Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Shared policy, unequal protection: climate justice and household vulnerability in four flood- and heat-exposed districts of Pakistan

Hadia Saif

hadia.22414012@spir.qau.edu.pk

Quaid-i-Azam University https://orcid.org/0009-0009-8397-6511

Saweeda Rehman

Quaid-i-Azam University

Research Article

Keywords: Climate justice, Social vulnerability, Composite vulnerability index, Adaptation governance, Loss and damage, Pakistan

Posted Date: November 6th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11630833/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: The authors declare no competing interests.

Abstract

Climate justice requires that protection from extreme weather follows social vulnerability, yet this is rarely tested within countries using linked household and governance evidence. This study examined four districts of Pakistan that share one national climate-policy framework but differ in hazard profile: Sohbatpur, Jacobabad, Muzaffargarh and Swat. Using the distributive, procedural and recognition dimensions of climate justice, it combined a survey of 240 climate-affected households, 42 key-informant interviews, screening of 100 public buildings and coding of 12 policy and finance documents. A composite exposure–sensitivity–adaptive-capacity index ranged from 0.78 in Sohbatpur and 0.74 in Jacobabad to 0.66 in Muzaffargarh and 0.51 in Swat; the ordering held under 91% of 20,000 random weighting schemes, and household scores differed strongly between districts (Kruskal–Wallis $H = 197.0$, $p < 0.001$). The most exposed district, Muzaffargarh, was not the most vulnerable. Sanitation deprivation, waterborne disease and distress asset sales were concentrated in the southern districts, whereas savings, home modification and consultation were highest in Swat; only 12–18% of southern households had ever been consulted on adaptation, against 38% in Swat. Other deficits were shared: 85 of 100 buildings required detailed structural assessment, 31% of households had not regained pre-disaster income, and insurance was almost absent. Half of the documents recognised the districts only in general terms. District adaptation capacity and budgets, routine consultation, disaggregated vulnerability data and universal safety standards for schools and health facilities emerge as priorities for just and sustainable climate adaptation.

Introduction

In the late summer of 2022, record monsoon rainfall left roughly one-third of Pakistan under water. The floods affected about 33 million people, killed more than 1,700 and caused damages and losses exceeding US$30 billion (Government of Pakistan et al. 2022). Attribution analysis found that climate change had likely intensified the extreme rainfall over the worst-affected provinces, and that the impacts were amplified by the high vulnerability of the communities exposed (Otto et al. 2023). Pakistan, however, accounts for less than 1% of global greenhouse-gas emissions (Government of Pakistan 2021a). The floods made visible a paradox that now sits at the centre of climate risk management: the populations least responsible for climate change often bear its heaviest and least protected costs (Shue 2014; IPCC 2022).

Climate risk is not distributed evenly within countries either. The same hazard produces different outcomes depending on exposure, sensitivity and the capacity of households and institutions to anticipate, cope and recover (Adger 2006; Thomas et al. 2019). Composite indices built on the decomposition of vulnerability into exposure, sensitivity and adaptive capacity have become a standard tool for describing such differences, from county-level social vulnerability indices (Cutter et al. 2003) to livelihood vulnerability indices for rural communities (Hahn et al. 2009) and recent household-level applications in coastal Africa (Ndenzako et al. 2026). Indices, however, describe where vulnerability concentrates more readily than they explain why public protection so often fails to follow it, and

adaptation interventions can even reinforce the vulnerability they target when they ignore the social and political processes that produce it (Eriksen et al. 2021).

Climate-justice scholarship offers a vocabulary for that explanation. Schlosberg (2007) argued that justice has three connected dimensions: the distribution of burdens and benefits, the procedures through which decisions are made, and the recognition of the identities and circumstances of affected groups. Drawing on Young (1990) and Fraser and Honneth (2003), this framework treats exclusion from decision-making and misrecognition as injustices in their own right rather than merely as causes of maldistribution. Paavola and Adger (2006) carried these principles into adaptation, and later work has applied them to local adaptation planning (Shi et al. 2016; Holland 2017) and to transformative and critical agendas for climate justice (Newell et al. 2021; Sultana 2022). Empirical applications that measure all three dimensions with linked household, infrastructure, governance and documentary evidence nevertheless remain scarce, particularly in South Asia (Schlosberg and Collins 2014; Thomas et al. 2019).

Pakistan provides a demanding test. Since the Eighteenth Amendment of 2010 devolved environmental competence to the provinces, a single national climate-policy architecture, comprising the National Climate Change Policy, the Pakistan Climate Change Act 2017, the Nationally Determined Contribution and the National Adaptation Plan, has been implemented through four provincial administrations of very different capacity (Government of Pakistan 2010, 2017, 2021a, 2021b, 2023a). Previous research has shown that Pakistani state actors frame climate justice mainly as an issue between countries while domestic inequalities in vulnerability receive less attention (Shawoo and McDermott 2020); that top-down design, weak consultation and unclear authority impede implementation of national climate policy (Masud and Khan 2024); and that agricultural vulnerability varies sharply between districts within a single province (Nadeem et al. 2022). Reviews have documented the country’s exposure to floods, heat, drought and glacial hazards (Hussain et al. 2023; World Bank 2022). What is missing is a comparison across provinces that connects measured household vulnerability to the governance processes and policy texts that determine whether vulnerable places are protected.

This article addresses that gap through a comparison of four districts, one in each province, that share a national policy setting but differ in hazard profile and governance capacity: Sohbatpur (Balochistan), Jacobabad (Sindh), Muzaffargarh (Punjab) and Swat (Khyber Pakhtunkhwa). It asks three questions. First, how are climate burdens and protective resources distributed among households, public infrastructure and districts (distributive justice)? Second, how far do affected communities and district institutions have a voice in the decisions that shape their exposure and response (procedural justice)? Third, are the specific vulnerabilities of these districts named and resourced in the policy and finance instruments that allocate adaptation support (recognition justice)? The study contributes an original multi-stream evidence base from all four provinces, an operationalisation of the climate-justice framework for district-level adaptation, and evidence that separates the protection deficits shared by all districts from those that track district vulnerability. Because many hazard-exposed countries implement national adaptation frameworks through decentralised administrations of unequal capacity, and because

the new loss-and-damage fund must decide how to reach subnational communities, the findings are relevant well beyond Pakistan.

Materials and methods

Analytical framework and research design

The study used a convergent mixed-methods comparative case-study design (Creswell and Plano Clark 2018) in which quantitative and qualitative evidence were collected concurrently in 2025, analysed separately and integrated at interpretation (Fig. S1; supplementary texts, figures and tables are in Online Resource 1). The climate-justice framework served as the analytical lens and the vulnerability index as a measurement instrument; keeping these functions separate prevented a numerical score from being treated as an explanation. Each dimension of justice was operationalised through indicators drawn from one or more evidence streams (Table S1). Distributive justice was assessed through household exposure, sensitivity, adaptive capacity, coping, recovery and programme access and through the condition of public buildings. Procedural justice was assessed through household consultation and key-informant evidence on coordination and district participation. Recognition justice was assessed through coding of policy and finance documents and through households' perceptions of whether policymakers understood their problems.

Study area and case selection

The four districts were selected through a combined most-similar and most-different logic (Table S2). They share a national constitutional and policy setting but differ systematically in hazard profile, ecological zone, socio-economic base and governance trajectory, which allows causes of vulnerability common to all four to be separated from district-specific dynamics. Sohbatpur lies on the arid lowland plain of eastern Balochistan, bordering Sindh, and experiences recurrent riverine flooding in the country's least developed province. Jacobabad, on the hot arid plain of upper Sindh, combines recurrent flooding with some of the most extreme humid heat recorded on Earth (Raymond et al. 2020). Muzaffargarh occupies the irrigated floodplain near the confluence of the Indus and Chenab rivers in southern Punjab and was flooded in 2010, 2014, 2022 and 2025. Swat is a mountain valley in Khyber Pakhtunkhwa exposed to flash floods, glacial-lake outburst floods and other mountain hazards, and it underwent a major reconstruction programme after 2010. Because the districts span all four provinces, the design gives national analytical reach without claiming statistical representativeness.

