Evidence Review:

Options Analysis for a Regional Climate Change Programme to Deliver More Effective Climate Services, Early Warning and Disaster Risk Reduction

Lead Authors: G. Vellingiri, K. Prasad, S.Wade, D. Lumbroso, T. Oakley, KR Viswanathan, S.Dugar, L. Dashora and R. Sogani
Support Authors: M. Joshi, S. H. M. Fakhruddin, M. Hanif and R Clements

June 2015

This report has been produced by Practical Action and the UK Met Office for Evidence on Demand with the assistance of the UK Department for International Development (DFID) contracted through the Climate, Environment, Infrastructure and Livelihoods Professional Evidence and Applied Knowledge Services (CEIL PEAKS) programme, jointly managed by DAI (which incorporates HTSPE Limited) and IMC Worldwide Limited.

Your feedback helps us ensure the quality and usefulness of all knowledge products. Please email enquiries@evidenceondemand.org and let us know whether or not you have found this material useful; in what ways it has helped build your knowledge base and informed your work; or how it could be improved.

DOI:http://dx.doi.org/10.12774/eod_cr.june2015.vellingirigetal

First published June 2015vn

EVIDENCE ON DEMAND
CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

Contents

List of Boxes

List of Figures

List of Tables

LIST OF ANNEXES

LIST OF APPENDICES

Acronyms

ACMAD	African Centre for Meteorological Applications and Development
AfDB	African Development Bank
AGRHYMET	Agro-meteorology and Hydrology Regional Centre
APECCC	Asia-Pacific Economic Cooperation Climate Centre
APN	Asian-Pacific Network
AU	African Union
AWOSs	Automatic Weather Observing Stations
AWSs	Automatic Weather Stations
CAS	Commission for Atmospheric Sciences
CBS	Commission for Basic Systems
CD	Capacity Development
CDMS	Climate Data Management System
CDS	Capacity Development Strategy
CCl	Commission for Climatology
CIIFEN	Centro Internacional para la Investigación del Fenómeno de El Niño
CIMH	Caribbean Institute for Meteorology and Hydrology
CHy	Commission for Hydrology
ClimDev (Africa)	Climate Development for Africa Programme
CLIPS	Climate Information and Prediction Services
COFs	Climate Outlook Forums
COMET	Cooperation Programme for Operational Meteorology Education and Training
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSIS	Climate Services Information Systems
CPC	Climate Prediction Centre
DARE &D	Data Rescue and Digitization
DCPC	Data Collection or Production Centre
DRR	Disaster Risk Reduction
ESSP	Earth System Science Partnership
EC	Executive Council
ETCCDI	Expert Team on Climate Change Detection and Indices
ET-SCBCS	Expert Team on Strategy for Capacity Building for Climate Services
EU	European Union
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization
GAW	Global Atmospheric Watch
GWATEC	GAW Training and Education Centre
GCW	Global Cryosphere Watch
GCOS	Global Climate Observing System
GDPFS	Global Data Processing and Forecasting System
GEF	Global Environment Fund
GEOSS	Global Earth Observation System of Systems
GFCS	Global Framework for Climate Services
GOS	Global Observing Systems
GOOS	Global Ocean Observing Systems
GPC	Global Prediction Centres
GSN	Global Surface Network
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunications System

