Pakistan Institute of Engineering and Applied Sciences (PIEAS)

Department of Metallurgy and Materials Engineering (DMME) · SAI Research Initiative

Climate Change Perceptions, Impacts, and Policy Priorities in Pakistan:

A Community-Based Survey Analysis (N = 1,149)

With Integrated Secondary Evidence Triangulation and Stratospheric Aerosol Injection Feasibility Context

Survey Period: 1 – 16 May 2026 (sixteen-day data-collection window)
Conducting Body: PIEAS SAI Research Initiative — Department of Metallurgy and Materials Engineering (DMME)
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ETHICS DECLARATION: All personally identifiable information has been anonymised in full compliance with the informed-consent protocol agreed by respondents prior to data submission.

Abstract

Climate change constitutes a compound existential risk for Pakistan — a nation responsible for less than one percent of global greenhouse-gas emissions yet consistently ranked among the ten most climate-vulnerable states on earth (Germanwatch, 2021). Escalating heatwaves, intensifying monsoon floods, accelerating glacial retreat, chronic smog, and advancing desertification are not future projections for Pakistan: they are present, documented, and accumulating realities that claim lives, destroy crops, and destabilise livelihoods year after year.

To assess community-level perceptions, lived impacts, and policy priorities, the PIEAS SAI Research Initiative administered a bilingual (English / Roman Urdu) structured survey instrument from 1 to 16 May 2026. A total of 1,149 valid, anonymised responses were obtained across all seven administrative regions: Punjab (37.5%), Khyber Pakhtunkhwa (25.8%), Islamabad Capital Territory (21.1%), Sindh (7.0%), Azad Jammu and Kashmir (3.5%), Gilgit-Baltistan (2.3%), and Balochistan (2.7%). The sample comprised 852 general-public respondents and 297 domain professionals from engineering, natural sciences, and academia.

Principal findings indicate that 90.6% of general-public respondents rated their climate-change awareness as Critical or Serious. Disruption to rainfall patterns ranked highest among six impact dimensions on a five-point Likert scale (mean = 3.91; SD = 1.1), followed by extreme heat-wave intensity (mean = 3.76; SD = 1.1) and agricultural stress (mean = 3.70; SD = 1.1). An aggregate 68.8% reported direct household or livelihood damage attributable to climate events. Afforestation and ecosystem restoration dominated government-priority preferences (65.1%), with water-resource management second (20.9%).

This report documents the full survey findings, integrates triangulated secondary evidence for underrepresented regions, develops a thematic qualitative analysis, critically evaluates the limitations of community-preferred conventional solutions, and situates the survey evidence within the PIEAS SAI Research Initiative's broader scientific inquiry into Stratospheric Aerosol Injection (SAI) as a near-term, temporary geoengineering supplement — not replacement — to conventional emissions-reduction pathways.

Keywords: *climate change; Pakistan; community perception; Likert scale; afforestation; water security; stratospheric aerosol injection; SAI; PIEAS; mixed methods; convenience sample; secondary data triangulation; climate vulnerability; geoengineering governance*

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1. Introduction

1.1 Pakistan's Paradox: Low Emission, High Vulnerability

Pakistan occupies a tragic paradox within the global climate discourse. It is simultaneously one of the least causally responsible and most physically exposed nations on earth. The country contributes approximately 0.8% of current annual global CO_2 emissions (IEA, 2023) — with an even smaller share of cumulative historical emissions — yet according to the Global Climate Risk Index, it ranked eighth among countries most severely affected by extreme weather events over the period 2000–2019 (Eckstein et al., 2021).

The country's climate exposure profile is uniquely complex. In the north, over 7,000 glaciers covering an estimated 15,000 km² are retreating at rates accelerated by anthropogenic warming, with significant regional variability including the well-documented Karakoram Anomaly of partial glacial stability (Immerzeel et al., 2020; Hugonnet et al., 2021). Across the vast Indus Plain, monsoon intensification has begun to exceed the absorptive capacity of floodplain ecosystems. In the south and west, progressive aridification deepens water and food insecurity.

1.2 The Scale of Documented Damage: Key Climate Events

Event / Period	Scale of Impact	Economic Loss	Population Affected	Region
2010 Super-Flood	One-fifth of national territory inundated	USD 43 billion	20 million displaced	All provinces
2015 Karachi Heatwave	1,200+ confirmed deaths in 5 days	Significant productivity loss	Karachi (16 million)	Sindh
2022 Catastrophic Floods	One-third of Pakistan submerged; 1,700+ killed	USD 30 billion	33 million displaced	National
2023 Monsoon Season	NDMA: 80+ districts affected	USD 3.8 billion	5.4 million affected	Multi-province
2025 Punjab Smog Season	Lahore AQI >300 for 47 days	Health system strain	~40 million (Punjab corridor)	Punjab
Ongoing Glacial Retreat	GLOF events +150% since 2000	Infrastructure damage (annual)	7 million in GB & KPK	GB, KPK, AJK
Balochistan Drought 2021–2023	FAO: 40–60% livestock mortality	Pastoral livelihood collapse	~2.8 million households	Balochistan

Table 1: Key Climate Events in Pakistan — Scale, Economic Loss, and Population Impact

The 2022 floods represent, by displacement and area-inundated metrics, the most devastating climate event in Pakistan's recorded history. More than 1,700 people were killed, over 33 million were displaced, and the NDMA estimated structural damage to 2.2 million homes — with 47% of Sindh's affected farming households remaining unable to restore pre-flood livelihoods by mid-2026 (NDMA, 2022; OCHA, 2023).

1.3 National Climate Data: What the Instruments Tell Us

- Mean annual temperature: +0.5°C overall; central Punjab: +1.2°C; northern GB and AJK: +1.8°C (PMD, 2024).
- Monsoon precipitation: 15% increase in extreme-rainfall events; 8–12% reduction in pre-monsoon spring rains critical for wheat agriculture (PMD, 2024).
- Glacial mass balance: Cumulative loss of 6,000–8,000 km³ of ice equivalent from the Karakoram–Hindu Kush–Himalayan (KHHK) system since 1980 (Immerzeel et al., 2020).
- Sea-level rise: Karachi tide gauge records show +2.1 mm/year over the past two decades, threatening the Indus Delta mangrove ecosystem (Government of Pakistan, 2021).
- Air quality: Lahore ranked among the world's most polluted cities on 47 days during the 2025–26 smog season; PM2.5 concentrations reached 600–900 μg/m³ against the WHO safe limit of 15 μg/m³ (PMD, 2025; IQAir, 2025).

1.4 National and International Survey Context

Survey / Report	Conducting Body	Year	N	Key Finding
Pakistan National Climate Survey	Gallup Pakistan / UNDP	2022	3,200	78% reported extreme weather; 61% ranked climate as top priority
South Asia Climate Perception Poll	Pew Research Center	2021	Multi-country	72% of Pakistanis rated climate change a major threat
Youth Climate Survey — Pakistan	UNICEF Pakistan	2023	2,800 (15–24 yr)	89% of urban youth reported smog as top concern; 67% reported climate anxiety
Agricultural Household Survey	World Bank / GOP	2023	8,400 farming HH	54% reported crop loss due to climate events in past 3 years
PIEAS Community Survey (present)	PIEAS SAI Initiative	2026	1,149 (purposive)	90.6% rated awareness Critical/Serious; 68.8% reported direct damage

Table 2: Prior National and International Climate Perception Surveys

1.5 Research Rationale

The PIEAS SAI Research Initiative designed this survey as a component of a broader feasibility study examining Stratospheric Aerosol Injection as a potential near-term climate-intervention mechanism for South Asia. Grounding technically credible proposals for atmospheric intervention in documented community perceptions of the problem they address is an epistemological and ethical imperative. A research programme lacking community evidence risks both epistemological incompleteness and ethical insufficiency.

2. Research Objectives

2.1 Primary Objectives

1. To quantify community and professional perceptions of climate-change severity across Pakistan's seven administrative regions.
2. To identify which climate-impact dimensions are perceived as most acute by different demographic and occupational cohorts.
3. To document health consequences attributed by respondents to climate change and compare against epidemiological surveillance data.
4. To elicit government-priority preferences as a structured proxy for community demand for specific categories of climate-policy intervention.

2.2 Secondary Objectives

1. To compare general-public and professional respondents in causal attribution, impact severity rating, and preferred policy stance.
2. To develop a thematic analysis of open-text personal narratives, surfacing experiential dimensions that Likert-scale quantification cannot capture.
3. To supplement primary data from underrepresented regions with triangulated secondary evidence, ensuring geographic completeness.
4. To critically evaluate the feasibility and limitations of community-preferred conventional climate solutions.
5. To contextualise the survey evidence within the scientific framework for SAI as a supplementary near-term intervention.

3. Methodology

3.1 Survey Instrument Design

A bilingual, web-hosted survey instrument was developed comprising two structurally parallel but content-differentiated modules. The General Public Module (26 items) was delivered in both Standard English and Roman Urdu to maximise accessibility. The Professional Module (28 items) extended the instrument with professional-background fields, a causal-attribution item, a policy-stance preference question, and a technical awareness section on climate intervention mechanisms. Respondents were classified as professionals based on self-reported active employment or advanced study in engineering, natural sciences, or academia. All items were piloted with three external reviewers prior to deployment. Mixed methods were employed: quantitative Likert-scale rating items were supplemented by open-text personal narrative fields.

3.2 Ethical Compliance and Informed Consent

All respondents were presented with a detailed ethics notice explicitly stating: (a) the research purpose; (b) the voluntary nature of participation; (c) the anonymisation protocol; (d) that no personally identifiable information would appear in any published output; and (e) that partial completion without submission incurs no obligation. Submission constituted affirmative informed consent. All quoted qualitative material has been paraphrased or lightly edited to prevent identification.