Household survey

The target population was households that had experienced flood, heatwave or related hazard impacts between 2015 and 2025. Within each district, the sampling frame was built from the most recent electoral rolls and union-council household listings, cross-referenced against district disaster-

management records of the union councils most affected by recent hazards. Households were reached through a four-stage cluster procedure. First, three union councils were selected purposively in each district on the basis of documented flood or heat exposure. Second, two settlements, a village and an urban neighbourhood where available, were chosen within each union council, giving six settlements per district. Third, ten households were drawn in each settlement by systematic random sampling from the settlement listing (every *k*-th household), with a defined replacement rule for unavailable or declining households. Fourth, the head of household or the most senior available adult was interviewed; where a male head was absent, the senior female member was interviewed directly so that gendered experience entered the data. Three union councils × two settlements × ten households gave 60 households per district and 240 in total.

Sample size was determined with Cochran's formula, $n_0 = z^2 p(1 - p)/e^2$ (Cochran 1977). With $z = 1.96$ for 95% confidence, $p = 0.5$ and a margin of error $e = 0.05$, a pooled estimate would require about 385 households. Equal allocation of 60 households per district was chosen instead to support between-district comparison, to remain above the conventional minimum of 30 per group and to keep fieldwork feasible. The pooled margin of error is therefore about ± 6.3 percentage points and the district-level margin about ± 12.7 points, and district estimates are reported with 95% confidence intervals (Text S1).

The structured questionnaire (Table S3) covered household composition, exposure history, coping, water, sanitation and shelter, programme access, recognition and procedural perceptions, economic impact and recovery, and risk perception. It was translated into Urdu, Sindhi, Balochi, Saraiki and Pashto, back-translated, piloted and administered by trained enumerators; poverty status was recorded against the national poverty line.

Vulnerability index

Exposure, sensitivity and adaptive-capacity sub-indices were each built from four to six survey indicators (Table S3): the exposure sub-index drew on the climate-exposure items, the sensitivity sub-index on the household-composition, poverty and water, sanitation and health items, and the adaptive-capacity sub-index on the coping, insurance, savings, home-modification and programme-access items. Binary items were scored 0 or 1 and continuous or ordinal items were rescaled to 0–1 by min–max normalisation, and indicators were averaged with equal weights within each sub-index. Adaptive capacity was inverted so that higher values always denote greater vulnerability, and the composite index was the unweighted mean of the three sub-indices (OECD and JRC 2008; Hahn et al. 2009). District values were aggregated from household scores. Because weighting and aggregation are normative choices, robustness was examined in four ways: geometric instead of arithmetic aggregation; the Intergovernmental Panel on Climate Change formulation of the livelihood vulnerability index, (exposure − adaptive capacity) × sensitivity (Hahn et al. 2009); omitting each sub-index in turn; and 20,000 random weight vectors drawn from a flat Dirichlet distribution, recording how often the district ordering was preserved. As a complementary household-level measure, each household received an additive score counting 38 binary

vulnerability flags recorded in the questionnaire (range 0–38). Because both measures derive from the same survey, they are treated as convergent rather than independent evidence.

Key-informant interviews

Forty-two semi-structured interviews were conducted through stratified purposive sampling across four tiers: federal officials and policy experts (*n* = 6); provincial disaster-management and climate staff (*n* = 10); district administration and line-department officials (*n* = 14); and community representatives, including local-government members, traditional leaders and civil-society actors (*n* = 12). The guide covered inter-tier coordination, climate finance, recognition and participation, and the gap between commitments and delivery (Text S2). Transcripts and open-ended survey responses were analysed thematically (Braun and Clarke 2006), combining deductive codes for the three dimensions of justice with inductive sub-codes. A second coder independently coded a 20% sub-sample, and inter-coder agreement was assessed with Cohen's κ, with values above 0.75 treated as acceptable following the agreement bands of Landis and Koch (1977); sampling continued until no new themes or categories of actor emerged (Guest et al. 2006). A question-by-question synthesis is given in Table S4.

Screening of public buildings

One hundred public and community buildings (schools, health facilities, water-supply structures and government or community buildings), 25 per district, were selected purposively from locations with documented flood or hazard exposure. A plain-language screening form adapted the pre-screening logic of rapid visual screening (FEMA 2015) to visible signs that a non-engineer can judge reliably, with checklists for structural warning signs, maintenance needs, urgent hazards and gaps in accessibility, water and sanitation (Text S3). A decision rule classified each site into one of five outcomes: safe; usable but needing improvements to inclusion or water and sanitation; needing repair; needing urgent safety action; or unsafe and requiring detailed engineering assessment, with any structural warning sign triggering referral. Forms were completed on site by facility custodians or district focal persons without engineering training, trained under the study protocol, and countersigned by the researcher. The screening identifies buildings for engineering assessment; it is not itself a structural assessment.

Document analysis

Twelve policy and finance texts at national (*n* = 5), provincial (*n* = 4), international (*n* = 2) and district (*n* = 1) levels were coded with a structured protocol covering allocation (distributive), participation (procedural), and the naming of the case districts and marginal groups (recognition). Recognition strength was rated on a three-point scale. As applied in the coding, weak meant that vulnerable communities were mentioned only in general terms; partial meant that provinces, or a case district's hazard, were named without district-specific allocations, plans or indicators; and strong meant that a

case district was named with allocations, reconstruction funding or documented local exposure. The documents and coding results are listed in Table S5.

Statistical analysis and integration

Proportions are reported with Wilson 95% confidence intervals (Wilson 1927). Differences between districts in binary and categorical indicators were tested with Pearson's χ^2 test of independence, with *p*-values from 5,000 Monte Carlo permutations because some expected cell counts were below five, and Cramér's *V* as the effect size. The 38-point score was compared with the Kruskal–Wallis test (effect size ε^2), followed by pairwise Mann–Whitney *U* tests with Holm correction (Holm 1979) and rank-biserial correlations. Because households were clustered within localities, *p*-values are likely to be somewhat anti-conservative, so interpretation emphasises effect sizes and consistency across evidence streams. Analyses were run in Python 3 with SciPy and statsmodels. A large language model (Claude, Anthropic; model claude-opus-5-5) was used to help restructure the thesis into article form, to draft the analysis and plotting scripts and for language editing; the authors checked every output against the original data and sources and take full responsibility for the content. The evidence streams were integrated through a joint display that arranged survey results, interview themes, screening results and document codes against the three dimensions of justice (Fetters et al. 2013); agreement across streams increased confidence in a finding, and divergence was treated as informative.

Ethical considerations

Interviewees are identified only by governance tier. Fieldwork avoided active disaster periods and major harvest and religious observances, enumerators were trained in trauma-aware interviewing, respondents showing distress could pause or withdraw, and no financial inducements were offered.

Results

Sample profile

All planned instruments were completed: 240 household surveys, 42 interviews, 100 building screenings and the coding of 12 documents. Deprivation was severe and near-universal in the three southern districts. Every surveyed household in Sohbatpur and Jacobabad and 93% in Muzaffargarh lived below the national poverty line, against 63% in Swat (Table 1; Table S2). Mean monthly household income ranged from 26,836 Pakistani rupees (PKR) in Sohbatpur to PKR 45,331 in Swat, and 65–70% of southern households depended on agriculture, against 42% in Swat. Female-headed households made up 13–20% of the sample, and dwellings in the southern districts were predominantly kacha (mud-built) and owner-occupied.

