ACT

ACTION ON CLIMATE TODAY

LEARNING PAPER

Using climate information for Climate-Resilient Water Management: Moving from science to action

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Abbreviations and acronyms

ACT	Action on Climate Today
AWS	Automated Weather Station
CRWM	Climate-Resilient Water Management
EWS	Early Warning System
GCM	Global Circulation Model
HEC-RAS	Hydrologic Engineering Centre – River Analysis System
HRVA	Hazard Risk and Vulnerability Analysis
IMD	Indian Meteorological Department
JSA	Jalyukt Shivar Abhiyan
NAP	National Adaptation Plan
NGO	Non-Governmental Organisation
SWAT	Soil and Water Assessment Tool
VCA	Value Chain Analysis
WOTR	Watershed Trust Organisation
WRM	Water Resource Management

Executive summary

This paper explores one critical challenge for promoting Climate-Resilient Water Management (CRWM) in South Asia and beyond: the availability and use of high-quality climate information. It is aimed primarily at those designing or delivering projects and programmes on CRWM, as it provides some practical guidance on the role and use of climate information.

One key difference between CRWM approaches and practices and a 'business as usual' approach to managing water resources is the use of high-quality climate information while designing and planning interventions (James et al., 2018). Climate information is a broad term that can cover data on climate variables and dynamics, as well as the outputs of different climate models. It can be based on measured data (e.g. from weather stations) and/or documented perceptions (e.g. surveys).

In South Asia, as in other regions, there are many challenges to the use of climate information to inform the policy-making process. There are limitations in the availability, reliability and accessibility of climate data, and capacity constraints in assessing the climate data to produce useful information and analysis that is then used to inform policy and practice. Together with wider political economy and governance constraints, these issues in turn challenge the extent to which CRWM can be effectively adopted in the region.

This is the challenge that Action on Climate Today (ACT), a programme funded by the UK Department for International Development, has taken up since 2014. ACT works with partner governments at the national and subnational level in five South Asian countries, and is designed to transform systems of planning and delivery for adaptation to climate change.

This paper presents learning from ACT on how to understand the role of climate information in producing analysis and informing climate change policy and action, particularly in the water sector, and how to overcome some of the challenges involved. It starts with an overview of the definition and typology of different types of climate information, and how it can be used in different ways to inform CRWM. It presents a large number of examples of initiatives from ACT to highlight the breadth of possible types of climate information and uses.

Pakistani porter with donkey leaving Korofong camp.

The paper then explores some of the major constraints to integrating climate information within the planning process, as well as some key enablers that have helped ACT overcome these challenges. A discussion then goes into more detail on specific learning from ACT from different 'data environments', meaning from contexts where data is more or less available than in others.

The final section of the paper is targeted at those seeking to design and implement CRWM programmes and initiatives and provides some recommendations on how best to use and integrate climate information. An Annex provides a set of online sources of climate information as an additional resource for those interested in CRWM.

1. Introduction

Climate change is already having an impact on the water cycle. In particular, climate change is thought to be making the monsoon more erratic and unpredictable, and leading to a decreasing number of rainfall days but with heavier intensity (Loo et al., 2015). In addition to shifting such baseline conditions, climate change is projected to increase the frequency and severity of both floods and droughts (Kundzewicz et al., 2007). In parallel, in South Asia, as in much of the world, water demand is increasing in response to population growth, urbanisation and increased per capita demand, increased industrial demand and a continued relatively high dependence on agriculture. This increase in demand is expected to continue and accelerate, especially in the agriculture sector, as temperature rises lead to higher evapotranspiration losses and greater crop water use (Cline, 2008).

Changes in the hydrologic cycle coupled with increased water demand will have manifold impacts on food and livelihood security, agriculture, urbanisation, industrialisation and hence the economy at large. As a result, the South Asian water resources sector needs to plan for climate change.

This challenge has been taken up by Action on Climate Today (ACT), a technical assistance initiative funded by the UK Department for International Development, which began in 2014. ACT is focused on climate-proofing governance systems in five South Asian countries at the national and subnational levels to transform systems of planning and delivery for adaptation to climate change.

One particular focus of the ACT programme is introducing Climate-Resilient Water Management (CRWM) into the water resource management (WRM) and agriculture sectors. CRWM aims to reduce the vulnerability of at-risk populations to the adverse impacts of climate change, which includes the ability to maintain services and support livelihoods in the face of short-term shocks and to adapt to an uncertain longer-term future.

The ACT programme is utilising a variety of CRWM approaches and practices based on the local context and demand from key stakeholders. For example, some interventions focus on conducting water use studies and overlaying them onto climate scenarios to inform WRM. Others focus on developing flood-forecasting systems. Other examples include informing national and state climate policy and planning. All of ACT's work on CRWM is based on three conceptual pillars for building resilience which underpin the approaches and practices ACT is pursuing (James et al., 2018):

1. Using the best available climate information and data to go beyond business as usual;
2. Systematically integrating the principles of resilience, such as 'buffers', flexibility and adaptability;
3. Sharply focusing on reducing the vulnerability of poor and marginalised communities to climate change.

This paper focuses on Pillar 1. ACT's conception of Pillar 1 suggests that the use of climate information is critical for differentiating CRWM interventions from 'business as usual', given that information on physical exposure and social vulnerability to climate shocks and stresses needs to inform CRWM. Understanding physical exposure and social vulnerability entails combining different types of climate information to create a comprehensive narrative of the impact of climate extremes, uncertainty and variability on WRM.

This paper evaluates challenges and opportunities, as experienced by ACT, in producing and using climate information for informed decision-making in South Asia. It seeks to inform government agencies and officials, practitioners and donors, consultancy firms, non-governmental organisations (NGOs) and individual consultants on 1) how best to put climate information into practice in WRM and 2) how to use climate information to inform and guide the policy-making process.

The paper is divided into the following sections:

- Section 2 presents a background review of how climate information could, in theory, be used to mainstream climate adaptation within WRM, and the challenges and gaps that exist in this effort in practice. This section concludes with a summary of the different approaches ACT is taking to incorporate climate information into CRWM.
- Section 3 discusses the factors that have enabled or constrained the use of climate information in ACT CRWM interventions, with examples from the various projects and contexts.
- Section 4, the discussion, explores how much climate information is 'enough', to guide practitioners and donors in designing new projects.
- Section 5 puts forward some recommendations – a set of suggested practices for integrating climate information into WRM projects.
- The final section presents some concluding thoughts, including take-home messages for CRWM projects, informed by all that ACT has learnt in the implementation of the programme.

2. The role of climate information in mainstreaming climate change adaptation within water resource management

2.1. What is climate information?

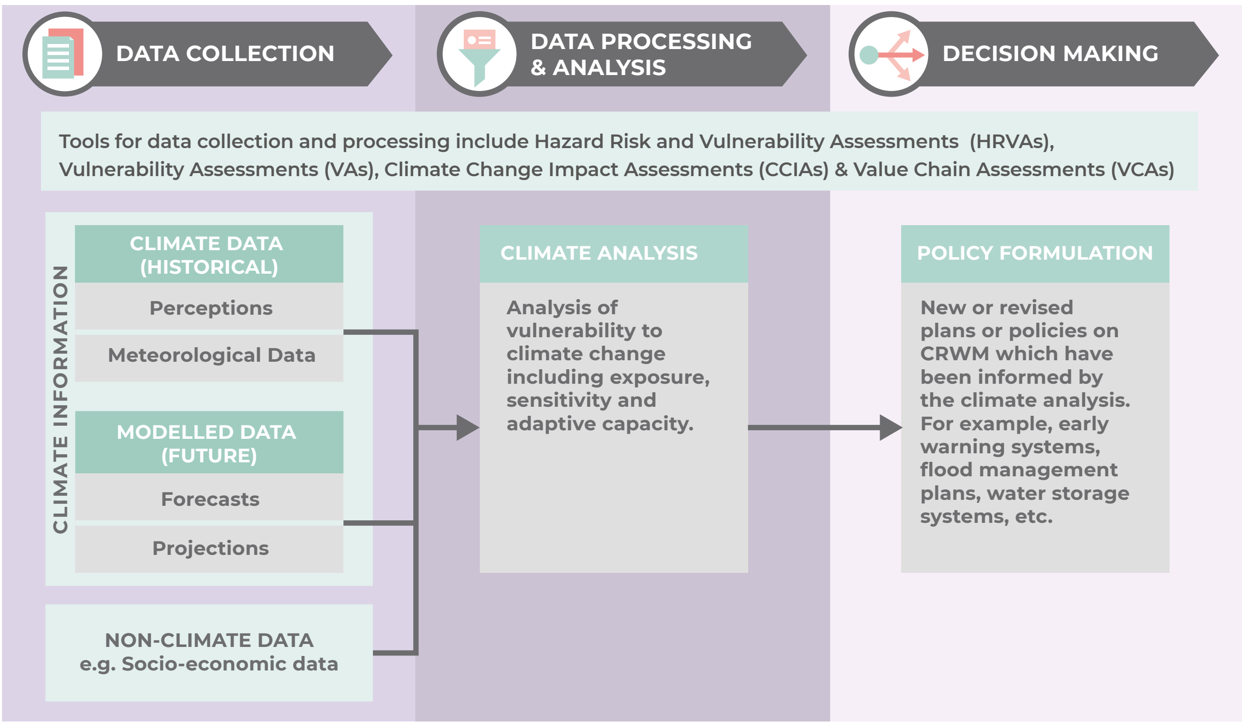
Climate information refers to the measurement of trends, projections and translated scientific data on weather that is used to inform policy and practice. 'Climate information' and 'climate change information' are not the same but have significant overlaps. To a large degree, climate change information is a subset of climate information:

- 'Climate change information' is specific to climate change and its current potential future trends and impacts (e.g. projections of future rainfall patterns).
- 'Climate information' broadly refers to climate variables and dynamics (e.g. information on rainfall patterns) and is informed by climate data (e.g. data on rainfall).
- Climate data entails measurements of temperature, precipitation, windspeed, etc., that are collected, analysed and translated to produce climate information.

