Ministry of Climate Change and Environmental Coordination

APPROACH FOR EXEMPLAR CLIMATE CHANGE RISK ASSESSMENT BASED ON CLIMATE STORYLINES

National Adaptation Plan for Pakistan

"Adapting Today for Sustainable Tomorrow"

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ABBREVIATIONS

ABBREVIATION	DEFINITION
CMIP	Coupled Model Intercomparison Project
CRA	Climate Risk Assessment
GCF	Green Climate Fund
GCM	Global Climate Model
IPCC	Intergovernmental Panel on Climate Change
KNMI	Koninklijk Nederlands Meteorologisch Institut
MCR	My Climate Risk (WCRP Lighthouse Activity)
NAP	National Adaptation Policy
NGO	Non-Governmental Organization
NMHS	National Meteorological and Hydrological Services
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SSP	Shared Socio-Economic Pathway
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WI	Walker Institute
WMO	World Meteorological Organization

FIGURE 1: MEN PADDLE ON MAKESHIFT RAFTS AS THEY CROSS A FLOODED STREET IN HYDERABED, PAKISTAN, 2022. SOURCE: YASIR RAJPUT/REUTERS

1. INTRODUCTION

Pakistan is one of the countries worst affected by climate change (1). The average rise in temperature over the last decade is well above the global average, increasing both the frequency and intensity of heat stress, droughts, and floods (2). The super floods of 2010 caused $11.8 billion in damage and affected 20.2 million people (3; 4). As the cost of the most recent flooding event, which started on 14th June 2022 and is continuing, is counted, the resulting devastation looks set to be even more extreme (5). However, hazards only become disasters when the capacity to deal with an event is lacking. Potential impacts are a combination of the physical hazard and the level of vulnerability of the communities, infrastructure and environment affected. By producing a comprehensive national risk assessment, effective adaptation to limit Pakistan's future vulnerability to extreme climate events can be implemented.

The Ministry of Climate Change (MoCC) in Pakistan has successfully obtained a grant funded through the Green Climate Fund (GCF) for a three-year project to advance the process of updating their National Adaptation Plan (NAP). The NAP seeks to support the multi-sectoral, medium- to long-term adaptation planning and budgeting in Pakistan and promote the integration of climate change adaptation issues into development planning processes and policies. This includes the reinforcement of systems for developing and sharing climate risk and vulnerability information, and the development of sustainable financing mechanisms for climate change adaptation initiatives.

In this report, an exemplar structure for constructing a risk assessment based on climate storylines has been set out. The methodology provides a framework for Pakistan stakeholders to generate plausible storylines at national, provincial, and local level to facilitate adaptation planning decision-making and create flexible and locally focused adaptive strategies. In Section 2 the theory and rationale behind using climate storylines and their importance to risk assessment is explained. Section 3 introduces key ideas used in quantifying risk, discusses the use of climate data in risk assessments, and underlines the necessity of collaboration with stakeholders for co-production of decision-centric storylines. Section 4 summarises the practical process involved in creating a risk assessment based on climate storylines. Section 5 outlines the expected outcomes of this process.

It is hoped that by describing the practical process used and situating the storylines approach to climate risk within the scientific literature, Pakistan will have enhanced capacity for the future development of contextually relevant, national, and provincial climate storylines. Bringing together climate scenarios with development and policy measures through a storylines approach, adds tangible value to current risk management practice. It provides a systematic framework for the scientifically robust and transparent integration of locally specific expert knowledge with climate projections that will enable Pakistan to build in long term adaptation and resilience across specific sectors.

2. WHY USE CLIMATE STORYLINES?

If action is not taken to limit the risks inherent in climate hazards, then national development gains are at risk of being eroded, or even reversed, potentially leading to greater inequality within societies, particularly for the most vulnerable marginalised sectors of a community (6). Risk assessment is a vital tool in establishing links between impacts and risks to identify opportunities for adaptation. Using climate storylines allows improved climate risk understanding, by incorporating the uncertainties associated with climate change impacts into the decision-making process.

A climate storyline is defined as: "*a physically self-consistent unfolding of past or future events or pathways*" (7). It is a powerful way to link physical climate events and socio-economic aspects of climate change. Storylines provide frameworks that ensure responses are best fitted to needs, highlighting areas where resources can be most effectively focused.

Key reasons to use storylines include:

- improving risk awareness by using events rather than probabilities, this better fits with individuals' perceptions,
- strengthening decision-making, by working from vulnerability and combining climate change information to address compound risk,
- providing a physical basis for partitioning uncertainty, to give more credible regional models, and
- allowing exploration of boundaries of plausibility surrounding event uncertainties.

When the uncertainty of model data is incorporated into results in a probabilistic way, decisions can no longer be made with confidence. However, risk assessment which uses this uncertainty to create a range of scenarios through storylines, strengthens the decision-making process. Uncertainties around climate predictions can result in major implications. These uncertainties fall into four main groups:

1. Uncertainty based on unknown future socio-economic pathways and levels of emissions
2. Uncertainty inherent in climate models used to make climate projections
3. Natural variability of the climate system
4. Sensitivity of people and systems to climate change

Climate storylines have been used in several contexts to bridge the gap between uncertain climate projections and detailed local knowledge. They can be applied to allow for the whole of Pakistan to be considered via specific adaptation sectors, such as health or agriculture, using expert input to guide this process. Use of local knowledge to improve and refine both climate storylines and risk assessments is both effective and cost efficient, bringing with it genuine ownership of the process by local stakeholders. Projections are conditional on both the future level of emissions and the socio-economic pathway. These are expressed through the Representative Concentration Pathway (RCP) and the complementary Shared Socio-Economic Pathways (SSP) currently being used by the Intergovernmental Panel on Climate Change (IPCC).

Different climate models rely on diverse dynamics and coupling mechanisms, which result in a range of future projections. In the sixth phase of the Coupled Model Intercomparison Project (CMIP6) there are 134 different models, from 53 different modelling centres (8; 9). In the past there has been a certain reliance on using an ensemble of such models and calculating a single overriding prediction across the results, but the output from such methods has been shown to depend strongly on the way results are combined and can lead to important patterns being missed (10). Looking at several plausible storylines allows a qualitative understanding to replace unrealistic quantitative precision. For example, infrastructure changes will be more long-lived if multiple futures are considered, as has been the case with the Thames Barrier in London. Here planning incorporated a range of possible future scenarios so that the infrastructure is adaptable to changes in sea level rise and climate change until the end of the century (11).

Climate storylines can be looked at in a national context, highlighting vulnerabilities that affect the whole of Pakistan, but also in a more targeted way to examine key adaptation sectors at a provincial level. By using a consistent method across these two scales, information can be presented in a useable and therefore, implementable format for decision-makers.

Not only does the method of climate storylines allow a full range of potential futures to be considered, but it also enables the probable impact of adaptation policies to be gauged across these disparate futures, through the involvement of expert stakeholders. Humans respond far better to episodic[1] rather than semantic[2] data, so by framing climate scenarios as scientifically constructed storylines, data is more likely to prompt a response that can lead to effective policies (7). In this way vulnerability stress testing, allowing a cascade of multiple impacts to be considered can also be undertaken (12).

Event-based storylines improve risk awareness, strengthen decision-making and explore the boundaries of physical events. By including uncertainty within the adaptation process, it is possible to plan for a full range of scenarios, making decisions more robust and building in a greater understanding of a likely policy tipping point.

