Ministry of Climate Change and Environmental Coordination

BUILDING CAPACITY TO ADVANCE NATIONAL ADAPTATION PLAN PROCESS IN PAKISTAN

SUMMARY FOR POILCY MAKERS
National Adaptation Plan for Pakistan

“Adapting Today for Sustainable Tomorrow”

June 2024

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This report was commissioned by the GCF PAK-RS-003 Project "Building capacity to advance National Adaptation Plan Process in Pakistan" which aims to support the Federal Ministry of Climate Change and Environmental Coordination (MOCC&EC) and its partners at Federal and Province levels to implement the National Adaptation Plan (2023). The Delivery Partner is the United Nations Environment Programme (UNEP).

United Nations Environment Programme

Building capacity to advance National Adaptation Plan Process in Pakistan

Summary for Policy Makers

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Contents

Executive summary

The project 'Building Capacity to Advance National Adaptation Plan (NAP) Process in Pakistan' was funded by the Green Climate Fund (GCF) as part of the support provided to develop a National Adaptation Plan (NAP) for Pakistan. It is delivered by the United Nations Environment Programme (UNEP) and led by the Ministry of Climate Change of Pakistan. This project aims to support multi-sectoral, medium- to long-term adaptation planning and budgeting in Pakistan and to promote the integration of climate change adaptation challenges 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.

UNEP contracted WSP Environment & Infrastructure Solutions UK Limited (WSP), with the Walker Institute and Climate Change Risk management (CCRM), to support the assessment of institutional capacities as part of the NAP process in Pakistan. The assignment had two key activities.

- Review the latest climate change projections and establish an approach for downscaling climate projections for Pakistan, including provision of information.
- Develop national and sub-national climate risk assessments (CRAs) in Pakistan.

The purpose of the climate change projection review was to take stock of the most up-to-date climate science and data published for Pakistan and identify gaps and areas for improvement. In addition, a methodological approach for downscaling specific to Pakistan was developed. Overall, this review indicated there is limited information on the interpretation and/or guidance of climate projections and climate risk science for decision-making in Pakistan. Where existing information is lacking, climate modelling should be undertaken, and the analysis should include interpretation and guidance to inform decision-making. These findings were shared through consultation with various key stakeholders.

A stakeholder engagement plan was developed to strengthen the key institutional partnerships needed for the effective implementation of the Pakistan NAP and the integration of climate change adaptation challenges into development planning processes and policies.

Climate risk assessments (CRAs) help establish links between impacts and risks to identify adaptation opportunities and should be informed by stakeholder input at local, provincial, and national levels, alongside climate projections from peer-

reviewed and grey literature. An exemplar structure for constructing a climate risk assessment (CRA) based on climate storylines was developed. This provides a framework for Pakistan stakeholders to generate plausible storylines at the national, provincial, and local levels to facilitate adaptation planning decision-making and create flexible and locally focused adaptive strategies. An approach paper was developed for undertaking a CRA using storylines, and a range of climate indicators were derived from a systematic literature review of academic studies, expert working groups and publicly available project reports.

Climate storylines are an effective and cost-efficient approach to bridging the gap between uncertain climate projections and detailed local knowledge. These storylines can be applied nationally to highlight vulnerabilities affecting all of Pakistan and more targeted at the provincial level, considering specific sectors like health or agriculture. Expert knowledge guides the process, considering both first-order (environmental) and second-order (economic) risks.

The climate in Pakistan is expected to change in several significant ways, including rising temperatures, higher rates of evapotranspiration, changing monsoon patterns, increased precipitation intensity, more frequent droughts, accelerated melting of glaciers, and rising sea levels.

Four storylines describe possible future scenarios for different regions: Balochistan may experience a monsoon shift to later in the year, heavy rains in March, less rain in November, longer dry spells in spring, and more dangerously hot days. Khyber Pakhtunkhwa might see warmer winters with fewer ice days, more rain in winter and spring, greater intensity of rain in spring, less intense rainfall in summer, and variable winter rain intensity. Punjab could have cooler, wetter summers, shorter and more intense dry spells, hot days in spring and autumn, and more intense rain in spring with an earlier monsoon start. Sindh may face shorter dry spells but more days with dangerously high heat indexes, more intense rain from July to September, a possible shift to June-August rains, and less intense rain by the end of September.

These climate changes will likely impact various sectors. Water resources in Balochistan are already strained by drought and monsoon flooding, with increased heatwaves potentially leading to food and water shortages. Rising sea levels threaten freshwater accessibility due to salinity. In Khyber Pakhtunkhwa, fewer ice days and higher temperatures could accelerate glacial melt, increasing the risk of glacial lake outburst floods. Punjab may face more flooding events, particularly during strong La Niña years. Improved irrigation systems, rainwater harvesting, and better water management are crucial. In agriculture, prolonged drought and heat have led to water scarcity for crops, especially in Balochistan, where poor infrastructure hampers goods transportation. Farmers should consider mixed cropping techniques and alternative crops less vulnerable to climate change. Health systems need improvement, particularly in sanitation and hygiene education, to prevent disease outbreaks following floods. Disaster preparedness must address the increasing number of cyclones, with strengthened storm defences and mangrove restoration in Balochistan, improved drainage in Punjab, and investment in flood early warning systems and local protection infrastructure across the provinces.

The expectation is that from this project's results, stakeholders will continue to collaborate in developing actions to address identified risks as part of Pakistan's NAP. The outcomes of this project lay the foundations for decision-making and sectoral planning, and future climate financing for the region.

1 Introduction

The United Nations Environment Programme (UNEP) is the leading global environmental authority, dedicated to promoting the environmental dimension of sustainable development within the United Nations system.

The Ministry of Climate Change (MoCC) in Pakistan successfully obtained a grant from the Green Climate Fund (GCF) for a multi-year project to build capacity to advance the NAP process in Pakistan. The UNEP is the Delivery Partner for the project, with the role of supporting and overseeing the project's implementation. The project aims to support policymakers in Pakistan in improving awareness and understanding of climate risks, climate change impacts, and associated uncertainties, as well as to develop a range of climate change adaptation actions as part of Pakistan's NAP. 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. The NAP will be developed along with its constituent Provincial Adaptation Plans for each of the provinces: Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh.

WSP, the Walker Institute and CCRM have been contracted by UNEP to support the assessment of institutional capacities as part of the NAP process in Pakistan. The assignment includes reviewing best available climate projections and climate change risk and vulnerability assessments, drafting methodological papers for conducting climate downscaling and developing climate storylines, and assessing capacities and developing a strategy for delivering a climate information system in Pakistan. Key activities of the assignment are to:

- Review the latest climate change projections, downscaling, and climate information systems in Pakistan;
- Develop national and sub-national climate risk assessments for Pakistan;
- Produce a summary for policy makers; and
- Provide a gap analysis and model for operation and maintenance of the climate information system over the long-term in Pakistan.

The project was informed by the views of key Pakistani stakeholders identified by the Ministry of Climate Change (MoCC) and relevant academic institutions, encompassing expertise in climate change adaptation, disaster risk reduction, gender and social inclusion, natural resource management, and response and recovery.

This report includes summaries of the methodology and findings of this assignment for policy makers in Pakistan.

2 Overview of current status of climate projections

A review was undertaken to address the current status of climate change projections for Pakistan. The review considered many sources including documents from the Government of Pakistan, the Provincial Government, international organisations and other research including research from universities within Pakistan and elsewhere. The documents were examined under the following themes: projections used at the global scale, projections used at the regional scale, emission scenarios, and uncertainties.

Under all themes, it was established that there was limited information provided regarding the choices of climate models, scenarios, and climate parameters addressed, as well as the methodologies used for downscaling. In addition, the documents either lacked or had limited interpretation and/or guidance for aiding decision-making.

Projections at a Global Scale

Global climate models come in a variety of types and have been developed continuously over recent decades, providing the bedrock information on which climate change scenarios can be developed. One model type is General Circulation Models (GCMs), which are important tools for assessing possible future climates, known as climate scenarios. GCMs, developed by a range of organisations and institutions, are computer models that use atmospheric dynamics and mathematical analysis to simulate global climate systems and quantify future climate variables, such as temperature, precipitation, and wind speed.

For Pakistan, the GCMs used across assessed studies varied from the use of CMIP3 and CMIP5, whereby Special Report on Emission Scenarios (SRES)[1] and Representative Concentration Pathways (RCPs)[2] have been derived, respectively. Two sources made use of the most up-to-date version, CMIP6[3], making use of Shared Socio-economic Pathways (SSPs)[4].

Except where individual models were used, no specific scenarios were created in the documents other than as ensemble means or individual projections. Temperature and rainfall were the main climate parameters studied, with minimal documents including

[1] SRES are scenarios made up of socio-economic storylines quantified through a number of integrated assessment models.

[2] The RPCs are trajectories for greenhouse gases based on low to high levels of expected action to reduce emissions. These scenarios do not consider any socio-economic issues but simply reflect the degree of forcing of climate change by greenhouse gases.

[3] The Coupled Model Intercomparison Project (CMIP) is an international climate modelling project. It uses a multi-model ensemble approach, which involves running multiple models developed by different research institutions. CMIP6 is the most recent phase of the project.

[4] SSPs are trajectories based on socio-economic considerations.

drought events, standard precipitation indicators, potential evapotranspiration, water surplus, and climate extreme indicators created by a working group of the World Climate Research Programme (WCRP), Expert Team on Climate Change Detection and Indices (ETCCDI). In some instances, generic quotations were extracted from the IPCC reports, particularly the anticipated increased frequencies of events such as droughts and floods (IPCC AR3, 2007).

Limited guidance was provided as to how to interpret the data for decision-making, especially in cases where alternative datasets were produced.

Projections at a Regional Scale

GCMs produce data with very coarse geospatial resolution, often with data only available in grids larger than 100×100 km. GCMs also produce data with very coarse temporal resolution, often monthly, seasonal, annual or over decades. National and sub-national planners typically require more spatial and temporal information than is currently provided by a GCM to develop adaptation plans. Regional Climate Models (RCMs) are combinations of numerical weather and climate models designed to run over specific regions of the globe. Because RCMs do not encompass the entire globe, they have the flexibility to operate at smaller spatial and temporal scales. Consequently, they can directly simulate more climate processes compared to GCMs, thereby offering decision-makers more detailed insights into these processes.

'Downscaling' from GCMs and RCMs provides future climate data at more localised spatial (e.g., 2.2km^2 to 600 km^2) and temporal (e.g., hourly, or daily) scales, is required. Downscaling is a multistep process by which information known at large scales is used to make predictions at local scales. Downscaling assumes that local climate variation is influenced by atmospheric conditions (e.g., pressure, temperature, moisture) and local geographic features (e.g., water bodies, canopy cover, mountain ranges). It is possible to model the interactions, and establish the current and future relationships between these, through the downscaling process.

There are two basic approaches to downscaling – empirical and numerical. Empirical approaches use various statistical techniques, often borrowed from those originally designed to interpret numerical weather forecasts. Numerical approaches involve the use of various models, with the Regional Climate Model (RCM) being the most common. Both empirical and numerical downscaling methods have been applied in Pakistan.

The justification for the methods, model selection, and scenarios within the documents reviewed were found to be limited. Additionally, the parameters assessed were limited to temperature and rainfall.