Much development planning and action can be conducted only if the supporting climate data and information is available – or at least it would strongly benefit from the inclusion of such information. For example, seasonal drought warnings can help farmers select more drought-tolerant crops or diversify their planting. Flood forecasts allow governments and first responders to issue advance warnings and to pre-stage rescue equipment and relief supplies. Planners can use historic flows of information and water demand data to determine the need for water storage and select the most effective sites for reservoirs and groundwater recharge. Urban heat island information and temperature trends can help water utilities anticipate demand increases and develop new water supplies and/or conservation campaigns.

Climate information and non-climate information (e.g. on population projections, water withdrawals, etc.), can be combined through various tools and methodologies to produce analysis for various time horizons on how different variables affect current and future development conditions.

Figure 1: The role of climate information in producing analysis and informing policy



Climate information can take many different forms, based on the type of information available, capacities to access and analyse the information and the intended use of the information. Table 1 presents a range of different sources of climate information, including how each source can be obtained and how it can be used in CRWM. This typology is not exhaustive – it simply provides a starting point in looking at ways to integrate climate information into water management based on the types of data available. The Annex presents a list of online sources of climate information, covering a range of different types and forms.

2.2. Climate information and the water resource management sector

WRM involves planning and using water resources in a manner that optimises their use relative to a predetermined set of preferred outcomes. Ideally, this will be a cross-sectoral, open, flexible process that brings all stakeholders to the table to set policy and make sound, balanced decisions in response to specific water challenges. Well-developed WRM systems not only address urban, agricultural and industrial use but also incorporate environmental uses.

WRM has been implemented to varying degrees in various countries; it is best established in water-limited areas with strong governance systems and ample climate data and information to inform trade-offs and decisions. While lack of climate data and information has not necessarily prevented decision-making on climate change and climate-related issues, academics have argued that climate-related policy and adaptive management decisions need to be grounded in science to be effective (Lemos et al., 2012; Singh et al., 2017). Climate information can be used to reduce vulnerability to climate extremes and variability as it provides warnings and helps identify opportunities on which to base planning and policy (Feldman and Ingram, 2011).

While short-term forecasting of climate-related extreme events has seen many successes, the use of long-term climate information in planning and policy for climate change adaptation and resilience is challenging, and often not actively pursued (Jones et al., 2015; Vincent et al., 2015; Singh et al., 2017). Lemos et al. (2012) attribute this to the 'usability gap', arguing that this gap lies at both the top and the bottom. That is, climate information is rarely used because its producers fail to consider users' decision-making needs and to adapt their data products to address these. Meanwhile, users of climate information often either do not know, or have unrealistic expectations for, how climate information fits into their decision-making process. For example, a common belief within decision-making and practitioner communities is that successful adaptation necessitates increasingly accurate and precise information on the future impacts of climate change. As a result, Dessai et al. (2009) ask if effective adaptation is 'tied to the ability of the scientific enterprise to predict future climate with accuracy and precision' (p. 64).

This raises the question of exactly how much climate information is needed for effective climate policy and action. Accurate and precise information is difficult to produce because climate change is a global phenomenon. Downscaling climate projections made at the global, regional and national levels is expensive, time-consuming and data-intensive, and introduces additional uncertainty.

Climate change is, by its very nature, uncertain. These uncertainties are a result of limitations in knowledge and the poor predictability of the human factors that contribute to climate change (Dessai et al., 2009). Dessai et al. state that, 'some of these uncertainties can be quantified, but many simply cannot, meaning that there is some level of irreducible ignorance in our understandings of future climate' (p. 67). These uncertainties are further complicated by the fact that processes beyond climate change, such as urbanisation, population growth and cultural change, influence outcomes targeted by decision-making processes (Dessai et al., 2009). Some policy-makers use the uncertainties around climate change (and the lack of high-accuracy projections) as an excuse for inaction, or even to deny it is a problem.

2.3. Using climate information for water resource management

Fortunately, starting with accurate, precise, highly detailed and locally focused climate projections (which are essentially impossible to produce) is not the only way to incorporate climate information into WRM. Indeed, there are many more effective starting points. Garcia et al. (2014) put forth several alternative approaches to account for climate risk in the WRM sector. These approaches rely on top-down climate information, but also start from asking, 'What is the decision at hand, and how does climate change factor into this decision?' before scaling climate information to inform that decision.

Alternatively, Dessai et al. (2009) suggest a scenarios-based approach for managing uncertainty. This requires decision-makers to

Table 1: Typology of climate information

What is it?	How is it obtained?	How is it used?	Potential constraints
Type of climate information: **Perception and awareness of climate events**			
Encompasses documentation of climate events by locals. This includes: • Casual observation: 'We get rain from September to December' • Semi-quantitative: 'In 2001 we had a flood on 14th November and the water came up this high on this doorway' • Quantitative: 'I've recorded planting and harvest dates for my crops for the past 30 years, and I can see the growing season timing is changing' • Speculative: 'We used to get more rain, but it's drier now and that's why wells are going dry'	Most useful when collected intentionally and systematically through focus group discussions or surveys and using other tools. Ideally, it is verified either through similar independent reports from multiple groups or communities or by cross-checking against measured data.	Where measured data is unavailable, carefully collected perception data, verified through independent discussion with multiple stakeholders, is often the best climate data available. Or, perception data can often validate and provide local detail and relevance to measured data. It can also be used to define local thresholds for risk. In general, it can provide a solid 'real-life' grounding for any proposed CRWM measure (Tanner et al., 2018).	The majority of the perceived climate information will be observed, semi-quantitative or speculative. It is critical to verify whatever data is obtained to the extent possible. Perception can be influenced by expectation or desire. Policy-makers can also question its validity.
Type of climate information: **Meteorological data/measured climate data**			
Includes measurements of variables such as temperature, rainfall, humidity, wind speed, wind direction, evaporation, soil moisture and river flow. It is often referred to as 'time series data' because it is collected at regular intervals – i.e. every day or hour, etc.	Most often collected at weather stations using thermometers and precipitation and wind gauges, or with stream gauges using pressure sensors or manual water height readings. Historically, climate data was collected by hand by someone on site. Increasingly, it is being collected remotely and transmitted to a central location for storage and analysis.	The simplest ways to use measured climate data are to look at: • Historical conditions – what kind of weather, including extreme events, should be expected • Trends – how weather events have been changing over time. Changes in trends can result from climate change. However, they can also owe to development, land use changes or other change processes • Thresholds – i.e. the measurement levels at which climate events cause serious harm All three of these approaches can help identify events for which communities need to be prepared and can support the design of CRWM measures.	Data will need to be acquired by the 'owner' (often at a significant cost) and may also need to be combined with other sources, cleaned and verified before use. Smaller datasets or manually collected data may require more checking. Datasets based on combined data will need to be carefully reviewed, and discrepancies, offsets and/or conflicting data resolved.

continued >

Table 1: Typology of climate information (continued)