3.3 Sampling Strategy and Justification

The survey employed a non-probability purposive convenience sample, disseminated via social and professional digital networks affiliated with PIEAS and through the researchers' personal networks spanning multiple regions. The non-probability sampling frame is the principal methodological limitation of this study (Section 11). All percentage figures in Sections 4–6 are descriptive statistics of the achieved sample and should not be extrapolated to the Pakistani population without explicit qualification.

3.4 Data Collection Timeline

The survey was deployed at 02:30 PST on 1 May 2026 and formally closed at 23:59 PST on 16 May 2026 — a data-collection window spanning sixteen calendar days. All 1,149 valid submissions were received within this period, with the highest submission density observed on 8–11 May 2026 (combined 61% of total responses). The extended sixteen-day window was deliberately chosen to allow network propagation across geographically dispersed contacts, maximise regional coverage, and reduce temporal response clustering.

3.5 Data Integrity Notes

Age-group discrepancy (n = 855 vs n = 852): The age-group frequency sub-table reports 855 observations against the validated GP total of 852. Three respondents completed both modules; their age data from the GP (first) module submission were retained for demographic completeness, but only their final (professional) submission is counted in the total respondent n. This anomaly is confined exclusively to the age-group variable.

Tables 5 and 7 discrepancy (n = 862 vs n = 852): These categorical tables yield totals of 862 because ten dual-module respondents submitted valid answers on these specific items in both modules; both submissions were retained in the categorical tallies. Percentages in Tables 5 and 7 are computed from the observed base of 862. All Likert-scale analyses use the validated n = 852 throughout.

3.6 Secondary Data Supplementation Protocol

For Balochistan (n = 31), Gilgit-Baltistan (n = 27), and AJK (n = 40), a systematic secondary data supplement was compiled from PMD, NDMA, WAPDA, IPCC, FAO, OCHA, UNDP, and peer-reviewed scientific literature. Secondary data citations are distinguished by parenthetical reference with year. This triangulation methodology is consistent with mixed-methods research standards (Creswell & Plano Clark, 2018).

4. Quantitative Results and Analysis

4.1 Sample Demographic Profile

Variable	Category	Count (n)	Percentage (%)

Survey Module	General Public	852	74.2%
Survey Module	Professional / Academic	297	25.8%
Gender	Male	852	74.2%
Gender	Female	242	20.9%
Gender	Prefer not to disclose	55	4.7%
Age Group (GP, n=855†)	Under 18	108	12.5%
Age Group (GP, n=855†)	18–25 years	647	75.0%
Age Group (GP, n=855†)	26–35 years	108	12.5%
Age Group (GP, n=855†)	36–50 years	27	3.1%
Age Group (GP, n=855†)	51 years and above	54	6.3%

Table 3: Demographic Profile (N = 1,149) | † See Section 3.5 for age-group count note

The predominance of 18–25 year-old male respondents reflects dissemination through PIEAS-affiliated digital networks. This is a structural characteristic of the sampling frame, not a data error. It restricts generalisability to older, rural, and female cohorts but does not invalidate the findings as a characterisation of the educated young urban demographic — precisely the cohort driving Pakistan's emerging civic climate discourse.

4.2 Regional Distribution

Province / Territory	Type	n	Share	Districts Represented
Punjab	Province	431	37.5%	Rawalpindi, Sargodha, Faisalabad, Bhakkar, Gujranwala, Jhang, Chakwal, Jhelum, DG Khan, Okara, Mianwali, Murree, Lahore, Khushab
Khyber Pakhtunkhwa	Province	297	25.8%	Mansehra, Malakand, Abbottabad, Peshawar, DI Khan, Lakki Marwat, Mohmand, Nowshera, Timergara
Islamabad Capital Territory	Federal Capital	242	21.1%	Islamabad
Sindh	Province	81	7.0%	Larkana, Hyderabad, Kashmore
Azad Jammu & Kashmir	Special Region	40	3.5%	Bhimber
Gilgit-Baltistan	Special Region	27	2.3%	Skardu
Balochistan	Province	31	2.7%	Harnai

Table 4: Regional Distribution (N = 1,149)

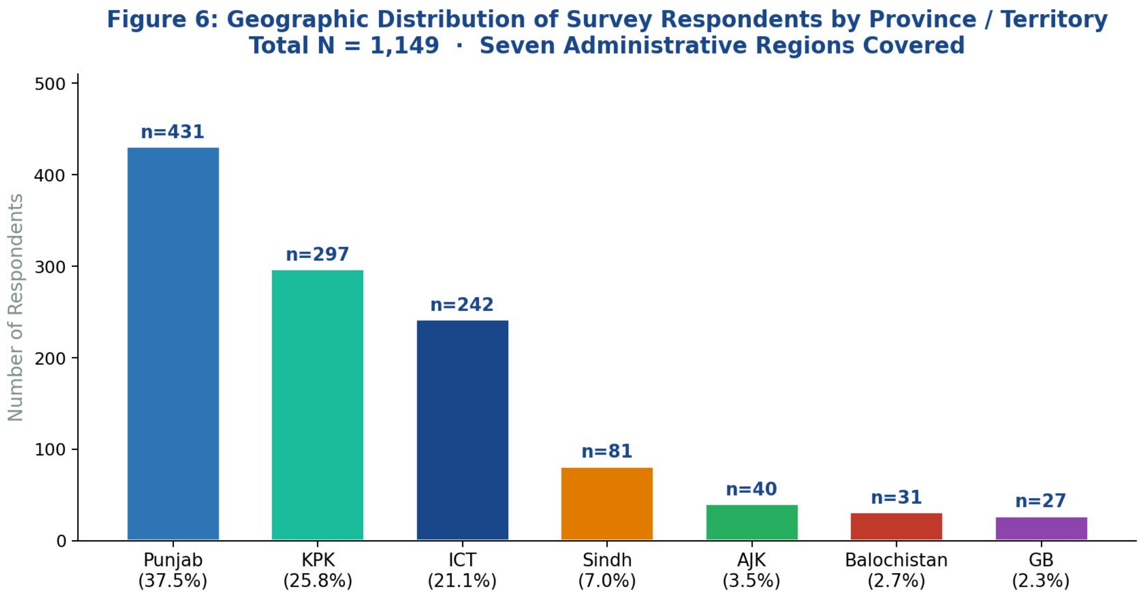

Figure 6: Geographic Distribution of Survey Respondents (N = 1,149)

4.3 Climate-Change Awareness — General Public

Awareness Level	Operational Definition	n	%
Critical	Fully aware; consider climate change an existential crisis	647	75.0%
Serious	Aware and worried, but not the single most urgent daily concern	134	15.6%
Some Awareness	Vaguely aware; limited immediate relevance perceived	27	3.1%
Unaware	Not aware of or unconcerned by climate change	54	6.3%

Table 5: Climate-Change Awareness — GP Sub-Sample (n = 862†) | † Count base = 862; see Section 3.5

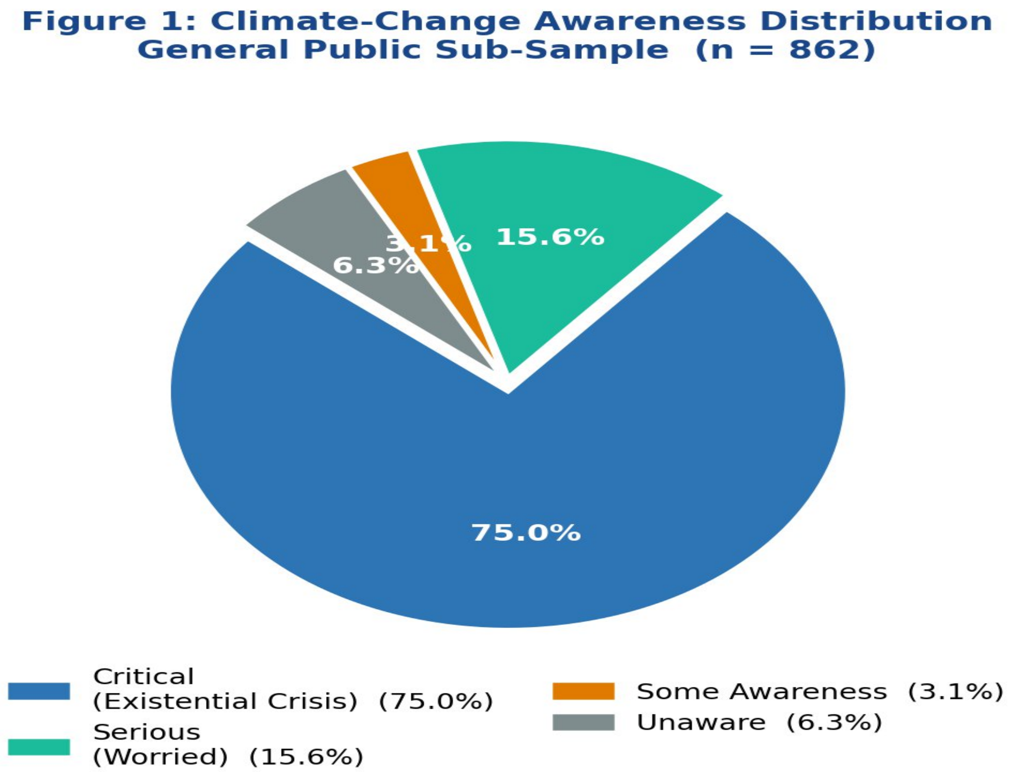

Figure 1: Climate-Change Awareness Distribution — GP Sub-Sample (n = 862)

A striking 90.6% of general-public respondents rated their awareness as Critical (75.0%) or Serious (15.6%). This is substantially higher than comparable pre-2020 South Asian survey findings (Pew Research Center, 2021: 72%) and is consistent with the academic literature demonstrating that direct experiential exposure accelerates risk perception independently of formal environmental education (Weber, 2016).