In Pakistan, a combination of droughts and floods, makes adaptation particularly challenging. A short-term increase in water from glacial melt, causing glacial lake outburst flooding and with further flooding implications downstream, also impacts future water resources for those relying on snow and glacier meltwater to irrigate their farms. Policies must be able to address a range of potential futures and deal not just with immediate impact events, like flash floods, but also slow-onset changes, like sea level rise. Where credible probabilities cannot be placed on climate modelling outcomes, due to uncertainties, then examining a range of climate storylines allows for the creation of policies which can address multiple potential future climates. Climate storylines also allow risk to be assessed even where data is sparse if local expert knowledge is available. From such an initial assessment, further expert input will then continue to inform later adjustments gradually refining an understanding of the level of risk iteratively.

3. APPROACH

3.1: Introduction to Key Concepts in Risk Assessment

Climate Risk Assessment (CRA) can be developed by a diverse number of approaches, including risk and vulnerability mapping, expert judgement, and sensitivity analysis. In this approach, we advocate for the use of climate storylines to incorporate uncertainty under different RCPs or SSPs. Within each storyline qualitative, quantitative, and expert inputs can be combined in a transparent way to ensure a cost effective, but nonetheless scientifically robust approach.

To use storylines for impact analysis and development of adaptation options a certain amount of data is necessary. Ideally this should include stakeholder input at local, provincial, and national level in addition to current climate projection data from both peer-reviewed and grey literature. Where existing data is not comprehensive, further climate modelling is necessary. This methodology is focused on the use of storylines for climate risk assessment only and does not elaborate on its application for impact analysis and development of adaptation options.

Climate risks are natural hazards which include:

- Geophysical (e.g. landslides, rock slope failures, earthquakes)
- Hydrological (e.g. floods)
- Cryospheric (e.g., avalanches, glacier slides, glacier surges, glacial lake outburst floods (GLOFs))
- Geomorphical (e.g., extreme soil erosion, changes in fluvial systems)
- Meteorological (e.g. extreme temperatures, extreme wind and rain storms, drought, wildfires)
- Biological (e.g. disease epidemics, insect plagues)

Clearly many of these are linked in space and time and may serve as the input conditions for other extreme events (e.g., rock slope failure may trigger GLOFs, severe rainstorms may trigger river floods and soil erosion on agricultural land).

Although many of these will have at their root changes to the climate, hazards can also be triggered by anthropogenic changes to natural ecosystems. For example, when urbanisation occurs this can cause problems such as altered surface water flows leading to floods or temperature increases due to the urban heat island effect causing health issues (13; 14). Environmental effects have been noted particularly around the coast of Pakistan, with the loss of mangroves and extra heat and acidification of the sea combining to cause reductions in shrimp growth and reproduction (15). This in turn has led to changes in livelihood as locals convert from shallow shore harvesting to more dangerous deep-sea fishing or in some cases even migrate from the coast to cities (16; 17).The frequency and severity of these events in Pakistan has been shown to have been amplified by climate change over the last 30 years (18).

[1] Episodic data: knowledge based on events, allowing connections between experiences and future projections (7).

[2] Semantic data: context-free knowledge based on facts rather than experiences (7).

Climate hazards pose a significant risk to people by its effect on both the built and natural environment at national and local levels. The full effect of climate change can be understood by pairing climatic and socio-economic scenarios.

Two domains are considered:

1. First order: direct impacts of natural hazards such as droughts, floods, agricultural yield, land/soil degradation, natural ecosystems
2. Second order: effects impacted by natural hazards, but mediated by the first order effects, such as health, productivity associated with livestock, infrastructure

This pairing is best illustrated by reference to a project undertaken in Iraq. In this case two main climate hazard indicators were selected for the region in conversation with the stakeholders. These were the change in the number of days annually with a heat index of over 32°C (corresponding to high heat stress on the human body) and the *percentage change in extreme precipitation annually*. Different levels of change for each of these climate indices were quantified using diverse RCPs and Regional Climate Models (RCMs), which were chosen to encompass the complete range of possible projections. By plotting this two-dimensional data **four climate change storylines** were defined in the four quadrants of the graph, two of which were then extended into full narratives. These were "*hot-humid with more extreme precipitation*" and "*hot-humid with less extreme precipitation*". Creating the narratives relied upon expert input to anticipate the socio-economic impacts of such changes and then fine tuning in further discussions with local stakeholders. This process continues as part of an ongoing and iterative climate risk assessment cycle, with stress-testing and dialogue at its centre helping to further shape adaptation interventions and sharpen the focus of additional quantitative impact modelling.

A fully illustrated description of the application of this process for the Persian Gulf region of Iraq will follow in Section 4.

Four elements help to establish the threat posed by any given risk. These are illustrated in Figure 2. Whilst natural climate hazards are unlikely to respond in the short term to direct local intervention, they may be reduced over longer periods by global mitigation efforts. Exposure and vulnerability, however, can be reduced by local action with immediate results, just as resilience can be built by working from the bottom-up, referencing the practical experience of national, provincial and district stakeholders. These components of risk will be discussed in detail in Section 3.3.

FIGURE 2: THE FOUR ELEMENTS USED TO DETERMINE CLIMATE RISK

3.2. Sources of Climate Data

An extensive review of available literature allows climate data to be gathered for past, present, and future time periods. Where this has been peer reviewed quantitative data can be used with confidence. The uncertainties inherent in such data due to the selection of climate models and the choice of RCPs and SSPs is acknowledged through the use of the climate storyline framework.

The data used is distilled into graphical sectors by choosing relevant climate indices. Storylines are then created for each sector. For Pakistan a typical graph might be similar to the one shown in Figure 3. This is in line with the Netherlands approach for national scenarios (19) as shown in Figure 4. Climate projections are unlikely to be the same for all regions of a country, just as there will be differences between changes projected for different seasons. On top of this, projections are made in the context of emissions scenarios and for particular time periods. All these factors need to be considered in creating climate storylines that cover the uncertainty engendered by this diversity of futures. Using a two-dimensional graph to focus on the two most relevant climate indices for a region, information can be plotted to represent all cases. Where data clusters into sections on the graph, this allows general projection statements to be made. For a practical example of the use of this technique, please see the example in Figure 7. The principal risk factors derived from these projections form the basis for the climate storylines, which can then be translated into qualitative descriptions of anticipated socio-economic impacts.

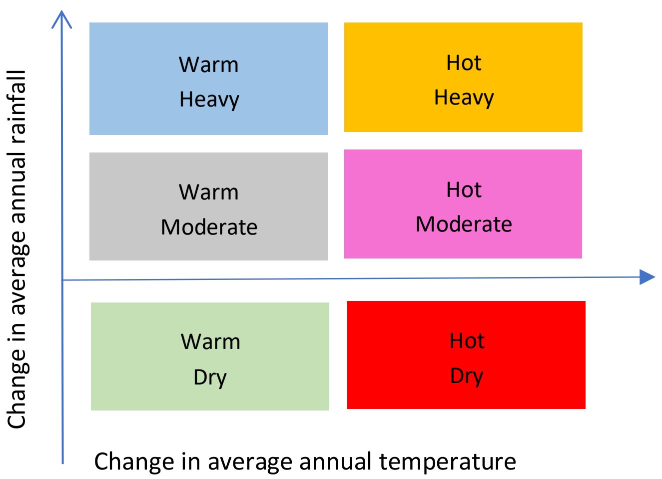


FIGURE 3: EXAMPLE OF GRAPHICAL SUMMARY OF POSSIBLE CLIMATE FUTURES FOR PAKISTAN BASED ON PROJECTED TEMPERATURES AND RAINFALL.