Emission Scenarios

Emissions scenarios are crucial for climate change projections, as they outline the anticipated changes in the climate over the coming decades. Since greenhouse gas concentrations in the atmosphere are key drivers of these changes, the scenarios represent potential future levels of these gases.

Throughout the documents, relatively high emission scenarios were analysed (specifically A2[5], A1B[6] of CMIP3 and RCP8.5[7] of CMIP5), with fewer uses of lower emission scenarios including RCP4.5[8] and RCP2.6[9] (of CMIP5).

For most documents, there was no indication of the justification for the use of particular scenarios. Regarding the choices of GCMs and RCMs, all results from different scenarios were presented without or with limited interpretation and/or guidance to inform decision-making.

Uncertainties

Climate models are used to simulate impacts, while emissions scenarios provide different narratives of possible change. Therefore, it is not possible to select a 'best' or a 'more likely' emissions scenario, just as it is not possible to select a 'best' or a 'more likely' climate projection.

Uncertainties arise from two main sources:

a. Various limitations in the abilities of models to simulate the climate system in all its forms, including feedback loops or mechanisms; and
b. Unknown details of anthropogenic impacts on the atmosphere, most significantly through emissions of greenhouse gases.

The IPCC AR6 WGI Chapter 6 outlines the key areas of uncertainty inherent in climate modelling: radiative forcing uncertainties, climate response uncertainties, natural and internal climate variations, and interactions between variability and radiative forcings.

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[5] A2: a very heterogeneous world. The underlying theme is that of strengthening regional cultural identities, with an emphasis on family values and local traditions, high population growth, and less concern for rapid economic development.

[6] A1B: a world of very rapid economic growth, low population growth and rapid introduction of new and more efficient technology. Major underlying themes are economic and cultural convergence and capacity building, with a substantial reduction in regional differences in per capita income. In this world, people pursue personal wealth rather than environmental quality.

[7] RCP2.6: One pathway where radiative forcing peaks at approximately 3 W/m^2 and then declines to be limited at 2,6 W/m^2 in 2100 (the corresponding Extended Concentration Pathway, or ECP, has constant emissions after 2100).

[8] RCP4.5: Two intermediate stabilisation pathways in which radiative forcing is limited at approximately 4.5 W/m^2 and 6.0 W/m^2 in 2100 (the corresponding ECPs have constant concentrations after 2150).

[9] RCP2.6: One pathway where radiative forcing peaks at approximately 3 W/m^2 and then declines to be limited at 2,6 W/m^2 in 2100 (the corresponding Extended Concentration Pathway, or ECP, has constant emissions after 2100).

Ensemble mean projections were analysed for different emission scenarios; however, there was no discussion provided within the documentation on the consequence of these scenarios. In addition, very few of the documents provided a likelihood for the scenarios.

In some instances, the attention was not on past performance, but on covering all aspects of climate sensitivities within the full ensemble. Selection by specific performance reduced the range of ensembles. Thereby suggesting lesser uncertainties and increased confidence. This increased the uncertainty as there is no approach to verify the realism of the smaller ensembles against the originals.

2.1 Downscaling approach and recommendations

This section describes both a) recommendations on strengthening the Climate Change Scenarios for Pakistan and b) the methodology for downscaling climate models at the provincial level.

Climate Change Projections and Scenarios

Some recommendations identified for strengthening the climate change scenarios include:

- A full range of scenarios should be considered, with reasoning provided as to why certain scenarios are chosen.
- The IPCC AR6 note that advances from CMIP5 are limited, and there is no clear reason for choosing CMIP6 over CMIP5. Decisions should be based on the required output to determine which CMIP version to use.
- The choice of which projections to use (and whether downscaling is required) should be based on the information needed for decision-making. Decision-making should not be an afterthought following the downscaling of results.
- Scientific knowledge and research should be considered when developing advice and solutions.

Methodology Options

The role of the assignment was not to develop climate change scenarios or to produce onward interpretations for decision-makers. However, the review was expected to provide critique and advice on the various approaches for developing scenarios. The findings from this review are detailed as follows:

- Use artificial intelligence (AI) to identify climate change pathways supported by the majority of projections (for each CMIP ensemble under the emission scenarios for RCP2.6, RCP4.5 and RCP8.5). This approach provides full ensembles, with equal weighting for the different emission scenarios.

- Determine a likelihood pathway using predictable theory. This approach provides information on uncertainty and assumes that the ensemble includes all possibilities in their correct likelihood.
- Production of two ‘extreme’ pathways, i.e. the most outlying pathways where no likelihood can be attached. This approach does not capture possible solutions external to the ensembles.
- Use the closest RCM to each pathway from the CORDEX data. Although CORDEX data provides more flexibility and is easier to use, the CORDEX ensembles tend to not consider the full width of CMIP ensembles and limitation in timing; therefore, the nearest RCM is required.
- Use the downscaled RCM information to provide detail on each pathway. Using the parameters available allows for the development of climate indicators, such as heat and drought indices.
- Make use of storylines that consider all the downscaled information and consolidate it into relatively simplified presentations suitable for provision to decision-makers.

Downscaling Methods

There is no ready translation of findings of the review into a final methodology for downscaling for Pakistan and/or the provinces. Some guidance to support future downscaling includes:

- Undertake projection work at a national level. This will eliminate the disparities between results across boundaries with the objective to provide guidelines for the future, as opposed to high-precision information;
- Plan and agree with national and provincial decision-makers on the downscaling output requirements, considering all possible parameters and indices ahead of beginning the downscaling;
- Do not use empirical downscaling because of restricted flexibility; instead, make use of numerical downscaling methods;
- Use a wide range of parameters and indices calculated from downscaling to inform work undertaken by decision-makers;
- Produce expertly-interpreted future scenarios;
- Unless strong scientific evidence to omit, use the full CMIP and CORDEX ensemble[10] and emission scenarios;
- All initial work should consider the full CMIP ensembles;

[10] There are 3 CORDEX domains that cover Pakistan in its entirety.

- The approach used to reduce the complexity of outputs should detail the full range of uncertainty, including those inherited from the original CMIP ensembles;
- Make use of at least two parallel sets of projections that capture the various climatological regimes influenced by large-scale atmospheric processes, for example, the zonal westerlies and the monsoon;
- Make use of process models, such as those focused on water or crops. Multiple process models should be developed, accounting for the various outputs and validated against historical data; and
- Results should be presented in a transparent manner with full documentation on the uncertainties and possible impacts.

3 Climate Risk and Vulnerability Assessment

3.1 Methodology

To conduct the climate risk and vulnerability assessment, the observed changes in Pakistan's climate and projected future changes were described and analysed. This analysis was based on peer-reviewed and grey literature, considering temperature, evapotranspiration, precipitation and monsoon patterns, glacial and snow cover, and sea level rise changes in Pakistan. Various global emission scenarios and time periods were considered.

Adaptation planning has the goal to reduce vulnerability. It is important to consider not just outcome vulnerability, based on the immediate and future impacts of climate change, but also contextual vulnerability, which takes a more multidimensional approach. This allows for profound changes that will lead to improved social structures, reducing vulnerability in a longer-term and more strategic way. To achieve real progress, environmental, social, political, economic and historic factors should all be taken into account in a vulnerability assessment.

The following key vulnerability factors were identified and reviewed for Pakistan:

- **Flood risk** associated with flooding and landslides in North Pakistan, the Indus Basin, development in flood zones and coastal and saltwater intrusion;
- **Disaster preparedness** at local and systemic levels;
- **Water security** considering hazards such as drought and glacial melt alongside socio-economic factors including groundwater harvesting and regional tensions;
- **Agriculture** including farming types (arable farming, livestock farming, fisheries and aquaculture), regional tensions over natural resources, environmental degradation and digital initiatives to support in agriculture;
- **Education and communication** including lack of climate change awareness, understanding and acting on early warnings, literacy and education and membership of organisations (civil society organisations);
- **Health** factors including food and nutritional security, water borne and vector borne diseases, respiratory and other diseases, heat related health impacts and disabilities;
- **Gender-based differences** accounting for differences in livelihoods, healthcare, water and flood resources, education and violence;
- **Climate migration and displacement** including push factors in migration, effects on vulnerability and potential conflict; and
- **Poverty** considering how climate impacts the vulnerable, accounting for the poorest areas in Pakistan, rural areas and access to funding.

Impact storylines were produced by gathering information on historical climate events and data on climate projections, and considering how socio-economic factors may increase event impact. These storylines were developed at the provincial level for Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh. Four key sectors have been reviewed at provincial level: water resources, agriculture, health, and disaster preparedness.

3.2 Climate Risk and Vulnerability Assessment for Pakistan

Expected Climate Changes for Pakistan

Temperature and humidity:

Projections indicate that Pakistan is likely to experience temperature increases above the global average in the coming years, leading to more frequent heatwaves in the north, as well as in arid and semi-arid regions. This is expected to accelerate the rate of snow melt and glacial shrinkage. The number of hot days and nights is also projected to rise, while the number of cold days and nights will decrease. Heatwaves are expected to become more intense and frequent.

Increases in evapotranspiration will differ spatially due to the varying rates of warming. The rise in evapotranspiration rates is anticipated to limit water availability across the Indus basin, posing a threat to crops, agriculture, and the livelihoods dependent on them.

Precipitation and monsoon patterns:

Pakistan is located within precipitation-bearing weather systems. Projected precipitation patterns vary widely based on both the considered emissions future and the climate models employed. It is expected that Pakistan will be impacted by erratic and unprecedented cyclone rainfall. It is also anticipated that monsoon rains will increase in western and northern mountain ranges. South Khyber Pakhtunkhwa and Central Punjab are expected to experience higher precipitation in June, while East Sindh and Southeast Punjab show a tendency towards being drier.

The IPCC has predicted a shift in the monsoon season, with an increased risk of flooding and drought in Punjab and Sindh, based on a stronger and more variable monsoon. If emissions continue at their current rate, greater initial rainfall is expected in the south and centre of the country. However, this will be insignificant in the long-term, with rainfall declining in the south but increasing by 15-25% in the north over the next century. Nevertheless, models show varying results, highlighting the variability and uncertainty in precipitation patterns.

Glacier and snow cover:

In the future, the pattern of shorter springs and hotter temperatures in summer will cause Pakistan's 7,000 glaciers to melt faster, with insufficient time to re-freeze. The increased melt rate for glaciers and snow in the northern regions will lead to Glacial Lake Outburst Floods (GLOFs) as well as riverine floods downstream on the floodplains. In the long-term, this will lead to scarcer water resources as the glaciers shrink and changes in patterns of river flows occur.

Sea level rise:

Projections indicate that the sea level will continue to rise, threatening to submerge low-lying areas. Impacts of these rises include erosion of beaches, inundation of wetlands and lowlands, salinisation of both groundwater and surface waters, and an increased risk of cyclones originating in the Arabian Sea. These winds also contribute to coastal erosion. If tropical cyclones wipe out the infrastructure of Sindh's coastal region, it will affect Pakistan's GDP, as the country's exports largely depend on Sindh's ports. Soil and land degradation from sea water intrusion affect grazing and crops, limiting the amount of available cultivable land. According to the Asian Development Bank (ADB, 2017), sea level rise is likely to degrade coastal mangrove forests, reduce drinking water quality, and decrease fish and shrimp stocks.