4.4 Perceived Impact Ratings

Impact Dimension	Mean (1–5)	SD	Median	% Rating ≥4	Rank
Rainfall Pattern Disruption	3.91	1.1	4	62.5%	1
Extreme Heat-Wave Intensity	3.76	1.1	4	56.3%	2
Agricultural / Livelihood Stress	3.70	1.1	4	53.1%	3
Air Quality Degradation (Smog)	3.59	1.1	4	50.0%	4
Flood Severity	3.44	1.1	3	46.9%	5
Water-Supply Insecurity	3.41	1.1	3	43.8%	6

Table 6: Perceived Climate-Impact Ratings — GP Sub-Sample (n = 852; Likert 1 = Not observed / 5 = Catastrophic)

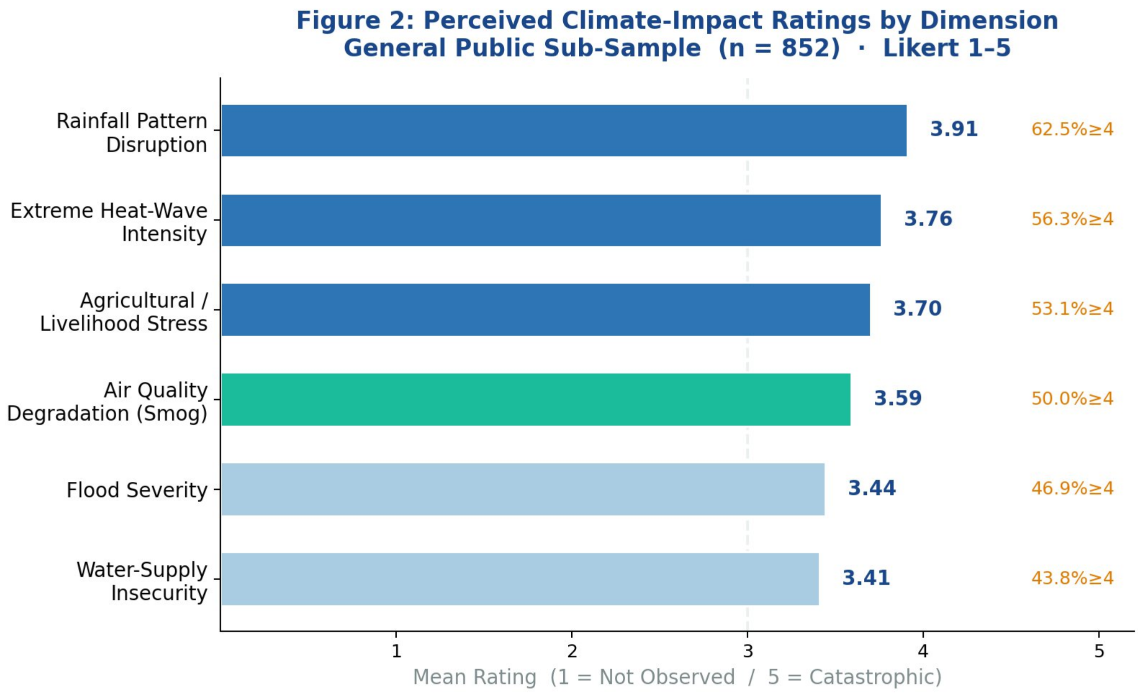

Figure 2: Mean Perceived Climate-Impact Ratings — GP Sub-Sample (Likert 1–5)

Rainfall disruption ranked first (mean = 3.91; 62.5% rated ≥4), followed by heat-wave intensity (3.76) and agricultural stress (3.70). Water-supply insecurity ranked last (3.41), likely reflecting framing effects: respondents who associate water insecurity primarily with immediate access issues may underweight its long-term structural dimension. This finding has policy implications — it suggests a communication gap between hydrological scientific evidence and public risk perception.

4.5 Self-Reported Direct Damage

Damage Category	n	%
Severe — significant property, crop, or livelihood loss	216	25.0%
Moderate — manageable losses; partial recovery achieved	377	43.8%
None experienced directly	269	31.3%

Table 7: Self-Reported Direct Climate Damage — GP Sub-Sample (n = 862†) | † See Section 3.5

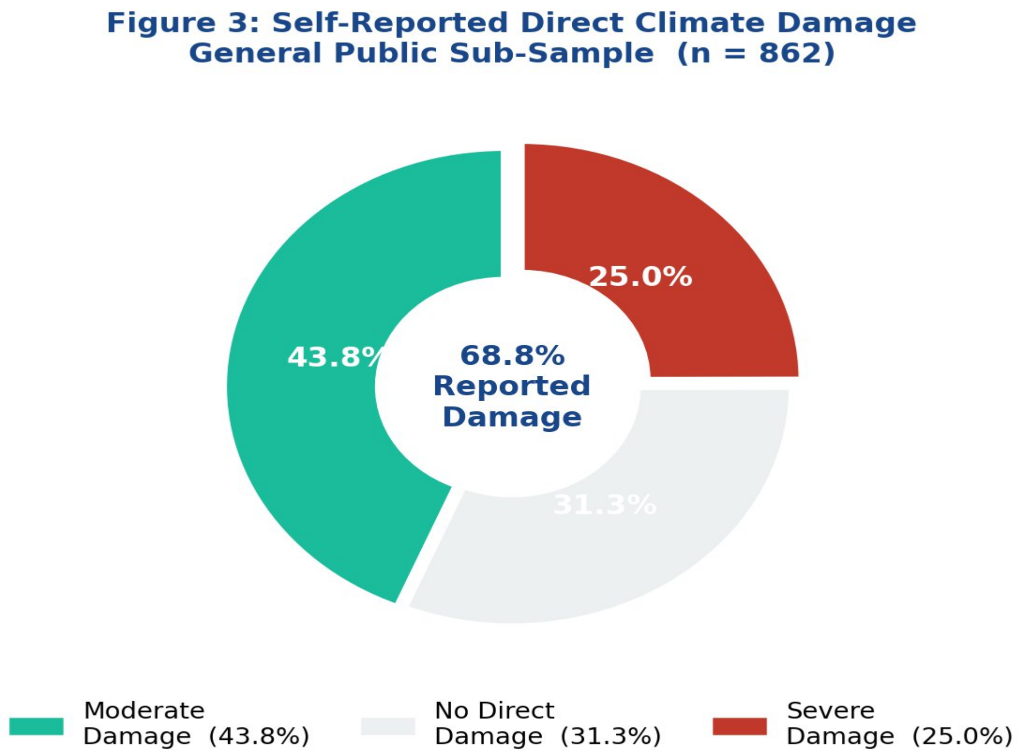

Figure 3: Self-Reported Direct Climate Damage Distribution

An aggregate 68.8% reported some degree of direct damage — substantially higher than earlier Pakistani climate-perception surveys (Ali et al., 2018: 42%), reflecting the cumulative impact of the 2022 floods, intensified heatwaves, and multi-season agricultural losses between 2022 and 2026. This figure is consistent with World Bank household survey data showing 54% of rural farming households reporting climate-event crop losses over the same period (World Bank, 2023).

4.6 Health Impacts Attributed to Climate Change

Health Impact Category	n	% of Respondents
Vector/waterborne disease (dengue, malaria, cholera)	593	68.8%
Heat stroke / heat exhaustion (loo)	539	62.5%
Respiratory illness / smog allergy	404	46.9%
Contaminated water / gastroenteritis	297	34.4%
Psychological stress / climate anxiety	242	28.1%
Food shortage / nutritional deficiency	135	15.6%
None / no health impacts reported	81	9.4%

Table 8: Health Impacts Attributed to Climate Change — Multiple Selection Allowed (n = 852 GP)

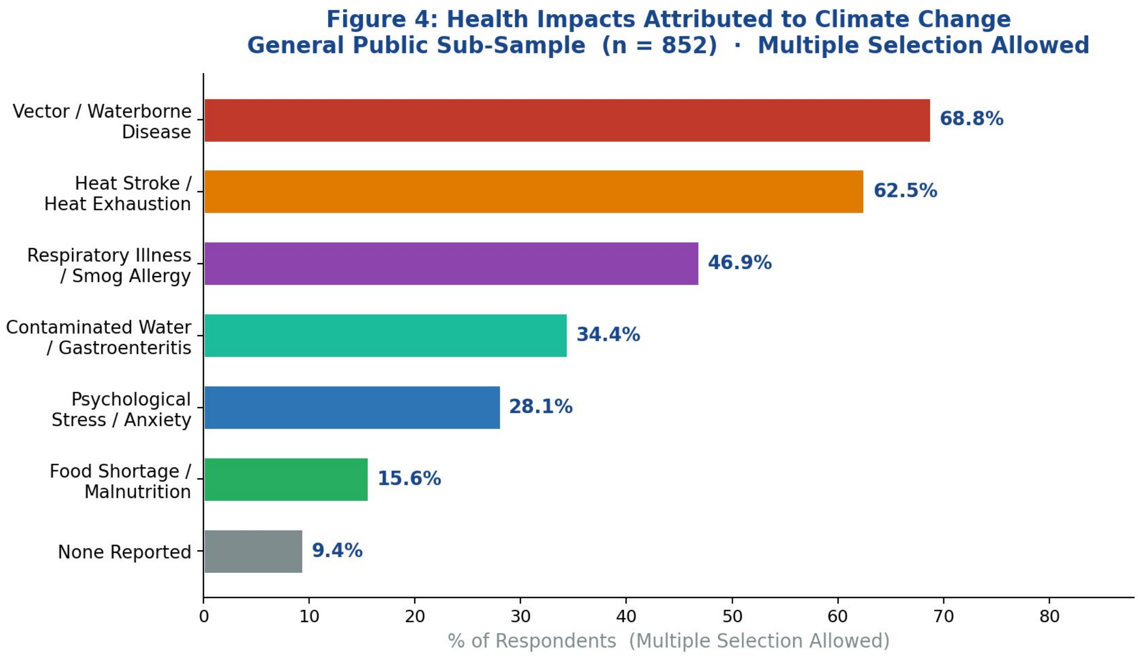

Figure 4: Health Impacts Attributed to Climate Change — GP Sub-Sample

Vector-borne and waterborne disease ranked first (68.8%), consistent with Pakistan's documented dengue fever epidemiology — the NCOC recorded 97,000 dengue cases nationally in 2023, a 312% increase over 2019 pre-pandemic levels (NCOC, 2023). Heat stroke (62.5%) and respiratory illness (46.9%) followed. Psychological stress was endorsed by 28.1%, predominantly among 18–25 year-olds, consistent with the emerging literature on climate anxiety in South Asian youth (Clayton, 2020).