Composite vulnerability

Composite vulnerability followed a consistent ordering: Sohbatpur 0.78, Jacobabad 0.74, Muzaffargarh 0.66 and Swat 0.51 (Fig. 1a; Table 2). The decomposition shows that exposure alone did not determine vulnerability. Muzaffargarh had the highest exposure sub-index (0.84) but ranked third, because both its sensitivity (0.66) and its inverted adaptive capacity (0.48) were markedly lower than those of Sohbatpur (0.79 and 0.74) and Jacobabad (0.77 and 0.66). Sohbatpur and Jacobabad combined high exposure with high sensitivity and weak adaptive capacity, the configuration in which households face hazards that their resources cannot absorb. Swat had the lowest value on every sub-index.

The ordering was robust. Geometric aggregation (0.78, 0.73, 0.64 and 0.50) and the livelihood vulnerability index formulation (0.43, 0.34, 0.21 and 0.01) reproduced it, as did omitting any one sub-index. Across 20,000 random weighting schemes the full ordering was preserved in 91.1% of cases, Sohbatpur ranked most vulnerable in 98.1% and Swat least vulnerable in all cases; the only reversals moved Muzaffargarh above Jacobabad (8.9% of draws, including 1.9% in which it also ranked first) when weights strongly favoured exposure. At household level the 38-point score differed strongly between districts (Kruskal–Wallis $H = 197.0$, df = 3, $p < 0.001$, $\varepsilon^2 = 0.82$; Fig. 1b). Mean scores were 29.9 (standard deviation 1.6) in Sohbatpur, 28.3 (1.7) in Jacobabad, 24.9 (1.6) in Muzaffargarh and 19.3 (1.6) in Swat. Every pairwise difference remained significant after Holm correction (all $p < 0.001$), with rank-biserial correlations of 0.48 between Sohbatpur and Jacobabad and 0.84–1.00 for all other pairs. Household scores in Swat (range 16–22) did not overlap with those in Sohbatpur or Jacobabad and barely overlapped with those in Muzaffargarh (22–28).

Exposure, sensitivity and health

Flood exposure during 2015–2025 was reported by every household in Sohbatpur and Muzaffargarh, 92% in Jacobabad and 80% in Swat, whereas heat exposure was universal in Jacobabad (100%) against 72–73% in Muzaffargarh and Sohbatpur and 55% in Swat (Fig. 2a; Table 1). Jacobabad therefore carried a distinctive compound burden of flood and extreme heat on the same population. Sensitivity was concentrated where it compounded exposure (Fig. 2b). Between 85% and 88% of households in the three southern districts had no functional toilet, against 42% in Swat ($\chi^2 = 51.2$, $p < 0.001$, $V = 0.46$), and waterborne disease after the most severe event was reported by 98% of households in Sohbatpur and Jacobabad, 80% in Muzaffargarh and 48% in Swat ($V = 0.52$). Lack of reliable clean drinking water was common everywhere (40–67%) and differed less between districts ($V = 0.19$). Drinking water came overwhelmingly from hand pumps and bores in the southern districts (90–98% of households), the shallow groundwater most readily contaminated by floodwater, whereas a quarter of households in Swat had piped supply.

Impacts, coping, buffers and recovery

The most severe event cost a household member paid work for more than 2 weeks in 72% of households in Sohbatpur and 43% in Swat, and caused injury or death in 43% and 13%, respectively (Table 1). Distress sales of assets or livestock followed the vulnerability gradient, at 98% in Sohbatpur, 100% in Jacobabad, 88% in Muzaffargarh and 57% in Swat ($\chi^2 = 59.9$, $p < 0.001$, $V = 0.50$), but other erosive

strategies did not (Fig. 3a). Informal borrowing (55–75%), reduced food consumption (55–60%), withdrawal of children from school (35–55%) and sending a member away for work (38–55%) were common in all four districts, with no significant differences between them (all $p > 0.12$). Protective buffers were scarce everywhere but concentrated in the least vulnerable district (Fig. 3b): 25% of households in Swat had modified their homes for resilience and 27% held formal savings, against 3–12% for each buffer elsewhere, while insurance was almost absent (0–8%).

Damage and recovery were severe and broadly shared. Sixty-one per cent of households reported that their dwelling had been fully destroyed or left them without shelter after the most severe event, with no significant difference between districts ($\chi^2 = 9.9$, df = 9, permutation $p = 0.36$). Only 5–13% had regained their pre-disaster income within 6 months, and 31% (25–37% by district) had not recovered at all at the time of the survey; the distribution of recovery times did not differ significantly between districts ($\chi^2 = 6.8$, df = 9, permutation $p = 0.66$; Fig. 4b).

Programme awareness and access

Programme indicators are reported in Table S6. Awareness of any government climate programme was lowest in Sohbatpur (30%) and highest in Muzaffargarh and Swat (53%; $p = 0.033$). Poverty-targeted support reached the poorest districts: cash transfers from the Benazir Income Support Programme and its Ehsaas component reached 73% of households in Sohbatpur against 32% in Swat ($V = 0.31$), and assistance from non-governmental and international organisations followed the same pattern (58% vs. 23%). Receipt of government relief or recovery support did not differ significantly between districts (38–58%). Awareness of the international Loss and Damage Fund was uniformly low (10–20%).

Public infrastructure and service continuity

Eighty-five of the 100 public buildings screened (95% confidence interval 77–91) were classified as unsafe and requiring detailed engineering assessment, a further eight required urgent safety action and seven needed repair; none was classified as safe or as usable (Fig. 4a). The share classified as unsafe ranged from 96% (24 of 25) in Sohbatpur to 76% (19 of 25) in Swat, but with 25 sites per district this difference was not statistically distinguishable (unsafe vs. all other outcomes, $\chi^2 = 4.0$, df = 3, permutation $p = 0.32$). Field records included tent classrooms replacing damaged blocks, classes held outdoors beside standing water and drainage failure as the most frequent urgent hazard. Service continuity after disasters, as reported by key informants and district records, showed a clearer gradient (Table S7): schools reopened within 60 days at about 30% of affected sites in Sohbatpur against 80% in Swat, and health units were operational within 30 days at about 25% and 85%, respectively.

Governance and implementation

Three governance themes emerged from the interviews (synthesis by question in Table S4). First, coordination was described as event-driven: inter-tier coordination activated around major disasters but receded in ordinary planning, and statutory coordinating bodies met infrequently relative to their mandates. A federal climate-policy official observed:

We have many committees. They meet, minutes are written and circulated. But next year's budget still arrives on the same template as last year's.

Second, provincial capacity was markedly uneven, so that one national policy produced very different provincial delivery. Third, the district tier, which is closest to affected populations, was the weakest link. District respondents reported little contact with provincial climate cells, little or no budget earmarked for adaptation and a working rhythm dominated by post-event response, and in the more peripheral districts climate responsibilities were attached to non-specialist portfolios (Table S7). Respondents described international climate finance as arriving overwhelmingly at the federal level through narrow, project-tied channels, tilted towards loans rather than grants, and constrained by accreditation and proposal-development requirements that left districts with no direct access. The Loss and Damage Fund featured as an aspiration rather than an operational reality, with no pipeline, allocation mechanism or district plan attached to it at the time of fieldwork. Asked what would most improve the situation, respondents across tiers most often named predictable grant-based finance reaching districts, dedicated district climate capacity and budget lines, and disaggregated vulnerability data that would make district need visible to funders.

Procedural and recognition justice

Consultation was rare everywhere but followed the vulnerability gradient: 12% of households in Sohbatpur, 15% in Jacobabad, 18% in Muzaffargarh and 38% in Swat had ever been consulted on any adaptation measure ($\chi^2 = 15.7$, $p = 0.002$, $V = 0.26$; Fig. 5a). Around seven in ten households in every district reported that policymakers did not understand their community's climate problems, and feedback after consultation was rare. In the interview synthesis, community and district respondents generally reported that they had not been consulted in the preparation of major climate documents, and that where consultation occurred it came after decisions had been taken. Swat was the exception at district level, with a dedicated climate officer and more frequent consultation events.