What is it?	How is it obtained?	How is it used?	Potential constraints
Type of climate information: **Forecast and outcome modelling (current conditions, future conditions from days to months from now)**			
There are many types of models that produce climate or climate-related information. In particular: • Forecast type models use current and past climate data (see previous) to forecast future weather or climate on different timeframes, including short-term forecasting (e.g. daily weather forecasts); extreme event forecasting (i.e. flood forecasting); seasonal forecasting (e.g. monsoon forecasts, whether it will be early or late, strong or weak) • Sector-specific climate outcome type models use climate data as an input to predict sectoral outcomes to weather events, e.g. flood impact models (i.e. not 'how high will the water be' but 'if the water is this high what will the impacts be'), agricultural models, economic models, etc.	Measured data, including both past and current climate variables, is required to build and run climate models. The level and type of data required will depend on the question you want the model to answer. Model accuracy generally improves with increased accuracy of the measured data on which it relies. Accuracy of data can be increased by means of quality control and verification systems, being collected at a finer time-step (e.g. every hour instead of every day) or being collected at a finer spatial resolution (e.g. greater number of meteorological stations in a given geography).	Models are generally built (often as a project itself) to answer a specific question – e.g. what will the weather be like for the next five days; for a given river level, where will it flood; will we get a strong monsoon this season? The output from both forecast- and outcome-type climate models can be very useful in understanding exposure and risk, in identifying needed preparedness or capacities and in informing the design of adaptive responses.	Models, because they are mathematical simplifications of natural systems, always have some uncertainty in their results. The uncertainty in model results generally increases the further into the future they project. The accuracy of model results is often questioned, and should be used to help understand conditions, rather than being presented as the 'truth'. It is important to communicate what questions the model can and cannot answer.
Type of climate information: **Modelling of future climate (20–100 years from now)**			
'Future climate' refers here to projections about possible climate conditions 20–100 years from now. This is the one category of climate information in this table that is always about future climate change. The other three categories could include elements of climate change, but it is generally difficult or impossible to identify exactly what has caused shifts in current or past weather and climate. In most locations, there are many change processes at work – including development, land use changes, population growth, urban heat island effects and others – that mimic or overwhelm climate change signals.	Future projections are obtained from Global Circulation Models (GCMs), which can be refined using regional models or statistical downscaling to provide more detailed information for a given geographical location. GCMs are very similar to forecast models but are designed to evaluate conditions 20 or more years into the future. As a result, they rely on assumptions about conditions in that future (e.g. population, land use, greenhouse gases) that affect future climate. For this reason, GCM outputs are referred to as 'projections' – i.e. possible future outcomes – not forecasts.	Future projections can be used to support adaptation and mitigation planning and help explore alternative development paths. Because these are projections based on assumptions about future conditions rather than forecasts, it is important not just to look at the average value for a future projection but also to take into account the possible range of conditions indicated by the models. For this reason, future projections are often best used in conjunction with scenario or threshold approaches (described in Box 1).	Future projections are not forecasts. They are, at best, estimates about what could happen if a wide range of assumptions about human behaviour and development paths come to pass. However, most projections are substantially better than no information about what may happen in the future.

assess potential adaptation options 'over a wide range of plausible futures driven by uncertainty about the future state of climate and many other economic, political and cultural factors' (p. 75) and to choose adaptation options that are robust across scenarios. Climate information certainly informs these scenarios but does not need to be accurate or precise, and is considered in the context of its uncertainties. Box 1 details scenario analysis and other tools for incorporating climate information into WRM.

Ultimately, what climate change information is *required* to achieve policy and planning goals, what climate information is *available* and how that climate change information is *used* are context-dependent. Wilby et al. (2009) state that 'entry points for mainstreaming scenario information in adaptation planning depend on the country-level technical and financial capacity, scale of risk(s), as well as the timing and type(s) of adaptation being considered' (p. 1211).

Box 1: Tools for integrating climate information into water resource management

Some tools for making climate information usable and for integrating it into WRM are as follows:

In **scenario analysis** for climate resilience, stakeholders identify a range of possible future climate conditions that they could reasonably expect. These future conditions could be based on perceptions of how conditions have been changing; measured trends in temperature, rainfall amount or timing, crop water demand, etc.; modelled seasonal forecasts, etc.; or future climate projections. The goal, for whatever condition is selected, is to identify a possible range of both possible climate conditions and possible behavioural responses. Stakeholders then explore how each proposed action would behave across the range of climate conditions. Climate scenarios are most useful when you consider broad changes that are expected to occur. To develop scenarios of future climate risk, the community should explore the types of weather events that are currently problematic (or disastrous) and think about how an increase in frequency or severity of those events might affect the community. In some cases, actions may perform well at one severity level but deliver no benefits or even be detrimental at other severity levels.

The **thresholds approach** identifies events that are already a problem and explores mitigation strategies, adaptations and other capacities currently in use to address those problems. A key part of this analysis lies in determining how those strategies need to change if events become more intense or frequent. If there is information about trends or rates of change of temperature, precipitation events, growing seasons, etc. that can be used to inform this process, this information can be incorporated. In moderate- to high-data environments, it may be possible to identify how frequent or intense current problem events are. In very data-rich environments, it may be possible to work with climate models to tailor future climate projections specifically to the identified thresholds and look at how current frequency or intensity of these events is projected to change.

Actions to reduce vulnerability and increase resilience are often selected based on events that occur at a certain severity or frequency. The thresholds approach directly addresses climate change by looking for approaches that will address changes in historic problem events. Some proposed actions may provide benefits regardless of the severity of the event, making them more appealing to the community. Alternately, there may be small modifications that can be made that would enhance a proposed action to work at multiple scales of changing severity and frequency, raising its value.

Hazard Risk and Vulnerability Assessment (HRVA) is a method to help any stakeholder to understand the risks they face locally and make risk-based choices to address vulnerabilities, mitigate hazards and prepare for hazard events. It involves a mix of methods and tools for collecting and using climate information, such as scenario development, risk ranking, hazard and resource mapping. It is often used at the local level to support communities to prepare for extreme events and can be solely based on their perceptions and subjective views. However, measured data can also be used and considered during the assessment and decision-making process.

This adaptive, scenario and priority-based approach to integrating climate information into WRM requires learning and collaboration. Mutual learning enabled through collaboration and adaptive management is critically important in making climate information more usable for decision support (Feldman and Ingram, 2011; Lemos et al., 2012). Only repeated iteration between climate information 'producers' and 'users' will result in climate information that is 1) within the capacity of the producer community to produce and 2) tailored to the decision needs of the user community. This collaboration and learning also entails integrating top-down sources of climate information with bottom-up sources of climate information on vulnerability, exposure, adaptive capacity and sensitivity. This will help ensure that climate impacts on communities and entry points for building community-level resilience are taken into consideration.

2.4. Different approaches to CRWM in the ACT programme

ACT is supporting government partners in South Asia to use climate information to inform the design and delivery of CRWM policy and practice in different ways, and in different contexts. ACT divides approaches to CRWM into three categories:

1. **Water resource management:** The approaches under this category are a) water resource assessment, b) water supply augmentation and c) water demand management. Some of the ways in which climate information is used under these approaches includes assessing water resource availability and demand in the context of agricultural value chains, as well as assessing current and future water needs across sectors by overlaying hydrologic model data on simulations of short- and longer-term climate scenarios. From here, options can be generated as to how best to allocate water across sectors and subsectors, increase the availability of surface and groundwater and reduce water demand under conditions of projected short- and longer-term climate impacts.
2. **Management of extreme events:** The approaches under this category are a) integrated flood management and b) drought management. Flood management consists of reducing flood risk, implementing flood control measures, undertaking advance flood preparation and conducting flood rescue and post-flood rehabilitation. Drought management consists of advance drought preparation and post-drought rehabilitation. Climate information can be incorporated into these approaches by strengthening forecasting and integrating revised risk models with climate change scenario analysis to identify at-risk populations.
3. **Supporting environment:** The entry-points which can be used for enabling CRWM in any governance context include a) policies, b) budgets and c) institutions. The goal is to generate a supporting environment that is informed by and consistently draws on climate information. For example, national and state water policies and plans to support watershed management need to be designed based on hydro-meteorological prediction and water resource assessments overlaid on climate change scenarios. They should also promote the development of robust early warning systems. Designing such a supporting environment involves strengthening data management systems within government and capacity-building to produce and use climate information.

Table 2 summarises examples of ACT's different approaches to using and producing climate information in the context of supporting CRWM at the national and subnational level.

Water management structure over bridge in Patna, Bihar, India.

Table 2: ACT projects and their use of climate information

	Name of ACT project	Climate data used/ produced	Climate-related models used/ produced	Climate analysis used/produced	Policy output
Water resource management	District integrated irrigation and agriculture planning, Odisha (India)	Uses measured data on current water usage for baseline	Climate change projections to determine impact of climate change on rainfall	Scenario analysis to understand implications for agriculture and irrigation	Recommendations for integrated planning between agriculture and water departments
	Water resource assessment, Chhattisgarh (India)	Uses measured hydrogeological data from different agencies: rainfall, stream flows, groundwater data	Overlaying water balance modelling of Mahanadi Basin with existing climate change scenarios on water resources and extreme events for the basin	Basin-wide baseline water balance assessment and estimates under future climate change scenario	Strategies for effective and CRWM for Chhattisgarh
	Water demand assessment (Pakistan)	Uses secondary sources of data on water supply and demand from different sectors, as well as expert stakeholder perceptions on impact assessment	Existing downscaled GCM outputs for northern and southern Pakistan used to estimate impact on water demand in 2025 and 2050	Estimates of the impacts of climate change on sectoral demand for water 2025 and 2050	Recommendations for demand-side management activities, etc.
	Climate-resilient agriculture, Assam (India)	Uses measured data on agriculture and water from secondary sources of data including Assam Statistical Handbook and the Economic Survey	N/A	Value chain analysis of different crops	Crop-specific strategies to address risks and demands from value chain analysis
	Water budgeting tool, Maharashtra (India)	Supports community to collect existing measured data on rainfall, groundwater, soil type, etc. and produce and map new data	N/A	Analysis on water 'budget' available (supply minus demand) under average and low rainfall conditions	Guidelines for local-level planning in times of low rainfall
Management of extreme events	Mahanadi river flood forecasting, Odisha (India)	Uses measured current precipitation levels from weather stations as input to model	Soil and Water Assessment Tool (SWAT) to plot and predict water movements in the main upstream catchment area. Hydrologic Engineering Centre – River Analysis System (HEC-RAS) model to analyse whether forecasted flood can pass safely downstream	Flood forecasting assessment	Set up early warning system (EWS) to expand advance notice from 8 to 36–72 hours

