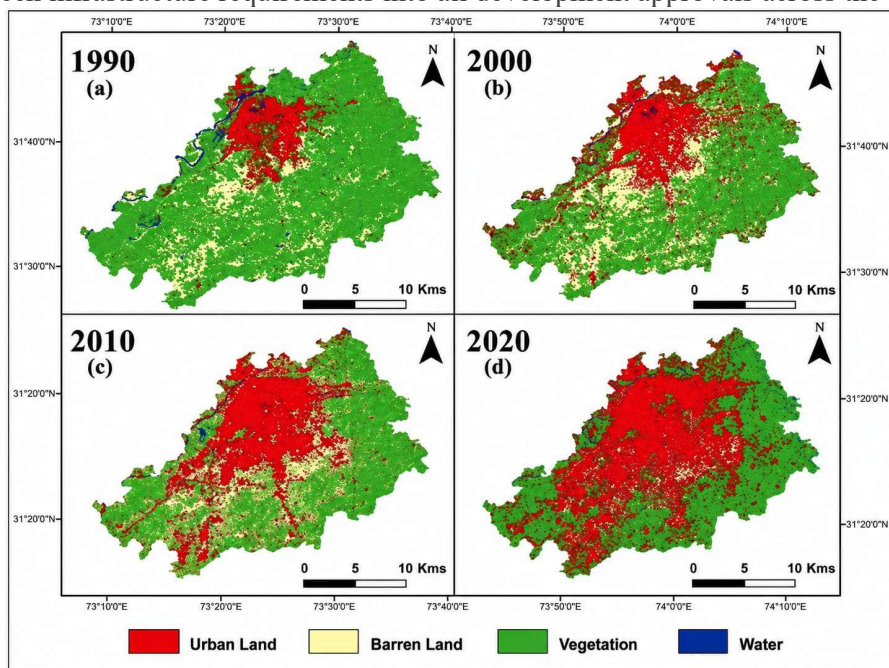
The tehsil-level disaggregation of these data reveals heterogeneous urbanization patterns across the five administrative tehsils Lahore Cantt, Lahore City, Model Town, Raiwind, and Shalimar. Raiwind and Shalimar recorded the highest relative rates of built-up expansion, reflecting their role as frontier zones of urban growth absorbing rural land during the study period. Across all tehsils, the data confirm a consistent inverse relationship between population density increase and green space retention, with per capita green space falling as population density rose in each successive decade (Amin, 2024).

These district-level findings are directly consequential for flood risk. Urban green spaces provide critical hydrological services: they intercept rainfall, promote infiltration, reduce surface runoff velocity, and attenuate flood peaks (Amin, 2024; Gordon, 2007). The progressive replacement of vegetated and permeable surfaces with impervious built-up cover across Lahore's district area from 218 km<sup>2</sup> in 1990 to 846 km<sup>2</sup> by 2020 has fundamentally altered the district's hydrological response, increasing the volume and velocity of stormwater runoff reaching the drainage network and thereby amplifying the frequency and severity of urban flood events documented in Table 3. The district-wide pattern thus provides the macro-scale context within which the more acute peri-urban dynamics identified in Section 4.1 are embedded: both scales of analysis converge on the same structural finding that decades of unmanaged urban expansion have systematically eroded Lahore's natural flood resilience.

Current green space provision in Lahore stands at approximately 5 m<sup>2</sup> per person according to the Lahore Master Plan 2016–2021, which is itself below the World Health Organization's recommended minimum of 9 m<sup>2</sup> per person (Amin, 2024). The spatial distribution of green spaces is also inequitable: newly developed peripheral housing schemes incorporate landscaped amenities, while older, high-density inner-city areas which are precisely the zones most exposed to pluvial flooding remain critically deficient in green infrastructure. This distributional inequity compounds the flood vulnerability of socioeconomically marginalized communities concentrated in green-space-poor, high-imperviousness zones. These findings



directly reinforce the case for Pillar 3 of the Resilience Integration Framework (Section 5.3): the mandatory embedding of green infrastructure requirements into all development approvals across the district.



**4.3 Policy Document Analysis: Planning-DRR Disconnect**

The structured policy analysis of 23 documents reveals systematic gaps in DRR-planning integration across Lahore's governance architecture. Table 4 presents the comparative analysis of key planning and disaster risk governance documents across six coding dimensions.