GUAN	GCOS Upper-Air Network
HLT	High-Level Taskforce
ICPAC	IGAD Climate Prediction and Applications Centre
ICTP	International Centre for Theoretical Physics
ICSU	International Council for Science
IFAD	International Fund for Agricultural Development
IFRC	International Federation of Red Cross and Red Crescent Societies
IGAD	Inter-Governmental Authority in Development
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute (for Climate and Society)
ISDR	International Strategy for Disaster Reduction
IUCN	International Union for Conservation of Nature
JMA	Japan Meteorological Agency
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
LDCs	Least Developing Countries
LRF	Long Range Forecasting
MALOF	Malaria Outlook Forum
MEDARE	Mediterranean Data Rescue Initiative
M&E	Monitoring and Evaluation
MOU	Memorandum of Understanding
NAPA	National Adaptation Programme for Action
NCAR	National Centre for Atmospheric Research
NCEP	National Centres for Climate Prediction
NCOF	National Climate Outlook Forum
NGOs	Non-Governmental Organizations
NMHSs	National Meteorological and Hydrological Services
NWP	Numerical Weather Prediction
O&M	Observation and Monitoring Pillar
QMS	Quality Management System
RAs	Regional Associations
RECs	Regional Economic Communities
RCC	Regional Climate Centre
RCOFS	Regional Climate Outlook Forums
RM&P	Research, Modelling and Prediction Pillar
RTCs	Regional Training Centres
SADC	Southern African Development Community
SADC CSC	SADC Climate Services Centre
SARCOF	Southern Africa Regional Climate Outlook Forum
START	Global Change System for Analysis, Research and Training
SIDSs	Small Island Developing States
SOP	Strategic Operation Plan
UIP	User Interface Platform
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environmental Programme
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom of Great Britain and Northern Ireland
USA	United States of America
VCP	Voluntary Cooperation Programme
WB	World Bank
WCRP	World Climate Research Programme

WCC-3	World Climate Conference-3
WHYCOS	World Hydrological Cycle Observing System
WFP	World Food Programme
WIS	WMO Information System
WIGOS	WMO Integrated Global Observing System
WHO	World Health Organization
WMO	World Meteorological Organization
WWF	World Wildlife Fund
WWRP	World Weather Research Programme
WWW	World Weather Watch

SECTION 1

Introduction

1.1 Background

The Department for International Development (DFID) is seeking to understand the state of climate information and services in South Asia, and considering possible intervention options aimed at strengthening the gathering, use and application of weather and climate information across the region for better decision making and responses around weather and climate risks. This scoping work aims to identify where DFID could build on other relevant initiatives globally and regionally,[1] providing a step change in the use of climate information to support poverty reduction and promote socio-economic development, with a particular focus on protecting poor and vulnerable communities, especially women and girls. Proposed options will be orientated by the range of interests, needs and demands from across the DFID Asia Regional Team's core countries (Afghanistan, Pakistan, India, Nepal and Bangladesh), Burma and South East Asia (where there is a strong case for doing so). Likewise, the options will focus on where the opportunities (i.e. best returns) are greatest for DFID to engage on: (i) information delivery (ii) communications (iii) regional coordination/cooperation (iv) decision making/responses.

This report provides a literature review of the current state of climate services in South Asia, user needs, and current and future capacity to produce and deliver timely, accurate and relevant climate information and services. The evidence review focuses on climate services in the five sectors that align with the priority areas identified under the Global Framework for Climate Services (GFCS 2015). Primarily, food security and agriculture, water and DRR, followed to a lesser extent by energy and health.[2] Supplementary evidence was gathered during telephone and email consultations with DFID regional and country teams, users of climate information, climate service providers, academic institutions, government departments and ministries, private sector entities, NGOs, UN agencies, development banks, bilateral and multilateral organisations, regional and inter-governmental agencies and others (for a full list see Annex 1).

Based on an assessment of major gaps and opportunities, the report sets out a preliminary prioritisation of intervention options for the proposed regional programme. This prioritisation was carried out at the request of DFID and will be further tested and explored with stakeholders during the workshops and consultations to take place during the subsequent phase of this scoping study.