	Name of ACT project	Climate data used/ produced	Climate-related models used/ produced	Climate analysis used/produced	Policy output
Management of extreme events (continued)	Urban flood management along Brahmaputra and Barak, Assam (India)	Uses measured data to prepare hazard maps, and community engagement tools (e.g. Shared Learning Dialogues) to understand causes of flooding and vulnerabilities	N/A	Value chain analysis of different crops	Crop-specific strategies to address risks and demands from value chain analysis
	Silt management in Kosi River, Bihar (India)	Uses measured existing hydrological data on river flow, sediment load data and satellite imagery	N/A	Estimates of quantities of silt in the Kosi river and chemical composition of silt	Sediment Management Policy Framework
	Climate screening Jalyukt Shivar Abhiyan (JSA) drought programme, Maharashtra (India)	Uses secondary data on temperature and rainfall averages for regions from existing climate assessment report	Secondary data on climate change projections and impacts for 2030 for different regions, from existing climate assessment report	Summary of key climate variables and projected climate change impacts for different regions	Recommendations on how the JSA can incorporate climate variables and projected climate change
Supporting environment	Climate-resilient water strategy (Afghanistan)	Measured data on rainfall and water availability	Secondary data on climate change projections (e.g. CORDEX models)	Analysis on current and future impacts of climate change on water sector	Recommendations for climate-resilient water strategy
	Integrated Automated Weather Stations (AWS), Bihar (India)	Hydro-meteorological data from AWS collected by different departments is made accessible to other users	N/A	N/A	AWS data made more accessible for inclusion in policy analysis
	National Adaptation Plan (NAP) (Nepal)	Uses existing measured data on water resources and hydro-meteorological data 'ground-truthed' through HRVA	New modelling on future scenario of climate change and its implications for water resources at the national level	Assessment of vulnerability to climate change, and cost-benefit analysis of adaptation options	Prioritised adaptation options for water resources
	Climate change impact survey (Nepal)	New perception-based survey of climate impacts conducted in 5,060 households across the country	N/A	Statistical analysis of impacts of climate change on water resources as reported by households	Survey report with evidence base for improving adaptation policy and practice

3. Learning from ACT: The constraints to integrating climate information into water resource management, and how to overcome them

This section explores key constraints to integrating climate information into WRM experienced by ACT's initiatives in South Asia (summarised in Table 2), and key enablers that have helped in overcoming these challenges.

3.1. Availability, reliability and accessibility of climate data

Key constraints

A key challenge across the majority of ACT's work on CRWM lies in obtaining robust climate data. Common issues encountered in the programme include:

Data may be incomplete or inconsistent. In Afghanistan, for example, little to no climate data exists for 1980–2000, owing to the civil war and other political strife. Similarly, in Assam, precipitation data had multiple years of data missing within datasets, and data was not uniformly available across all four cities where flood planning was taking place (Dibrugarh, Majuli, Silchar and Jorhat). Existing data had also not been ground-truthed.

Databases of climate data (e.g. hydro-met data) are not centrally maintained. National and state-level databases are incomplete in many ACT locations. Those that exist are often not accessible to the public, data is often not digitised and data-sharing is not streamlined. For example, in Odisha and Assam, a varied of stakeholders, both government and non-government, collected and maintained climate data. In Assam, ACT staff had to reach out to a variety of state departments, district-level forest officers, municipal corporations and tea plantations for data. Much of this data was stored as paper records and needed to be digitised to be usable.

Obtaining data is challenging. Requesting data is time-consuming, and there is no guarantee that requests will be honoured. For ACT's programme in India, the Indian Meteorological Department (IMD) has been willing to share data; however, securing access at the subnational level has been more problematic. Some departments have been hesitant to share their data as there are gaps in their datasets that they were afraid they would be asked to help clean. Frequent changes in government and bureaucracy can further delay access to data. In Assam, Odisha and Maharashtra, the key to obtaining data was the support of high-level government officials who enabled and authorised its collection. In Assam, state government offices were open to sharing data – the programme was a technical assistance programme for the government and there was therefore already government buy-in at the state level – but the city government was not. Data access was further complicated by the fact that city governments maintained datasets haphazardly in paper records, making it extremely difficult to decipher and compile data.

Available data can be expensive. In some cases, data is available and maintained in usable formats by a dedicated agency authorised by the government (e.g. the Maharashtra Remote Sensing Application Centre) but it is possible to access this only by purchasing it at a substantial cost. If there is a prior agreement between the agency and the government department involved in the work, this cost can sometimes be waived.

Data requires substantial cleaning, requiring staff capacity and time. In areas where multiple agencies are collecting data but central data repositories are lacking, the compilation of one useable dataset from multiple, unstandardised datasets is a significant, time-consuming challenge. Data collection varies according to capacity and purpose across sectors and scales of government. In Afghanistan, for example, climate data infrastructure is poor, with few rain gauges and weather stations, and the people recording the data are often not trained on how to properly collect and input it into existing databases. In Pakistan, there were discrepancies in secondary data sources; different reports gave different data on basic climate variables. These shortcomings are further complicated by a lack of metadata – that is, information on how the data was collected, what instruments were used, how the instruments were set up and who collected the data. Data can also look different when it is collected by and for different purposes across sectors and scales. In Odisha, for the Mahanadi Flood Forecasting initiative and the District Integrated Irrigation and Agriculture Planning, the same parameters did not match between datasets, and it was difficult to accurately clean and collate the data into one consistent, usable dataset that could be used to produce credible climate information.

Overcoming constraints

When certain climate datasets are not available, there are often alternatives that can be used. Challenges accessing data have led many ACT projects to minimise the need for subnational climate datasets, and they have instead integrated climate projections made at a national or regional level. In Pakistan, Assam, Afghanistan and Maharashtra, ACT has relied on secondary data such as global climate model projections, peer review articles and non-ACT project and programme reports that are focused on short- and long-term climate trends. In Assam, ACT conducted HRVAs, which combined perceptions of hazard risk and measured climate data to help close the data gap.

3.2. Analysing climate data to produce climate information and analysis

Key constraints

Data gaps and duplicate data may exist. A lack of accurate, complete data poses challenges in data analysis. If data has significant gaps or is short term, it cannot be used to model climate change or to accurately identify climate trends. More data is not always helpful, however. In Pakistan, secondary sources provided conflicting analyses of long-term climate change trends. One set of studies, utilising long-term data (e.g. over 100 years), showed little change in precipitation; other studies, using 10–25 years of data, showed significant shifts in the monsoon. The analyses were dependent on the timeframe examined and the perspective of the analyst, which made it challenging to choose which projections to use.

GCM data is often considered too coarse to be useful. GCMs are built on very coarse grids; the cell size in a GCM model is usually 50–200 km because smaller grid sizes would make the models too complex and model run times far too long to be usable. However, for many parts of the world, particularly along coasts or in areas with significant topographic variation, average weather conditions over 50 km^2 do not provide the level of precision people want or expect (Rummukainen, 2016).

Downscaling introduces additional uncertainty into the resulting climate information. The demand for highly granular, sector-specific data is driving a push to downscale GCM data. Downscaling is a process that creates high-resolution information from low-resolution information. With GCM data, this means producing high spatial resolution data from the relatively low spatial resolution GCM output. Downscaling is done either dynamically or statistically. Dynamical downscaling uses a Regional Circulation Model that is very similar to a GCM but for a smaller, regional, area and using a smaller grid size. Results provide more local detail. Statistical downscaling uses data from one particular place to establish a relationship between the GCM output and conditions at that location.

For both dynamical and statistical downscaling, the assumption is that downscaled climate information will enable more accurate understanding of climate impacts at the local level, and thus better information for local planning. This is not necessarily true. Because downscaling begins with GCM outputs, there is already a layer of modelling assumption and some amount of uncertainty being used as a model input. This then goes through another layer of modelling in the downscaling, which has its own assumptions and creates its own layer of uncertainty. The result is a more spatially refined output, but one with potentially more uncertainty than GCM output alone.