**Table 4**

*Policy Document Analysis Matrix - DRR Integration Across Planning Instruments*

Policy / Planning Document	Flood Hazard Data	Floodplain Mgt.	GI Provisions	Inter-Agency Coordination	Community Participation
Lahore Master Plan 2021-2041	Partial	Absent	Limited	Absent	Minimal
National DM Act 2010	Present	Partial	Absent	<b>Mandated</b>	Mentioned
Punjab Local Govt. Act 2022	Absent	Absent	Absent	Absent	Partial
NDMA NDRR Strategy 2025-2030	<b>Present</b>	<b>Present</b>	Partial	<b>Mandated</b>	Endorsed
Sendai Framework 2015-2030	<b>Present</b>	<b>Present</b>	<b>Present</b>	<b>Present</b>	<b>Present</b>
PDMA Monsoon Reports (Annual)	<b>Present</b>	Absent	Absent	Absent	Absent

Source: Authors' systematic document analysis (2024). Assessment based on structured coding framework. "Present" = explicitly mandated; "Partial" = mentioned but not operationalized; "Absent" = no provision found.



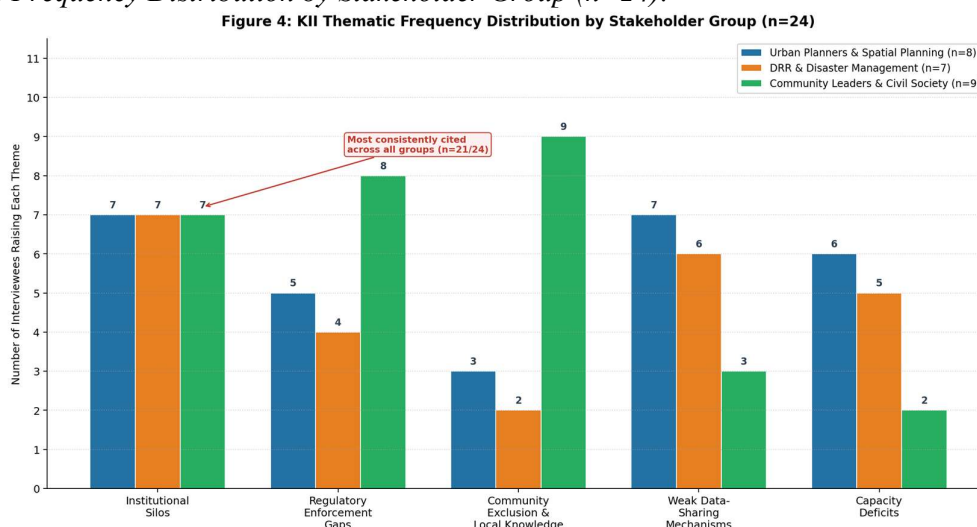
The analysis reveals that the Lahore Master Plan 2021-2041 the primary land use planning instrument for the study area scores "Absent" or "Minimal" on four of six DRR integration dimensions. While the Plan acknowledges climate risk in its environmental sustainability chapter, it contains no flood hazard overlay maps, no risk-graded development restrictions, and no binding provisions requiring flood risk assessment as a precondition for development approval. By contrast, the Sendai Framework scores "Present" on all six dimensions, illustrating the significant gap between global DRR norms and their local operationalization.

4.4 Qualitative Analysis: Key Informant Interview Findings

Thematic analysis of the 24 KII transcripts identified five dominant barrier themes, with varying salience across stakeholder groups. Figure 4 presents the frequency distribution of barrier themes across the three stakeholder categories.

Figure 4

KII Thematic Frequency Distribution by Stakeholder Group (n=24).



Source: Authors' primary data (2024), n=24 interviewees. Respondents could identify multiple themes; values represent number of interviewees raising each theme. Thematic analysis per Braun & Clarke (2006).

Grouped bar chart showing the number of interviewees raising each of the five barrier themes, disaggregated by stakeholder category. Institutional silos was the most consistently cited barrier (n=21/24). Respondents could identify multiple themes. Source: Authors' primary data (2024); thematic analysis per Braun & Clarke (2006).