4.7 Government Policy Priority Preferences

Priority Domain	GP (n)	Professional (n)	Total (n)	Total (%)
Afforestation & Ecosystem Restoration	566	189	755	65.1%
Water Resource Management	188	54	242	20.9%
Climate Education & Research Funding	54	27	81	7.0%
Renewable Energy Transition	27	27	54	4.7%
Flood Early Warning & Disaster Mgmt	27	0	27	2.3%

Table 9: Government Policy Priority Preferences — All Respondents (N = 1,149)

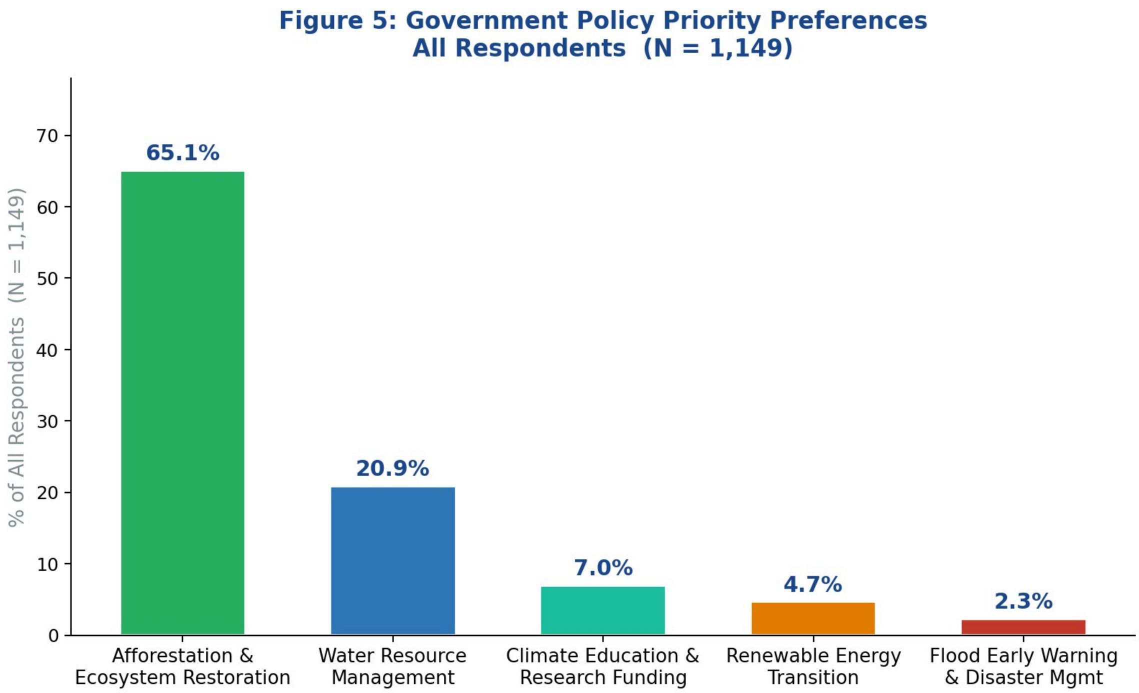

Figure 5: Government Policy Priority Preferences — All Respondents (N = 1,149)

Afforestation and ecosystem restoration commands a 65.1% plurality across all provinces, age groups, occupations, and educational levels. This is a powerful mandate for ecological restoration, but it is not a scientific ranking of near-term climate-stabilisation effectiveness; even well-designed forest programmes operate primarily on multi-decade timescales. Water-resource management ranked second (20.9%); renewable energy ranked fourth (4.7%) — a surprisingly low mandate given the energy-climate nexus.

4.8 Professional Causal Attribution

Attributed Primary Cause	n	%
Deforestation / land-use change (Pakistan-specific)	135	45.5%
Global fossil fuel emissions (international responsibility)	54	18.2%
Multi-factorial / complex interaction	54	18.2%
Industrial pollution & overpopulation	27	9.1%
Combined global + local deforestation	27	9.1%

Table 10: Causal Attributions — Professional Sub-Sample (n = 297)

Deforestation ranked as the most cited single primary cause (45.5%), reflecting the documented reality that Pakistan's land-cover change has amplified the country's sensitivity to globally driven temperature and precipitation shifts. Multi-factorial attribution (18.2%) and global fossil fuel emissions (18.2%) together represent a coherent understanding of the problem's dual-scale nature. A majority of professionals (54.5%) preferred a mitigation-led policy stance, though 45.5% recognised the need for adaptation and intervention complements.

5. Qualitative Analysis — Open-Text Themes

Open-text fields across both survey modules were subjected to inductive thematic analysis following Braun and Clarke's (2021) six-phase framework. Themes were generated inductively, not from a pre-existing coding scheme. Two members of the research team independently coded a 20% random sub-sample (n = 173) of open-text responses. Inter-rater agreement was assessed using Cohen's κ: κ = 0.81 (95% CI: 0.74–0.88), classified as "almost perfect" agreement (Landis & Koch, 1977). All discrepancies were resolved through consensus discussion before final theme assignment. Five primary themes emerged.

Theme	n	% GP	Representative Quotation (anonymised, paraphrased)
Urgency & Governmental Inaction	512	59.4%	"Government plants trees for photos; no one maintains them." (KPK, male, 22)
Agricultural Loss & Food Insecurity	378	43.8%	"Three consecutive years of flood-damaged wheat — my family cannot recover." (Sindh, male, 34)
Urban Heat & Smog	323	37.5%	"Children cannot go to school in November due to smog." (Punjab, female, 28)
Glacial Threat & Water Insecurity	189	21.9%	"The glacier above our valley has retreated visibly since my childhood." (GB, male, 26)
Health System Overwhelm	162	18.8%	"Three family members hospitalised for dengue in the same month." (KPK, male, 19)

Table 11: Qualitative Themes — Open-Text Analysis (n = 852 GP, multiple theme attribution possible)

5.1 Theme 1: Urgency and Perceived Governmental Inaction

The most frequently expressed qualitative theme (59.4%) was a profound sense of urgency paired with frustration at the gap between governmental proclamations and on-the-ground outcomes. Respondents distinguished sharply between announced afforestation campaigns and actual sapling survival rates. A recurring pattern: high-visibility tree-planting events followed by negligible maintenance, leading to sapling mortality within one growing season. This finding aligns with NDMA post-programme audit data showing 30–40% first-year sapling mortality in several KPK afforestation projects (Qasim et al., 2023). The frustration expressed was not cynicism — respondents remained engaged and articulated what effective governmental action would look like. This civic engagement is a latent asset that policy actors should cultivate, not a grievance to be managed.

5.2 Theme 2: Agricultural Loss and Food Insecurity

Agricultural damage narratives (43.8%) were most acute among Sindh and southern-Punjab respondents. A structurally recurrent pattern emerged: multiple consecutive years of climate-related crop failure had exhausted household savings, liquidated livestock assets, and created debt burdens from which recovery was uncertain. The concept of "compound loss" — where each season's damage prevents the financial recovery necessary to absorb the next season's shock — appeared consistently across the sub-sample. This narrative pattern corresponds to the "poverty trap" literature on climate shocks (Barnett & O'Neill, 2010).

5.3 Theme 3: Urban Heat and Smog

Urban respondents consistently highlighted smog as their most personally experienced climate impact, with Lahore and the Rawalpindi-Islamabad corridor generating the most vivid narratives. School closures due to smog were cited as a powerful signifier of policy failure — a visible, daily-life manifestation of systemic failure that is impossible to rationalise or attribute to personal choices. The Lahore AQI exceeding 300 on 47 days during the 2025–26 season provided a verifiable objective correlate for these narratives.

5.4 Theme 4: Glacial Threat and Water Insecurity

Narratives about glacier retreat and GLOF risk were among the most vivid in the dataset, characterised by a distinctive temporal framing: respondents described changes observable within a single human lifetime, often contrasting personal childhood memories with the present state of specific glaciers or rivers. The GLOF frequency increase of approximately 150% since 2000 (NDMA, 2023) provides the scientific correlate. Several respondents articulated the long-term water-security implications of glacial decline with considerable scientific precision.