Overcoming constraints

Build local capacity to work with and understand climate data and information. Governments must understand the uncertainty inherent in the data, and understand the information the data is conveying, in order to be able to use it effectively. However, it is often more likely to be local research institutes and consultants, rather than governments, that actually use climate data, run models and produce climate analysis. ACT supports and trains local consultants to conduct data collection and analysis and to be able to provide ongoing support to government staff to use climate models and information.

Build government trust in climate modelling. In Chhattisgarh, there was significant resistance to overlaying climate projections on water balance studies to come up with a plan to allocate water resources in the context of competing water demands and climate change scenarios. The climate information indicated increasing variability of precipitation but did not show exactly what would happen with climate change – for example how the frequency and intensity of droughts would increase, how river flows would be affected and so on. Although government stakeholders were open to new methods and approaches for policy and planning, they were uncomfortable with the uncertainty surrounding the climate information this new approach generated. The programme has tried to build government stakeholders' capacity and understanding on the limitations and use of climate information, and there is now much greater trust in ACT's analysis.

'Ground-truth' climate modelling. To build the confidence and trust of governments in climate information, particularly that generated through climate modelling, it is sometimes useful to illustrate that model results reflect the perceptions and experiences of local communities. For example, in Nepal, to inform decision-making on the National Adaptation Plan (NAP), ACT used existing measured water resources data and supported new modelling of future climate change scenarios and their implications for water resources. However, ACT also contrasted and compared these findings with HRVA results from a sample of locations across

Box 2: Odisha early warning system

The Mahanadi Flood Forecasting Model in Odisha represents a specific example of how to navigate the labyrinthine process of collecting data and obtaining government buy-in. Both WRM and agriculture are extremely important sectors in Odisha that are seeing severe impacts as a result of climate change. Regular floods occur in the Mahanadi River Basin. The team did not start with a fixed model; rather, it weighed up the various model options, taking into account the data available, efforts needed and outputs required. In the end, the team was confident that the only way a flood model would work was if the entire basin was taken into consideration, not just the Odisha part.

A draft scoping study was provided to the Water Resources Department, chalking out the climatic and other data required to develop the model, as well as the various agencies, each of which had parts of the data. This data covered temperature and rainfall patterns, river gauge locations, man-made interventions, land-use patterns, soil patterns and digital elevation, among others. The ACT team took up the responsibility to collect the data from the various agencies but at the same time obtained the necessary authorisations from the Water Resource Department to collect such data on its behalf. Thus, from the very beginning, project ownership was established immaterial of who did the actual groundwork.

The data, when obtained, presented a new set of problems: gaps, mismatches between multiple sources and clear errors. In some cases, data was purposefully withheld for different inter-departmental reasons, and it was necessary to use persuasion to get it shared with the team. The ACT team worked in a pragmatic, technical and politically savvy way to address concerns and navigate the structures of authority, using many technical and contextual iterations, such as data recalibration, continuous collection, correction, sanitisation and recollection for modelling. The team identified the right decision-making structures to work with and presented the data and a roadmap for the work professionally and effectively. Many rounds of discussions were held to build confidence on the effectiveness of the model even before starting the development of basin-wide hydrological modelling.

The Principal Secretary of the Water Resources Department approved the model during an important meeting with ACT, stating that he appreciated ACT's work and asking if the calibration of the model could be improved. The demonstration also opened up other areas of WRM work, which the Principal Secretary asked the Water Resources Department to embark upon immediately.

The model was recalibrated and presented to the government in December 2016, leading to a decision by the Chief Minister of Odisha to launch it in a timely manner as the political situation in the state demanded that the government highlight its efforts on Mahanadi management. The model was launched in June 2017 and is being implemented in the Hirakud Dam Project and the Flood Management and Information System in the Water Resource Department, where it is presently being field-tested and continuously being improved upon.

the country. Although this required an additional investment of time and resources, it provided a more comprehensive and complete picture for the government and they were more confident in using the findings.

3.3. Using climate information and analysis to produce CRWM policy

Key constraints

Governments want clarity and specificity. Although government partners regularly work with uncertainty in markets, economic projections, population estimates and many other parameters, when it comes to climate, particularly future climate, they are often uncomfortable with uncertainty. As a result, even where there is relatively reliable climate information, if this lacks specificity, stakeholders sometimes reject it, claiming they need further granularity or certainty. For example, in Maharashtra, the government wanted highly granular information on climate impacts by sector and initially questioned the validity and utility of broader-level climate change data ACT had obtained from secondary data sources.

Perception and bias can also lead to errors. It is not uncommon for climate data or climate information to not align with on-the-ground experiences. It is important to examine whether there are perception or bias errors before assuming the data is at fault. For example, farmers may communicate that summers are drier than they used to be and streamflow is reduced, yet precipitation data may show rainfall frequency and intensity is basically unchanged. This does not necessarily mean the core perception – streamflow is reduced – is incorrect. Nor does it necessarily mean the climate data or climate analysis is incorrect. Instead, it may be pointing to other contextual factors and changes, for example changes in groundwater pumping or upstream land use or water diversions, both of which could change streamflow irrespective of rainfall.

Overcoming constraints

Start with issues governments care about and then include climate change. A key enabler of the use of climate information in the ACT programme is that the technical support is all demand-driven. Often, governments do not request assistance with climate change, but rather require technical assistance on a 'development' issue – like water budgeting and irrigation planning – that has a climate dimension but not necessarily a climate focus. This is not surprising; climate change is a long-term phenomenon, whereas governments have short-term priorities they need to address regarding water scarcity, poverty, infrastructure and so on. Governments are managing competing demands, and climate change is just one of many priorities, and often perceived as an intangible one at that.

As a result, ACT has focused more directly on immediate issues and subtly woven in climate change where there are synergies with short-term needs. In Odisha, for the District Integrated Irrigation and Agriculture Planning project, this meant focusing on immediate issues of flood control and irrigation planning and using 2020 and 2030 climate scenarios to explore those issues rather than 2050 scenarios, which feel too far-off to be meaningful. Other ACT interventions have utilised climate information to help governments with stated goals and targets, for example making watershed planning more efficient by using climate information to identify where to establish water storage or increase groundwater recharge.

Be clear on the purpose, and limitations, of the climate information. Effective communication with government partners, as well as formal training, can help ensure expectations are aligned. This is not always straightforward. In Odisha, to develop the flood forecasting system, ACT conducted capacity-building trainings to shift the mindsets of flood managers from a reactive response to a proactive forecast-based response. However, there was some initial push-back against the model developed; it was highly accurate for flood forecasting, but, like all models, had a degree of error. The model was also designed and calibrated for flood conditions and was not particularly predictive during low-flow periods, giving department staff the opportunity to question its accuracy. Consistent engagement, along with endorsement from government champions who understand the value of this type of climate information and modelling, has been key to generating support for the model, maintaining stakeholder interest and communicating how climate information can be used within the context of its uncertainty.

Extreme climate events can provide an entry point for engaging with the government on CRWM. Demand for climate information stems partly from international debates but is more directly spurred by experiences with climate extremes. For example, Assam had two severe floods in 2017, which raised people's awareness of and interest in climate. People are often open to climate information when they see that very

Hirakud dam on Mahanadi river, Odisha, India.

palpable losses may arise from sudden-onset extreme events like floods.

Demand for climate information needs to be assessed against the 'need' for such information. Not every climate information demand needs to be filled. In Maharashtra, ACT pushed back against the government's desire for granular data by emphasising that the ACT demand-side water budgeting tool would help people address changes in rainfall regardless of what happened with water supply (Box 3).

Make it easy to incorporate climate information into decisions. One of the ways ACT encourages the use of climate information is through the development of decision support tools. In Maharashtra and Assam, ACT has integrated climate change information into Value Chain Analysis (VCA) for agriculture, to produce a set of tangible interventions that address both immediate priorities and long-term adaptation needs. VCA is a standard economic tool that takes market actors, inputs, outputs and processes into account to deliver a product or service for the market, and also highlights where there are blockages or opportunities along the value chain. ACT used this methodology to identify crop-specific strategies in the context of market needs and dynamics, local ecology, ongoing development pressures and climate uncertainty for a variety of agro-ecological zones. By integrating climate information, market decisions can be made considering not only market dynamics but also longer-term climate impacts and variance. VCA does not require downscaled information; rather, broader-scale climate projections and local perceptions of hazard risk provide enough climate risk information on which to base crop options.

3.4. Wider political economy context

Key constraints

Poor coordination and communication constrain access to climate data and the use of climate information. Both climate change and WRM span sectors and scales, and, as a result, involve multiple line ministries and departments (agriculture, water management, civil works, etc.). Each of these has its own processes, data and tools, and they are not quick to share with other agencies. ACT's work has to be rooted and led by one ministry or department (it is not possible to work across all) but this agency usually does not have purview over the processes and decisions of other agencies, which means that progress can be delayed or suddenly set back by the decisions of others.