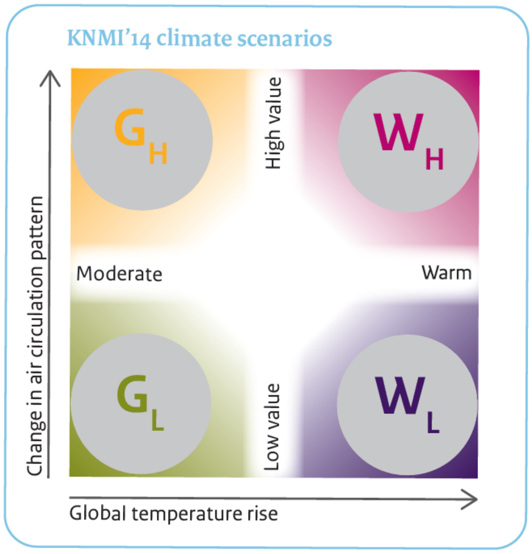


FIGURE 4: EXAMPLE OF GRAPHICAL SUMMARY OF POSSIBLE CLIMATE FUTURES TAKEN FROM NETHERLANDS APPROACH FOR NATIONAL SCENARIOS.

In developing countries where data availability is sparse, modelling capabilities are compromised, and so simplified methods can be used just as effectively (11). If data is limited and the timescale short, then a certain reliance on published and grey literature will be necessary to form coherent socio-economic narratives. However, these can be enhanced using expert input through stakeholder consultation.

This will form the focus of any climate modelling that is to be undertaken, either using an ensemble of Global Climate Models (GCMs) or downscaling via Regional Climate Models (RCMs). Where such data is already available or the project timescale prohibits new modelling, climate projections can be drawn from available peer-reviewed literature. Using these projections alongside the initial survey data from stakeholders, material from previously published papers and grey literature, climate storylines can be constructed.

3.3. Key Steps of Developing Climate Risk Assessments Using Climate Storylines

The following steps are required to develop **a climate risk assessment as part of the climate storyline:**

Step 1: Assess Level of Hazard

The level of hazard is quantified based on its intensity, duration and return period.

- Where there is insufficient information on the severity, frequency, and consequences of hazards to develop a continuous response function, it is recommended to use the following thresholds and base decisions on the extent of historical events detailed in literature:
  - **Minor:** Adverse impacts low, <30% reduction in system capacity
  - **Moderate**: Medium impacts about 50% reduction in system capacity
  - **Major**: Disruptive high impact event about 80% reduction in system capacity
- Expert stakeholder judgement should be sought to confirm these qualitative rankings.

Step 2: Assess Exposure

Exposure depends on the geographical extent of any event. In Pakistan, exposure is highly variable, with some regions susceptible to multiple hazards. Exposure depends on the size of a system defined as a combination of land, infrastructure and communities based in a certain area.

Step 3: Assess Resilience

Resilience of any system is based on its hardiness. A system with a high level of resilience will, in the long-term, be only mildly affected by an event, due to pre-planning of a response and quick recovery time. This ability to bounce back from an event, does not involve a system's sensitivity, but rather how impacts once they do occur can be limited. The United Nations 2020 report on building resilient societies considers systems as resilient when "*they have absorptive, adaptive, anticipative, preventive and transformative capacities and resources to cope with, withstand and bounce back from shocks*" (20).
It has also been shown that a large part of resilience involves enabling people to access the necessary information to respond to the changing climate in a timely manner, including both early warnings and longer-term monitoring of future projections (21).

Step 4: Assess Vulnerability

Vulnerability is a measure of sensitivity to a hazard. This can be altered both in a positive or negative way by actions taken. Determining vulnerability requires a combination of stakeholder views and literature review. Where literature alone is relied upon to make these judgements, both peer reviewed academic papers and grey literature must be considered, as vulnerability is not a static measure, and it is necessary to use the most current information available.

The four types of vulnerability are shown in Table 1, alongside examples of important vulnerability inputs that can be ascertained by stakeholder engagement. Examples of questions that can be used to begin stakeholder engagement are given in the table.

To provide more rigour, the process must be refined, with further areas to examine, complete with new relevant questions, created based on initial responses.

Step 5: Calculate the Level of Risk

Level of risk is calculated as a combination of the four elements: hazard, exposure, resilience and vulnerability (see Figure 2). This demonstrates how risk can be reduced by means of adaptation. Although the severity and frequency of climate events may be beyond human control in the short term, adaptation provides a path to alter risk levels. Reducing exposure could mean relocating communities away from areas of coastal erosion or planting screening trees to shade crops. Resilience can be increased by having disaster management plans set-up and relief centres stocked ready for extreme climate events. Vulnerability, can be reduced by supporting those in poverty, improving the drainage in urban areas or increasing local access to the findings of agricultural research. All of these adaptations should be based on stakeholder knowledge of specific areas for improvement to ensure action is as effective as possible. This information gathering involves a snowballing interview process, in which an initial consultation leads to further contacts and continuing in this way, accumulates a broad range of personal perspectives. The inclusion of this bottom-up planning, working from how people perceive their own risk (viz. "My Climate Risk" (22)) and what they feel are their key challenges in adapting to climate change, allows a two-way communication trail between policy makers and communities, fostering a spirit of trust, transparency and engagement. An example list of risk indicators for Pakistan based wholly on a literature review is given in Annex 1.

TABLE 1: A SUMMARY OF FACTORS DETERMINING VULNERABILITY

Vulnerability	Comprises	Examples of Stakeholder Input
Physical	Condition of materials, population density, relief services	• Has infrastructure been risk sensitively planned? • Has infrastructure been built to withstand climate hazards? • What is the level of local disaster preparedness? • Is water management in place to deal with both floods and droughts?
Social	Education, social equity, security, health, values of people affected	• How straightforward it is for the public to access critical information such as early warnings? • Is literacy sufficient to access information on climate events? • Are links between flooding and waterborne diseases understood?
Economic	Financial security of those involved	• How homogenous is the local community? • Do certain community groups stand to lose the most?
Environmental	Depletion or degradation of natural resources	• Have natural defences been eroded by previous climate events? • Has there been a major change to local land use?

Step 6: Develop Storylines

Storylines are developed by bringing together summary information on current and future climate risks and interpretation through socio-economic information. By using this method, a storyline can combine climate projections with the impacts that are likely to incur based on a combination of stakeholder and historical evidence. The synthesis of analytic data and individuals' perceptions of potential local impacts bridges the gap between climate science and context-specific impacts. This follows from the framework of the WCRP My Climate Risk Activity (22). To account meaningfully for the range of possible future emission scenarios (e.g., affecting global mean temperature) and the uncertainty in projections of regional circulation change (e.g., affecting local precipitation change), several climate storylines should be constructed, where these conditions are expressed by two major axes describing future changes. In Figure 5, depending on the future period chosen, the temperature relative to pre-industrial levels varies to different extents with the choice of future carbon scenario, CMIP5 model and realisation from that model. All these causes of uncertainty can be expressed by using climate change storylines to provide plausible descriptions of future climate conditions. They offer a synthesised form that translates complex global-scale projections to practical local-scale impacts.