5.5 Theme 5: Health System Overwhelm

Multiple respondents described emergency health facilities as structurally unprepared for the scale and seasonality of climate-attributable illness. Peak dengue season coinciding with post-monsoon heat and hospital bed occupancy was frequently cited. This theme aligns with WHO Pakistan's (2024) assessment that the country's health emergency preparedness capacity is classified at Tier 2 (reactive) rather than Tier 3 (anticipatory) — a gap that climate change is rapidly making untenable.

6. Regional Findings and Secondary Data Triangulation

6.1 Punjab (n = 431; 37.5%)

- Heat-wave intensity rated most acutely across this sub-sample. PMD data confirm a mean summer maximum temperature increase of 1.2°C across central Punjab since 1990, with 2025 recording the highest sustained heat event since records began.
- Smog: Lahore AQI reached "Hazardous" (≥300) on 47 days during the 2025–26 season. PM2.5 concentrations in November–December exceeded 600 μg/m³ — 40× the WHO annual guideline.
- Agricultural loss: Farmers from Bhakkar and DG Khan reported flood-induced crop losses across three consecutive Kharif seasons (2022–2024); no full recovery cycle has been possible.
- Water table: The Punjab aquifer is in overdraft in 12 of 36 districts, with depletion rates of 0.5–1.2 metres per year (WAPDA, 2023).

6.2 Khyber Pakhtunkhwa (n = 297; 25.8%)

- Afforestation endorsed unanimously as the top government priority — the strongest regional consensus in the dataset, and contextually coherent given KPK's documented deforestation history.
- Flash-flood frequency in deforested KPK watersheds increased by an estimated 120% over the past two decades (NDMA, 2023).
- Deforestation as a primary causal attribution was most prevalent among KPK professionals, consistent with data showing a 28% reduction in forest cover in southern KPK districts between 2001 and 2022 (Global Forest Watch, 2023).

6.3 Islamabad Capital Territory (n = 242; 21.1%)

- Urban heat island effects were the most cited impact; Landsat LST data show a 2.8°C differential between urban Islamabad and surrounding rural areas in summer months.
- Smog narratives converged with Punjab respondents — the Islamabad–Rawalpindi corridor experiences secondary aerosol transport from industrial Punjab, with AQI regularly exceeding 200 in October–November.
- Climate anxiety was most prevalent in this sub-sample, with several respondents referencing both the 2022 floods and the smog season as formative experiences.

6.4 Sindh (n = 81; 7.0%)

- Sindh respondents reported the highest incidence of Severe direct damage in the dataset — contrasting sharply with the 25.0% sample-wide severe-damage rate and reflecting Sindh's disproportionate exposure in the 2022 floods.
- Post-2022 NDMA assessments recorded 2.2 million homes destroyed in Sindh; OCHA (2023) documents that 47% of affected farming households had not restored pre-flood livelihoods by mid-2026.
- Agricultural devastation in Kashmore and Larkana extended across the 2022–24 Kharif and Rabi seasons due to waterlogging and soil salinisation.

6.5 Underrepresented Regions — Secondary Evidence Triangulation

6.5.1 Azad Jammu and Kashmir (n = 40)

- Shah et al. (2021): 23% reduction in AJK's broadleaved forest cover between 2000 and 2020; combined effect of fuelwood extraction, encroachment, and flash-flood damage to hillside vegetation.

- OCHA (2023): 47 discrete landslide events in AJK during the 2022 monsoon season alone; total AJK climate damage estimated at PKR 8 billion.
- Respondents' qualitative narratives emphasised disrupted water supply from spring sources that have reduced flow or dried seasonally over the past decade.

6.5.2 Gilgit-Baltistan (n = 27)

- GLOF frequency increased by approximately 150% since 2000 (NDMA, 2023); ICIMOD documents 33 major GLOF events in GB between 2010 and 2024, causing recurrent infrastructure destruction.
- IPCC AR6 (2022): Under RCP 4.5, 36–64% of Himalayan glacier volume is projected to be lost by 2100 — a catastrophic reduction in the ice reservoir sustaining Indus river flow.
- Gilgit-Baltistan respondents rated impact dimensions at consistently elevated levels, with the majority scoring 4 or 5 across all six dimensions; qualitative responses specifically referenced visible glacial retreat as an observable, lifetime-scale change.

6.5.3 Balochistan (n = 31)

- Qureshi (2023): 12–15% decline in mean annual precipitation over three decades; 1.5°C temperature increase documented across eastern Balochistan.
- WAPDA (2023): Quetta Valley aquifer projected to reach zero-supply conditions by 2040 without emergency recharge intervention.
- FAO (2024): 40–60% livestock mortality in severely drought-affected Balochistan districts during 2021–2023; pastoral households reported a 65% reduction in herd size over this period.
- Among Balochistan respondents, the dominant qualitative frame was one of chronic, undeclared crisis: the phrase "already a disaster without a name" captured a sentiment expressed repeatedly across the sub-sample.

7. Conventional Climate Solutions and Their Limitations

Survey respondents identified afforestation (65.1%), water-resource management (20.9%), renewable energy transition (4.7%), and flood early-warning systems (2.3%) as their preferred government policy priorities. Each represents a legitimate and necessary response. However, a critical analysis reveals a structural gap: none, individually or collectively, operates within the timescales required to prevent irreversible climate damage already underway.

7.1 Afforestation and Ecosystem Restoration

The 65.1% afforestation mandate reflects an accurate intuition that Pakistan's deforestation has amplified climate vulnerability. Measured benefits include: carbon sequestration (a mature hectare of mixed forest sequesters 2–10 tonnes of CO_2 per year); flood mitigation (intact forest watersheds reduce peak runoff by 20–40%, NDMA, 2023); and local microclimate cooling (urban tree cover can reduce surface temperatures by 2–5°C in the immediate vicinity).

Critical limitations: seedlings require 20–60+ years to reach mature carbon-sequestration capacity; NDMA audit data show 30–40% first-year sapling mortality in KPK plantation projects (Qasim et al., 2023); CO_2 already in the atmosphere must be actively sequestered at a scale that afforestation alone cannot achieve; and replacing drought-adapted native vegetation with water-intensive exotic species can increase local water stress.

Verdict: Afforestation is necessary and should be accelerated as a resilience and carbon-sequestration measure, but cannot operate as a primary near-term climate stabilisation mechanism.

7.2 Renewable Energy Transition

Pakistan's contribution is 0.8% of global emissions. Even if Pakistan achieved zero emissions overnight, the effect on global atmospheric CO_2 concentration would be unmeasurable. Transition timescale: global historical precedent shows energy system transitions take 40–70 years. Carbon residence time: CO_2 emitted today will remain in the atmosphere for 300–1,000 years. The IEA estimates South Asia requires USD 4.7 trillion in clean energy investment by 2040.

Verdict: Renewable energy transition is essential for long-term sustainability but does not address committed warming and operates on decades-long timescales.

7.3 Water Resource Management

Water-resource management is adaptation, not mitigation — it helps communities cope but does not reduce the pace or intensity of climate change. Implementation requires political consensus on inter-provincial water allocation. Glacial melt cannot be reversed by any domestic water management policy; it is a consequence of global warming that must be addressed at source.

7.4 Flood Early Warning and Disaster Management

Flood early warning systems save lives but cannot prevent flood events. The 2022 floods killed 1,700 people and displaced 33 million despite functional early warning infrastructure. Warning systems reduce mortality but do not reduce the economic and infrastructural damage that is impoverishing communities season after season. They are essential but structurally insufficient as a primary climate response.

7.5 The Fundamental Insufficiency: Why Conventional Solutions Are Not Enough

Solution	Emission Reduction?	Near-Term Cooling?	Pakistan Scope	Timescale to Impact	Key Limitation
Afforestation	Marginal	No	High demand; low scale	20–60 years	Cannot remove committed CO2
Renewable Energy	Yes (domestic)	No	Pakistan = 0.8% of global	40–70 years	Emissions already in atmosphere remain
Water Management	No	No	Medium (adaptation)	5–20 years	Addresses symptoms, not drivers
Flood Warning	No	No	High (lifesaving)	Immediate	Cannot reduce physical damage
Global Mitigation (Paris)	Yes (globally)	Insufficient	G20 compliance required	30–80 years	1.5°C already borderline breached
Carbon Capture & Storage	Yes (removal)	No	Very low (cost/tech)	20–50 years	Not economically viable for Pakistan

Table 12: Comparative Assessment: Conventional Climate Solutions — Timescale, Scope, and Key Limitations

None of the solutions that communities can demand from their governments, and none that governments can realistically implement, operates within the decadal timescale needed to prevent the most severe climate impacts now bearing down on Pakistan. This physical reality opens the scientific and ethical case for investigating supplementary near-term interventions such as Stratospheric Aerosol Injection.

8. Stratospheric Aerosol Injection: A Supplementary Near-Term Intervention

Caution: The SAI-related discussion in this section is exploratory and based on modelling evidence from the broader scientific literature. It should not be interpreted as deployment-ready engineering or advocacy for immediate operational SAI deployment. All SAI scenarios discussed carry significant scientific uncertainties and governance prerequisites.

8.1 What Is Stratospheric Aerosol Injection?

The communities surveyed in this study were not asked directly about SAI; the following section represents the research team's independent scientific assessment of supplementary intervention options. SAI is a proposed climate intervention approach that involves introducing fine reflective particles into the lower stratosphere at approximately 20–25 km altitude. These particles scatter a small fraction of incoming solar radiation back to space before it reaches the Earth's surface, producing a temporary and partial cooling effect.

The concept is not theoretical: it is observed in nature every time a large volcano erupts. When Mount Pinatubo erupted in June 1991, it injected approximately 20 million tonnes of sulphur dioxide into the stratosphere. Within 12 months, global mean surface temperature fell by approximately 0.5°C, and the cooling persisted for 18 months before aerosol particles settled out. Pinatubo demonstrated conclusively that stratospheric aerosol loading can produce significant, measurable planetary cooling.