Document coding revealed a recognition gradient by level of government (Fig. 5b). Six of the 12 documents recognised the case districts only in general terms, four partially and two strongly. The five national texts (Government of Pakistan 2017, 2021a, 2021b, 2023a, 2023b) were coded weak (National Climate Change Policy, Climate Change Act and Nationally Determined Contribution) or partial (National Adaptation Plan and the Resilient Recovery, Rehabilitation and Reconstruction Framework, which name provinces but not districts), and both international texts, the Green Climate Fund project documents for Pakistan and the loss-and-damage decisions of the 27th and 28th Conferences of the Parties, were coded weak. Strong recognition appeared only closer to the districts: in the Khyber Pakhtunkhwa post-2010 framework, which funded reconstruction in Swat, and in district disaster-management records. A local-government council member in Sohbatpur summarised the gap:

We are on the list of climate-vulnerable districts. They list us, and list us again the next year. A list is not a road, not a school, not a wall to hold back the river.

Discussion

Four districts that share one national policy architecture differ sharply in climate vulnerability, and the differences are robust to how vulnerability is measured. Read through the climate-justice framework, the evidence shows two layers of injustice: a protection deficit shared by all four districts and, above it, a district-differentiated pattern in which the most vulnerable places have the weakest buffers, the least voice and the least recognition in the texts that allocate adaptation resources.

Exposure does not determine vulnerability

Muzaffargarh was the most exposed district but only the third most vulnerable, while Sohbatpur and Jacobabad combined high exposure with deep sensitivity and weak adaptive capacity. This confirms, for a cross-provincial sample, the long-standing argument that vulnerability is socially produced rather than a direct function of hazard (Adger 2006; Thomas et al. 2019), and it extends to four provinces the subnational heterogeneity that Nadeem et al. (2022) documented for agricultural vulnerability within Punjab. For climate risk management the implication is practical: allocating adaptation resources on the basis of hazard maps alone would under-serve districts such as Sohbatpur and Jacobabad, where sanitation deprivation, waterborne disease and asset depletion convert each flood or heatwave into a prolonged crisis. Composite indices are useful precisely because they make this distinction visible, provided that their weighting choices are tested; here the ordering survived geometric aggregation, an alternative index formulation and most random weighting schemes, which strengthens confidence in using it for prioritisation (OECD and JRC 2008).

A shared protection deficit beneath the gradient

Several deficits did not follow the vulnerability gradient. The condition of public buildings, damage to dwellings, slow recovery, the near absence of insurance and erosive coping strategies such as borrowing, eating less and withdrawing children from school were common to all four districts, including Swat. These are failures of a national protection floor rather than of district governance alone. That 85 of 100 schools, health units and other public buildings in hazard-exposed locations required detailed structural assessment, with none screened as safe, is particularly important because these are the facilities that communities depend on during and after disasters. The finding argues for universal measures, such as systematic safety screening and retrofitting of schools and health facilities in exposed districts and shock-responsive social protection, alongside measures targeted at the most vulnerable districts. The reach of Benazir Income Support Programme cash transfers into the poorest districts suggests that an existing delivery channel could be used to support recovery after shocks, although our data cannot show whether transfers reduced erosive coping.

Procedural exclusion and misrecognition as mechanisms

The district-differentiated layer coincided with procedural and recognition deficits. Swat had the highest household consultation, the only dedicated district climate officer, a partial adaptation budget line, the

most frequent coordination meetings, the strongest recognition in a provincial framework, the best post-disaster service continuity and the lowest vulnerability; Sohbatpur was weakest on almost every one of these measures. This pattern is consistent with the argument that recognition is a precondition for participation and for fair distribution (Schlosberg 2007) and with evidence that procedural justice in local adaptation depends on the political capabilities of affected groups (Holland 2017). It also gives district-level substance to earlier findings that Pakistani climate policy has been designed top-down with little consultation of implementers (Masud and Khan 2024) and that state actors have framed climate justice largely between countries rather than within Pakistan (Shawoo and McDermott 2020). The document analysis shows how misrecognition operates: national and international instruments acknowledged vulnerability in general terms without district-specific allocations or indicators, so that what was not named was not budgeted for. As the Sohbatpur council member put it, being listed as vulnerable is not the same as being protected.

These associations should not be read as causal estimates. With four cases, co-variation between governance and vulnerability cannot be separated from other differences, and Swat's advantages also reflect lower poverty, a more diversified economy and substantial reconstruction investment after 2010. Causality may also run in both directions, since poorer and more peripheral districts may find it harder to secure recognition and staff. The value of the multi-stream design lies in the convergence of independent sources (survey, interviews, records and documents) on the same ordering, which makes the governance pattern a credible explanation that warrants testing with a larger sample of districts.

Connections to adaptation and loss-and-damage finance

The district evidence connects to international climate finance in two ways. Key informants described finance that arrives at the federal level, is weighted towards loans and is difficult for districts to access, and the international texts analysed recognised Pakistan's vulnerability without subnational differentiation. Respondents saw the Fund for Responding to Loss and Damage, operationalised at the 28th Conference of the Parties (UNFCCC 2023), as an aspiration with no pathway to the districts; whether its access modalities can reach subnational institutions in places such as Sohbatpur and Jacobabad is central to its distributive effect. The same three dimensions of justice can be applied to the international architecture, where contested finance accounting (Weikmans and Roberts 2019) and unequal negotiating capacity raise parallel concerns. This study suggests, but cannot test, such a continuity between domestic and international injustice.

Implications for climate risk management

Four practical priorities follow from the evidence. First, districts need dedicated climate-adaptation officers and budget lines, so that the tier closest to affected populations can plan before disasters rather than respond after them. Second, consultation should be institutionalised at union-council level with feedback to participants, and its reach should be monitored as an indicator of procedural justice. Third, national and provincial instruments, including the National Adaptation Plan, should use district- and gender-disaggregated vulnerability data in allocation and monitoring, so that recognition carries

resources. Fourth, a universal programme of rapid screening, engineering assessment and retrofitting of schools and health facilities in hazard-exposed districts, combined with priority investment in water and sanitation in flood-prone southern districts, would address both the shared and the differentiated deficits identified here. Disaggregated vulnerability evidence of the kind assembled in this study is also what funders require to direct adaptation and loss-and-damage finance to where need is greatest.

Limitations

Several limitations qualify these findings. District estimates carry margins of about ± 12.7 percentage points, and localities were selected purposively for documented hazard exposure, so the results describe affected households rather than district populations. Statistical tests did not model clustering within localities. Households recalled events across a 10-year window, and recall of earlier or less severe events is less reliable. The building screening was a non-engineering instrument designed to identify sites for detailed assessment, and its classifications should not be read as structural verdicts. The district index rests on four units, and the governance and service-continuity indicators in Table S7 combine district records with key-informant reports and are indicative. The document sample was small and coded by one coder. Finally, the design is cross-sectional and cannot establish causal effects of governance on vulnerability.

Conclusions

Comparing four districts across Pakistan's four provinces, this study found that climate vulnerability under a shared national policy setting is both differentiated and shared. Composite vulnerability ranged from 0.78 in Sohbatpur to 0.51 in Swat, robustly to measurement choices, and the most exposed district was not the most vulnerable. The differentiated layer of sanitation deprivation, waterborne disease, asset depletion, scarce buffers and low consultation coincided with weak district capacity and with recognition only in general terms in national and international policy and finance texts. The shared layer of unsafe public buildings, severe dwelling damage, slow recovery and near-absent insurance affected all four districts. Protective buffers, district capacity and voice were thus weakest where need was greatest, even though poverty-targeted cash transfers did reach the poorest districts, and the vulnerabilities of peripheral districts were acknowledged without being resourced. Adaptation in Pakistan, and the adaptation and loss-and-damage finance that supports it, will be more effective and more just if it builds district capacity, institutionalises consultation, allocates on disaggregated evidence and guarantees a universal floor of safe public infrastructure. Larger, district-representative and longitudinal studies are needed to test the mechanisms suggested here.