Climate Storylines for Provincial regions

In the following section, narratives for climate storylines are presented for the four provinces with the aim of summarising the uncertainty in future climate projections with a few likely climate scenarios. The storylines describe possible future scenario for the different sectors in the provinces and the human and socio-economic impacts that might be experienced by the people living in these regions.

The climate storyline for Balochistan is shown in Figure 1. Key issues in Balochistan include reducing water resource losses, improving infrastructure to limit post-harvest food loss, increasing livelihood diversity, reducing malnutrition, improving healthcare services, and raising public awareness of health and climate change issues. There is also an urgent need for earlier action to prevent increased impacts of climate disasters.

The climate storyline for Khyber Pakhtunkhwa is shown in Figure 2. Adaptation needs in Khyber Pakhtunkhwa include continued reforesting of slopes to help prevent landslides, improved water storage and irrigation methods, enhanced regulation in water and health provision, increased training of healthcare staff, continued agricultural adaptation to exploit warmer weather, and an improved cascade of early warning information so that this can be acted upon at a local level.

The climate storyline for Punjab is shown in Figure 3. Punjab has a better health record and lower poverty rates than other provinces. However, the over-use of groundwater is a real issue in the province, with agricultural water inefficiency reducing resources at an alarming rate and little focus on climate change adaptation policies. There is involvement in agricultural research, but this is not always backed up by the necessary funding to make adaptation universally accessible. In terms of healthcare, the province has been at the forefront of immunization programmes and disease reduction, but the smog caused by crop burning, road vehicles, and brick kilns is threatening to increase cases of respiratory diseases across Punjab.

The climate storyline for Sindh is shown in Figure 4. Sindh’s biggest issues are water scarcity, particularly for drinking water in the mega-city of Karachi and waterlogging along the coastal areas as sea levels rise. Increasing salination of water sources and agricultural soil is reducing productivity, but with better water harvesting and storage this could be reversed. The mangroves around the coast need to be replanted to prevent further coastal erosion and improve conditions for the fishing communities living in the province. However, this alone will not be enough to counter sea level rises, so action to build defensive infrastructure should also be a priority. Sindh’s healthcare needs improvement, especially in terms of education about sanitation and hygiene to help to prevent large disease outbreaks, particularly following flooding events. Better urban drainage and improved access to heatwave shelter also needs to be carefully planned to reduce climate impacts.

Balochistan summary storyline

- Monsoon shift to later.
- Heavy rains in March.
- Less rain in November.
- Longer dry spells in spring.
- More dangerously hot days.

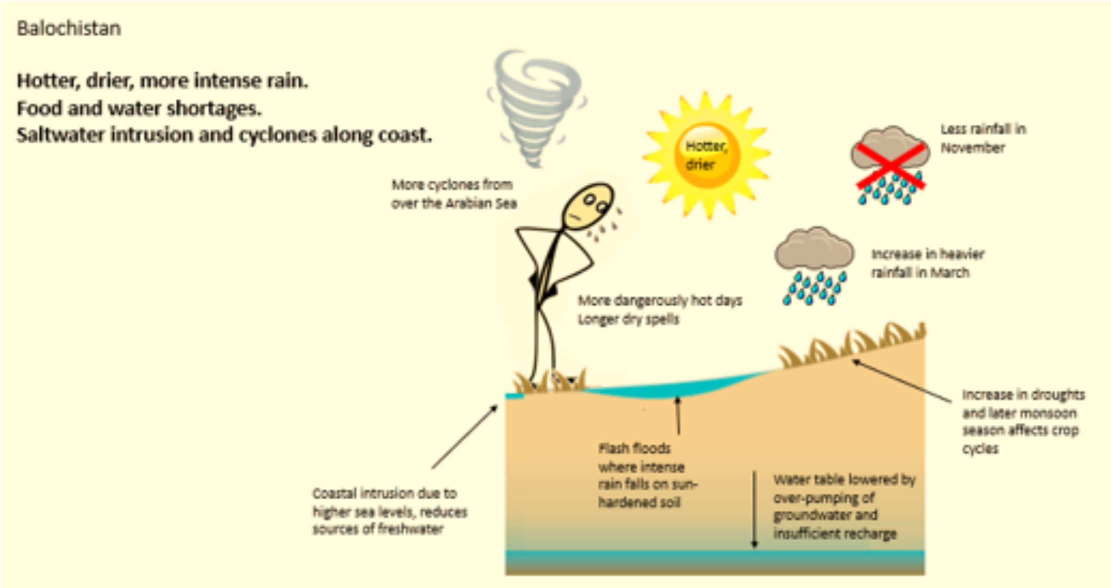

FIGURE 40: INFOGRAPHIC SHOWING POSSIBLE FUTURE SCENARIO FOR BALOCHISTAN

Matching these points up with the historical list of climate hazards encountered in Balochistan, this is likely to increase the risk of heatwaves leading to droughts. It could also cause food and water shortages without adequate forward planning. Equally flash floods due to sun hardened soil and lack of proper irrigation infrastructure could occur in the late spring and summer.

The correct crops should be planted to exploit the extra heat, but planting cycles need to be carefully considered to ensure that the likelihood of sudden heavy rains are taken into account. Livestock needs will also require forward planning to ensure water and fodder are available.

The number of cyclones over the Arabian Sea is projected to increase, so storm defences on the coast will need to be strengthened to cope with sudden heavy rainfall and strong winds, as well as higher sea levels leading to coastal intrusion. Mangrove restoration and proliferation could help to reduce vulnerability.

The short-term socio-economic implications would be a need for support from extension services to assist farmers adapt their farming strategies such as:

- introducing mixed cropping to provide a fall back if one crop fails;
- increasing ground cover to protect the soil
- focusing on wheat and maize varieties that can withstand higher temperatures
- adopting production of fast maturing vegetables

Climate related tolerances of these crops should be examined to establish sustainability of adaptation approaches under different climate futures.

Ways in which outdoor workers in the construction and agricultural sectors can be protected from increased temperatures should be explored including education, changes to working hours and labour regulation.

Investment in mangrove restoration and proliferation is necessary. Possibilities for value addition in the seafood sector generating local employment would also be useful. The potential 'lifespan' of these investments under different climate futures must, however, be considered.

Figure 1 - Climate Storyline for Balochistan

6.2: Khyber Pakhtunkhwa summary storyline

- Warmer winters with many fewer ice days.
- More rain in winter and spring.
- Greater intensity of rain in the spring.
- Less intense rainfall in summer.
- Possibly more or less intense rain in the winter.

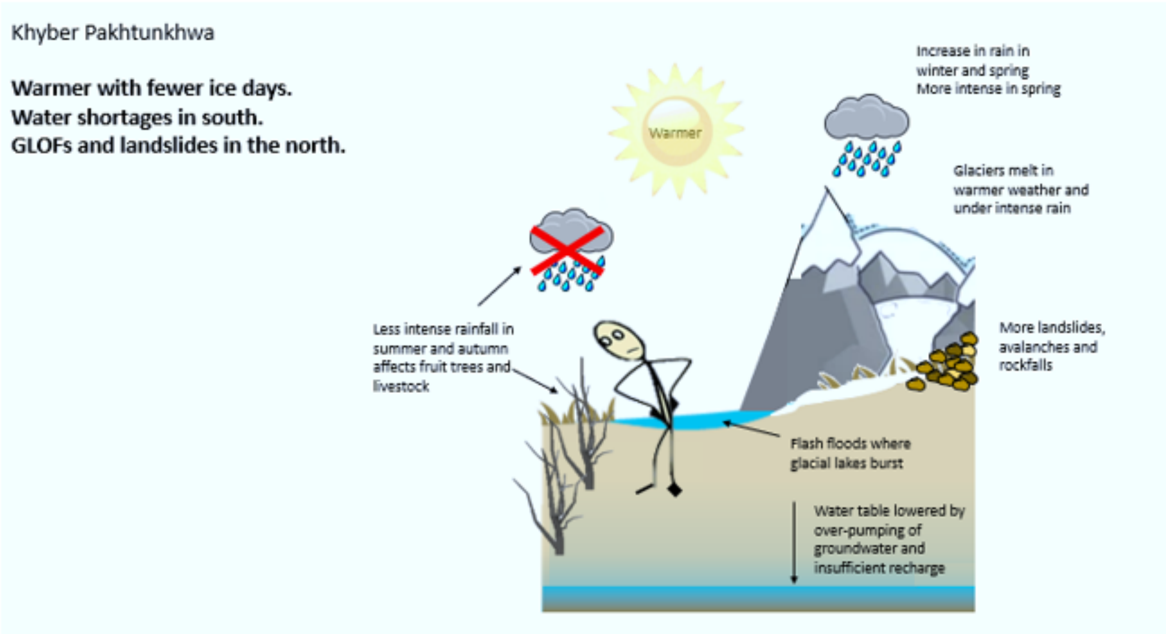

FIGURE 41: INFOGRAPHIC SHOWING POSSIBLE FUTURE SCENARIO FOR KHYBER PAKHTUNKHWA

Fewer ice days and generally increased temperatures are likely to lead to accelerated glacial melt. This will bring with it the threat of GLOFs. With careful district led water monitoring schemes in place, lake water depth can be lowered artificially to prevent these events (48).

More intense rain is likely to lead to more landslides. To reduce vulnerability to such events it will be important to look at land-use across the province. Maintenance of slope vegetation and reforestation could reduce risks greatly.

Reductions in summer rainfall will need to be planned for, especially in terms of orchard areas and livestock rearing. Education and communication about the climate changes that are projected, and possible methods of adaptation should be disseminated directly to local communities.

There is a need to explore capacity for adapting farming practices particularly among poorer tenant farmers. Appropriate support and inputs are required where production is falling, for example in fruits and cereals in some areas. Based on future climate projections, scope to introduce alternative crops should be explored as conditions become warmer with less intense rainfall in summer. Out migration of the poor, landless population is likely to increase, putting pressure on urban areas if provision is not made to support adaptation.

Figure 2 - Climate Storyline for Khyber Pakhtunkhwa

6.3: Punjab summary storyline

- Cooler, wetter summer.
- Shorter dry spells, but more intense heat days in the spring and autumn.
- More intense rain in spring with an earlier start to the monsoon.