1.2 Climate Services

The World Meteorological Organisation definition of a climate service is as follows:

"A climate service can be considered as the provision of climate information in such a way as to assist decision-making. The service needs to be based on scientifically credible

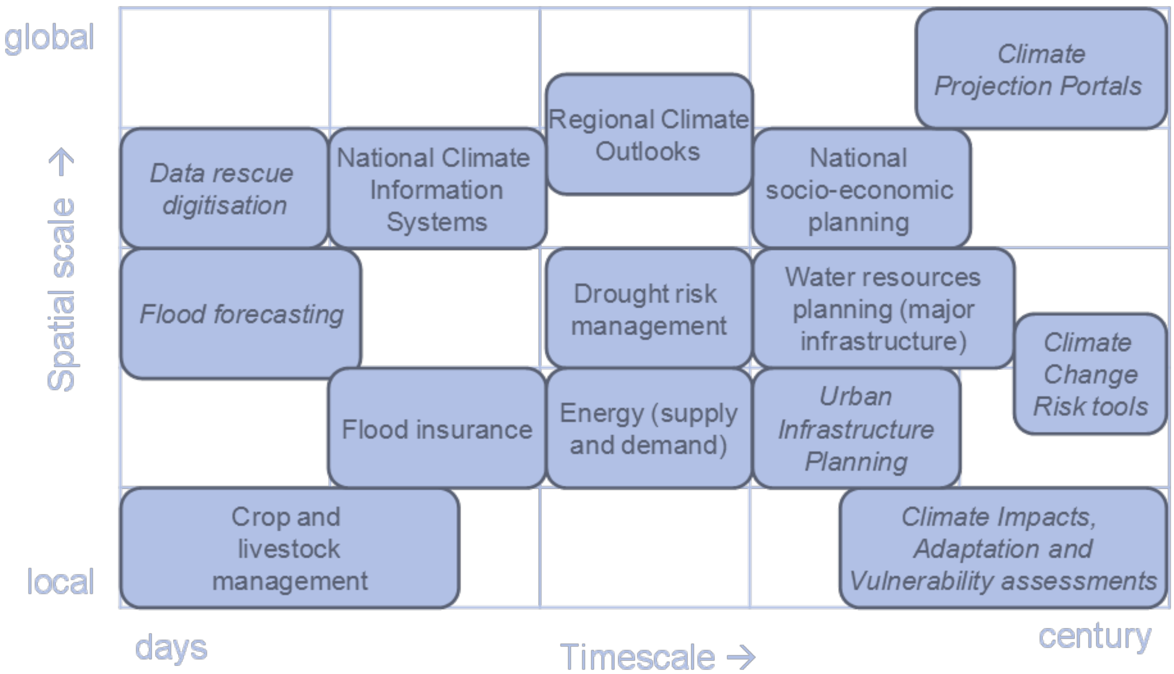
[1] Such as the Science for Humanitarian Emergencies and Resilience (SHEAR) programme, the Sphere project and the Climate Research and Information Services in South Asia (CRISSA) programme

[2] This prioritisation was agreed with DFID during the study kick-off meeting held on 16th April, 2015.

information and expertise, have appropriate engagement from users and providers, have an effective access mechanism and meet the users' needs."

Examples of climate services cover a range of spatial scales and time-scales, from provision of short-term forecasts for crop management to regional climate outlooks based on seasonal forecasting and future climate change information to support long term national adaptation planning (Figure 1). Examples of the potential benefits of climate services include greater use of seasonal forecasts, resulting in greater food production and reduced sensitivity to climate hazards; better asset protection and improved planning of responses to climate-related disasters and greater understanding of the linkages of diseases to climate factors as well as better planning of disease control and improved infrastructure planning (WMO, 2014a).