Declarations

Acknowledgments

This article is derived from the first author's MPhil thesis (Saif 2026). The authors thank Kokkyo naki Kodomotachi (KnK) Japan Pakistan, Islamic Help Pakistan and the Yar Muhammad Samejo Educational

Society and Development Organization (YMSESDO) for facilitating field access, enumerator support and community liaison; the federal, provincial and district authorities, including the Provincial and District Disaster Management Authorities, for access to records and interviews; and the households and key informants in Muzaffargarh, Sohbatpur, Jacobabad and Swat who shared their time and experience.

Author contributions

Hadia Saif: conceptualization, methodology, investigation, data curation, formal analysis, visualization, project administration and writing of the original draft. Saweeda Rahman: conceptualization, methodology, supervision, validation, and review and editing of the manuscript. All authors read and approved the final manuscript.

Data availability

The anonymised household dataset and codebook supporting this study are available from the corresponding author on reasonable request. Source data for Figs. 1–5 are provided in Online Resource 2. Interview recordings and transcripts are not publicly available because they could identify participants; anonymised thematic summaries are given in Table S4.

Compliance with ethical standards

Funding Kokkyo naki Kodomotachi (KnK) Japan contributed USD 5,000 towards the costs of fieldwork (no grant number). The funder facilitated field access but had no role in the study design, data analysis, interpretation or the decision to submit the article for publication.

Conflict of interest Kokkyo naki Kodomotachi (KnK) Japan, which part-funded the fieldwork, implements humanitarian and climate-adaptation programmes in Pakistan. The authors declare no other financial or non-financial conflict of interest.

Research involving human participants The study was conducted under the ethics approval for the first author's MPhil research at the School of Politics and International Relations, Quaid-i-Azam University, and in accordance with the University's research-ethics guidance. No animals were involved.

Informed consent Informed consent was obtained from all individual participants, orally and, where literacy permitted, in writing, after the purpose of the study, the voluntary nature of participation, the right to withdraw and the confidentiality protections had been explained. Interviewees consented separately to audio-recording. The article contains no identifiable personal data.

References

1. Adger WN (2006) Vulnerability. Glob Environ Change 16:268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

2. Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual Res Psychol 3:77–101. https://doi.org/10.1191/1478088706qp063oa
3. Cochran WG (1977) Sampling techniques, 3rd edn. Wiley, New York
4. Creswell JW, Plano Clark VL (2018) Designing and conducting mixed methods research, 3rd edn. SAGE, Thousand Oaks
5. Cutter SL, Boruff BJ, Shirley WL (2003) Social vulnerability to environmental hazards. Soc Sci Q 84:242–261. https://doi.org/10.1111/1540-6237.8402002
6. Eriksen S, Schipper ELF, Scoville-Simonds M, Vincent K, Adam HN et al (2021) Adaptation interventions and their effect on vulnerability in developing countries: help, hindrance or irrelevance? World Dev 141:105383. https://doi.org/10.1016/j.worlddev.2020.105383
7. FEMA (2015) Rapid visual screening of buildings for potential seismic hazards: a handbook (FEMA P-154), 3rd edn. Federal Emergency Management Agency, Washington, DC
8. Fetters MD, Curry LA, Creswell JW (2013) Achieving integration in mixed methods designs—principles and practices. Health Serv Res 48:2134–2156. https://doi.org/10.1111/1475-6773.12117
9. Fraser N, Honneth A (2003) Redistribution or recognition? A political-philosophical exchange. Verso, London
10. Government of Pakistan (2010) Constitution (Eighteenth Amendment) Act, 2010 (Act No. X of 2010). National Assembly of Pakistan, Islamabad
11. Government of Pakistan (2017) Pakistan Climate Change Act, 2017 (Act No. XXXIV of 2017). Government of Pakistan, Islamabad
12. Government of Pakistan (2021a) Updated nationally determined contributions 2021. Ministry of Climate Change, Islamabad
13. Government of Pakistan (2021b) National climate change policy (updated 2021). Ministry of Climate Change, Islamabad
14. Government of Pakistan (2023a) National adaptation plan. Ministry of Climate Change and Environmental Coordination, Islamabad
15. Government of Pakistan (2023b) Resilient recovery, rehabilitation and reconstruction framework (4RF). Ministry of Planning, Development and Special Initiatives, Islamabad
16. Government of Pakistan, Bank AD, European Union, United Nations Development Programme, World Bank (2022) Pakistan floods 2022: post-disaster needs assessment. Ministry of Planning, Development and Special Initiatives, Islamabad
17. Guest G, Bunce A, Johnson L (2006) How many interviews are enough? An experiment with data saturation and variability. Field Methods 18:59–82. https://doi.org/10.1177/1525822X05279903
18. Hahn MB, Riederer AM, Foster SO (2009) The livelihood vulnerability index: a pragmatic approach to assessing risks from climate variability and change—a case study in Mozambique. Glob Environ Change 19:74–88. https://doi.org/10.1016/j.gloenvcha.2008.11.002

19. Holland B (2017) Procedural justice in local climate adaptation: political capabilities and transformational change. Environ Polit 26:391–412. https://doi.org/10.1080/09644016.2017.1287625
20. Holm S (1979) A simple sequentially rejective multiple test procedure. Scand J Stat 6:65–70
21. Hussain MA, Shuai Z, Moawwez MA, Umar T, Iqbal MR et al (2023) A review of spatial variations of multiple natural hazards and risk management strategies in Pakistan. Water 15:407. https://doi.org/10.3390/w15030407
22. IPCC (2022) Climate change 2022: impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. https://doi.org/10.1017/9781009325844
23. Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. Biometrics 33:159–174. https://doi.org/10.2307/2529310
24. Masud S, Khan A (2024) Policy implementation barriers in climate change adaptation: the case of Pakistan. Environ Policy Gov 34:42–52. https://doi.org/10.1002/eet.2054
25. Nadeem F, Jacobs B, Cordell D (2022) Mapping agricultural vulnerability to impacts of climate events of Punjab, Pakistan. Reg Environ Change 22:66. https://doi.org/10.1007/s10113-022-01918-y
26. Ndenzako DS, Pauline NM, Nobert J, Masao CA, Mabhuye EB et al (2026) Assessment of tropical cyclone vulnerability of coastal communities in Mtwara Municipal Council, Tanzania: a composite vulnerability index approach. Front Clim 8:1970749. https://doi.org/10.3389/fclim.2026.1970749
27. Newell P, Srivastava S, Naess LO, Torres Contreras GA, Price R (2021) Toward transformative climate justice: an emerging research agenda. Wiley Interdiscip Rev Clim Change 12:e733. https://doi.org/10.1002/wcc.733
28. OECD, JRC (2008) Handbook on constructing composite indicators: methodology and user guide. OECD Publishing, Paris. https://doi.org/10.1787/9789264043466-en
29. Otto FEL, Zachariah M, Saeed F, Siddiqi A, Kamil S et al (2023) Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan. Environ Res Clim 2:025001. https://doi.org/10.1088/2752-5295/acbfd5
30. Paavola J, Adger WN (2006) Fair adaptation to climate change. Ecol Econ 56:594–609. https://doi.org/10.1016/j.ecolecon.2005.03.015
31. Raymond C, Matthews T, Horton RM (2020) The emergence of heat and humidity too severe for human tolerance. Sci Adv 6:eaaw1838. https://doi.org/10.1126/sciadv.aaw1838
32. Saif H (2026) Climate change vulnerability in Pakistan: domestic challenges and international responsibilities. MPhil thesis, Quaid-i-Azam University, Islamabad
33. Schlosberg D (2007) Defining environmental justice: theories, movements, and nature. Oxford University Press, Oxford. https://doi.org/10.1093/acprof:oso/9780199286294.001.0001
34. Schlosberg D, Collins LB (2014) From environmental to climate justice: climate change and the discourse of environmental justice. Wiley Interdiscip Rev Clim Change 5:359–374.