4.4.1 Theme 1: Institutional Silos. Institutional fragmentation was the most consistently cited barrier across all three stakeholder groups (n=21/24 respondents). Urban planners described a planning process in which flood hazard data, when available, was not systematically incorporated into development plan preparation. One senior Urban Unit planner described the disconnect in these terms (Interview 3, March 2024):

"We receive PDMA's annual flood reports, but there is no formal mechanism to translate those risk assessments into our zoning maps or approval criteria. The two systems run on parallel tracks."

DRR professionals from PDMA confirmed that requests from the Urban Unit for spatial hazard data were "occasional and informal," without a structured data-sharing protocol (Interview 11, April 2024).

4.4.2 Theme 2: Regulatory Enforcement Gaps. Regulatory enforcement gaps were most prominently identified by community stakeholders (n=8/9). Community informants described multiple instances of housing scheme approvals in known flood zones, sometimes with the tacit approval of local political representatives. A civil society representative in Babu Sabu noted (Interview 20, June 2024):

"Every year after the floods, officials come and promise the area will be protected. The next season, more houses go up in the same spots. Nobody enforces anything."



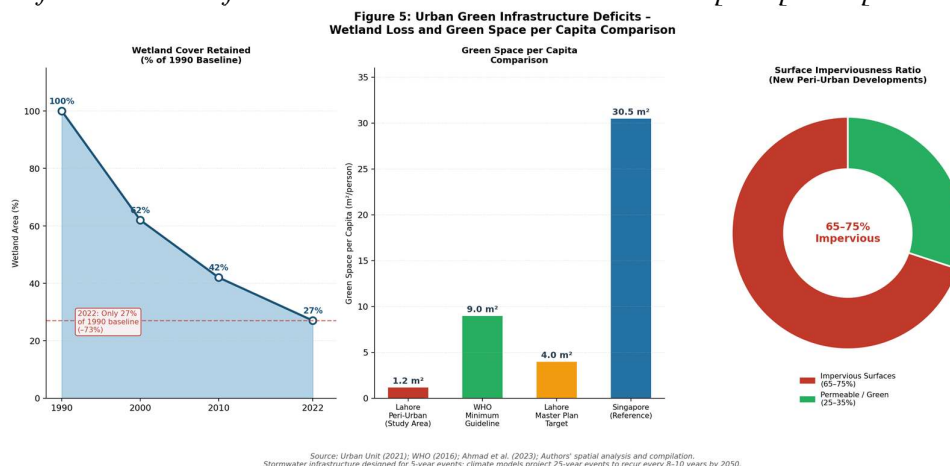
**4.4.3 Theme 3: Community Exclusion and Local Knowledge.** Community-level interviews revealed that peri-urban residents possess nuanced and detailed knowledge of local flood dynamics including flood pathways, relative safety of structures, and seasonal risk indicators that is entirely absent from formal risk assessments and planning documents. Despite this institutional exclusion, communities have developed sophisticated informal risk reduction strategies, including the elevation of ground floors, maintenance of informal drainage channels, and collective monsoon monitoring systems. These strategies represent a valuable but unacknowledged and unsupported foundation for formal DRR-planning integration.

**4.5 Green Infrastructure Deficits**

The spatial analysis reveals severe green infrastructure deficits in the peri-urban study area. Wetlands along the Ravi River have been reduced by an estimated 73 percent since 1990, largely through encroachment facilitated by weak enforcement of wetland protection regulations. Within the peri-urban settlement zone, green space per capita is estimated at 1.2 m<sup>2</sup> per person far below the WHO guideline of 9 m<sup>2</sup> and the Lahore Master Plan's own target of 4 m<sup>2</sup>. Figure 5 presents these deficits visually.

**Figure 5**

*Urban Green Infrastructure Deficits – Wetland Cover Loss and Green Space per Capita Comparison.*



*Left: wetland cover retained as percentage of 1990 baseline (only 27% remained by 2022). Centre: green space per capita in the study area (1.2 m<sup>2</sup>/person) compared against WHO guideline (9 m<sup>2</sup>), Lahore Master Plan target (4 m<sup>2</sup>), and Singapore reference (30.5 m<sup>2</sup>). Right: surface imperviousness ratio in new peri-urban developments (65–75%). Source: Urban Unit (2021); WHO (2016); Ahmad et al. (2023); Authors' analysis.*

The imperviousness ratio of newly developed areas in the peri-urban fringe is estimated at 65 to 75 percent, dramatically increasing flood peak flows and reducing drainage response time. Stormwater drainage capacity assessments found that existing infrastructure is designed for 5-year return period storm events, while climate-adjusted models project that events formerly classified as 25-year events will occur every 8 to 10 years by 2050 (Ahmad et al., 2023).