Figure 1 Climate services based on examples of the GFCS Implementation Plan (WMO 2014a)



1.3 Relevance for the South Asian Context

There is a critical need for effective and timely climate related information services in South Asia because of the requirement to cater to comprehensive social needs, to mitigate and reduce economic losses and to support countries in adapting to the impacts of climate change and extreme events (Box 1). In South Asia, the capabilities of many National Meteorological and Hydrological Services (NMHSs) have weakened over the past three decades or so, owing to economic reforms, underfunding and underutilisation of capacities, amongst other factors. Many of the climate services operating in the region are inefficient, ineffective, often not timely nor in accordance with needs of the users. In addition, there are issues associated with the quality and nature of information provided, often with data not being available in the correct format or level of details required to inform user actions and responses. What is more, the policy and institutional architecture is not supportive enough, neither at the national nor at the regional level (see Section 1.4 below). Regional coordination mechanisms are weak, unresponsive, ineffective and mired in geo-political quick sands. Furthermore, international support to NMHSs is significantly below the required levels. Similarly, a multiplicity of uncoordinated projects funded by different donors, each with their own policies, objectives and equipment suppliers, is being implemented without sufficient regard for individual country (and regional) needs, circumstances and priorities.

Box 1 Overview of Priority Areas for Climate Services in South Asian Countries

Afghanistan's rugged mountain landscape and generally arid climate make it prone to several natural hazards, particularly **drought** and **floods**. The Government of Afghanistan is not well prepared for natural disaster emergencies since it relies heavily on the support of the international community. **Early warning systems are non-existent** and comprehensive risk assessments have not been undertaken at any level. There is an urgent need to put in place the **basic minimum weather and climate information services** and response mechanisms.

The geographic and climatic features of Bangladesh, coupled with its social and economic environment, make it highly vulnerable to natural hazards including **flood**, **drought**, **cyclone** and **earthquake**. A robust response-oriented disaster management infrastructure exists in Bangladesh, which proved successful during the recent cyclone event in 2007. Despite this, **implementation capacity for disaster preparedness and risk reduction** plans, especially at the sub-national level, **is limited**. The threat of increased risk caused by climate change has not been sufficiently addressed. There is a need to **strengthen DRR initiatives and response mechanisms**, for which continued international engagement is called for.

Burma is vulnerable to multiple natural hazards, such as **earthquakes**, **cyclones**, **floods**, **tsunamis** and **landslides**. Rainfall induced flooding is a recurring phenomenon across the country. The cyclonic storms originating in the Bay of Bengal are another frequent source of weather hazards in the long coastal belt. Though Burma has in place a **minimum basic infrastructure** for providing weather and climate information services, there is a strong need for modernisation. The Department for Meteorology and Hydrology requires financial and technical support to **replace observational instruments with automatic weather stations** and to **computerise data quality control facilities** to improve provision of information to regional and global climatic centres.

India is prone to all major natural hazards and has experienced the highest number of disasters in South Asia including **floods**, **droughts**, **cyclones**, and **landslides**. While India has a **strong infrastructure in place** for providing weather and climate services within the country and the region as a whole, work remains to be done to build a comprehensive disaster **risk financing** strategy, which has assumed greater significance following recent cases of suicide amongst farmers in some states due to heavy crop losses caused by drought as well as unseasonal rains and hailstorms. India has **multiple centres of expertise** at national and state levels and strong international collaboration in climate science. It hosts the **Regional Climate Centre** with responsibility for South Asia and should play a central role in the provision of regional climate services.

In Nepal, **earthquakes**, **floods** and **landslides** are the most frequently recurring hazards. Floods are the source of the greatest economic loss and highest casualty rate. The Department of Hydrology and Meteorology has a **basic infrastructure** to generate weather and climate forecasts. There seems to be **no national mechanism for sharing climate data** as was evident during 2013 Mahakali/Uttarakhand floods, 2014 Hud-Hud cyclone, and 2014 west Nepal floods. According to recent figures, the high intensity earthquake and aftershocks that occurred during April 2015 have caused over 9,000 fatalities, as well as considerable infrastructural damage and important losses to agricultural productivity. Relief efforts continue alongside an on-going threat of landslides. The existing DRR structure faces several challenges as it is **limited to a reactive approach**. Continued international engagement and regional collaboration in overall improvement of weather and climate forecast services and DRR activities is required.