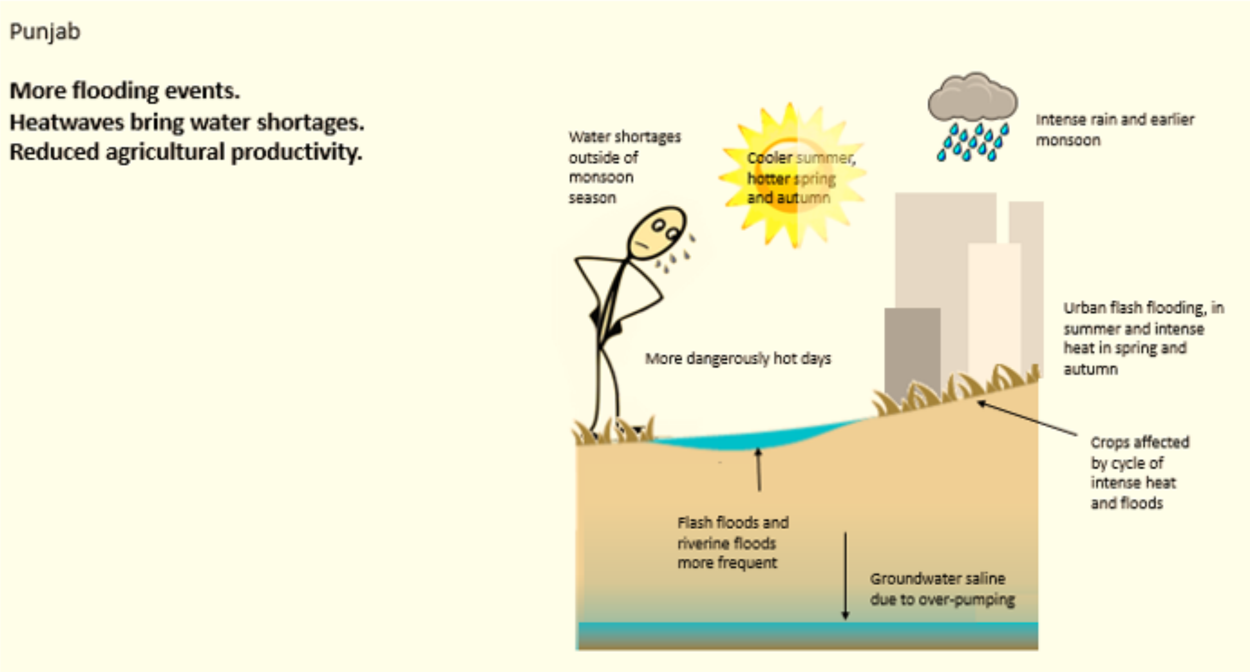

FIGURE 42: INFOGRAPHIC SHOWING POSSIBLE FUTURE SCENARIO FOR PUNJAB

Punjab is likely to encounter more flooding events in the future, with increases of instances of both riverine flooding and flash flooding, particularly in strong La Niña years. Irrigation systems will need improving and regulating better to ensure that water is fairly distributed across Pakistan.

Given a greater chance of more intense rain in spring, drainage in urban areas must be carefully monitored and improved. Water harvesting to cope at times with intense heat will need to be a priority. Public information about the best ways to stay cool in a heatwave is needed, to avoid inefficient use of air conditioning that could lead to power outages.

Punjab produces 74% of Pakistan's food crops (mainly wheat, rice, maize) and is a major source of revenue from cash crops (sugarcane and cotton). Investment in new cereal varieties that are adapted to cooler, wetter summers with more intense heat days and potential flash flooding is critical. Similarly, work is needed to establish whether cotton and sugar cane production will remain viable under defined future climate projections. The possibility of alternative cash crops must also be explored, should these reach the climatic limits of profitable exploitation.

Investment in flood early warning systems and local flood protection infrastructure would reduce the economic impact of extreme climate events. Future climate projections should inform decisions on the specification for these flood defences, in both rural and urban areas. This would be best implemented using a Dynamic Adaptive Policy Pathway (DAPP), so that short-term actions could be planned with trigger points identified showing when a different action would need to start. This form of adaptation has already been used to great effect in the long-term management of the Rhine Delta in the Netherlands, as it takes into account uncertainties arising from social, political, technological, economic and climate changes (259).

Figure 3 - Climate Storyline for Punjab

6.4: Sindh summary storyline

- Shorter dry spells, but more days of dangerously high heat index.
- More intense rain from July to September.
- Also a possible shift to June to August rains, depending on SSP and time window.
- Less intense rain by end of September.

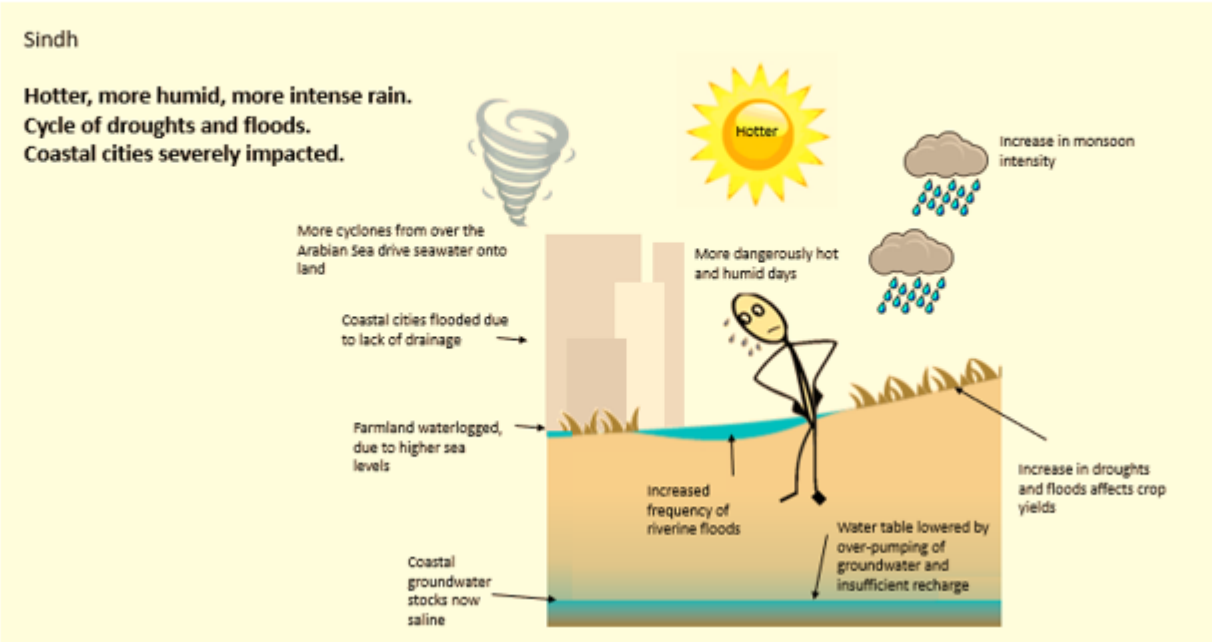

FIGURE 43: INFOGRAPHIC SHOWING POSSIBLE FUTURE SCENARIO FOR SINDH

Like Balochistan, Sindh must be prepared for both climate hazards associated with more intense rainfall and dangerous heat. Irrigation methods should be made as efficient as possible to reduce the risk of both a lack of enough water in the drier, hotter periods of the year and avoidable inundations during the monsoon season. The increased frequency of drought and floods on such a major crop producing region, where rice, cotton, wheat and sugar cane are all particularly important, will need to be addressed by way of a comprehensive set of measures to include both flood protection and proliferation of drought resistant crops. Irrigation systems upgrades are vital for the higher value crops such as tomatoes and chillies. Such investment in water management will result in better resilience and lead to a better living standard in the future. Equally farmers with livestock need to have their livelihoods safeguarded as temperatures rise. Measures as simple as distribution of fodder during drought conditions and more provision of shelter to protect animals from heat stress will pay dividends in maintained productivity.

Education is needed at district level, to help farmers to adjust to changes in the monsoon season and to plant the most appropriate crops. Poverty reduction via properly regulated loans and grants would reduce the vulnerability of the poorest agricultural workers. This would also reduce the rate of migration to cities, particularly Karachi, which will become more vulnerable to floods, cyclones and sea water intrusion as sea levels rise. With coastal storms becoming more severe, early warning systems to protect the fishing community should be improved. Continuing to redevelop the mangroves in the coastal region will reduce coastal climate induced hazards, but man-made defences will still need to be strengthened. Climate friendly urban development is also essential if urban drainage issues are to be reduced.

With rates of malnutrition very high in Pakistan, improving access to food could reduce the vulnerability of the population, so that the increased death toll associated with the aftermath of climate events, rather than the hazard itself, can be reduced. Equally more education and resources are needed to improve sanitation and hygiene. Diseases associated with overcrowding and poor sanitation, have a higher mortality rate than drowning and other direct causes of death due to climate disasters (98; 101; 102).

Figure 4 - Climate Storyline for Sindh

4 Adaptation Emphasis to Limit Vulnerability

This section summarises the most important issues highlighted in the stakeholder survey and in current literature that must be addressed to ensure adequate climate change adaptation in Pakistan.

The diagrams are based on the Enabling Framework for Action, to empower users to see quickly where important information, resources, funding, research, regulation and communication may be missing. The diagrams have been produced to summarise all concerns raised up to national level. The same technique can be used at provincial and local level to provide the required focus for relevant policy makers. The framework allows for clarity on where increased investment and more research will have the greatest effect.

Figure 5 shows the diagram structure. This has been repeated for the four sectors examined.

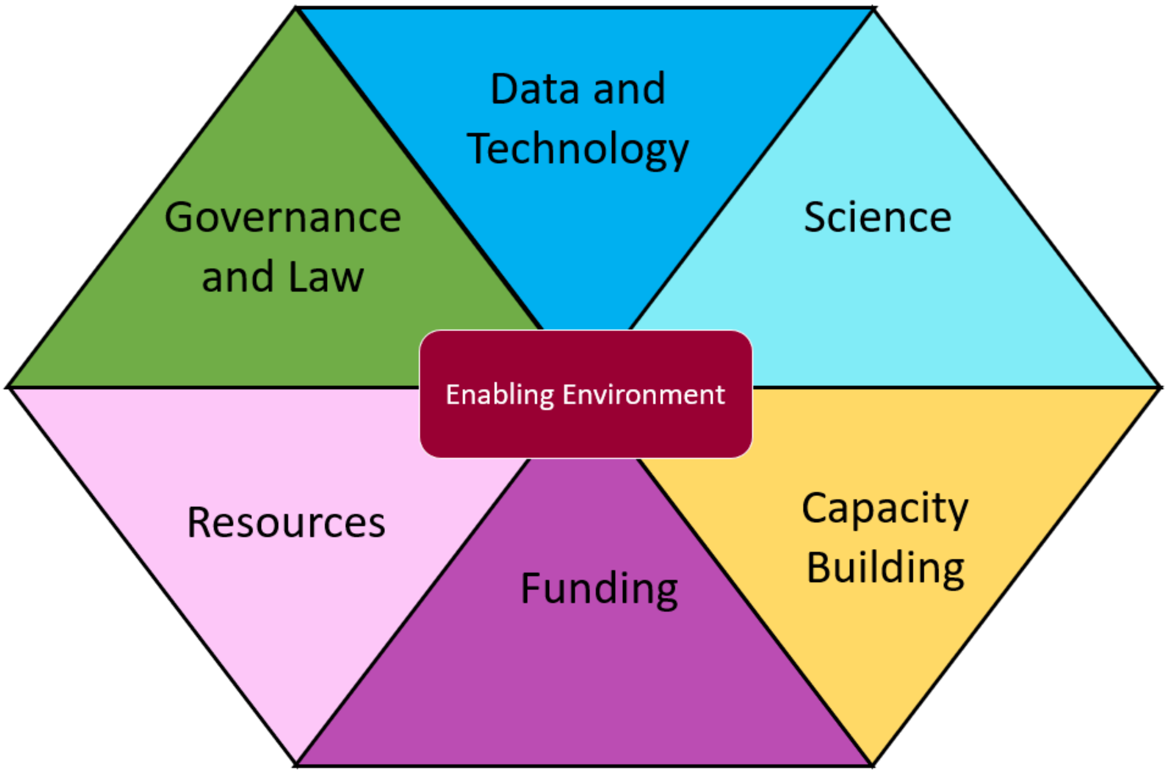

Figure 5 - The Enabling Environment diagram structure

There is some overlap between the diagrams, as some changes may have a positive effect on more than one sector. Some of the suggestions for research are already underway in particular establishments. By highlighting the necessity of such studies here, it is hoped that other regions will be able to collaborate or add to this research and that it will continue to be updated. These suggestions will need to evolve as more becomes known about how the climate is changing. Long-term planning is vital; however, it is important to understand that it must include different adaptation paths that can be switched to once particular trigger points are reached (Haasnoot, 2013).