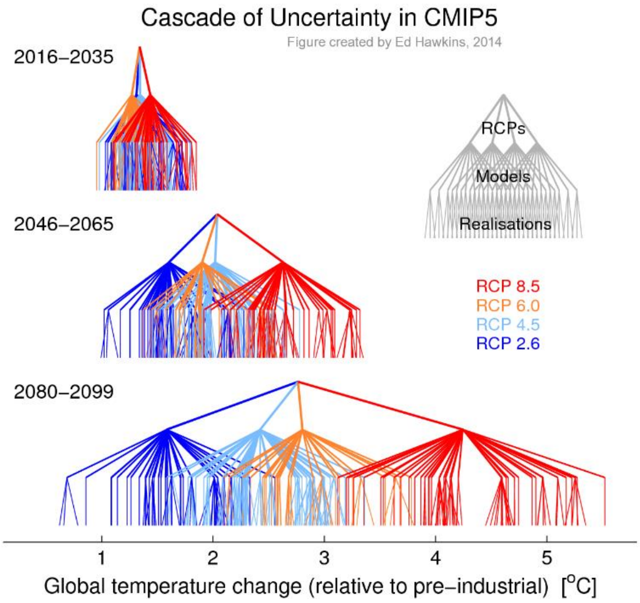


FIGURE 5: ED HAWKIN'S 'CASCADE OF UNCERTAINTY' DIAGRAM FOR GLOBAL MEAN SURFACE TEMPERATURE FROM CMIP5 SIMULATIONS. THE RCP, GCM AND REALISATION OF CLIMATE VARIABILITY ARE SIGNIFIED BY THE THREE LEVELS OF EACH PYRAMID (65).

It must be noted that formal attribution of extreme natural hazards to climate change is in its infancy. While this has been achieved for some meteorological metrics (e.g. extremes in rainfall, temperature, and drought) and earth system processes with limited degrees of freedom (e.g. glacier melting) many other natural extremes are too complicated for current attribution methodologies to assess. For instance, large rockslides, rock slope failures and GLOFs may be triggered by climate change but their behaviour is also driven by other, non-climatic factors. In addition, given the paucity of long-term instrumental records of meteorological variables and extreme events in Pakistan (and elsewhere) it is not possible in many cases to obtain information on natural variability in such systems (this is called unforced variability). Without these data, we cannot differentiate between unforced and forced variability and, we cannot explore likely return periods for such events. This is a long-standing problem in climate impacts science and is not only an issue in Pakistan.

3.4. Making Recommendations and Developing Adaptation Plans

Once the climate storylines have been generated and paired with the relevant socio-economic narratives, then the potential adaptation option can be re-assessed. The constraints faced by decision makers, however, will limit the range of adaptation options and climate futures that can be considered and so decision makers will need to determine which risks should be prioritised and to what extent adaptation is possible.

In producing adaptation recommendations based on a variety of climate storylines, there will likely be some redundancy included in planning. Although planning for more than one future may be deemed an unnecessary expense in the short-term, it has been shown that in extreme events, the extra capacity built into a system can provide a vital contingency when systems fail to be as resilient as originally thought (11).

In finding the correct action to take to limit climate risk, longer policy timeframes must be considered, not just the short term. When a super-cyclone hit Bangladesh in May 2020, the death toll was limited to just 12 due to an enhanced early warning system and well-planned evacuation strategy (23). However, after the event, the land remained inundated leading to lost livelihoods, food insecurity and health risks (11). Reduced exposure needs to go hand in hand with a reduction in vulnerability (24). This twin-track approach will limit future climate risk (11).

In Pakistan, there is much potential for nature-based solutions to reduce vulnerability to multiple climate impacts, such as planting urban forests to reduce vulnerability to both flash floods and heat stress. At the same time, enhanced public understanding, early warning systems and clear communication channels would reduce exposure to the same hazards.

One of the key focuses for climate risk assessment should be reducing the vulnerability of marginalised groups within society. It has been shown that groups subject to inequity, due to such factors as gender, race, disability, income, and migratory status are often disadvantaged by their lack of decision-making power, increasing their vulnerability (25; 26).

Adopting a participatory governance approach to CRA, can help to reduce this inequity and will ensure adaptation plans can be implemented at a local level. Knowledge from national through to local levels can be brought into the process through adopting a storyline approach to CRA and establishing multi-sectoral, multi-stakeholder dialogue processes. At the outset, initial discussions can be convened with those responsible for final policy decisions, but these should evolve to bring in wider and increasingly multi-level stakeholder discussions – using a combination of workshops, focus group discussions and 1:1 stakeholder interviews to explore and shape the finer detail of the climate storylines. Importantly, such stakeholder dialogue processes not only ensure local expert judgement on the vulnerabilities associated with each storyline is integrated robustly but has the important added value of putting people and decisions front and centre . Combining these dialogue processes with information from a literature review (published and grey), allows the risk posed by any specific climate hazard to be estimated. The final stage (of a first round of the iterative process) demands a highly participatory workshop with all stakeholders previously involved, so that adaptation policies which fit a wide range of projected future scenarios can be sought. This discussion may well prompt the need for a finer focus to be applied (in round two) and certain areas (such as sectors and geographies) can be chosen at the workshop for further demand-led research and/or risk assessments etc.

3.5. The Importance of Stakeholder Input

Stakeholder input is vital if adaptation to climate change is to be effective at local, provincial, and national scales. Decision-making that has not been contextualised by local circumstances, despite a firm basis in interdisciplinary research across both physical and social sciences, will lack relevance and lose some of its potential for positive adaptive change. A multi-stakeholder approach has the advantage of synthesising research, technology, and data within a specific, practical framework, which through the involvement of stakeholders, also builds capacity for future national and local level planning.

If policy is grown from the local level up, then local stakeholders are already invested in its success. Considering locally appropriate climate change scenarios will improve the likelihood of increasing resilience and reducing vulnerability across all sectors of a community. Without this input there is also the risk that decision-making is seen as remote and there is a perceived "elite custodianship" of data (27).

Stakeholder information can help to highlight vulnerabilities that are not immediately apparent, such as gender roles and cultural practices that could reduce the access that women have to adaptation strategies, compared to men (27). Once a community has engaged in planning for adaptation, then communication and implementation of new policies becomes far simpler.

Indigenous groups often have well-evolved coping strategies for dealing with climate hazards that can be used to inform policy not just for that community, but on a wider scale. Local farmers in Pakistan are already adapting their crop sowing and selection practices, but this requires a level of land ownership, education and funding that is not accessible to all. By including a full range of stakeholders in the planning process, this important component of climate adaptation is preserved.

To ensure that all stakeholders are approached for their views, a stakeholder mapping exercise based on literature and expert knowledge is necessary. After this, general questionnaires are useful to establish the most important factors of concern. Where further information will be useful, a 1:1 conversation is recommended with a subset of those surveyed. Another effective way to ensure that all stakeholders are included in the process is through an open workshop in which groups can focus on storylines relevant to them. Through discussion of personal experience in particular sectors of government, communities, public services, and academic institutions decisions can be based on a full cross-section of views and expertise. In a recent project supporting development of the NAP in Iraq, the feedback from this process was overwhelmingly positive (see https://iraq.un.org/en/192300-iraq-track-preparation-its-climate-change-national-adaptation-plan).

4. SUMMARY OF METHOD

SOCIETIES MUST EITHER ADAPT TO THE CLIMATE-RELATED HAZARDS THEY ARE LIKELY TO FACE OR BE IMPACTED BY THESE EVENTS IN AN UNPLANNED AND FREQUENTLY CATASTROPHIC MANNER (28). THIS REPORT DESCRIBES THE EXEMPLAR APPROACH TO THE CLIMATE RISK ASSESSMENT USING CLIMATE STORYLINES FOR PAKISTAN AND IS SUMMARISED IN

Figure 6.