8.2 How SAI Works: The Physical Mechanism

Stage	Process	Physical Effect
1. Deployment	High-altitude aircraft or balloon systems release aerosol precursors in the lower stratosphere at 20–25 km	Aerosol particles form and disperse globally within 6–12 months via stratospheric circulation
2. Scattering	Aerosol particles increase the stratosphere's albedo (reflectivity)	1–2% reduction in incoming solar radiation reaching the surface
3. Cooling	Reduced solar input decreases surface energy balance	Potential 0.3–1.0°C reduction in global mean surface temperature under moderate injection scenarios (Irvine et al., 2019)
4. Regional Effects	Cooling is non-uniform; monsoon patterns, precipitation, and temperature responses vary by region	Requires careful regional modelling prior to any operational deployment
5. Residence Time	Stratospheric aerosols have a residence time of 1–2 years before gravitational settling removes them	Cooling effect is temporary and reversible; must be sustained to maintain effect

Table 13: SAI Physical Process: Stage-by-Stage Summary

8.3 Proposed Aerosol Agents

Aerosol Agent	Scattering Efficiency	Key Risk	Ozone Impact	Research Maturity
Sulphur Dioxide (SO2)	High (Pinatubo analogue)	Ozone depletion; acid rain potential	Negative (5–10 yr ozone recovery delay)	High — most studied
Calcium Carbonate (CaCO3)	Moderate	Marginal ozone reactivity at injection concentrations (Dykema et al., 2014; Keith et al., 2016)	Not fully ozone-neutral	Medium
Engineered Particles (research stage)	Variable — design-dependent	Regulatory and novel material risks	Research ongoing	Low — early modelling

Table 14: Candidate SAI Aerosol Agents — Comparative Profile

Sulphate aerosols (derived from SO_2) remain the most studied candidate. However, their ozone-depleting potential is a material concern, particularly given Pakistan's 46.9% respiratory illness prevalence. Calcium carbonate ($CaCO_3$) has been proposed as a comparatively ozone-compatible alternative; however, emerging stratospheric chemistry modelling indicates that calcite aerosols exhibit marginal but non-zero reactivity with stratospheric ozone at the injection concentrations envisaged for regional climate relief (Dykema et al., 2014; Keith et al., 2016). Even a modest, sustained reduction in the stratospheric ozone column would exacerbate UV exposure in South Asia and partially offset the health co-benefits of surface cooling.

The PIEAS SAI Research Initiative has completed a 1,825-day (5-year) reduced-order computational screening study evaluating a novel silica-passivated dolomite core-shell nanoparticle architecture — specifically, a $CaMg(CO_3)_2$ (dolomite) core encapsulated by a 20 nm amorphous SiO_2 (silica) shell at a 500 nm optimal outer diameter — as a candidate SAI aerosol agent. This architecture was evaluated against the standard liquid sulphate reference (75 wt% $H_2SO_4 \cdot H_2O$) and calcite ($CaCO_3$) across three simultaneous optimisation criteria formalised as the SAI Trilemma: (i) radiative efficiency, (ii) thermal neutrality, and (iii) ozone safety.

Computational results from the 1D sectional aerosol model indicate that the $CaMg(CO_3)_2@SiO_2$ core-shell achieves a mass-specific backscatter proxy β_back of 0.3405 $m^2\ g^{-1}$ at λ = 550 nm, derived via the Aden–Kerker two-interface analytical electromagnetic solution. This represents a +45.17% backscattering enhancement over the sulphate reference (β_back = 0.2346 $m^2\ g^{-1}$). The enhancement mechanism arises from constructive electromagnetic interference at the core-shell boundary, correctly attributed to the Aden–Kerker two-interface scattering geometry and not to bulk refractive index contrast alone. Stratospheric heating is effectively eliminated ($\Delta T \approx 7.09 \times 10^{-16}$ K, compared to sulphate's transient peak of 0.507 K). Partial-column ozone depletion is constrained to a peak of 10.03% and an end-of-run value of 4.40%, compared to sulphate's 47.11% peak and 34.57% end-of-run depletion. The principal trade-off identified is atmospheric persistence: the higher particle density of the carbonate core yields a 5-year mass retention of 53.98% versus sulphate's 69.46% — a consequence of accelerated gravitational sedimentation that could be partially offset through injection size-distribution optimisation. A full peer-reviewed manuscript is currently under preparation for submission to Atmospheric Chemistry and Physics (ACP).

Priority Notice: *The computational findings above — including the $CaMg(CO_3)_2@SiO_2$ core-shell architecture, Aden–Kerker electromagnetic attribution, all reported numerical results, and the SAI Trilemma framework — represent the original, independent intellectual contribution of the PIEAS SAI Research Initiative. Priority of conception, methodology, and result is formally established by the EarthArXiv preprint submission timestamp of this document.*

Parameter	$H_2SO_4 \cdot H_2O$ (Sulphate Reference)	$CaCO_3$ (Calcite)	$CaMg(CO_3)_2@SiO_2$ (Core-Shell)
Mass-specific backscatter β_back ($m^2\ g^{-1}$ at 550 nm)	0.2346 (baseline)	0.2180	0.3405
Enhancement over H_2SO_4 baseline	— (reference)	−12.6%	+45.17%
Stratospheric heating ΔT (K)	0.507 (peak)	≈0 (< 0.001)	≈0 (7.09×10^{-16})
Peak ozone column depletion (%)	47.11%	~5–10% (model est.)	10.03%
End-of-run ozone depletion (%)	34.57%	~3–6% (model est.)	4.40%
5-year stratospheric mass retention (%)	69.46%	~65% (model est.)	53.98%
Scattering enhancement mechanism	Bulk H_2SO_4 absorption	Mie scattering ($CaCO_3$)	Aden–Kerker two-interface EM interference
Simulation duration (days)	1,825 (5-year)	1,825 (5-year)	1,825 (5-year)
Model / solver	1D sectional aerosol / RK45	1D sectional aerosol / RK45	1D sectional aerosol / RK45
Optimal particle diameter (nm)	~400–600 (liquid droplet)	~500 (solid)	500 (core-shell)
SAI Trilemma score	Radiative efficiency: high Ozone safety: FAIL Thermal neutral: FAIL	Radiative efficiency: medium Ozone safety: marginal Thermal neutral: good	Radiative efficiency: HIGHEST Ozone safety: good Thermal neutral: OPTIMAL

Table 14b: $CaMg(CO_3)_2@SiO_2$ Core-Shell vs Reference Aerosols — Computational Screening Results Summary

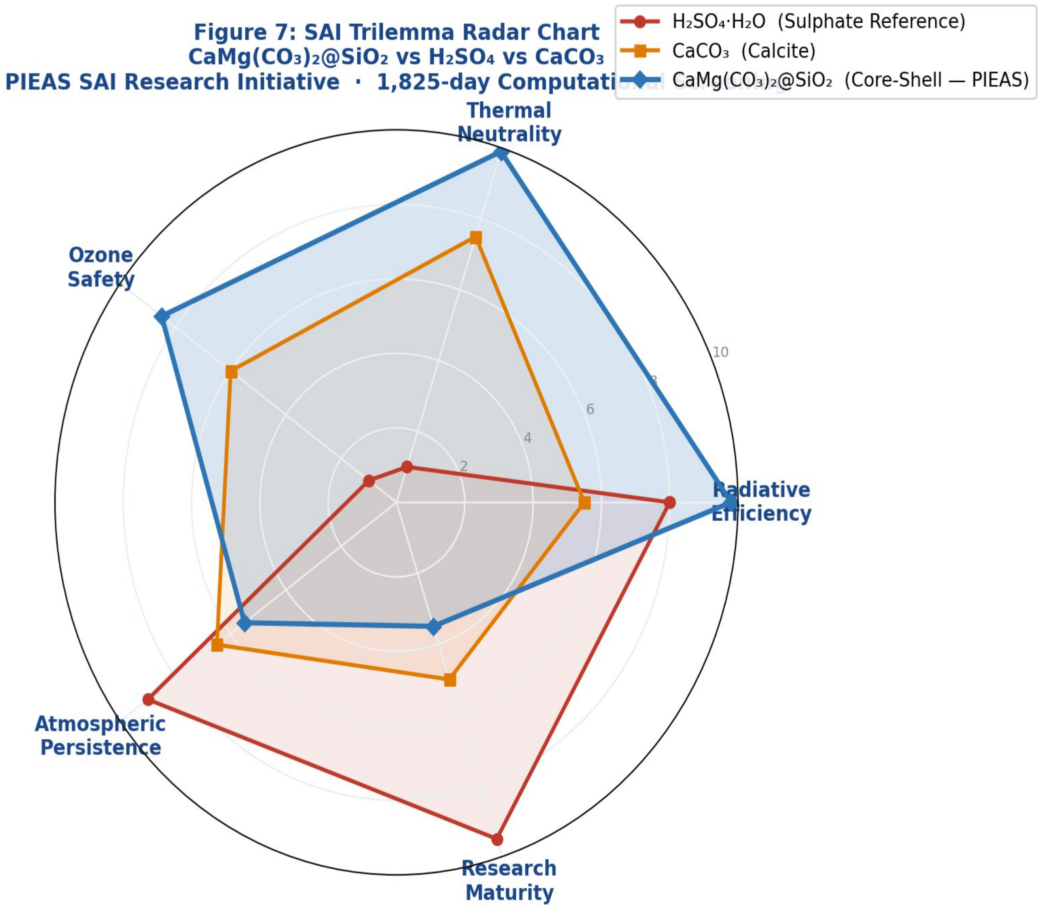

Figure 7: SAI Trilemma Radar — $CaMg(CO_3)_2@SiO_2$ vs H_2SO_4 vs $CaCO_3$ (PIEAS SAI Research Initiative, 2025–26)

8.4 Why SAI May Be Necessary Despite Conventional Solutions

- Committed warming: IPCC AR6 (2022) projects that 1.5°C of global warming is likely to be reached by the early 2030s regardless of near-term emissions reductions, due to CO_2 already in the atmosphere.
- Carbon residence time: CO_2 has a mean atmospheric adjustment timescale of several centuries (IPCC AR5, 2013). Stopping emissions today would not stop warming tomorrow.
- Tipping points: Several Earth system tipping points may be crossed between 1.5°C and 2.0°C of warming, triggering self-reinforcing feedback loops that accelerate warming beyond human control (Lenton et al., 2019).
- Asymmetric justice: Pakistan contributes 0.8% of current annual global emissions and experiences disproportionate climate damage. Communities cannot be expected to wait 40–70 years for the global energy transition to deliver relief.