Climate Change Preparedness

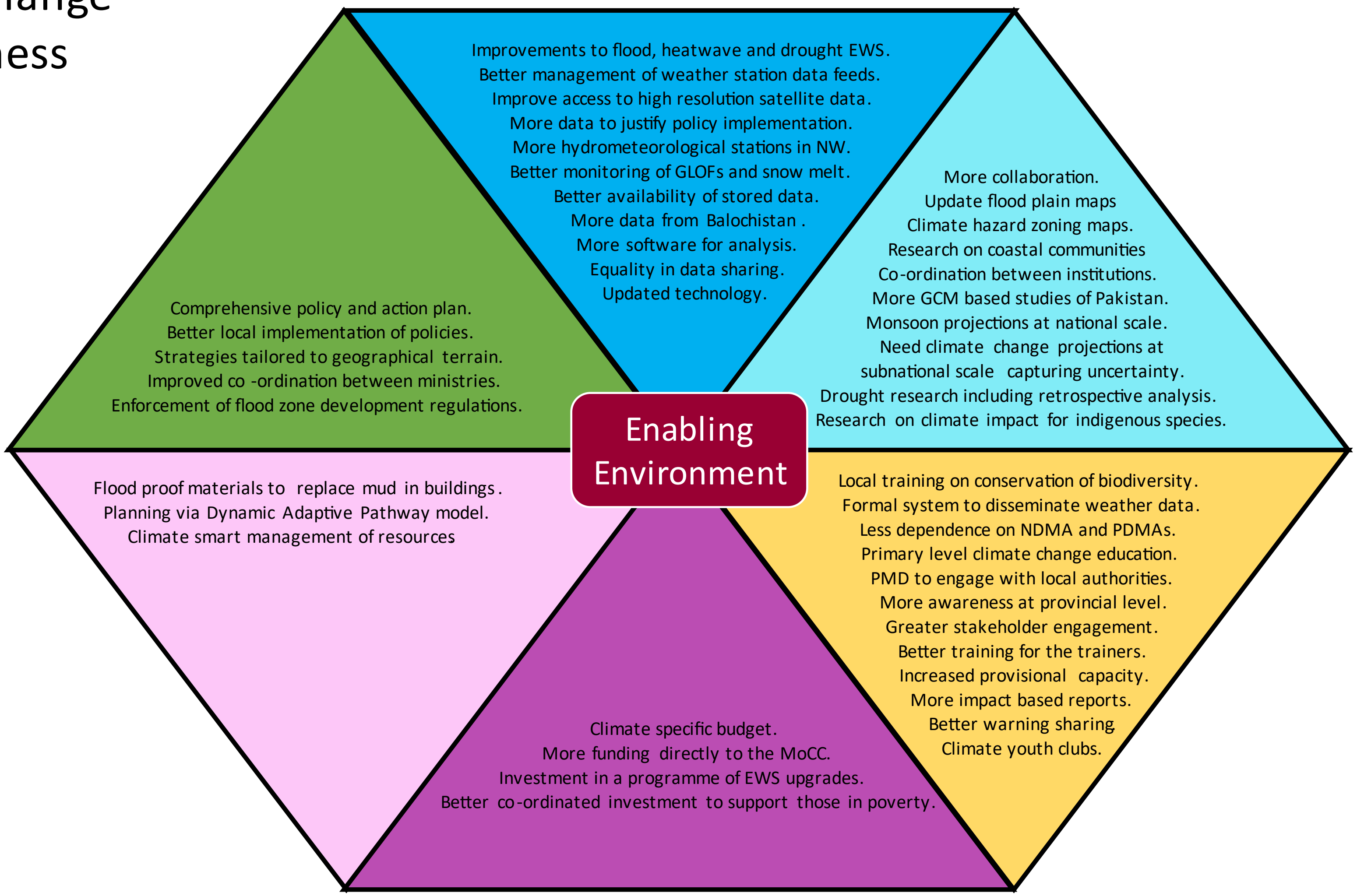

Figure 6 - Enabling Environment for Climate Change Preparedness

Water Resources

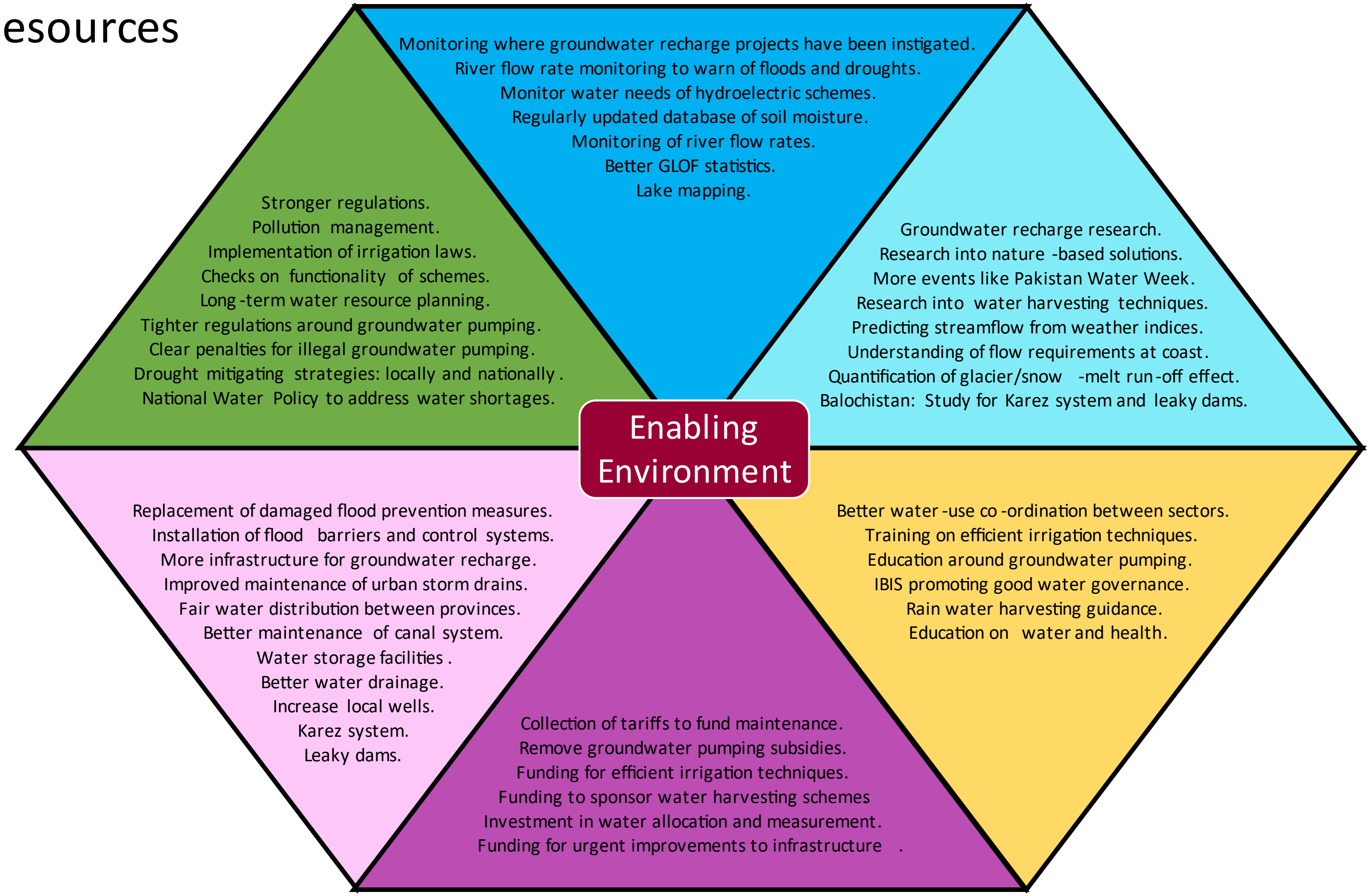

Figure 7 - Enabling Environment for Water Resources

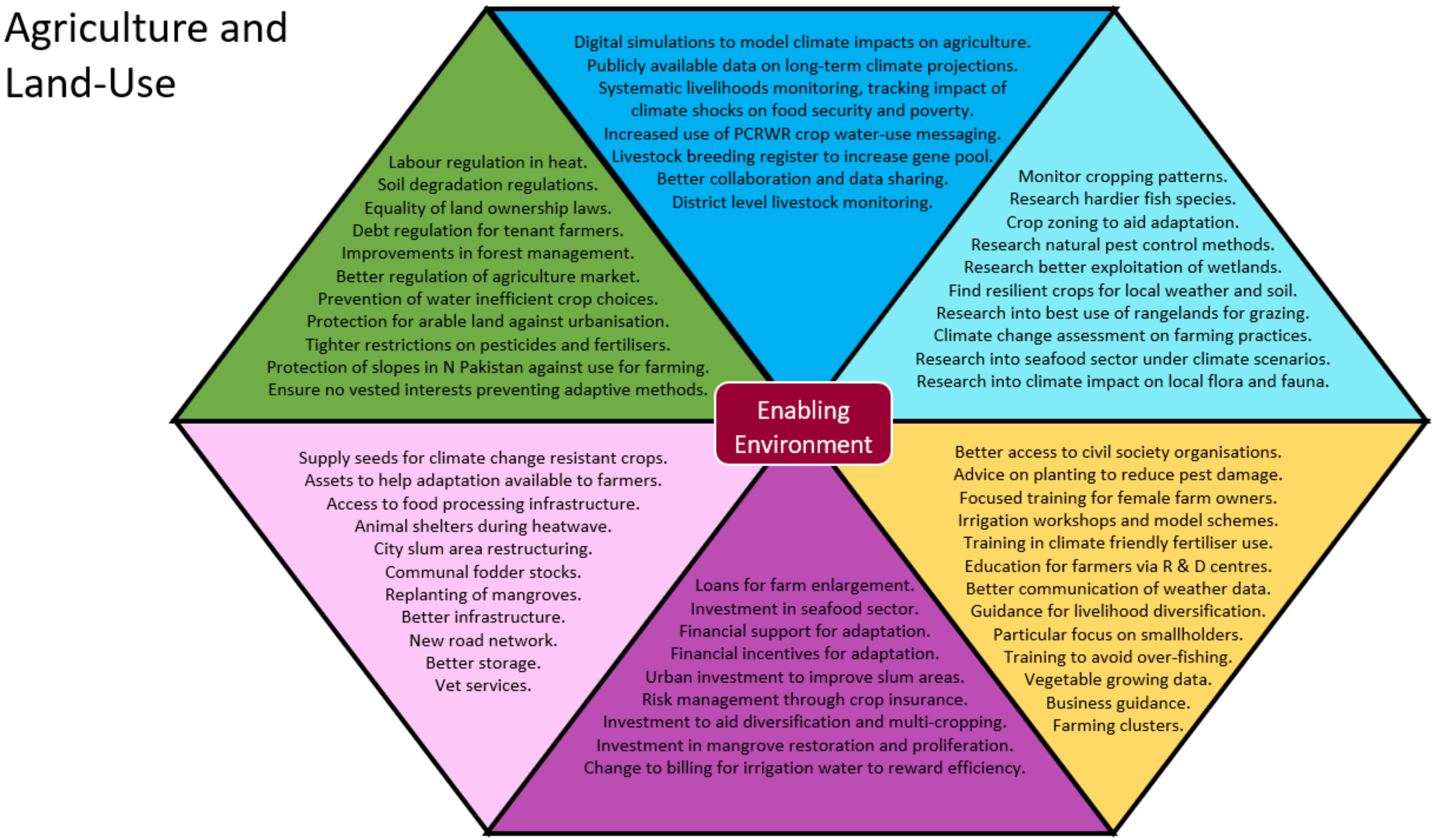

Figure 8 - Enabling Environment for Agriculture and Land-Use

Health

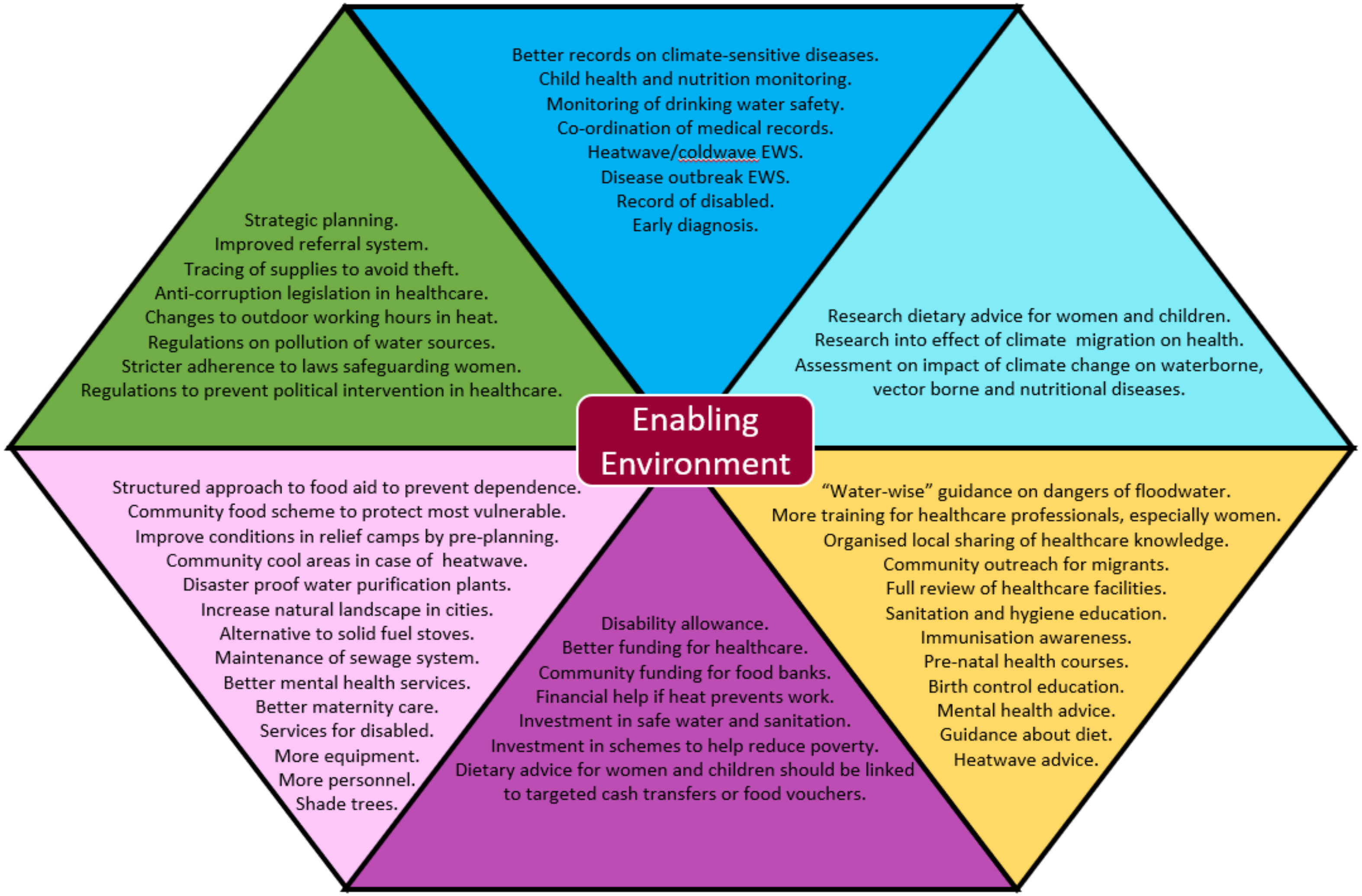

Figure 9 - Enabling Environment for Health

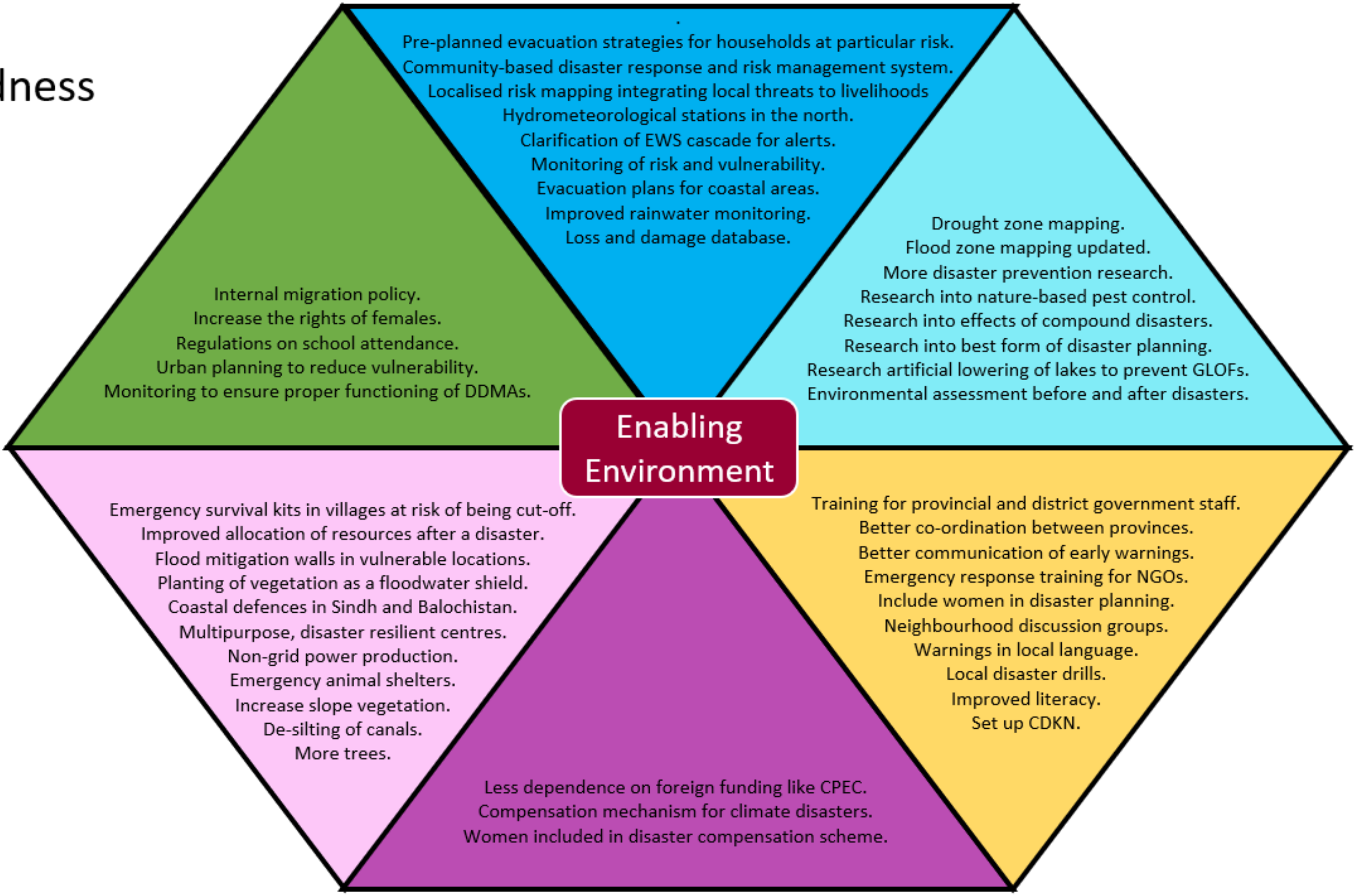

Figure 10 - Enabling Environment for Disaster Preparedness

5 Stakeholder Engagement

Early dialogue with government agencies, national actors, and project partners was central to identifying the intended outcomes and indicators of success for the project. The engagement also aimed to provide support, where possible, to strengthen the key institutional partnerships needed for the effective implementation of the Pakistan NAP and integration of climate change adaptation issues into development planning processes and policies.

Coordination activities were undertaken to communicate with the National Climate Change Policy Implementation Committee (NCCPIC) through the MoCC and UNEP, and the established NAP stakeholder groups.

The collection of stakeholder views was based on the 'knowledge-to-action' approach. The stepwise approach used is comprised of the following steps, and is summarised in Figure 11.

a. **Defining knowledge needs**: Review, compilation, validation and refinement of adaptation knowledge needs (as specified by Pakistan stakeholders) and formulation into questions that partners and experts can respond to;

b. **Scoping**: Review and synthesis of existing adaptation knowledge and needs; using inputs such as authoritative reports (e.g., the latest IPCC reports, World Bank reports, etc.) and peer-reviewed literature to ensure that associated actions are demand-driven from the outset; and exploration of linkages with work under the UNEP and the Pakistan institutional structures;