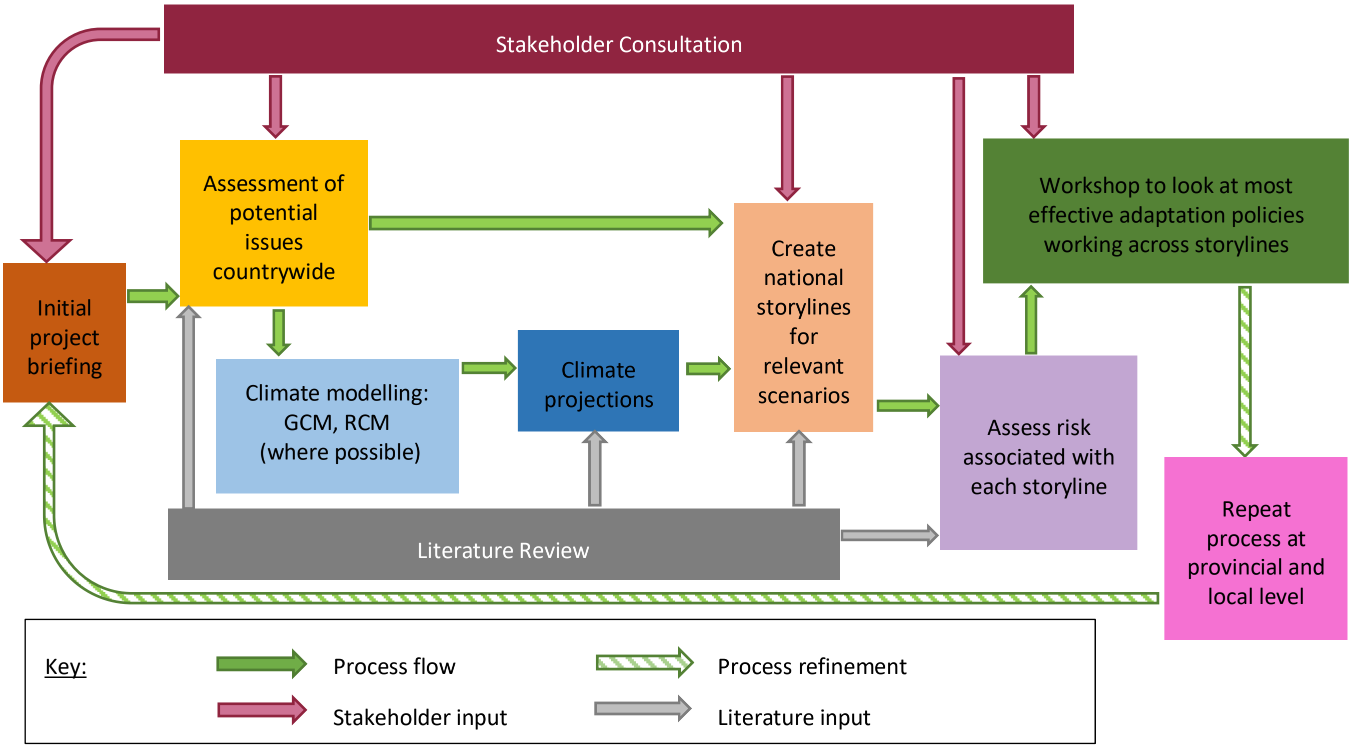


FIGURE 6: FLOWCHART OF EXEMPLAR APPROACH TO CLIMATE RISK ASSESSMENT USING CLIMATE STORYLINES FOR PAKISTAN

4.1 Practical Example of Process Application:

To illustrate each stage of this process in a practical context, the CRA using storylines recently completed in Iraq (October 2022, (29)) is now described. The underline colours reflect those used in Figure 6.

(i) Initial Project Briefing

Initial consultation with the Ministry of Environment of Iraq, followed up by a later technical workshop, informed the process in the first stage. This allowed for a review and synthesis of existing knowledge and future needs.

(ii) Assessment of Potential Issues Countrywide

Identified local experts provided inputs into the methodology to be used and identified key areas of interest and capacity gaps in providing climate modelling. Two eco-regions were chosen, the Southern Marshes and the Persian Gulf. First order, direct impacts of climate hazards were prioritised and linked with risks, indicators of exposure and potential climate impacts.

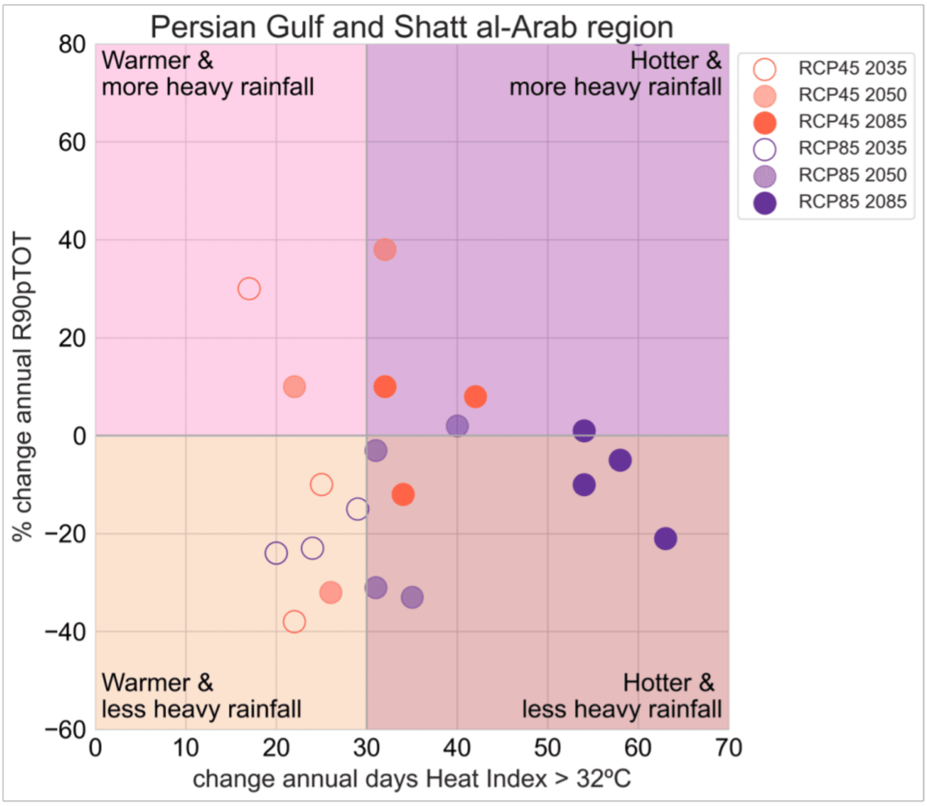
(iii) Climate Modelling Analysis

For each of the two regions up to four climate impact indicators were developed. In the case of the Persian Gulf eco-region these were hot-humid extremes, sea-level rise, and extreme precipitation. Using CMIP5 GCMs across RCP4.5 and RCP8.5 the most widely representative selection of RCMs from the CORDEX set was selected using a statistical method called Self-Organising Maps. The selected RCM set comprised three models for RCP8.5 and two for RCP4.5. To inspect future conditions, changes with respect to the historical period (1980-2005) were calculated daily for time windows of 25 years around 2035, 2050 and 2085.

(iv) Climate Projections Analysis

Looking regionally, the key results affecting the Persian Gulf were the increase in hot and humid days and the increase or decrease in local precipitation extremes, which were plotted together to create a climate change matrix across the time periods, scenarios, and models. This chart is shown in Figure 7.