**5. The Resilience Integration Framework (RIF)**

Based on the empirical findings and grounded in the conceptual literature, this paper proposes the Resilience Integration Framework (RIF) as a structured, context-specific approach to embedding flood risk reduction into urban land use planning in Lahore and comparable South Asian cities. The RIF operates across four interconnected pillars, each addressing a specific dimension of the governance and planning failures identified in the findings. Table 5 presents the framework overview, mapping each pillar to its target governance failure, key mechanisms, and expected outcomes.



Table 5
Resilience Integration Framework (RIF) - Four-Pillar Structure

Table with 4 columns: Pillar, Governance Failure Addressed, Key Mechanisms, and Expected Outcome / Indicator. Rows include Risk-Informed Spatial Planning, Institutional Integration, Green Infrastructure Embedding, and Community-Based Risk Knowledge Integration.

Source: Authors' framework development based on empirical findings, KII data, and conceptual literature review.

5.1 Pillar 1: Risk-Informed Spatial Planning

The first pillar involves the systematic incorporation of flood hazard data into all stages of the spatial planning cycle. Concretely, this requires: mandatory preparation of Flood Hazard Overlay Maps at a minimum scale of 1:10,000 for all planning areas, updated every five years; adoption of risk-graded land use classification that prohibits high-density development in high-hazard zones; incorporation of climate change projections into design flood standards; and establishment of regulatory setbacks along all mapped floodplain boundaries.

5.2 Pillar 2: Institutional Integration

The second pillar addresses institutional silos by establishing structured coordination between planning and disaster management agencies. Key mechanisms include: a Joint Technical Committee (JTC) co-chaired by the Urban Unit and PDMA with a permanent secretariat; a shared geospatial database integrating PDMA flood hazard layers, NDMA risk assessments, and Urban Unit data in interoperable formats; a formal protocol requiring PDMA review and clearance for all development approvals in mapped high-hazard zones with binding recommendations; and capacity development programs to build flood risk literacy among urban planning professionals.

5.3 Pillar 3: Green Infrastructure Embedding

The third pillar responds to the identified green infrastructure deficit by requiring the systematic integration of nature-based solutions into spatial planning and development standards. Specific provisions include: designation of a Peri-Urban Green Infrastructure Network as a protected spatial layer in the Lahore master plan; revision of building and subdivision standards to require a minimum of 20 percent permeable surface coverage in new developments (rising to 35 percent in flood risk zones); mandatory incorporation of on-site storm water management systems in all developments exceeding 0.5 hectares; and a Green



Infrastructure Maintenance Protocol as a condition of occupancy certification. International evidence demonstrates that well-designed urban green infrastructure can reduce peak storm runoff by 30 to 60 percent (Caroppi et al., 2023; Liu & Zhang, 2025).