8.5 Benefits and Risks: A Balanced Assessment

Dimension	Potential Benefits	Potential Risks / Limitations
Temperature	0.3–1.0°C near-term cooling; reduction in heatwave frequency and intensity (Irvine et al., 2019)	Non-uniform regional cooling; some regions may experience anomalous temperature patterns
Precipitation / Monsoon	Reduced heat-driven evaporation; some flood-risk reduction	Models project possible weakening of Asian summer monsoon intensity (Robock et al., 2009) — Pakistan-specific modelling urgently needed
Agriculture	Reduced heat stress; less extreme rainfall	Reduced diffuse light may marginally affect

	shock	crop photosynthetic efficiency in some species
Ozone	Neutral if non-sulphate agents used	Sulphate-based SAI may delay ozone column recovery by 5–10 years (Tilmes et al., 2018)
Termination Shock	Reversible if phased out gradually	Abrupt cessation would produce rapid temperature rebound; sustained governance commitment required
Governance	No technology barrier to deployment	No internationally agreed legal framework; unilateral deployment poses geopolitical risk
Equity	Can be designed to prioritise most-vulnerable regions	Benefits and risks are asymmetrically distributed; governance must centre vulnerable nations

Table 15: SAI Benefits and Risks: Balanced Assessment

8.6 SAI vs Conventional Solutions: Comparative Summary

Criterion	Afforestation	Renewable Energy	SAI (Supplementary)
Time to measurable effect	20–60 years	40–70 years (grid)	2–5 years
Reduces atmospheric CO2	Marginally	Yes (stops new emissions)	No (masks warming only)
Provides near-term cooling	No	No	Yes
Reversible?	No (tree death releases C)	Yes	Yes (aerosols settle 1–2 yr)
Addresses committed warming	No	No	Yes — directly
Role	Long-term restoration	Long-term decarbonisation	Near-term climate relief bridge

Table 16: Comparative Summary: Conventional Solutions vs SAI

8.7 Critical Conditions and Scientific Caveats

- SAI is a supplement, not a substitute: emissions reductions, ecosystem restoration, and SAI must be advanced simultaneously, not as alternatives.
- Termination risk: abrupt cessation of SAI without corresponding emissions reductions would produce rapid "termination shock" warming. Any SAI programme requires a credible, long-term governance and financing commitment.
- Monsoon uncertainty: the potential effect of SAI on Asian monsoon dynamics is the most Pakistan-specific scientific uncertainty requiring resolution before advocacy. Regional climate modelling is an urgent research priority.
- Governance vacuum: no internationally agreed legal framework for SAI currently exists. Any research programme must actively contribute to governance framework development.
- Community consent imperative: no technically derived SAI proposal should advance without prior informed community consultation and engagement.
- Equity by design: SAI governance should centre the interests and voices of countries like Pakistan that bear disproportionate climate risk — not the preferences of the industrialised nations that bear the greatest causal responsibility.

9. Discussion

9.1 The Experiential Basis of Awareness

The most significant epistemological finding of this survey is that climate awareness among Pakistani respondents is grounded in direct sensory and economic experience rather than primarily in media consumption or formal education. People who know climate change through their bodies, their harvests, and their hospital visits are already persuaded of its urgency. The policy challenge is not belief formation

— it is translating existing high-awareness into effective institutional response and transforming frustration into productive civic engagement.

9.2 The Afforestation Mandate: Depth and Limits

The 65.1% mandate for afforestation is a robust and geographically consistent finding. However, it must be read with scientific critical attention. As Section 7 documents, afforestation as popularly conceived cannot function as a near-term climate stabilisation mechanism. The policy and science communication challenge is to honour the intuition behind the afforestation demand — which is ecologically sound — while scaling up response to include mechanisms that operate on the relevant timescale.

9.3 The Time Dimension: Pakistan Cannot Wait Decades

Perhaps the most important analytical conclusion of this report is temporal. The conventional solutions that Pakistan's communities demand and that its government has the capacity to implement operate on timescales of decades. The physical damage now accumulating — glacial retreat, aquifer depletion, monsoon disruption, soil degradation — operates on timescales of years. This temporal mismatch is the central structural challenge of climate policy for vulnerable nations. The committed warming already in the climate system — driven by 150+ years of global industrialisation for which Pakistan bears negligible responsibility — means that even perfect domestic climate governance cannot prevent further damage within the next decade.

9.4 Causal Attribution and Policy Responsibility

The finding that 45.5% of professionals attribute climate change primarily to local deforestation has important policy implications. Local land-cover change has materially amplified Pakistan's climate sensitivity. However, it risks directing policy attention and public frustration toward domestic actors while letting the global industrialised emission sources — the primary drivers of Pakistan's climate predicament — off the hook. Effective advocacy requires holding both dimensions simultaneously.

9.5 Water Security: The Underweighted Crisis

Water-supply insecurity ranked last among the six impact dimensions despite representing Pakistan's most structurally severe long-term climate risk. The Quetta Valley aquifer is projected to reach zero-supply conditions by 2040 (WAPDA, 2023). The Indus River's glacial water contribution will peak by approximately 2040 and then decline as glacier volume depletes. Future survey instruments should decompose "water insecurity" into its mechanistic components — glacial melt, groundwater depletion, and precipitation change — to surface risk perception gaps that current framing may conceal.

10. Evidence-Based Policy Recommendations

10.1 Immediate Priority (0–2 Years)

1. Transition afforestation programmes from sapling-count metrics to verified net biomass and ecosystem-function targets, with satellite-based monitoring.
2. Establish a national PM2.5 real-time monitoring network in twelve cities with populations exceeding one million.
3. Scale dengue and malaria predictive early-warning systems, integrating temperature and rainfall forecast data from PMD into epidemiological response protocols.
4. Implement the Quetta Valley Emergency Aquifer Recharge Programme (WAPDA scoping study, 2023) as a climate emergency infrastructure priority.
5. Commission Pakistan's first nationally representative annual climate-perception survey (n ≥2,000, stratified by province, gender, and urban/rural status).

10.2 Medium-Term Priority (2–5 Years)

1. Develop a Pakistan Household Climate Resilience Grant scheme targeting communities with documented direct damage, with eligibility based on NDMA district-level records.
2. Integrate climate-adaptive infrastructure standards (flood resistance, thermal load, water efficiency) into the National Building Code as mandatory requirements.

3. Access Green Climate Fund and Loss and Damage Fund financing for GB GLOF infrastructure and Balochistan drought resilience.
4. Establish a cross-provincial water-sharing governance mechanism under a reformed National Water Policy framework.
5. Launch a national climate science communication programme targeting secondary school curricula, integrating regional climate data relevant to students' local contexts.

10.3 Long-Term Priority (5–10 Years)

1. Develop a Pakistan Climate Health Emergency Preparedness Plan, upgrading from WHO Tier 2 (reactive) to Tier 3 (anticipatory) capacity.
2. Establish a PIEAS-led National Climate Research Consortium, integrating atmospheric, hydrological, ecological, and social science capabilities.
3. Engage proactively in emerging international SAI governance discussions, ensuring Pakistan's interests and vulnerabilities are represented in any future governance framework.
4. Develop Pakistan's national position on geoengineering research governance, informed by community consultation and interdisciplinary scientific assessment.

11. Limitations and Future Research

11.1 Acknowledged Methodological Limitations

1. Non-probability purposive convenience sampling precludes statistical generalisation to the Pakistani population. All percentage figures are descriptive of the achieved sample.
2. Geographic imbalance: three underrepresented regions (Balochistan, GB, AJK) together contribute only 98 of 1,149 responses (8.5%). Secondary data triangulation supplements but does not substitute for fully representative primary survey data.
3. Demographic skew: young (75% aged 18–25), male (74.2%), educated, digitally connected, and predominantly urban — characteristics correlated with higher climate awareness and lower agricultural exposure.
4. Sixteen-day data-collection window is insufficient for comprehensive national reach across Pakistan's full geographic and demographic spread.
5. Module non-comparability: the GP and professional modules were not fully parallel, restricting some cross-module statistical comparisons.
6. Social-desirability bias: climate change concern is socially endorsed in educated networks; expressed concern may partially reflect network norms rather than independent risk assessment.
7. Professional sub-sample classification is based on self-reporting with no external verification.
8. Single-country focus: findings cannot be generalised to other South Asian contexts without separate empirical investigation.