FIGURE 7: CLIMATE CHANGE MATRIX OF STORYLINES FOR THE PERSIAN GULF REGION, IRAQ. CHANGE IN EXTREME PRECIPITATION VERSUS CHANGE IN HEAT INDEX. LINES DIVIDING FOUR QUADRANTS REPRESENT NO CHANGE IN PRECIPITATION EXTREME AND MODERATE CHANGE IN HOT-HUMID EXTREMES.

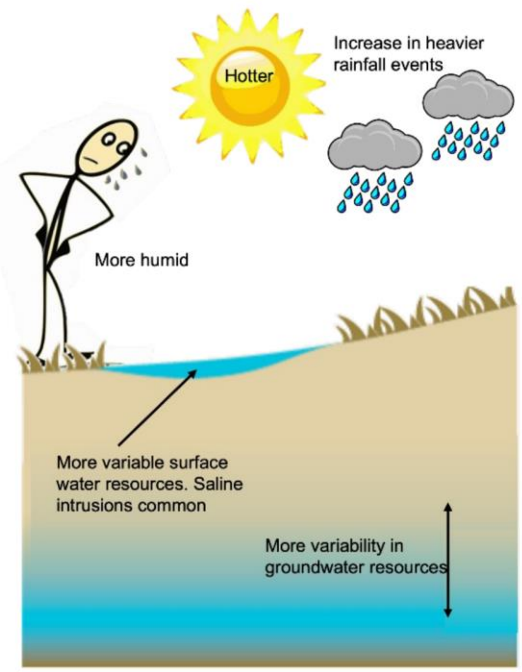


(v) Development of the Storylines

Based on the clustering of the points in Figure 7 and given that the impacts of increasing heat stress are the same, although they could be of different magnitudes, two storylines were chosen based on the quadrants on the right of the matrix:

1. Hot-humid and more extreme precipitation
2. Hot-humid and less extreme precipitation

These were represented as infographics, as well as through a more detailed narrative describing projections, based on expert input, data, and historic events. The diagram and narrative for the first of these storylines is given in Figure 8.



The temperature is noticeably hotter and more humid with almost 4-5 months a year of Heat Index (HI) consecutively above 32ºC, compared to 100 days per year in the historical record. Of this, about 1 month the HI is above 41ºC, compared to almost 0 days per year in the historical record. The higher temperature and humidity rises are felt particularly in the urban areas due to the 'heat island' effect.
Maximum temperatures have also increased by a similar amount and hot days are now extremely hot.
The coastal areas are experiencing a sea level rise (SLR) of around 0.5m to 1m threatening the city of Basra and the port, as well as the marshes.
With the temperature increases, there is also an increase in heavy and more intense rainfall events increasing humidity dramatically, making days very uncomfortable for working.
Despite the increases in extreme rainfall events, there is no clear trend in annual local rainfall. But there is less water available upstream from the Tigris and Euphrates. Overall, interannual recharge of water resources is more variable. The heavier rainfall and higher humidity potentially outweigh increases in evapotranspiration from the hotter climate, with the possibility of a long-term rise in groundwater levels.
Attention is required to monitor how much water is available in the first place which can offset the more extreme rainfall events.

FIGURE 8: CLIMATE INFOGRAPHIC AND STORYLINE FOR HOT-HUMID AND MORE EXTREME PRECIPITATION IN PERSIAN GULF REGION OF IRAQ.

(vi) Assess risk

Headline impacts for water, health, agriculture, and livelihoods could now be examined using expert input. This led to the production of a list of future risks occasioned by the projected climate changes which was used to inform further discussion with key local stakeholders.

(vii) Workshop Discussing Adaptation Options

A two-day workshop enabling comprehensive sharing of a broad range of local knowledge and expertise allowed the further refinement of the assessment of future risks in each eco-region. The analysis completed in Iraq can now be used to build capacity within the country for further projects to be undertaken in different local areas, to feed into the National Adaptation Plan.

5. EXPECTED OUTCOMES OF THE PROCESS

This process aims to allow in-depth understanding of the specific climate change challenges faced by Pakistan. It can be applied at a national, provincial, or local level depending on the focus required.

The key objectives are:

- to engage stakeholders across governmental and non-governmental groups
- to exploit research previously undertaken through reference to literature
- to generate storylines based on climate projections which incorporate uncertainty
- to allow qualitative estimation of intensity and frequency of projected climate hazards
- to refine narratives based on expert local information
- to show how risk can be reduced by examining exposure, vulnerability, and resilience
- to provide a basis for bottom-up adaptation planning that enables a smooth implementation of the NAP process
- to build capacity at all levels so that this process can be maintained, and conclusions updated regularly.

In Pakistan, with its diverse geography and climate, it is necessary to work not just at a national or provincial level, but also to focus on districts. Given that there already exists in Pakistan a cascade structure for information on disaster management, a similar system could be used for risk assessment. Focusing on the four main Provinces accords with current disaster management practices in Pakistan and also best serves the majority of the population. The MoCC could imitate the current system through which the NDMA administers training to Provincial representatives from the PDMAs, who then provide workshops for the DDMAs. If the MoCC are able to establish representatives at provincial and then district levels these groups can then follow the guidance to document local levels of exposure, resilience and vulnerability. The MoCC will be best placed to supply downscaled climate projections for each Province so that the likelihood of climate change hazards can be judged appropriately.

This method does not aim to give a single number to risk in each district, but rather to document what is causing exposure and vulnerability and preventing resilience so that adaptation at a local scale is more effective.

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ANNEX 1: RISK INDICATORS FOR PAKISTAN

The tables below give examples of risk indicators for Pakistan pertaining to environmental, social and economic risks. These are based on a comprehensive review of current literature, as stakeholder engagement has not been possible up to this point. These will be refined in consultation with local experts as this becomes possible.
The evidence centre column gives the province on which cited research or data is based. B stands for Balochistan, KP for Khyber Pakhtunkhwa, P for Punjab and S for Sindh.
Due to the interconnected nature of risk indicators and impacts there is repetition between columns and rows as necessary.

TABLE A 1: ENVIRONMENTAL KEY RISK INDICATORS

Key Risk Indicators: Environmental	Description	Evidence centre
Deforestation	• Removal of mangroves for building and also their degradation due to sea level rise, leads to coastal erosion, salination of inland water bodies and reduction in fish and shrimp stocks (30). • Trees removed from farmland can reduce shade for both crops and workers (31).	B, S
Soil erosion	• More vulnerable to poor crop yields (32). • Less cultivable land leading to tension between communities (17). • Land could become super arid, leading to further desertification (13). • Can lead to migration (33).	B, KP
Sea water intrusion	• Salinisation of land affects grazing and crops (34). • Drinking water sources may also be polluted (30). • Degrades mangroves (30). • Reduces fish and shrimp stocks (30).	B, S
Urbanisation	• Reduces drainage, so increases chances of flash floods (35; 36). • Concreting of vegetation and loss of open space (34; 14). • Greater chance of disease transmission in cities (32). • Urban heat island effect causes greater severity of heatwaves (14; 37).	B, KP, P, S
Overuse of pesticides, insecticides and fertiliser	• Lead to degradation of soil and pollution of water courses in some cases (13; 38).	P
Lack of flood barriers and control systems	• Susceptible to monsoon floods, flash floods, river breeches, urban floods, coastal floods (39; 30)	P, S
Building on flood plain, due to lack of implementation of regulations	• Susceptible to riverine flooding (35; 32). • Reduces drainage potential, trapping water (35).	KP, S
Outdated coastal infrastructure and lack of sea defences	• Tropical cyclones could damage ports preventing the majority of exports (30). • Sea intrusion is a problem in Sindh as sea levels rise (30).	S
Building near glacial lakes and glaciers	• Buildings near glaciers could be lost as new lakes appear due to increased temperature melting glaciers and snow at a faster rate (40; 32; 41).	KP
Glacial retreat	• In the short term causes floods both locally and downstream, compounding heavier monsoon rains (13; 42). • In the long term will lead to severe water shortages, compounding erratic rainfall (32). • 80% used for irrigation, so food security issues will follow (43; 37). • Water shortages will threaten hydroelectric power supply (32).	B, KP, S
Lack of water storage	• Floods destroy, but cannot recharge water resources (14; 30; 33) • Water security very poor (37; 32; 34). • Rainwater harvesting not being exploited (32). • Rain fed fruit farms decreased fruit yield (44). • Lower survival rates for livestock in drought (45).	B, KP, S