Institutional and governance constraints limit basin-scale action. Poor coordination, both across sectors and across scales, limits learning, understanding of climate data and production of climate information, and hinders governments' ability to integrate planning and action and work at the basin scale. For example, in Afghanistan, groundwater usage is poorly regulated across sectors. Acting on this requires cross-sector

Box 3: Water budgeting tool

The water budgeting tool developed by the Watershed Trust Organisation (WOTR) and ACT, and adopted and now being used by the government of Maharashtra, is a decision support tool targeted at rural agrarian communities to make informed water allocation and use decisions in the context of the Jalyukt Shivar Abhiyan (JSA) programme, a large-scale water conservation programme in Maharashtra. The tool is being used to get communities involved in WRM decision-making and to ensure WRM decisions take drinking water and livelihood needs into account. As such, the water budgeting tool is helping:

- Identify opportunities for additional water harvesting and augmentation;
- Prioritise water use allocation for drinking, agriculture and livelihoods; and
- Establish rules that ensure equitable access and sustainable use of water resources.

Shared learning is an approach to participatory planning and problem-solving in complex situations, characterised by non-extractive, mutual learning among participants. The concept is straightforward: fostering iterative deliberation and sharing of sector- or group-specific knowledge and knowledge from both local practitioners and external experts will improve the quality and effectiveness of decision-making. Shared learning processes, when iteratively and carefully enacted, can also help break down established disciplinary and psychological divides and assist decision-makers to identify possible interventions, target potential constraints and set priorities.

The water budgeting tool consists of a Water Budgeting Manual and an accompanying Training Module. This tool was developed for government staff, development practitioners, promoters and village resource persons. The tool consists of a series of calculations that can be used to determine water allocation under three scenarios: normal rainfall, recent low rainfall and high rainfall. The input for the tool is basic rainfall data.

The government has adopted the manual to be used by government staff and facilitators who are responsible for implementing 'Jal Shaksharta Abhiyan', the water literacy campaign of the JSA. The manual draws on government literature and manuals and incorporates the appropriate technical practices and mechanisms followed by departments involved in soil and water conservation and irrigation management, to facilitate quick adoption of the water budgeting methodology. It delves into the types of data required for water budgeting, how to use this data to calculate water balances and how water balances should inform water budgeting and allocation decisions. The manual also identifies institutional mechanisms that should be developed at the village level to ensure decisions made are implemented and enforced. The Training Module consists of 20 sessions spread over 4 days to equip around 4,000 facilitators with the necessary skills to use the tool to create water budgets and use these for decision-making. The government is now rolling out the use of the tool, with trainings underway at the village level.

coordination and a supporting environment for developing evidence-based policies, in particular an agreement on future water scenarios which will be used as a basis for planning. In India, WRM is a state-level responsibility, but there are insufficient incentives (from the centre or at the state level) to incorporate climate change within water management and coordinate across subnational boundaries. Lack of institutional capacity, together with insufficient political will in some cases, also constrains the integration of climate information within WRM policy.

Climate information is often political. This is especially the case when it pertains to ecosystem services like water, which cross state and national borders. In India, for example, the Mahanadi River Basin spans Odisha and Chhattisgarh, and water allocation between the two states is contentious. Water balance studies suggesting that upstream states will have a surplus of water in scenarios of climate change can worsen relationships between upstream and downstream states. These factors affect the availability and sharing of data between states and countries, the types of projects donors are willing to fund and even the issues researchers, donors and other stakeholders are willing to discuss.

Wider institutional and governance constraints limit the effectiveness of WRM (regardless of the use of climate information). This is a more fundamental challenge. If water resources are generally not being managed effectively, then adding further complexity by introducing climate information may not help. There are many reasons why a WRM intervention or regime may not be working well, including lack of government interest or capacity, insufficient finance or political commitment, etc. Adding climate information cannot address these issues. However, there may be occasions when climate information can help put a spotlight on WRM and provide a more compelling narrative around which government officials can engage and give a mandate to a government agency to tackle the problems. However, in general, starting from a point of a dysfunctional WRM, and incorporating climate information to try and improve the effectiveness of the intervention, will require significant technical and capacity support.

Overcoming constraints

Persistence and communication are key to making progress. In Maharashtra, JSA is a large programme involving several different departments, which makes coordination and collaboration a challenge. At the request of the state government, ACT and WOTR created a water budgeting tool to help select crops based on rainfall forecasts (see Box 3). ACT was coordinating mainly with officials in the Water Conservation Department who were responsible for the JSA. In parallel, a different organisation delivered a similar but less climate-responsive tool to the agriculture department. The second tool considered only normal rainfall, rather than low, normal and high, and did not account for soil moisture. Despite these significant omissions, the

Table 3: Summary of the key constraints and enablers in integrating climate information in WRM

Key Issue	Constraints	Actions to overcome constraints
Availability, reliability and accessibility of climate data	• Incomplete or inconsistent data • Databases not centrally maintained • Obtaining data a challenge	• When certain climate datasets are not available, alternatives can often be used • Sanitise any data obtained through statistical tools • Always find ways to authorise the collection of data through normal government channels
Analysing climate data to produce climate information and analysis	• Data gaps and duplicate data • Downscaling introduces additional uncertainty	• Build local capacity to work with and understand climate data and information • Build government trust in climate modelling • Speak in a language that relates climate information to day-to-day governance problems, without jargon
Using climate information and analysis to produce CRWM	• Governments want clarity and specificity • Lack of data and/or poor-quality data can produce errors in the analysis • Perception and bias can produce errors in the analysis	• Start with issues governments care about, and then include climate change • Be clear on the purpose and limitations of the climate information • Extreme climate events can be an entry point for engaging with the government • Demand for climate information needs to be assessed against 'need' for such information • Make it easy to incorporate climate information into decisions
Wider political economy context	• Poor coordination and communication constrain access to climate data and use of climate information • Institutional and governance constraints limit basin-scale action • Climate information is often political	• Persistence and communication are key to making progress • Strengthen the supportive enabling environment as a central pillar of CRWM • View the timing of interventions from a political angle

Water efficient agriculture practices in Assam, India.

agriculture department went ahead and chose this second tool without adequately considering ACT and WOTR's tool. ACT is now working with the government to revise the chosen tool to better incorporate climate information and incorporate aspects of the tool it developed.

Strengthen the supportive enabling environment as a central pillar of CRWM. ACT has made strengthening the enabling environment, including building systems for data collection and coordination across government, a central tenet of its work on CRWM. For example, ACT worked with the Nepal Bureau of Statistics to mentor and coach the team to carry out the country's first-ever national climate change survey and to encourage the wider community of practice to use such perception-based data within its climate change work (Tanner et al., 2018).

4. Discussion: Working in different data environments

Climate data and information is important for policy planning and implementation – but the previous sections have shown that CRWM policy planning and implementation can also take place with limited climate data. Data availability is only one of several potential barriers to integrating climate information in WRM (e.g. government capacity to analyse and use climate information) but requires a specific focus, as data availability is a prerequisite for any analysis and use of climate information. This section discusses medium- to high- and low- to medium-data environments – and summarises ACT's learning on how best to use available climate data for policy planning and implementation in these environments.

4.1. Medium- to high-data environments

Characteristics of this environment

It tends to be relatively easier to incorporate climate information into WRM in medium- to high-data environments, given the amount of data available and the relative ease of accessibility. These environments often have access to primary climate data that has been collected over a long period of time, including hydro-met data and other sectoral data that is relevant for WRM (e.g. data on sectoral water allocation and demand, soil type, etc.). This data can be used for cutting-edge modelling, in particular producing more localised climate projections that can then be used for policy and planning via modes of translation like scenarios and thresholds. In locations where data is readily available, there may also be generally higher capacity to utilise data, or at least a greater likelihood of finding champions to support efforts to integrate climate information into WRM.

Of course, what is considered high-data is relative: a relatively data-rich environment in one country may be considered data-poor in other countries. As a result, even seemingly high-data environments come with their challenges and constraints, and mobilising and leveraging data appropriately may require substantial efforts.

ACT experience in this environment

Within the ACT portfolio in South Asia, the Mahanadi Flood Forecasting initiative in Odisha is an example of the type of work that can be undertaken in a medium- to high-data environment. The IMD was a key data provider, as it had a long history of collecting hydro-met

Climate change survey underway in Layyah, Punjab, Pakistan.

data. It was a willing partner as it was keen to have data and products used and because ACT involved it in initial workshops. The model, which utilises temperature, precipitation, humidity and wind data, allows 36–72 hours of advance notice of flooding. It is housed in the Water Resources Department in Odisha and was calibrated using historical datasets. The accuracy of a basin-scale model like this will be influenced by both the variability of rainfall across the basin and the density of the Automated Weather Station (AWS) network. The types of rainfall events – that is, monsoonal systems vs. more localised thunderstorms vs. tropical depressions – may affect the accuracy of the results. Though the Mahanadi model is not currently being used to run future climate scenarios, it could be modified to do so.