5.4 Pillar 4: Community-Based Risk Knowledge Integration

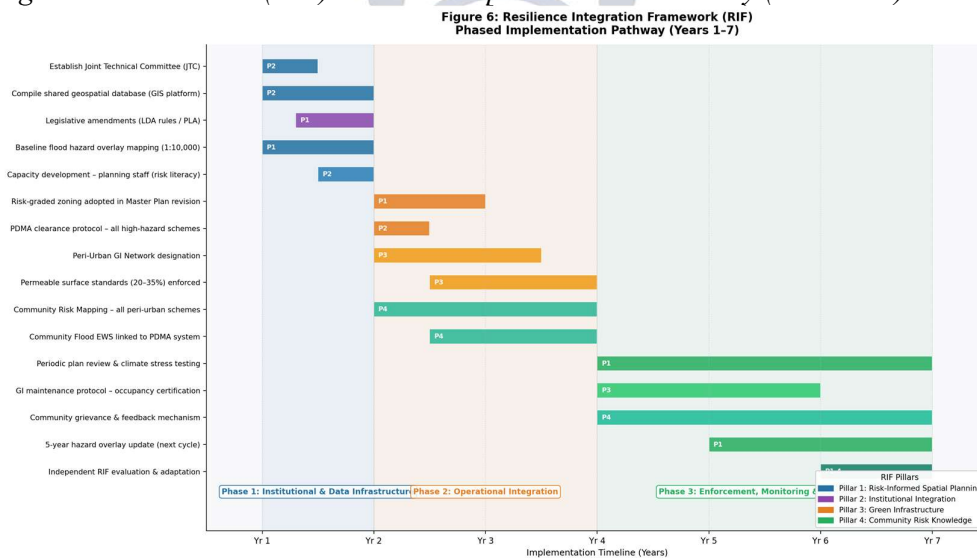
The fourth pillar institutionalizes participatory risk assessment as a required step in the planning cycle. Mechanisms include mandatory Community Risk Mapping exercises for all planning schemes in peri-urban zones; establishment of Community Flood Early Warning Networks linked to PDMA's provincial system; a Grievance and Feedback Mechanism enabling community reporting of unauthorized development; and integration of community-based risk knowledge into Flood Hazard Overlay Map preparation. This reflects a growing evidence base demonstrating that community participation in risk governance improves both the accuracy of risk assessments and the legitimacy of planning decisions (Dodman et al., 2019; UN-Habitat, 2022).

5.5 Implementation Pathway

The RIF is designed as a phased implementation pathway aligned with Lahore's existing planning cycles. Phase 1 (Years 1-2) focuses on institutional and data infrastructure. Phase 2 (Years 2-4) involves operational integration. Phase 3 (Years 4-7) focuses on enforcement, monitoring, and adaptation. Figure 6 presents the implementation Gantt chart.

Figure 6

Resilience Integration Framework (RIF) – Phased Implementation Pathway (Years 1–7).



Source: Authors' framework design. Phase durations are indicative and subject to provincial planning cycles and funding availability.

Gantt chart showing 16 key tasks across three phases, colour-coded by RIF pillar. Phase 1 (Yrs 1–2): institutional and data infrastructure. Phase 2 (Yrs 2–4): operational integration. Phase 3 (Yrs 4–7): enforcement, monitoring, and adaptation. Source: Authors' framework design.

6. Discussion

6.1 Implications for Lahore

The Resilience Integration Framework proposed in this paper represents a significant departure from the status quo of urban governance in Lahore. Its implementation would require political will at the provincial level to revise enabling legislation, substantial investment in institutional capacity, and a fundamental reorientation of development authority culture toward risk-informed decision-making. However, the findings suggest that the cost of inaction measured in lives lost, assets damaged, and development potential destroyed by recurring flood disasters substantially exceeds the costs of institutional reform. The spatial analysis findings, showing that 163 km² of Lahore's settled area is exposed to fluvial flooding and that peri-urban green



infrastructure has declined by 73 percent since 1990, establish a compelling baseline case for urgent intervention.

These exposure figures will only worsen in the absence of structural planning reform: climate projections for Punjab indicate that extreme monsoon events previously classified as 25-year occurrences may recur as frequently as every 8 years by mid-century, amplifying the humanitarian and economic consequences of current governance failures.

### **6.2 Contextual Transferability and Policy Alignment**

The RIF's four-pillar structure reflects governance failures common across South Asian peri-urban contexts. Cities including Dhaka (Bangladesh), Chennai (India), Colombo (Sri Lanka), and Kathmandu (Nepal) exhibit analogous patterns of rapid peri-urban growth, institutional fragmentation between DRR and planning agencies, green infrastructure degradation, and community exclusion from risk governance (UN-Habitat, 2022; Revi et al., 2014). The RIF's modular design facilitates adaptation to other South Asian urban contexts with similar structural characteristics. The framework also directly responds to Pakistan's National Disaster Risk Reduction Strategy 2025-2030, which identifies urban risk governance as a priority area and calls for mainstreaming DRR into provincial and local development plans (NDMA, 2025).

### **6.3 Study Limitations**

This study has several limitations. First, the spatial analysis relies on Landsat imagery and SRTM elevation data at 30-meter resolution, which may not capture fine-grained topographic variability relevant to localized pluvial flood risk. Higher-resolution data drone-based photogrammetry, LiDAR would improve hazard zone delineation precision. Second, the KII sample, while purposively selected for diversity, cannot claim representativeness of all relevant stakeholder groups. Third, RIF is presented as a design framework rather than an evaluated intervention: its operational effectiveness will require empirical testing through pilot implementation.