c. **Engaging with expert groups**: Identification of relevant experts and institutions, and the establishment of a diverse and inclusive expert group to inform the climate risk assessments and co-develop the long-term strategic operation of the Pakistani climate information system and forward partnerships;

d. **Refining knowledge**: Identification of priority knowledge gaps and first-order and second-order risk domains, in partnership with the Pakistani government and expert groups, and exploration of further opportunities to share the knowledge gaps with the government, experts and institutions with knowledge gaps and needs are further refined on the basis of feedback;

e. **Co-designing actions:** Co-development of NAP actions with the expert groups, partners and/or government agencies to address knowledge needs and enhance national, regional and local adaptation actions and capacity;

f. **Reporting and disseminating findings**: Dissemination and sharing of risk assessments into usable formats for government officials, scientific communities and the general public in Pakistan, with targeted trainings to increase the awareness and technical skills of key actors and relevant stakeholders;

g. **Facilitating collaboration and partnerships**: Foster and strengthen partnerships between the expert groups and other stakeholders including the government agencies and academic communities to mobilise support for implementing NAP actions and to close knowledge gaps, while facilitating collaboration among the expert groups;

h. **Implementing actions**: Implement actions in partnership to close existing knowledge gaps and help integrate climate change into development planning processes, ensuring consistency in methodology and approach; and

i. **Tracking and learning:** In partnership with the expert groups, document and report outcomes, actions and multi-stakeholder consultations undertaken to close knowledge gaps.