Pakistan's diverse geography exposes it to a large number of hazards, and the highly dense population that often resides in disaster prone areas makes the country highly vulnerable to adverse natural events. **Flood** events have been the most recurrent and have had the greatest impact. A **reasonably well-functioning national system** for collecting, archiving, and disseminating data on hydro-meteorological hazards is available through the Pakistan Meteorological Department. Significant progress in implementing the DRR agenda has been inhibited mostly by a **lack of capacity within the government**, particularly at the sub-national levels, and insufficient resources. **Capacity building** at the national and sub-national level is the main issue, for which international assistance is called.

Sources: World Bank 2005 and 2012, Emergency Events Database

Regional coordination is important because many weather-related extremes and their impacts transcend national boundaries and require cross-border collaboration. Furthermore, isolated national interventions are insufficient to remedy critical regional gaps. There is significant potential in the region for lesson learning, establishing approaches that can operate at wider scales, and sharing of information and perspectives. Some countries in the region (e.g. India) are building strong climate services, forecasting systems and disaster risk reduction capacity, while others are much more basic (World Bank 2012). However there is currently little regional co-ordination, and capacity to use weather and climate-related information is variable among the different users.

A regional programme provides significant opportunity for DFID to make a fundamental contribution to the rapidly evolving landscape for climate services in South Asia. Regional initiatives have an important role in the delivery of climate information services due to the requirements for:

i. Sharing knowledge, data and information to develop early warning systems, consensus seasonal forecasts and long term climate projections (at all scales and for all hazards).
ii. Forecasting and early warning of hazards that operate at the regional scale including regional floods, droughts and tropical cyclones with potential co-benefits for other non-climate hazards including earthquake, volcanic eruptions and tsunamis.
iii. Promotion of joint action for managing cross-border risks, such as flooding, agricultural drought and regional air quality, e.g. where activity in one country may benefit multiple countries by reducing 'downstream' risks.
iv. Enhancing the capacity of NMHSs and other 'boundary organisations' to improve the delivery of information, which could be achieved through better regional cooperation with advanced NMHSs and other regional centres (India, China, Korea) or global centres.

v. Providing regional information to fill gaps in services that are not available at the national and state level in countries where NMHSs have limited capacity (aka, the role of ECMWF in Eastern Europe).

Thus, it is clear that in South Asia, effective responses to the risks presented by extreme weather and climate change will require regional action.

1.4 The Policy Environment

Overall in South Asia, national policies relating to climate services are expressed within policy statements addressing a broad range of sectors such as climate change adaptation, water, agriculture, renewable energy and disaster risk reduction. On the other hand, the expression of policies on climate services at the regional level occurs within frameworks of cooperation covering such areas as DRR, early warning and flood control, amongst others. Unfortunately, these regional mechanisms are largely uncoordinated and lack adequate institutional architecture and financial resources for effective promotion and delivery of climate services. What is more, there appears to be a dearth of political will to operationalise these regional frameworks, statements and agreements that often remain for many years as political declarations without materialising into concrete regional actions.

1.4.1 Regional Policy

Despite an absence of regional policy relating to climate services, there is evidence of increasing regional commitment to strengthening production of climate information and tools for decision making, including cross-border collaboration (see Annex 4 for a map of interventions). For example, the South Asian Association for Regional Cooperation (SAARC) Disaster Management Center (SDMC) has developed a number of Road Maps on different aspects of disaster management through a participatory process involving Member States and expert from relevant fields. Road Maps that mention climate services include the *Application of Science and Technology for Disaster Risk Reduction and Management (2008)* which identifies low investments in S&T as a considerable barrier to strengthening DRM in the region and recognises the need to improve Early Warning Systems, modelling, database management, emergency communication, risk mapping, assessment and monitoring, climate risk analysis, and downscaling of global circulation modelling. Other road maps that focus on specific risks such as urban, earthquake, landslide, floods and drought also highlight the need for state-of-the art climate information and tools.[3]