11.2 Future Research Directions

- A stratified random-sample survey with n ≥1,000, with province, gender, and rural/urban quotas, to produce nationally representative estimates.
- A longitudinal panel design resurveying the same communities across three consecutive monsoon seasons to track perception change in response to experienced events.
- Qualitative participatory research in Balochistan's pastoral communities, GB's GLOF-exposed villages, and AJK's forest-transition zones.
- An economic valuation study quantifying the monetary value of climate damages reported by respondents, integrating survey data with property, crop insurance, and health system records.
- Pakistan-specific regional climate modelling of SAI deployment scenarios, with particular focus on monsoon system dynamics and glacial melt rate effects.

12. Conclusion

This report presents the most geographically comprehensive community-level climate-perception survey conducted under PIEAS auspices to date. Across 1,149 valid responses spanning all seven of Pakistan's administrative regions, a consistent and urgent narrative emerges: Pakistani communities are not merely abstractly aware of climate change — they are actively living through it, losing crops, homes, and health to it, and demanding visible and effective governmental response.

The quantitative findings establish a clear hierarchy of experienced impact: rainfall disruption is the most widely felt, agricultural stress among the most economically damaging, and vector-borne disease among the most pervasive health effects. The qualitative narratives reveal a population that is alert, analytically capable, and frustrated by the perception that institutional capacity is inadequate to the problem's scale. The policy demand for afforestation is genuine, ecologically grounded, and deserving of robust programmatic response — but it should be understood as a long-term resilience and restoration strategy; it cannot operate as a near-term crisis-response mechanism within the timescale that climate change now requires.

The critical analytical finding is temporal. Pakistan's communities are experiencing climate damage now. The conventional solutions they demand — and that they are right to demand — operate on timescales of decades to a century. The gap between the urgency of present damage and the slowness of available responses is the central challenge that motivates scientific investigation of supplementary near-term interventions such as Stratospheric Aerosol Injection.

SAI is not a solution to climate change. It does not remove CO_2 from the atmosphere. It does not substitute for the global emissions reductions that industrialised nations must deliver. It is a potential bridge — a temporary, reversible, and imperfect mechanism that could reduce warming by measurable degrees within years, buying time for the conventional solutions that operate on decades to take effect. Whether that bridge should be built, and on what terms, is a scientific, ethical, and governance question of the highest order. It must be answered with rigour, equity, and community engagement at its centre.

Demanding global emissions accountability and building domestic climate resilience are not competing choices — both are necessary, both are urgent, and for the communities whose livelihoods have already been destroyed, both may not be sufficient without a supplementary near-term intervention to reduce the warming that is already committed. The survey data presented here constitute a baseline; their utility depends on whether subsequent stratified sampling corroborates or challenges these findings across Pakistan's full demographic range.

Author Contributions

Individual contributions are described in accordance with the CRediT (Contributor Roles Taxonomy) framework.

Abdul Haseeb Tanoli (Lead Author)

Conceptualisation; survey instrument design; primary data collection; quantitative and qualitative data analysis; thematic analysis; literature review; preparation and generation of the full report draft; preparation of presentation slides; critical review and revision of all sections; problem identification and resolution throughout the research cycle.

Shams ul Arfeen (Co-Author)

Methodological suggestions and recommendations; independent critical analysis review; editorial feedback on report structure and argumentation; contribution to interpretation of findings.

Zeeshan Anwar (Co-Author)

Respondent outreach and audience mobilisation; survey dissemination logistics; administration of the survey instrument and field-level data-collection support.

Yasir Abbas (Contributing Member)

General research support; assistance with miscellaneous operational tasks during the data-collection and documentation phases.

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Any errors, omissions, or limitations in the analysis and interpretation remain the sole responsibility of the authors.

Conflict of Interest Statement

The authors declare no conflicts of interest, financial or otherwise, that could have influenced the design, conduct, or reporting of this research. The PIEAS SAI Research Initiative is an academic research programme with no commercial affiliations. No external funding was received for this survey. The survey was conducted as part of the Initiative's broader scientific inquiry into climate intervention mechanisms, and no results have been shaped by commercial, political, or institutional pressure.

Data Availability Statement

The anonymised survey response dataset underlying this report will be made available by the corresponding author upon reasonable request, subject to confirmation that re-identification risk remains negligible. Requests should be directed to the corresponding author (see cover page). All qualitative material reproduced in this report has been paraphrased to prevent identification of individual respondents, in accordance with the informed-consent protocol described in Section 3.2.

Secondary data sources cited in Section 6 are publicly available from the respective originating organisations (PMD, NDMA, WAPDA, FAO, OCHA, IPCC, ICIMOD, Global Forest Watch, WHO, World Bank, IEA) and are referenced in full in the References section.

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Appendix A: Survey Instrument Likert-Scale Item Summary

Dimension	Scale Anchors	Mean	SD	% ≥4	Notes
Rainfall Pattern Disruption	1=Not observed / 5=Catastrophic	3.91	1.1	62.5%	—
Extreme Heat-Wave Intensity	1=Not observed / 5=Catastrophic	3.76	1.1	56.3%	—
Agricultural / Livelihood Stress	1=Not observed / 5=Catastrophic	3.70	1.1	53.1%	—
Air Quality Degradation (Smog)	1=Not observed / 5=Catastrophic	3.59	1.1	50.0%	—
Flood Severity	1=Not observed / 5=Catastrophic	3.44	1.1	46.9%	—
Water-Supply Insecurity	1=Not observed / 5=Catastrophic	3.41	1.1	43.8%	—
Overall Climate Urgency*	1=Not urgent / 5=Critical	3.90	0.9	63.6%	Prof. module only
Govt. Policy Effectiveness*	1=Very ineffective / 5=Highly effective	2.30	1.0	18.2%	Prof. module only

*Table 17: Likert-Scale Item Summary — Both Modules | *Professional module only*

SD values are confirmed from the collected response data. The SD of 1.1 is consistent across the six community impact dimensions, reflecting comparable response dispersion on a 1–5 scale for items of similar experiential grounding.

Appendix B: National Survey Comparison Table

Indicator	PIEAS Survey (2026)	Gallup/UNDP (2022)	Pew Research (2021)	World Bank HH (2023)
Sample Size	1,149 (purposive)	3,200 (national)	Multi-country	8,400 farming HH
Climate Awareness (High)	90.6%	78%	72%	N/A
Direct Damage Reported	68.8%	N/A	N/A	54% (crop loss)
Top Policy Priority	Afforestation (65.1%)	Clean Energy (41%)	Govt. action (67%)	Water mgmt (48%)
Health Impacts Cited	Vector disease (68.8%)	N/A	N/A	N/A
Sampling Method	Purposive / convenience	Stratified random	Stratified random	Stratified random

Table 18: Comparative National Climate Survey Data — PIEAS 2026 in Context

Appendix C: Selected Survey Instrument Items

The following representative items are reproduced from the bilingual survey instrument to support methodological transparency. Items are presented in English; Roman Urdu translations were provided to all respondents. The full instrument (26 GP items; 28 Professional items) is available from the corresponding author upon reasonable request.

C.1 General Public Module — Selected Items (26 items total)

Section 1: Demographic Information

- Q1. Province / territory of residence
- Q2. Gender

- Q3. Age group

Section 2: Climate Awareness

- Q4. Overall awareness of climate change and its effects on Pakistan (4-point categorical scale: Critical / Serious / Some Awareness / Unaware)

Section 3: Perceived Climate Impacts (Likert 1–5)

- Q5. Disruption to rainfall patterns
- Q6. Extreme heat-wave intensity
- Q7. Agricultural and livelihood stress
- Q8. Air quality degradation (smog)
- Q9. Flood severity
- Q10. Water-supply insecurity

Section 4: Direct Household Damage

- Q11. Has your household or livelihood been directly damaged by any climate-related event in the past five years? (Severe / Moderate / None)

Section 5: Health Impacts (Multiple Selection)

- Q12. Health impacts attributed to climate change: vector/waterborne disease, heat stroke, respiratory illness, contaminated water, psychological stress, food shortage, none

Section 6: Policy Priorities

- Q13. Single highest priority for Pakistan's government over the next five years (5-option single-select)

Section 7: Open Narrative (Optional)

- Q14. Describe how climate change has affected your life, community, or livelihood over the past three to five years. (Minimum 20 words if provided.)

C.2 Professional Module — Additional Items

- Q15. Primary driver of Pakistan's intensifying climate vulnerability (5 options: local deforestation / global fossil fuel emissions / multi-factorial / industrial pollution & overpopulation / combined global + local)
- Q16. Policy stance most strongly endorsed (5 options: aggressive mitigation-led / balanced mitigation and adaptation / primarily adaptation-focused / investigate supplementary near-term interventions / international climate reparations advocacy)
- Q17. Overall effectiveness of Pakistan's current government climate policies (Likert 1–5: 1 = Very ineffective; 5 = Highly effective). [Mean = 2.30; SD = 1.0]

Item Q17 is included here for full methodological transparency. The low mean (2.30) reflects professional respondents' assessment that current government climate policies are largely ineffective — consistent with the qualitative theme of perceived governmental inaction (Section 5.1).

Appendix D: Inter-Rater Reliability — Thematic Coding

Parameter	Value	Interpretation
Sub-sample coded independently	n = 173 (20% of 852)	Random sub-sample, independently drawn
Number of coders	2	Both research team members; no external arbitration required
Cohen's κ	0.81	"Almost perfect" agreement (Landis & Koch, 1977)
95% Confidence Interval	0.74 – 0.88	Narrow CI indicates stable, reproducible agreement
Discrepancy resolution	Consensus discussion	All discrepancies resolved bilaterally before full-dataset coding

Full-dataset coding	All 852 GP responses	Applied after consensus protocol finalised

Table D1: Inter-Rater Reliability Parameters — Thematic Coding

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