https://doi.org/10.1002/wcc.275
35. Shawoo Z, McDermott CL (2020) Justice through polycentricity? A critical examination of climate justice framings in Pakistani climate policymaking. Clim Policy 20:199–216. https://doi.org/10.1080/14693062.2019.1707640
36. Shi L, Chu E, Anguelovski I, Aylett A, Debats J et al (2016) Roadmap towards justice in urban climate adaptation research. Nat Clim Change 6:131–137. https://doi.org/10.1038/nclimate2841
37. Shue H (2014) Climate justice: vulnerability and protection. Oxford University Press, Oxford
38. Sultana F (2022) Critical climate justice. Geogr J 188:118–124. https://doi.org/10.1111/geoj.12417
39. Thomas K, Hardy RD, Lazrus H, Mendez M, Orlove B et al (2019) Explaining differential vulnerability to climate change: a social science review. Wiley Interdiscip Rev Clim Change 10:e565. https://doi.org/10.1002/wcc.565
40. UNFCCC (2023) Decision 1/CP.28: operationalization of the new funding arrangements, including a fund, for responding to loss and damage referred to in paragraphs 2–3 of decisions 2/CP.27 and 2/CMA.4. United Nations Framework Convention on Climate Change, Bonn
41. Weikmans R, Roberts JT (2019) The international climate finance accounting muddle: is there hope on the horizon? Clim Dev 11:97–111. https://doi.org/10.1080/17565529.2017.1410087
42. Wilson EB (1927) Probable inference, the law of succession, and statistical inference. J Am Stat Assoc 22:209–212. https://doi.org/10.1080/01621459.1927.10502953
43. World Bank (2022) Pakistan country climate and development report. World Bank, Washington, DC. https://doi.org/10.1596/38277
44. Young IM (1990) Justice and the politics of difference. Princeton University Press, Princeton

Tables

Tables 1 and 2 are available in the Supplementary Files section.

Figures

Fig. 1

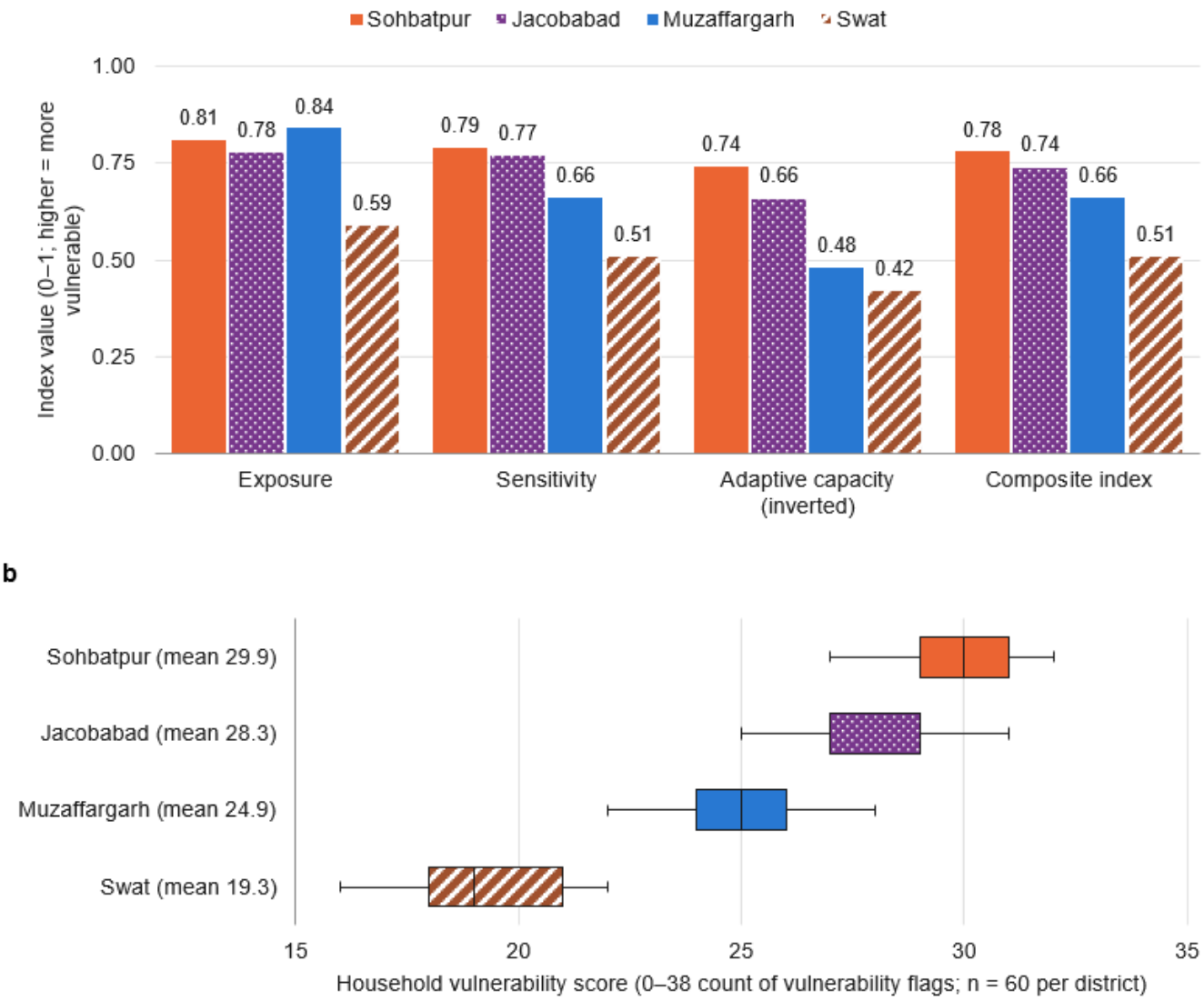


Figure 1

Climate vulnerability by district. **a** Exposure, sensitivity and inverted adaptive-capacity sub-indices and the composite vulnerability index (0–1; higher values denote greater vulnerability). The vertical line separates the sub-indices from the composite. **b** Distribution of the household vulnerability score (additive count of 38 binary flags; *n* = 60 households per district). Boxes show the interquartile range and median, whiskers the range, and points individual households (jittered). Kruskal–Wallis $H = 197.0$, df = 3, $p < 0.001$, $\varepsilon^2 = 0.82$. Districts are identified by the same colours in Figs. 1–3 and 5a, where Jacobabad bars also carry a dot pattern and Swat bars a diagonal pattern