The expert group of policy advisers, government officials, and researchers representing the key institutions, facilitated by the MoCC, was established October 2022. A multi-sectoral, multi-stakeholder forum and capacity-building workshop was held at the end of 2022. This included sharing key findings from the climate risk and vulnerability assessment report and targeting several specific capacity-building needs.

All the reports were finalised after the forum with partnership actions identified to take forward. Strong onward communication flows were determined to be critical in the successful implementation and cascading of the NAP actions at provincial level and below.

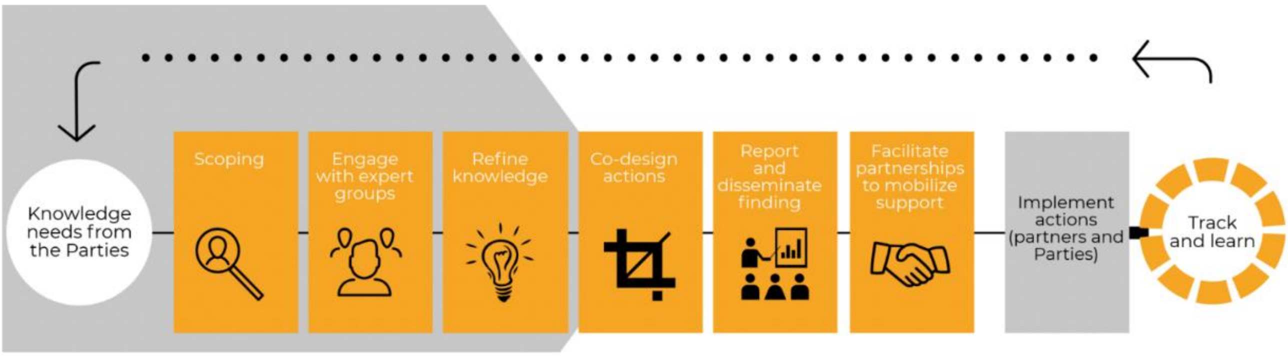

Figure 11 - Understanding and responding to knowledge gaps. Source: Progress in implementing activities under the Nairobi work programme on impacts, vulnerability and adaptation to climate change

6 Concluding Summary

The climate is likely to change in Pakistan in the following ways:

- rising temperatures
- higher rates of evapotranspiration
- changing monsoon patterns
- increased precipitation intensity
- more frequent droughts
- accelerated melting of glaciers
- rising sea levels

This assignment required a review of the latest climate change projections, their downscaling, and the climate information system in Pakistan. The purpose of the review was to take stock of the most up-to-date climate projections and climate risk science for Pakistan and identify gaps, areas of improvement, and provide recommendations on approaches to downscaling climate projections for Pakistan. Throughout this review, it was indicated that the specific climate projections and downscaling methodologies to be used should be determined by decision-making requirements at the provincial level.

Another aspect of the assignment was to develop national and sub-national climate risk assessments (CRAs) in Pakistan. CRAs are used to establish links between impacts and risks to identify opportunities for adaptation and should be informed by stakeholder input at the local, provincial and national level, in addition to climate projections from peer-reviewed and grey literature. Where existing information is not comprehensive, climate modelling should be undertaken. The analysis of the climate projections should be accompanied by interpretation and/or guidance to inform decision-making.

Climate storylines are both an effective and cost-efficient approach to achieving this. They are used to bridge the gap between uncertain climate projections and detailed local knowledge. Climate storylines can be applied for the whole of Pakistan at a national context, highlighting vulnerabilities that affect the whole of Pakistan, but also in a more targeted way to examine adaptation at a provincial level considering specific sectors, such as health or agriculture. Expert knowledge is used to guide the process, and it considers the full impact chain: first order (environmental) risks and second order (economic: health, energy, agriculture, water, disaster management, and transport) risks.

Four storylines were used to describe the possible future scenarios in the regions as follows:

Balochistan storyline:

- Monsoon shift to later
- Heavy rains in March

Khyber Pakhtunkhwa storyline:

- Warmer winters with many fewer ice days

- Less rain in November
- Longer dry spells in spring
- More dangerously hot days

- More rain in winter and spring
- Greater intensity of rain in the spring
- Less intense rainfall in summer
- Possibly more or less intense rain in the winter

Punjab storyline:

- Cooler, wetter summers
- Shorter and more intense dry spells
- Hot days in the spring and autumn
- More intense rain in spring with an earlier start to the monsoon season

Sindh storyline:

- Shorter dry spells, but more days of dangerously high heat index
- More intense rain from July to September
- A possible shift to June to August rains, depending on scenario and time window
- Less intense rain by end of September

These climate storylines will likely lead to the following sectoral impacts:

Water resources

- Drought conditions have affected Balochistan in the recent past, with a large proportion of the population being directly and indirectly exposed to drought. Monsoon flooding occurs almost every year in Balochistan.
- There is an increased risk of heatwaves leading to droughts in Balochistan. This can result in food and water shortages.
- Sea level rise threatens to decrease accessibility of freshwater as salinity pollutes water sources.
- Due to a lack of regulations and incentives for efficient water use, groundwater sources are over-pumped in the Balochistan districts. In Khyber Pakhtunkhwa, a reduction in the number of ice days alongside an increase in temperature, is likely to lead to accelerated glacial melt, bringing with it the threat of GLOFs. These events can be prevented using water-led monitoring schemes to artificially lower lake water depth.
- Punjab is likely to encounter more flooding events, with an increase in both riverine and flash flooding, particularly during strong La Niña years.
- Irrigation system improvements and regulations should be implemented to ensure that water is fairly distributed across Pakistan.
- Rainwater harvesting will need to be a priority to cope with intense heat and prolonged drought.

Agriculture

- Prolonged drought and heat induced increased evapotranspiration have led to scarcity in water irrigation for crops.
- Balochistan has poor physical infrastructure, which impacts the transportation of goods. Food processing would support in the longevity of end products.

- Agricultural production in the Balochistan region is declining, resulting in increasing pressure on resources and widespread poverty in the province.
- Rainwater harvesting and better water management are vital if areas of Balochistan without streams are to remain not just cultivable, but even habitable under climate change. Appropriate support and inputs should be put in place to support farming where production is failing.
- Farmers should explore using mixed cropping techniques and switching to alternative crops (alternative cash crops) which are less vulnerable to climate change. Planting cycles should be considered to ensure that the likelihood of sudden heavy rains is considered.

Health

- The public should be informed on the best ways to stay cool during heatwaves.
- Healthcare systems need to be improved, especially in terms of education about sanitation and hygiene, to help to prevent large disease outbreaks, particularly following flooding events.

Disaster preparedness

- The number of cyclones over the Arabian Sea is projected to increase. Storm defences on the coast of Balochistan will need to be strengthened to cope with heavy rainfall, strong winds, sea level rise, and coastal intrusion.
- Mangrove restoration and proliferation in Balochistan is necessary and could help reduce vulnerability.
- More intense rainfall will likely lead to more landslides. Land use should be assessed across the province of Khyber Pakhtunkhwa. Maintenance of slope vegetation and reforestation would support the reduction of this risk.
- Drainage in urban areas of Punjab should be monitored and improved to deal with the intense rain in spring.
- Investment in flood early warning systems (EWS) and local protection infrastructure would reduce the economic impact of extreme climate events.
- Education and communication about projected climate change and methods of adaptation should be disseminated directly to local communities.
- The public should be informed on the best ways to stay cool during a heatwave to avoid inefficient use of air conditioning that could lead to power outages.
- Future projections should inform decisions on the specifications for flood defences. This would be best implemented using the Dynamic Adaptive Policy Pathways (DAPP) approach so that short-term actions could be planned with trigger points identified to determine when different actions would need to start.

The Enabling Framework for Action was used to provide an overview of crucial information, resources, funding, research, regulation, and communication that may be lacking. It sheds light on areas where increased investment and further research are essential at the national level, specifically addressing Climate Change Preparedness, Water Resources, Agriculture and Land-Use, Health, and Disaster Preparedness. The framework considered action through various lenses. These include Government and Law (accounting for legislations, policies, regulation, strategies and action plans), Data and Technology (including improved EWS for climate hazards and disease outbreaks, data management and storage, developing and improving databases and monitoring of impacts and needs), Science (through greater collaboration between institutions and highlighting various research and assessment needs), resource considerations (including improved infrastructure and service requirements, disaster and future proofing materials and techniques), Funding (financial support and incentives to consider for implementing adaptation and reducing vulnerabilities across the sectors) and Capacity Building (considering access to civil society organisations, raising awareness across sectors and provinces through training and engagement activities, and developing guidance documents).

Throughout the project, consultative processes were maximised whenever possible. This approach aligns with the best practices employed by the broader community of UN stakeholders, particularly in their support for National Adaptation Planning in other countries and linked UNFCCC programmes. These initiatives similarly aim to foster ownership of both the process and results. The stepwise consultation ‘knowledge-to-action’ approach was adopted to gather stakeholder views on priority knowledge gaps in existing climate modelling capacity. The most important ‘foundation stones’ upon which rigorous and useful climate change research should be undertaken could be summarised under three priority actions: (i) improved access to data and information, (ii) enhanced research capacity; and (iii) enhancing the impacts of research.

The ultimate objective of this work is to support 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. Systems for developing and sharing climate risk and vulnerability information will be reinforced, and sustainable financing mechanisms for climate change adaptation initiatives are set to be developed. A NAP will be developed along with its constituent Provincial Adaptation Plans for each of the four provinces.

Abbreviations

AI	Artificial Intelligence
CRA	Climate Risk Assessment
CMIP	Coupled Model Intercomparison Project
CORDEX	Coordinated Regional Downscaling Experiment
DAPP	Dynamic Adaptive Policy Pathways
ETCCDI	Expert Team on Climate Change Detection and Indices
EWS	Early Warning System
GCF	Green Climate Fund
GCM	Global Climate Model
GLOF	Glacial Lake Outburst Flood
IPCC	Intergovernmental Panel on Climate Change
IPCC AR6	IPCC Sixth Assessment Report
MoCC	Ministry of Climate Change
NAP	National Adaptation Plan
NCCC	National Committee on Climate Change
NCCPIC	National Climate Change Policy Implementation Committee
PMD	Pakistan Meteorological Department
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
SLR	Sea level rise
SOM	Self-organising maps
SRES	Special Report on Emission Scenarios
SSP	Shared Socio-economic Pathways
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	Work Climate Research Programme
WFP	World Food Programme
WGI	Working Group 1
WI	Walker Institute
WMO	World Meteorological Organization

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Appendix A

Storylines for Illustrating Climate Change Risk Assessments

Introduction

A climate risk assessment (CRA) is vital 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*" (Shepherd, 2018). It is a powerful way to link physical climate events and socio-economic aspects of climate change. Storylines provide frameworks that ensure responses are fitted to the appropriate 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, as 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 the exploration of boundaries of plausibility surrounding event uncertainties.