	• In a disaster people resorting to unsafe water sources (37; 45).	
Blocked drainage systems	• Increase chance of flash floods during heavy rain in cities (46).	P, S
Water and irrigation regulation breaches	• Where farmers are pumping water from the irrigation canals, others downstream are left with very little, hastening drought conditions (30). • Water management not co-ordinated between agriculture, industry, food and health sectors (39; 32).	KP, P, S
Lack of research into irrigation and water systems	• Outdated river and reservoir management is leading to difficulties dealing with floods and droughts (35). • Difficulties in predicting low stream flow leading to droughts means water use is not carefully planned (47).	B, KP, P, S
Unsuitable irrigation methods being used	• Waterlogging in heavy rainfall (31). • Flood irrigation is not water efficient (48; 49). • Furrow irrigation causes plant stress with cycles of too much and too little water (48; 49).	KP
Outdated irrigation system	• In Balochistan only 5% of the land can be irrigated from the Indus River (33). • 80% of irrigated land nationally affected by variation in irrigation system supply (50). • 50% of water in system extracted from ground, which is unsustainable (48; 37).	B, KP, P, S
Over-exploitation of groundwater extraction	• Tube wells lead to water wastage and lower the water table (44; 31; 33). • Soil moisture is reduced by lack of groundwater which can lead to desertification (30; 33).	B, KP, S
Lack of research into crops and sowing cycles	• Greater pest, fungal and weed attacks to crops (31; 38; 45). • Rain damage to crops (14; 40). • Crop types and methods not updated (51; 52; 50; 31).	B, KP, P, S
Over-fishing of coastal areas	• Tension between communities (17). • Need to fish further out to sea (16). • Reduced livelihood for fisher folk (45).	B, S
Working outdoors	• Heatwaves worse for those working outdoors during the day, leading to loss of productivity where temperature exceed safe levels (2; 53; 13)	B, KP, P, S

TABLE A 2: SOCIAL KEY RISK INDICATORS

Key Risk Indicators: Social	Description	Evidence centre
Urban population growth in Karachi	• More susceptible to coastal flooding and saltwater intrusion (17). • Could affect more than 1 million people by 2100 (13).	S
Population growth	• Exacerbates water and food shortages (16; 54). • Highest rates of birth for those below poverty line (46).	S
Lack of Disaster Management	• Communities in the North unprepared for GLOFs (45). • Sindh has un-co-ordinated use of climate data, warning systems and disaster planning (30; 50). • No planned evacuation areas, so people made more vulnerable by staying in unsuitable locations for 2-3 months (50) . • Livestock drowning or being electrocuted due to lack of proper evacuation plan (50; 45; 39). • Poor sanitation after a climate event leads to increased rates of waterborne diseases (2). • Those with disabilities often not included in plans (55).	B, KP, S
Poor dissemination of climate data	• Lack of warning for forward planning in the case of GLOFs (46). • Poorest unaware of climate hazards and so more vulnerable (43; 31; 33).	B, KP, P, S
Lack of understanding of climate data	• Rain harvesting is not happening at local level (32; 46). • Inefficient irrigation is rife (49; 48; 31). • Overuse of groundwater is drying the land (30). • Even in institutions there is a lack of training (50; 38). • Vulnerable ecosystems are not being protected (30).	B, KP, S
Lack of education	• Literacy needed to understand results of climate research (45; 46). • Capacity building impossible without basic literacy and numeracy (30; 46). • Higher level of education reduces climate vulnerability (51). • People drink unsafe water leading to cholera and diarrhoeal diseases (2; 37; 56).	B, KP, P, S
Early Warning Systems inadequate	• Not reaching communities (34). • Not understandable to many locally as in English (32). • Messages ignored due to mistrust (31). • People with disabilities often excluded from warnings (55).	B, KP, P, S
Not enough membership of civil society organisations	• Lack of sharing of traditional coping strategies (34). • Lack of sharing of progressive new techniques (30). • Forum for discussion of loss and damage needed (43).	B, KP, P, S
Poor healthcare facilities	• Lack of personnel and equipment and flawed referral system (2; 32; 30). • Mental health issues from previous disasters not treated (46). • In aftermath of climate events facilities damaged and cut-off (30). • Difficulty dealing with expected higher rates of dengue fever and malaria (2; 30; 32). • Untreated respiratory ailments will be intensified by higher temperatures (2; 32).	KP, S
Malnutrition and food insufficiency	• Less able to cope with health issues relating to climate change when underweight (2; 57; 37). • 45% rate of stunting in children under 5 (30; 45). • Exacerbated weakness from lack of food in disaster situation (50).	B, KP, P, S
Lack of fruit and vegetables in diets	• Lessens ability to cope with disease (13).	B, KP, P, S
Poor facilities for those with a disability	• Less able to cope in a disaster due to lack of mobility and other factors (58; 50; 59; 34). • Lower water and food security (60; 55).	B, KP, P, S

	• Assistive devices hard to procure and often lost or damaged in climate event (60; 55).	
Gender inequality	• Daily chores of finding firewood, water and fodder harder (32; 50; 45). • More likely to reduce food intake to feed others, so at more risk of malnutrition and disease (50; 34). • Limited access to healthcare as need chaperone and female healthcare worker (34). • Lack of decision-making power lowers likelihood of adaptation (34). • Lack of education so less able to understand climate information, correct usage of pesticides, ways to adapt (32; 61; 51). • Poor security and safety in disaster relief camps (50). • Unable to access funding and disaster compensation payments if female led households (34; 32).	B, KP, P, S
Climate migration	• Male-out migration leaves female led households vulnerable (50). • Large slum areas of cities with inadequate waste and sanitation (34). • Slum areas vulnerable to floods, cyclones, dust storms and heatwaves (34; 50) • Migrants can be marginalised to disaster prone land (34). • Displaced rural households least able to cope with climate events (50).	B, KP, S

TABLE A 3: ECONOMIC KEY RISK INDICATORS

Key Risk Indicators: Economic	Description	Evidence centre
Large percentage of small farms	• Limited financial capacity for adaptation so most vulnerable (17; 62). • More efficient irrigation methods like drip irrigation are too costly for many to use (49; 63). • Little or no diversification (34; 45; 51; 52). • Reduced employment opportunities when yield drops (50; 45).	B, KP, P, S
High poverty levels	• No coping mechanisms (64; 38). • High agricultural dependence (33). • Relief in disasters aimed at more influential (50). • Harder to recover after large losses (51; 43). • Harder hit by heatwaves as less prepared (14). • Wages rising more slowly than food prices (45).	B, KP
Lack of preparation for climate events	• This has led to massive unnecessarily inflated costs (43).	B, KP, P, S
No off-grid power facilities	• In the case of a disaster, power often lost (30).	S
Lack of crop insurance systems and loans	• Poorest become poorer as most dependent on agriculture (46; 33). • Adaptation methods too costly for many (39; 38). • Hard for poorest to access funding (30). • Exploitation by landlords when using informal loans (16). • No emergency credit if crops fail (38; 62).	B, KP, P, S
Under-developed rural market facilities	• Triggers migration to cities (33). • Economic concerns at root of 80% of rural to urban migration (17).	B, KP
Landless labourers	• Debts to landowners prevent migration (50). • Stuck with infertile soil if already in debt (50). • Cannot adapt as no influence or resources (51; 14). • If yield is poor, jobs are insecure due to informal contracts (50; 45; 62).	B, KP, P, S