Fig. 2

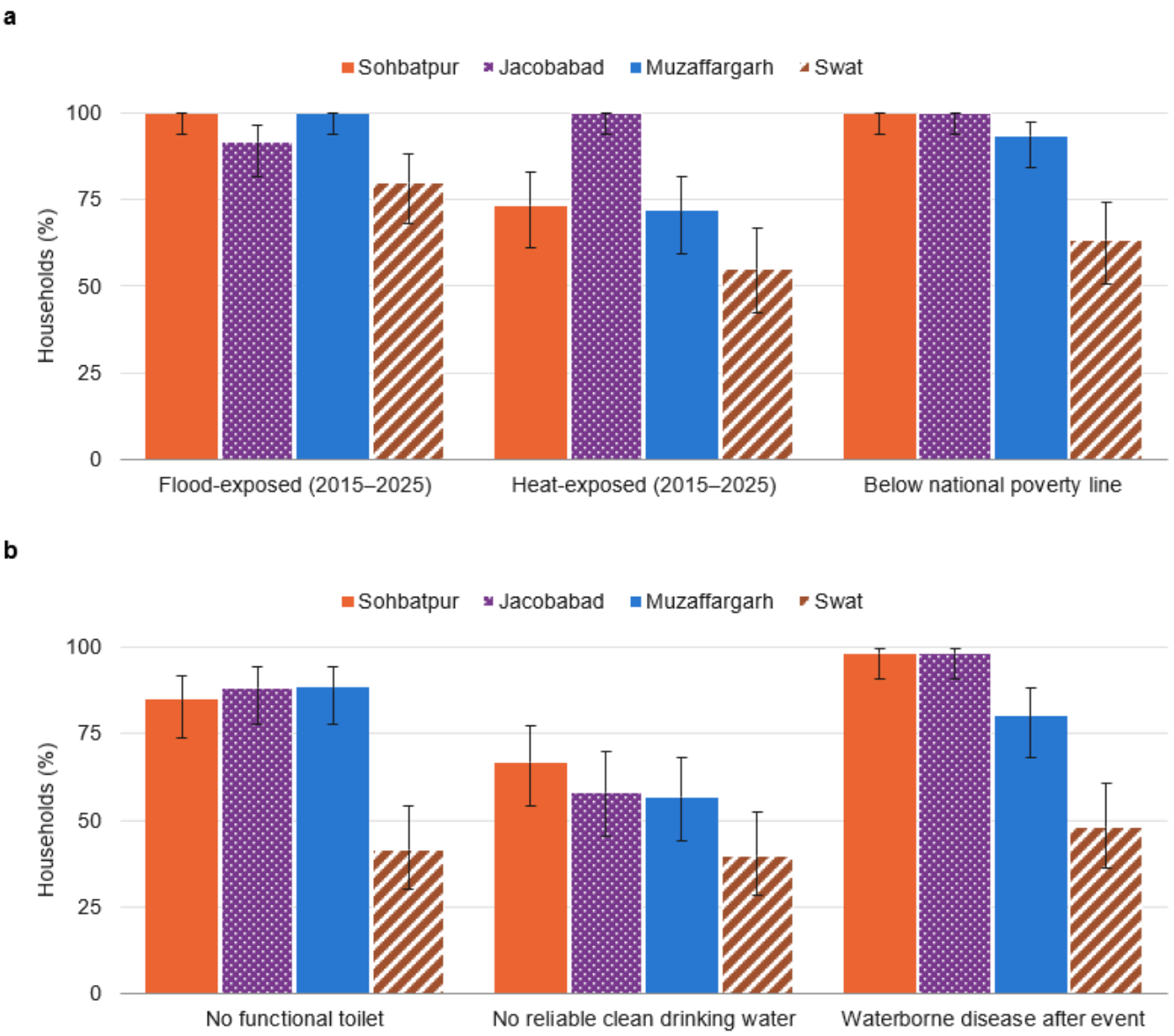


Figure 2

Household exposure, poverty and water, sanitation and health conditions by district. **a** Flood and heat exposure during 2015–2025 and share below the national poverty line. **b** No functional toilet, no reliable clean drinking water and waterborne disease after the most severe event. Bars show percentages of households (*n* = 60 per district); error bars show Wilson 95% confidence intervals. Test statistics are given in Table 1

Fig. 3

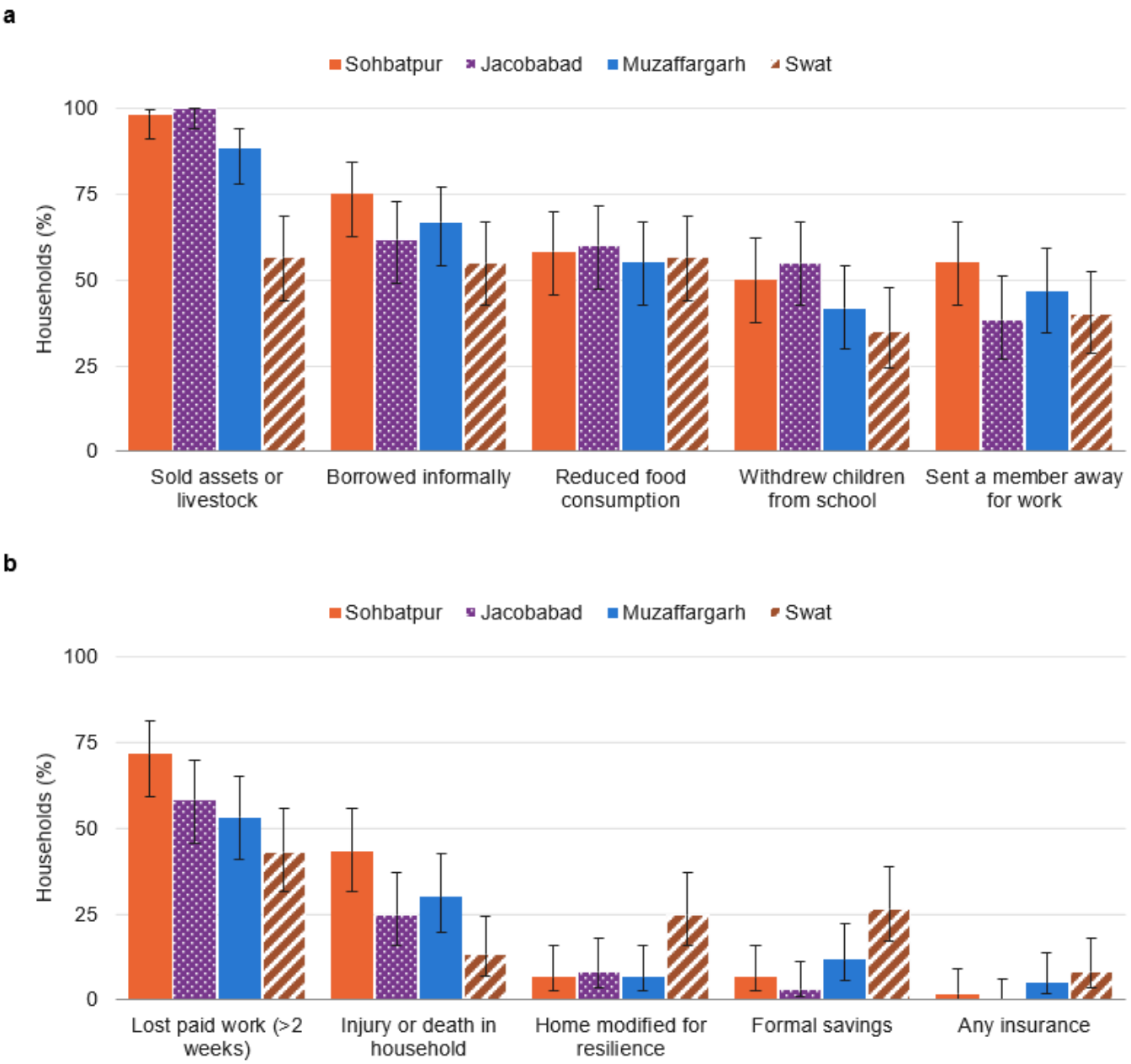


Figure 3

Coping, impacts and protective buffers by district. **a** Coping strategies used after the most severe event. **b** Impacts of the most severe event (left of the vertical line) and protective buffers (right). Bars show percentages of households (*n* = 60 per district); error bars show Wilson 95% confidence intervals. Test statistics are given in Table 1