While the climate data was certainly there to produce the flood-forecasting model, there were challenges to institutionalising the use of climate data. ACT came across pushback from flood managers, as the forecast-based model necessitated utilising climate data in a different way from what they were accustomed to. Climate data had been used previously just for measuring rainfall, which allowed only for reactive rather than advanced forecast-based response. As a result, ACT conducted a series of capacity-building activities and consistent engagement to build understanding of the utility of forecast-based models and how to account for model error and uncertainty in decision-making, and overall to generate buy-in for this particular use of climate data. ACT is now working on training government staff to use and modify the model.

Learnings on how best to use available climate data for policy planning in this environment

- **Producing climate models is an option in medium- to high-data environments if you have sufficient historical data to support model calibration.** Calibration will require a longer data record if the climate and/or hydrology are particularly variable.
- **Producing forecasting models requires an environment with reliable and extensive data infrastructure for measurement and management of data to provide real-time reliable and accessible climate data.** Forecasting builds on clearly established forecasting science, existing model technology and the willingness and ability of data providers to provide data in real time. It is reliant on a network of AWS transmitting data in real time to a central location, like a national or state-level repository or database, from where it can feed immediately into a model.
- **Data providers need to be key stakeholders in data-driven projects.** Data-driven projects

The Head of Wetlands of Kol-e-Hashmat Khan in Afghanistan discusses water resource management practices with researchers and journalists.

require a constant supply of up-to-date data. Data providers are key for the development, implementation and long-term sustainability of such projects, and therefore should be involved throughout the course of the project.

- **Data alone is not enough: the climate information produced using climate data needs to be usable.** Medium- to high-data environments have data, but this data needs to be used to produce and translate climate information such that it can be used in policy and practice. Translating climate information is an ongoing process and requires consistent engagement with information users and capacity-building to ensure they not only use the information but also do so appropriately. Intermediaries and policy entrepreneurs may be needed to harness, analyse, translate and utilise climate data and information.
- **All of the entry points identified in the low- to medium-data environments can also be implemented in medium- to high-data environments.** Often, the most persuasive projects combine data-intensive, top-down studies with bottom-up, low-data studies.

4.2. Low- to medium-data environments

Characteristics of this environment

Data-deficient environments tend to have little to no data available. Where there is data, it is often difficult to access and use. Data may be spread across several sectors and scales of government; data is unlikely to be digitised. There often is not a central data repository or database, and it may be necessary to collect data from multiple sources and digitise, clean and combine the datasets as best possible.

Stakeholder capacity and interest in using climate data may be limited. Limited understanding of climate and climate change may complicate the process of data validation if on-the-ground perceptions of climate, influenced by other factors such as development, land-use change, etc., differ from what the data is saying.

ACT experience in this environment

ACT's Climate Resilient Flood Management for Cities along the Brahmaputra and Barak project in Assam is focused on developing action plans for climate-resilient flood management for Dibrugarh, Majuli, Silchar and Jorhat. Availability of and access to data have posed a significant challenge in this project. Data was spread across several government agencies and private sources like tea gardens; much of it was not digitised. Data needed to be procured directly from city and district governments, which was time-consuming. Existing datasets had gaps, did not cover whole regions and had not been ground-truthed. Producing a clean dataset required substantial effort, because of data gaps and because the data had been collected and reported in different ways across the different datasets.

The project would have benefited from flood hazard simulations to identify low-lying areas prone to flooding. However, ACT forwent such simulations because of the lack of topographic information and because precipitation data alone was not enough to understand climate and flood risk; instead, it used a combination of secondary data and bottom-up HRVA to demarcate low-lying flood areas and better understand flood risk and its association with climate trends. HRVA used local knowledge and historic events to build hazard scenarios and determined the capacity of communities to cope with these.

For another initiative in Assam, ACT utilised both broad climate projections and locally available basic climate data on precipitation, temperature, flood impacts and incidence of droughts to provide the state government with an assessment of climate risk and vulnerability of agro-climatic zones in the state. This information was integrated into a VCA to select economically viable crops in the context of climate risk. The VCA tool has allowed Assam to pursue climate planning and identify practical adaptation options despite poor climate data.

Learnings on how to best use available climate data for policy planning in this environment

- **Budget time for accessing and cleaning data.** Data is likely to be held across several agencies and scales of government and it can be a time-consuming task to access and clean it.
- **Utilise secondary data from modelling projects and other studies.** This secondary data may include regional and global model results, climate downscaling data or datasets compiled for other projects. Any of these sources can potentially be used as a means to broadly understand climate risk in the project location.
- **Leverage qualitative sources of climate information.** Bottom-up sources of information, derived through stakeholder consultations, community meetings, vulnerability and capacity assessments, surveys, etc., can be very useful

A duck farmer in backwaters of Kerala, India.

for understanding hazard risk and vulnerability. This type of information can be paired with broader climate projections, and perhaps tools like climate scenarios and VCA, to develop plans and policies that will be responsive to a range of conditions.

- **Consider using tools like climate scenarios and VCA.** These tools are useful for working in low- to medium-data environments as they can incorporate a range of different types and complexities of data, be it historic, current, trends or projections. Ultimately, these tools allow for the identification of viable adaptation options and strategies using the best available data, which may be data with gaps or data that is uncertain.

5. Recommendations: How best to integrate climate information into WRM planning

This section provides a set of 10 recommendations for how best to integrate climate information into WRM, based on learning from ACT projects (see Figure 2). These are targeted at those seeking to design and implement CRWM programmes and projects that utilised climate information.

1: Work with government and stakeholders to align supply and demand for climate information. The climate information a project needs to use or produce will depend on the purpose of the project and the wider data and institutional capacity context. Climate information that is not requested or does not meet government-defined goals will likely go unused over the long term.

At the same time, government-defined goals for climate information need to be in line with what is actually achievable in the given context; for example, do not introduce highly complex models that require significant climate data infrastructure if either the underlying data or the capacity to use it are lacking. It is also not advisable to commit to producing downscaled climate information to inform policy and planning without first determining if granular data is necessary. Existing global, regional or national projections may provide enough information to move forward without introducing additional uncertainty and complexity. In general, it is important to be clear with the government on the purpose of any information requested to ensure it will be used, and to ensure 'supply' and 'demand' are aligned.

2: Obtain government buy-in by using entry points via their existing priorities and appropriate time frames. This also requires that those expected to 'use' the climate information are key stakeholders in its production. This means researchers and scientists need to work with government stakeholders on their key priorities, which are often immediate and short term. In India, for example, ACT offered state governments technical assistance on WRM and state governments identified critical issues (and, from these, the ones that required ACT's assistance). These issues were not necessarily 'climate' issues; rather, they were an entry point for addressing climate risk. This is also important to help facilitate access to government climate data for the work. Projects may need to manage their own expectations and be willing to compromise; for example, in Odisha, ACT agreed to look at climate scenarios for 2020 and 2030 rather than 2050 and 2080, a far distant future that felt irrelevant to government staff responding to immediate demands.

3: Map existing available data and determine who has it. Frequently, multiple entities, both governmental and non-government, collect and maintain climate data. In Assam, data mapping was critical to the urban flood management planning process, to determine what data was needed and how it could be accessed or obtained. This showed that data was held at the district and city levels and also among tea gardens, and that it needed to be requested in person. In data-deficient environments, mapping can help maximise the use of non-traditional sources. In some cases, letters of request from high-level officials will be required; in others, stakeholders have to be approached directly to make the request. In medium- to high-data environments, data mapping can help identify what data there is and prevent the collection of duplicate data or introducing parallel structures for collecting data.

4: Engage and work with climate champions in government. Poor coordination in government constrains access to climate data and the ability to pursue evidence-based WRM. Climate champions at high levels can enhance access to key decision-makers and garner commitments from different agencies to share data and learning. They can also be key to scaling out the use of climate information. In Maharashtra, a champion in government has invited ACT to train 4,000 water volunteers on water conservation and create water champions. This has presented an entry point for ACT to scale out the water budgeting tool and share learning emerging from its work.

5: Allocate sufficient time for data compilation, cross-checking and cleaning. Collecting climate data from a range of agencies, and cleaning it to the point that it is ready to use, takes substantial time and effort. Short-cutting this process can undermine project results. Particularly in data-poor and/or data-protective environments, there may be multiple sources of data that will need to be tracked down, converted to digital format, compiled and compared. Where multiple agencies are involved,

Kodar water reservoir in Mahasamund District, Chhattisgarh, India.

datasets often conflict, requiring decisions about which data to consider primary or more reliable.

6: 'Ground-truthing' data in some instances can make the climate data more reliable. This will require working closely with data collectors and communities, though this needs to be done with care to avoid incorporating local misperception and/or misrepresentation into datasets. Data gaps may require piecing together multiple datasets or may represent time periods that cannot be addressed, meaning it is necessary to modify project plans or goals.