## **7. Conclusion**

This paper has demonstrated that flood disaster losses experienced annually in Lahore's peri-urban areas are not primarily the result of natural hazard intensity but of accumulated planning failures: land use decisions that have placed growing populations in flood-exposed terrain, degraded the ecological infrastructure that buffered flood impacts, and perpetuated institutional arrangements that prevent risk information from shaping development choices. These findings confirm a core argument of contemporary DRR scholarship: disasters are socially constructed through governance choices, and their reduction requires governance reform at least as much as hazard engineering.

The Resilience Integration Framework offers a structured response through four mutually reinforcing pillars: risk-informed spatial planning, institutional integration, green infrastructure embedding, and community-based risk knowledge integration. The research makes several original contributions. Empirically, it provides the first integrated spatial-institutional analysis of the DRR-planning interface in Lahore's peri-urban fringe, combining spatial risk mapping at two scales—district-level LULC change from 1990 to 2020 (Amin, 2024) and peri-urban fringe analysis from 2000 to 2022—with policy document analysis and community-level qualitative data. Together, these two scales of evidence establish a coherent, multi-scalar picture of flood risk accumulation: built-up area across the district quadrupled from 218 km<sup>2</sup> to 846 km<sup>2</sup> between 1990 and 2020, while vegetation declined by over 400 km<sup>2</sup> before a partial recovery (Amin, 2024); and in the peri-urban fringe alone, wetlands contracted by 73 percent and 87 km<sup>2</sup> of natural flood attenuation capacity was converted to built-up use between 2000 and 2022. Theoretically, the study advances the concept of risk-sensitive land use planning by specifying the institutional mechanisms necessary to make risk sensitivity operational rather than aspirational. Policy-wise, it provides actionable and sequenced recommendations that align with Pakistan's National Disaster Risk Reduction Strategy 2025–2030 and the Sendai Framework's priorities for urban resilience.

As Lahore's peri-urban fringe continues to grow at approximately 3.5 percent annually, each planning cycle that passes without risk integration creates new layers of vulnerable settlement requiring decades of



costly retrofitting. Future research should pursue pilot implementation of the RIF in selected peri-urban communities, quantitative modelling of green infrastructure runoff reduction benefits, and comparative research applying the RIF to other South Asian cities experiencing similar peri-urban risk dynamics. The window for proactive, prevention-oriented planning intervention is narrowing rapidly; the Resilience Integration Framework offers a practical and evidence-based roadmap for seizing that window before it closes.