Fig. 4

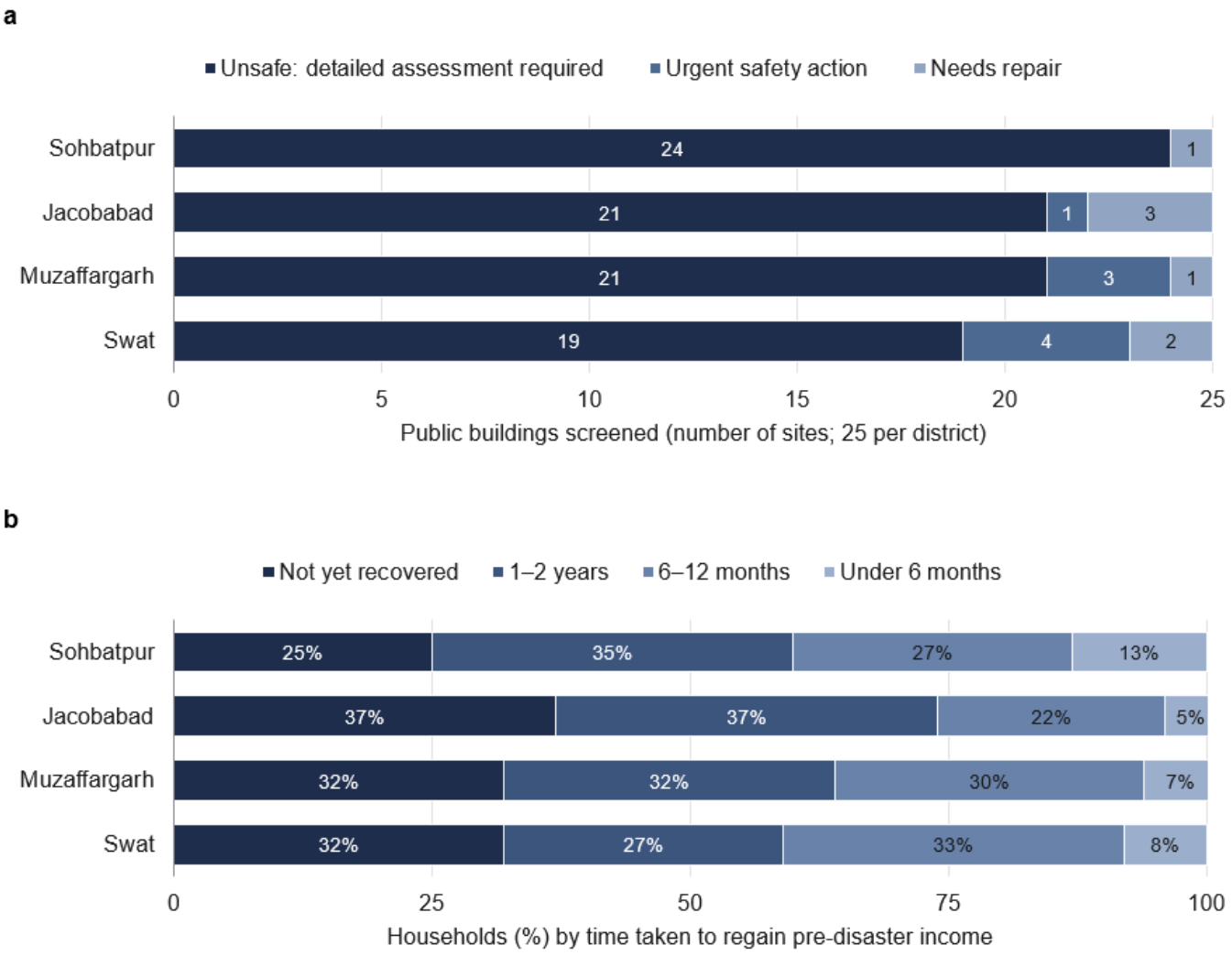


Figure 4

Shared deficits in public infrastructure and recovery. **a** Results of the plain-language screening of 100 public buildings (25 per district); no site was classified as safe or usable. The distribution of outcomes did not differ significantly between districts ($\chi^2 = 7.2$, df = 6, permutation $p = 0.30$). **b** Time taken by households to regain pre-disaster income after the most severe event ($n = 60$ per district; $\chi^2 = 6.8$, df = 9, $p = 0.66$). Darker shades denote worse outcomes

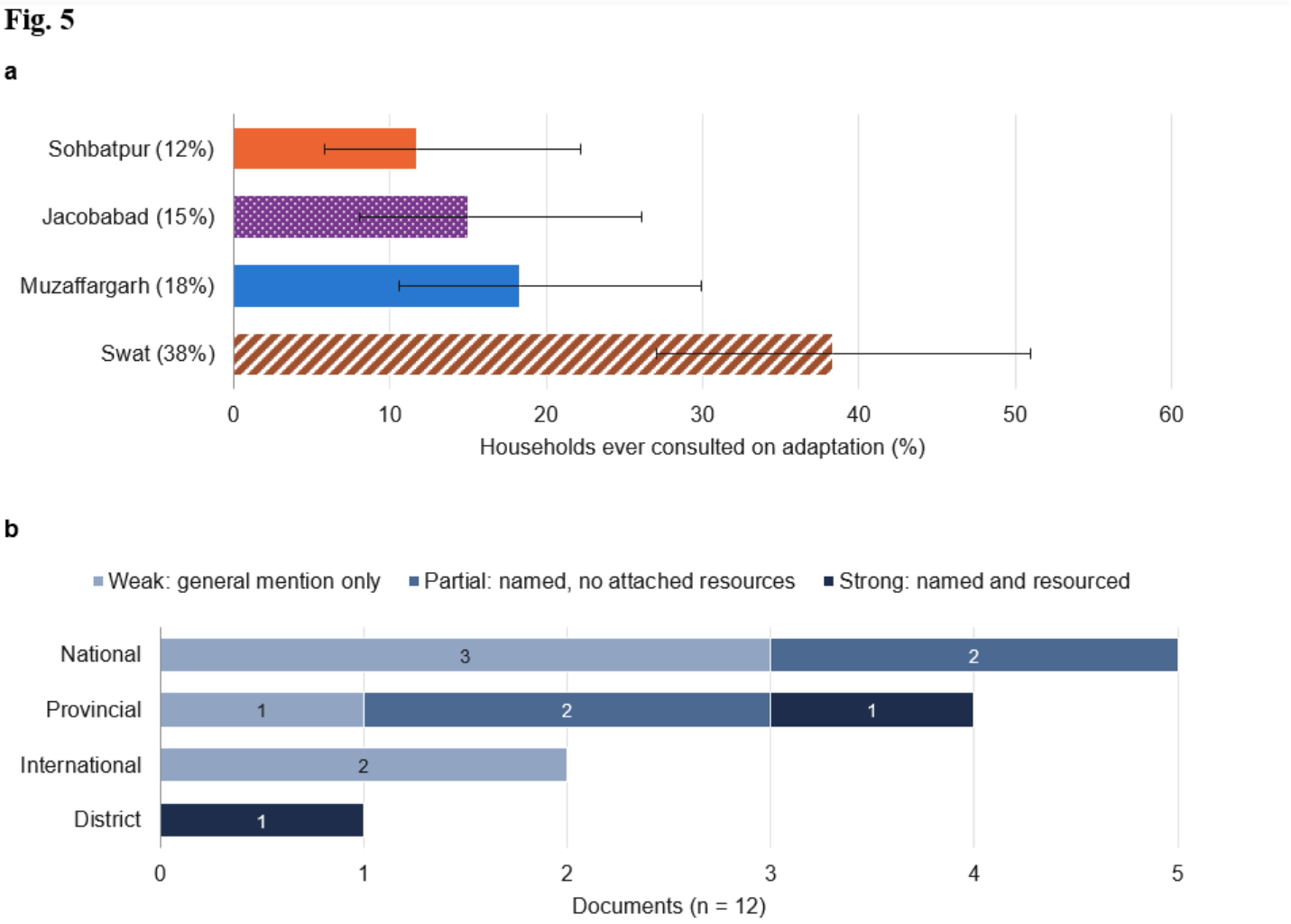


Figure 5

Procedural and recognition justice. **a** Share of households ever consulted on climate adaptation, with Wilson 95% confidence intervals ($\chi^2 = 15.7$, $p = 0.002$, Cramér's $V = 0.26$). **b** Strength of recognition of the case districts in 12 policy and finance documents, by level of government. Weak, general mention only; partial, provinces or a case district's hazard named without district-specific allocations, plans or indicators; strong, a case district named with allocations, reconstruction funding or documented local exposure

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TablesREC.docx