7: Invest in capacity-building. Given the need for ownership of climate data by those who will be using it for planning and policy, it is important to build the capacity of key local stakeholders to produce climate information, maintain climate models and systems and use climate information over the long term. Otherwise, the generation and use of climate information will likely cease soon after project funding ends. ACT's experience has shown that local stakeholders, like universities, local consultants and think tanks that have long-term and stable local presence, need to be identified and trained in the following as appropriate:

- *Climate risk and why it is important to consider it in planning:* Governments often perceive climate change as a long-term issue that is not reflective of, and perhaps is in conflict with, immediate local priorities. Awareness needs to be built around what climate change is, how it will manifest locally and how it ties into shorter- and longer-term policy and planning priorities.
- *Collecting and maintaining climate data:* Basic climate data is the building block of any higher-level climate analysis. Ensuring its accuracy and usability should be reinforced whenever possible. Agencies need to know how to collect and maintain data accurately and be encouraged to store it with metadata on how and why the data was collected, inconsistencies or gaps, accuracy, etc. Seemingly inconsequential actions, like moving a thermometer to the other side of a building, can introduce step changes in the data. If such actions are not documented, later users will have no way of knowing why there has been a change or what to do about it.
- *Developing climate information systems:* These include data infrastructure, models and decision support tools to hep integrate climate information into policy and planning. Decision support tools give governments ownership over approaches for producing and using climate information and help build their understanding of the types of investments and capacities these approaches entail. This will become especially important as climate conditions shift and more government departments begin to develop and implement climate adaptation and mitigation policies.
- *Limitations of climate information:* The uncertainty surrounding climate information poses significant challenges in ensuring its uptake and use. Stakeholders need to understand the bounds within which they are assessing

trade-offs and making decisions. As a result, they need to be trained from the outset on the limitations of climate information overall, and on the limitations of the information being produced in the project relative to their policy and planning goals. They also need to know how to use climate information in the context of its limitations.

Note that capacity-building is an ongoing process, not a one-time workshop or training. Much of it will occur through consistent engagement with key stakeholders, in particular local consultants and department staff. It cannot be limited to high-level government stakeholders and consultants. This cross-scalar capacity-building has been a key aspect of the water budgeting tool developed in Maharashtra, as the tool requires data inputs from local stakeholders like village resource persons and local governments, and will be used by a variety of stakeholders, including government, development practitioners and villages. Therefore, building, using and maintaining climate information requires awareness, participation and capacity across scales and sectors within and outside of government.

8: Develop decision support systems to help decision-makers use climate information. Developing and housing decision support systems locally can help ensure the interpretation of climate information is embedded in the local context. Such systems can also help decision-makers navigate climate uncertainty, as they tend to focus on prioritising concepts like flexibility, adaptability and redundancy – all 'good development' characteristics in rapidly changing environments. In agriculture, VCA has been an important avenue for integrating climate information into decision-making, especially in identifying climate-resilient crops, how best to build a supporting environment to ensure their cultivation and ultimately strengthening livelihoods in the context of climate change. Similarly, scenarios analysis has provided a useful way of examining and identifying adaptation options in the WRM sector that are robust across a variety of potential climate scenarios.

9: Institutionalise the use of climate data and information in decision-making. This requires local ownership of the production and use of climate information. ACT projects have been delivered by local consultants collaborating with key local government departments. This has helped build long-term relationships and ensured that technical support to governments in the production and use of climate information can continue after the project has ended. Furthermore, local ownership ensures the project is embedded in, and climate information is tailored to, the local context, and thus reflects local needs, capacities and realities. In Odisha, the local consultant who delivered the District Integrated Irrigation and Agriculture Planning project was chosen because he was an expert in the agriculture sector and was well known to and respected by the government. The government cannot be expected to maintain the climate information models on its own in the long term; rather, this trained local consultant can continue to manage the model and support the uptake of climate information by the government.

10: Prioritise problem-driven iterative adaptation approaches. The production and use of climate information needs to allow continuous political engagement and respond to political challenges and opportunities. This encourages learning among stakeholders from across scales and sectors to ensure the climate information is being used appropriately within the bounds of its benefits and limitations, and its production is consistently being refined to improve its value for decision-making. This requires consistent engagement to build strong relationships between project stakeholders, and active development and application of systems of evaluation and reflection.

Figure 2: **Recommendations on how best to integrate climate information into WRM planning**

1 What is the issue – and can climate data help to address it?

More data are not always better – what data are really needed?

2 Obtain government buy-in by using entry points via their existing priorities

Those using climate information should be partners in the collection process

3 What data are available – and who has them?

Mapping avoids collecting duplicate data

If adequate data exist but are not shared:

- be aware that climate information can be political
- use interest in recent extreme weather events to explain the issue's importance
- mobilise public interest through citizen-led initiatives
- identify champions within government who can advocate for access to the data

If available data are not adequate:

- use data from regional climate projections instead
- supplement with other data (e.g. qualitative data on perceptions of hazard risk and vulnerability)

4 Engage and work with champions in government

To build collaboration and coordination between different owners and users of climate information

5 Allow enough time for data compilation, cross-checking and data cleaning

Short-cuts here will affect the reliability of conclusions based on the analysis

6 Ground-truth the data with communities to avoid perception bias

Establishing a common understanding of the data trends is vital to ensure proposed solutions are accepted

7 Invest time and resources in capacity building within government departments

To clarify why climate data are important for planning; how to produce and maintain climate databases; and the limitations of climate data

8 Develop decision-support systems linking climate data to policy options

To encourage decision-makers to use climate information

9 Institutionalise the use of climate data in relevant government departments

To help decision-makers use climate information

10 Prioritise iterative approaches to producing and using climate information

Because iterative processes encourage learning

6. Conclusion

Governments across South Asia and beyond have recognised that WRM policy and practice need to incorporate climate change. WRM has historically been backward-looking, and therefore based on how water resources were used, supplied and stressed in the past. Climate-Resilient Water Management (CRWM) can address this need through a forward-looking approach which takes into account how water supply and demand are currently affected by climate and how they are likely to be affected in the future by climate change, in conjunction with processes like urbanisation, development and population growth.

However, moving beyond recognising the need for CRWM to adjusting existing WRM plans and projects and designing new projects and plans which incorporate 'climate-resilient' elements is not straightforward. It requires the climate information needed to understand current and future climate risks, and the capacity to use that information appropriately, understanding both its value and its limitations.

This Learning Paper has identified some opportunities for overcoming the challenge of accessing and using climate information based on the experiences of the ACT programme. Cutting across the specific learning and recommendations are the following key themes:

Firstly, climate information in some form is always available. The paper shares many examples of governments in the region that have had only limited climate data and information available but have still been able to design CRWM policies and projects. It highlights the opportunity to utilise qualitative data derived from community-level engagement tools, as well as what is more traditionally considered climate data, such as data measured at meteorological stations.

Secondly, the scope and nature of climate information and analysis should 'match' government priorities and interests as much as possible. Climate change itself does not need to be the central focus of the analysis. For example, climate information could be subtly woven into analysis focused on increasing agriculture productivity, making watershed planning more efficient or some other development goal. Extreme climate events and natural disasters are often a useful entry-point to talking about climate change more generally.

Rain water flowing at Tamhini Ghat, Pune, Maharashtra, India.

Thirdly, the expected 'users' of the climate information should be partners in the process of collecting and analysing it. This includes being upfront about the limitations and uncertainty inherent in much climate information and building trust in the analysis. It may involve working with government officials directly or working with local research institutes and consultants who are trusted by the government and can provide long-term support.

Fourthly, consistent effort should be devoted to strengthening institutional capacity for collecting and using climate information within the decision-making process. This includes building systems and mechanisms for accurately collecting data, sharing information freely with relevant stakeholders, and developing the institutional capabilities needed to analyse and incorporate that information within decision-making processes.

Lastly, and most importantly, the paper emphasises that Climate Resilient Water Management can be done now. Anywhere in the world, there is a viable and appropriate avenue for locating climate information, making it relevant to local stakeholders and decision-makers, and incorporating it into the decision-making process. The paper encourages those designing or delivering technical assistance programmes to utilise the learning and experience of ACT to ensure a more efficient and effective intervention.

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Annex: Online sources of climate information

There are a number of online sources of data, information and reports about climate change around the world, including the following:

World Bank Group's Climate Change Knowledge Portal: http://sdwebx.worldbank.org/climateportal/

Intergovernmental Panel on Climate Change (IPCC) Data Distribution Centre: http://www.ipcc-data.org/ar4/gcm_data.html

Sistema Regional de Visualización y Monitoreo de Mesoamérica (SERVIR): http://www.servir.net/

National Oceanic and Atmospheric Administration (NOAA) Climate Services: https://www.climate.gov/

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) GCM Downscaled Data Portal: http://ccafs-climate.org/

International Research Institute for Climate and Society (IRI), Columbia University Climate Data Library: http://iridl.ldeo.columbia.edu/

University of East Anglia Climate Research Unit (CRU): http://www.cru.uea.ac.uk/data/

United Nations Development Programme (UNDP) Climate Change Country Profiles: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

Climate Impacts: Global and Regional Adaptation Support Platform (ci: grasp 2.0): http://pik-potsdam.de/cigrasp-2/

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