## References

- Ahmad, I., Shao, Z., & Javed, A. (2023). Urban flood hazard mapping using remote sensing and GIS techniques: A case study of Lahore City, Pakistan. *Water*, 8(9), 373. <https://doi.org/10.3390/w8090373>
- Ali, M., & Mahmood, S. (2024). Geo-spatial assessment of pluvial floods in city district Lahore, Pakistan. *Environmental Monitoring and Assessment*, 196, 189. <https://doi.org/10.1007/s10661-023-12291-6>
- Amin, A. (2024). *Effect of urban green spaces in reducing urban flooding in Lahore, Pakistan* [Unpublished master's thesis]. Government College University Lahore.
- Baig, A., Atif, S., & Tahir, A. (2024). Urban development and the loss of natural streams leads to increased flooding. *Discover Cities*, 1(1), 9. <https://doi.org/10.1007/s44327-024-00010-w>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Caroppi, G., Pugliese, F., Gerundo, C., De Paola, F., & Deidda, R. (2023). Green infrastructure for urban flood resilience: A review of recent literature on bibliometrics, methodologies, and typologies. *Water*, 15(3), 523. <https://doi.org/10.3390/w15030523>
- Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, 18(4), 598–606. <https://doi.org/10.1016/j.gloenvcha.2008.07.013>
- Dodman, D., Hayward, B., Pelling, M., Castán Broto, V., Chow, W., Chu, E., Dawson, R., Khirfan, L., McPhearson, T., Prakash, A., Zheng, Y., & Ziervogel, G. (2022). Cities, settlements and key infrastructure. In H.-O. Pörtner et al. (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability* (pp. 907–1040). Cambridge University Press.
- Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: Integrating resilience, adaptability and transformability. *Ecology and Society*, 15(4), Article 20. <https://doi.org/10.5751/ES-03610-150420>
- Gordon, A. (2007). Urban green space and flood risk mitigation in peri-urban areas. *Landscape and Urban Planning*, 82(4), 197–205.
- Government of Pakistan. (2010). *National Disaster Management Act, 2010*. Ministry of Climate Change.
- Gupta, A., & De, B. (2024). A systematic review on urban blue-green infrastructure in the South Asian region: Recent advancements, applications, and challenges. *Water Science & Technology*, 89(2), 382–403. <https://doi.org/10.2166/wst.2024.005>
- Holzmann, R., & Jørgensen, S. (2001). Social risk management: A new conceptual framework for social protection, and beyond. *International Tax and Public Finance*, 8(4), 529–556. <https://doi.org/10.1023/A:1011247814590>
- International Science Council. (2023). *Report for the mid-term review of the Sendai Framework for Disaster Risk Reduction*. ISC. <https://doi.org/10.24948/2023.01>
- Liu, N., & Zhang, F. (2025). Urban green spaces and flood disaster management: Toward sustainable urban design. *Frontiers in Public Health*, 13, Article 1583978. <https://doi.org/10.3389/fpubh.2025.1583978>
- Lv, J., & Sarker, M. N. I. (2024). Integrated urban systems and climate resilience in Asian cities. *Sustainable Cities and Society*, 108, Article 105445.
- Malik, O. A. (2026). Agentic AI deployment in infrastructure-limited environments: Observability gaps, failure modes, and AI governance primitives. *Journal of Engineering and Computational Intelligence Review*, 4(1), 1–11.



- Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, 147, 38–49. <https://doi.org/10.1016/j.landurbplan.2015.11.011>
- Mitchell, T. (2012). *Risk-sensitive land use planning: An overview* (GFDRR Working Paper). World Bank.
- National Disaster Management Authority. (2023). *National Disaster Risk Reduction Strategy 2025–2030*. Government of Pakistan.
- National Disaster Management Authority. (2025). *Pakistan Infrastructure Risk Atlas*. Government of Pakistan.
- ND-GAIN. (2024). *ND-GAIN country index 2024*. University of Notre Dame Global Adaptation Initiative. <https://gain.nd.edu/our-work/country-index/>
- OCHA. (2022). *Pakistan: Monsoon floods 2022 situation report*. United Nations Office for the Coordination of Humanitarian Affairs.
- OECD. (2019). *Resilient cities: Policies for an urban world*. OECD Publishing.
- Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.
- Pelling, M. (2011). *Adaptation to climate change: From resilience to transformation*. Routledge.
- Revi, A., Satterthwaite, D. E., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R. B. R., Pelling, M., Roberts, D. C., & Solecki, W. (2014). Urban areas. In C. B. Field et al. (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability* (pp. 535–612). IPCC.
- Salem, M., Ravetz, J., Divigalpitiya, P., Rajan, S. C., & Sahana, M. (2025). Land-use management in peri-urban areas. *Frontiers in Sustainable Cities*, 7, Article 1586052. <https://doi.org/10.3389/frsc.2025.1586052>
- UN-Habitat. (2022). *World cities report 2022: Envisaging the future of cities*. United Nations Human Settlements Programme.
- UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. United Nations Office for Disaster Risk Reduction.
- UNDRR. (2022). *Global assessment report on disaster risk reduction 2022*. United Nations Office for Disaster Risk Reduction.
- UNDRR. (2023). *Making Cities Resilient 2030 progress report*. United Nations Office for Disaster Risk Reduction.
- Urban Unit. (2021). *Lahore master plan 2021–2041*. Planning and Development Department, Government of Punjab.
- Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At risk: Natural hazards, people's vulnerability and disasters* (2nd ed.). Routledge.
- World Bank. (2022). *Pakistan cities resilience program: Urban flood and climate risk assessment*. World Bank Group.
- World Bank. (2024). *Sialkot flood exposure assessment* (World Bank South Asia Urban Resilience Series). World Bank Group.
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.
- Zia, A., Nasar-u-Minallah, M., Zahra, S. M., & Hanif, M. (2022). Analysing Lahore through the lens of just city. *Cities*, 137, Article 104295.