Climate storylines are used 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. Local knowledge is used to improve and refine both climate storylines and risk assessments. The use of storylines is both effective and cost efficient, bringing with it genuine ownership of the process by local stakeholders.

Climate storylines can be developed 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. Climate Storylines also enable the probable impact of adaptation policies to be gauged across these disparate futures, through the involvement of expert stakeholders.

Climate Risk Assessment Approach

A CRA can be developed by a diverse number of approaches, including risk and vulnerability mapping, expert judgement, and sensitivity analysis. Prior to constructing a CRA based on storylines, the following conditions should be considered:

- A certain amount of data is necessary when developing storylines for impact analysis and adaptation planning. Data 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 (as addressed in Section 2).

- Climate hazards pose a significant risk to people by their effect on both the built and natural environment at national and local levels. The full impact of climate change can be understood by pairing climatic and socio-economic scenarios. A CRA should consider first order direct impacts of natural hazards such as drought, floods, and soil degradation, alongside entities impacted by natural hazards (i.e. second order domain), such as health, livestock and agricultural productivity and infrastructure.

The following steps are required to develop a CRA as part of the storyline.

Step 1. **Assess hazard level:** The level of hazard is quantified based on its intensity, duration and return period. Where there is insufficient quantitative information, it is recommended to use particular thresholds and base decisions on the extent of historical events from literature. Expert stakeholder judgement should be sought to confirm these qualitative rankings.

Step 2. **Assess exposure:** Exposure is dependent on the geographical extent of any event, and 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 is based on the hardiness of the system. 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.” 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.

Step 4. **Assess vulnerability:** Vulnerability is a measure of sensitivity to a hazard. Vulnerability is determined through a combination of stakeholder views and literature review (both peer reviewed academic papers and grey literature). As vulnerability is not a static measure, it is necessary to use the most current information available.

Step 5. **Calculate the level of risk:** Climate risk should be established considering the hazard (severity and frequency), exposure (area, infrastructure and people), vulnerability (instability and sensitivity) and resilience (resistance, response and recovery). 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 developing disaster management plans and ensuring relief centres are stocked and 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.

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.

Methodology

An exemplar structure for constructing a CRA based on climate storylines was developed. This methodology provides a framework for Pakistan stakeholders to generate plausible storylines at national, provincial, and local levels to facilitate adaptation planning decision-making and create flexible and locally focused adaptive strategies.

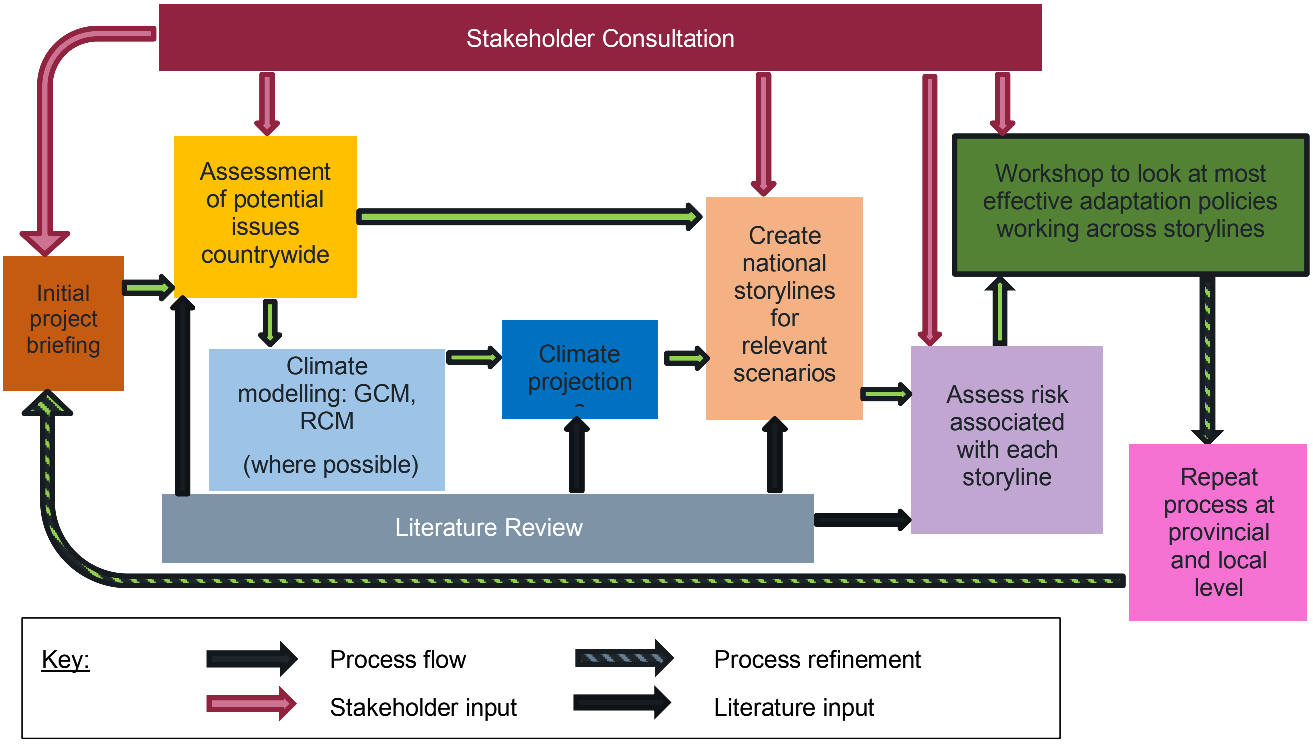


Figure 12: Flowchart of exemplar approach to Climate Risk Assessment using climate storylines for Pakistan

To illustrate each stage of the process in a practical context, the CRA using storylines recently completed in Iraq (October 2022, (Cornforth, 2022)) is described below. The underline colours reflect those used in Figure 12.

a. 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.

b. 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.

c. 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 included: 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 were 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.

d. Climate Projections Analysis: At a regional level, 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 is shown in Figure 13.

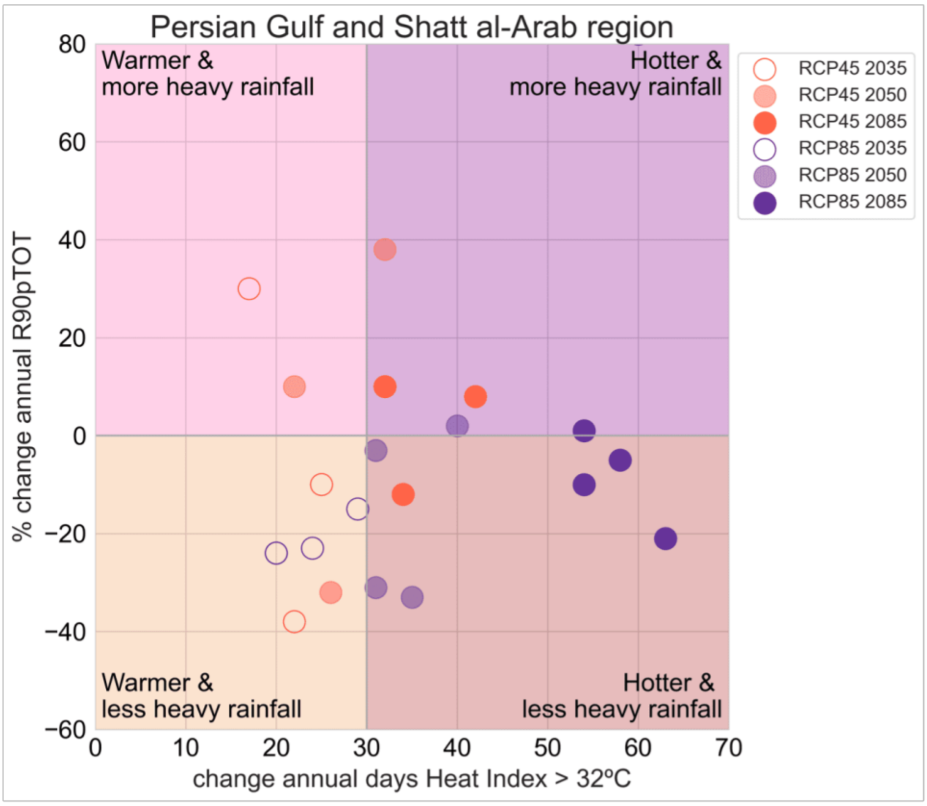


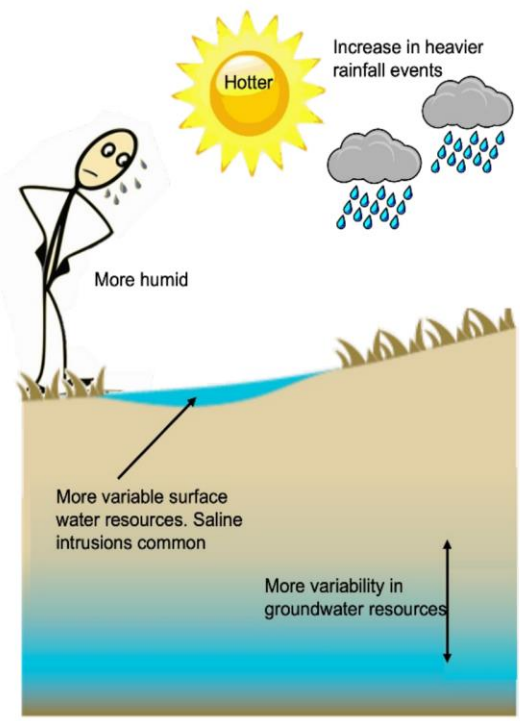
Figure 13: Climate change Matrix of Storylines for the Persian Gulf region, Iraq. Change in extreme precipitation versus change in heat index. Lines dividing four

quadrants represent no change in precipitation extreme and moderate change in hot-humid extremes.**

e. Development of the Storylines: Two storylines were chosen based on the quadrants on the right of the matrix (Figure 13):

- Hot-humid and more extreme precipitation; and
- Hot-humid and less extreme precipitation.

Based on expert input, data and historic events, infographics and a detailed narrative were developed. An example of these storylines is provided in Figure 14.



The temperature is noticeably hotter and more humid with almost 4-5 months a year of Heat Index (HI) consecutively above 32°C, compared to 100 days per year in the historical record. Of this, about 1 month the HI is above 41°C, compared to almost 0 days per year in the historical record. The higher temperature and humidity rises are felt particularly in 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 14: Climate infographic and storyline for hot-humid and more extreme precipitation in Persian Gulf region of Iraq.

f. Assess risk: Following expert examination of headline impacts for water, health, agriculture and livelihoods, a list of future risks occasioned by the projected climate changes was produced. This list informed further discussions with key local stakeholders.

g. Workshop on Adaptation Options: A two-day workshop enabled comprehensive sharing of a broad range of local knowledge and expertise and allowed the further refinement of the assessment of future risks in each eco-region. The analysis completed in Iraq can 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.

Steps a to g can be applied at a national, provincial, or local level. Due to Pakistan's diverse geography and climate, it is necessary to work not just at a national or provincial level, but also to focus on districts. A cascade structure for information on disaster management already exists for Pakistan, and as such, a similar system could be used for risk assessment.

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 can 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 is 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 documents what is causing exposure and vulnerability and preventing resilience so that adaptation at a local scale is more effective.

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