ANNEX 2: INTERVIEW PROTOCOLS FOR STAKEHOLDERS (TASKS 2,4)

2A: INTERVIEW PROTOCOL FOR STAKEHOLDERS: UNEP CLIMATE RISK ASSESSMENT TASK ORDER 2 NATIONAL AND SUBNATIONAL

Under Task 2 for Pakistan, Walker Institute is tasked with supporting the development of a national and subnational climate risk assessment for Pakistan. The aim of the approach is to ensure that policy makers focus on climate change in their planning, so stakeholders will be directly involved in the development of the risk assessment via participatory decision tools. Sub-tasks within Task 2 include:

consultations with identified stakeholders to identify risk indicators relevant to vulnerable groups specific to the four provinces of Pakistan, with particular interest in environmental, social and economic factors,

- sharing identified key climate change risks for Pakistan as a whole and each province separately based on return periods and relevant storylines for extreme weather patterns and consequences for the most vulnerable groups.

We are currently working to gather inputs from key stakeholders on the status of how climate information is shared and integrated in policy making.

We would be very grateful if you could spare an initial 60 minutes to speak on the phone. We will revisit the initial priority questions from the questionnaire and then follow up for more in-depth discussions on the remaining topics outlined below which form part of the Enabling Environment framework. Names will be removed from all responses unless the interviewee requests otherwise.

Initial Priority Questions

1. What organisations are responsible for sub-national climate change adaptation planning?
2. What climate risk/vulnerability assessments have you produced or used? Please provide web links if available.
3. What do you think are the key barriers to successful development and implementation of a national and sub-regional adaptation plan across Pakistan and how would you suggest these could be overcome?
4. At a provincial level, what do you see as the key vulnerabilities increasing risk from climate impacts? Please answer for as many regions as you feel able to.

Follow-up In-depth Questions

Inclusion of climate change risk in policy planning:

1. What policies ensuring inclusion of climate change risk in planning currently exist in Pakistan?
2. Are these policies national or do they differ by province?
3. How effective are these policies at both the national and sub-national levels?
4. Do the key barriers to policy implementation vary across regions?
5. Is there any hierarchical structure in place to link provincial and national initiatives?

Climate change risks and their impact on the most vulnerable:

1. Which are the most vulnerable groups to each climate change risk in each province in Pakistan?
2. What supportive measures are already in place for vulnerable groups in each province?
3. Is there a difference in the level of focus on different climate change risks?
4. How would you rank the perceived importance of each climate change risk in each province?
5. How does this differ from the way you would rank the threat posed by each climate change risk in each province?

6. In identifying climate change risks, what level of data is currently used (IPCC data, nationally produced figures, data gathered in provinces, more local data)?

Current funding of initiatives to adapt to climate change

1. Is funding available at a national/provincial/local level for climate change adaptation and if so through which agencies?
2. Are there differences in the level of funding available based on geographical location?
3. Are there any cross-boundary funding initiatives currently in place, for example across the mountainous regions?
4. What funding is available in the long-term? How sustainable are any policies implemented now?

2B: INTERVIEW PROTOCOL FOR STAKEHOLDERS: UNEP CLIMATE RISK ASSESSMENT TASK ORDER 4 CAPACITY BUILDING

Under Task 4 for Pakistan, Walker Institute is tasked with leading on the analysis of gaps in existing climate modelling capacity within relevant academic institutions and developing a strategy for implementing functional climate services. Sub-tasks within Task 4 include:

- consultations with identified stakeholders to assess the current status of climate information services in Pakistan and their 'readiness capacity', including the technical infrastructure and human capacity, with particular interest in tailoring any new strategies to development of countrywide effective climate services,
- identifying gaps in bringing the hydro-met system up to WMO standard for development planning, gaps in human capacity and institutional systems support, and barriers to successful progression of an effective climate service offering in Pakistan.

We are currently working to gather inputs from key stakeholders on the status of climate information services in Pakistan, gaps and barriers to implementation of effective climate services to support the National Adaptation Plan (NAP).

We would be very grateful if you could spare an initial 60 minutes to speak on the phone. We will revisit the initial priority questions from the questionnaire and then follow up for more in-depth discussions on the remaining topics outlined below which form part of the Enabling Environment framework. Names will be removed from all responses unless the interviewee requests otherwise.

Initial Priority Questions

1. What climate data and information services currently exist in Pakistan?
2. How are the various institutions responsible for climate information services connected?
3. What are the key institutions that use or rely on climate data in their operations?
4. What do you think are the key barriers to successful implementation of effective climate services in Pakistan and what are the gaps in understanding climate impacts?

Follow-up In-depth Questions

1. What climate information services currently exist in Pakistan?
    a. What types of climate information do these services cover? For example - early warning systems? Short-range, seasonal or long-range weather forecasts? Near-real time monitoring data? Drought indices from remote sensing? Glacier/river level monitoring?
    b. What timescales do these services operate on (daily, weekly, monthly)?
    c. What is the spatial coverage of climate information services?
    d. Is the provision of such services equal across the four main provinces of Pakistan?
    e. Are there links between international organizations in place to facilitate the monitoring of cross boundary weather effects, particularly across the Himalayas?
2. Which institutions are responsible for managing and developing these climate services (health, energy, DRR, social protection, agriculture)? What are the sizes, structures and mandates of each of these organizations?
3. How are these climate information services communicated? What media is used (TV, radio, mobile, internet)?
4. Do you think there are any types of climate information services missing (e.g. drought/flood early warning system)?
5. Do you think existing services meet the diverse information needs and access requirements of all stakeholders? Are they locally relevant to e.g. rural communities and farmers? Are they freely accessible to the public?
6. How are the various institutions responsible for climate information services connected? Where do they sit in the structure of the Government and how are they connected to industry?
7. Who/which institutions are responsible for decision making on climate information services – is there a nationally coordinated approach and decision structure?
8. What is the status of current technical infrastructure to support climate information services in Pakistan? Weather stations, monitoring equipment, data collection and sharing? Is data coverage good and is it comparable with other countries data collections?

9. What is the status and history of training or capacity building on climate information services in Pakistan? Who has already been trained and on which types of services? Has this training been maintained/updated?
10. What do you think are the key barriers to successful implementation of effective climate services in Pakistan?
11. In your experience, what kind of support is most needed to support effective climate services in Pakistan? Technical (i.e. data and modelling and infrastructure)? Capacity building (i.e. human capacity to deliver services)? Governance (i.e. connections between institutions)? Communication?
12. What are the potential delivery mechanisms and funding sources which could support effective climate services in Pakistan that are sustainable in the long-term? Are there funding constraints? Are the alternative sources of support that could be accessed? Is support needed to access these funds?
13. What kind of partnerships exist between the Met Office and higher education institutions in Pakistan? How does this influence the progression of students into careers in the Met Office?

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