In 2008, the SAARC SDMC members agreed to creating a Natural Disaster Response Mechanism to adopt a coordinated and planned approach to meet emergencies and a draft agreement was signed in 2009. In January 2015, a visit supported by USAID took place to the ASEAN Coordinating Centre for Humanitarian Assistance (AHA Centre) to learn about ASEAN's regional disaster response mechanisms and promote larger cooperation between the two regions. It is expected that the key learnings from the study visit will contribute to the preparation for the implementation of the SAARC Agreement on Rapid Response to Natural Disasters, which is expected to come into force in the near future (ASEAN 2015).

At the Bhutan Climate Summit for A Living Himalayas held in 2011 Environment Ministers from Bangladesh, Bhutan, India and Nepal adopted a regional 'Framework of Cooperation' aimed at implementing regional cooperative actions to build resilience to climate change in the southern watersheds of the eastern Himalayas. Key actions related to climate services include:

- Establish network to share climate information

3 SDMC Road Maps can be found on the website: http://saarc-sdmc.nic.in/roadmap.asp

- Sharing of related knowledge products for improving the understanding of climate change impacts on water resources in the region
- Exchange of information on trans-boundary pest and diseases including weeds (plant, livestock, fish)
- Establish mechanisms for 'regional early - warning systems' related to food security (production, supply & demand) and natural disasters
- Institutionalize sharing of weather and climate related information including the development of sub regional web-based portals
- Establishment of mechanisms for 'early-warning systems' related to biodiversity (pests, diseases, impending droughts)

At the recent SAARC Heads of State Summit in Kathmandu (November, 2014), members agreed to establish a cross-border information sharing and regional cooperation mechanism to fight climate change and to minimize the risks of natural disasters. It was agreed to establish a SAARC Environment and Disaster Management Centre (SEDMC) to spearhead this regional effort.

Despite some progress, managing water and other natural resources of South Asia's trans-boundary river basins for mutual benefit and sustainable development is still an "unfinished agenda" (ADB 2013) and there do not appear to be any multi-lateral treaties to govern the use of trans-boundary rivers. Owing to regional imbalances in power among South Asian countries, mutual hostility, suspicion and the absence of universally binding legal regime, sharing of trans-boundary rivers and simultaneously ensuring health of the riparian ecosystems has become highly complex (Figure 2 below) (Chintan 2011 and HR Wallingford 2014).

Figure 2 Perceptions (%) of trans-boundary water co-operation in South Asia

Source: Price et al. 2014

1.4.2 National Policy

Almost all the countries of the South Asia region have formulated national climate change policy/action plans over the last seven to eight years. These guide and govern the strategies, approaches and interventions of national governments in the areas of climate compatible development.[4] The significance of climate and weather services is expressed in many of these national climate change policies and action plans as well as in national policies related to the DRR, water, agricultural, energy/renewable energy and the environmental sector, as summarised below:

- **DRR** policies, strategies and programmes stress the importance of timely availability of climate/weather information and services. National DRR policies also deal with the impacts of disasters (both climate and non-climate related) on key economic sectors and infrastructure, agriculture and food security, housing, health, education, energy, environment, promote measures to reduce vulnerability to hazards and to ensure future development initiatives add to resilience. They also seek timely, adequate and focused investments in hazard mitigation and preparedness. In Pakistan, national policy covers DRR in a more holistic way by introducing proactive and anticipatory approaches with a special emphasis on risk assessment, disaster mitigation and preparedness.

4 Examples include the 2008 National Action Plan on Climate Change of India and the 2012 National Climate Change Policy of Pakistan.

- **Water** policies, strategies and initiatives focus on conservation, development, integrated water resources management and institutional and legal systems. National policies recognise the importance of climate and weather services for achieving various strategic objectives and operational targets in the water sector.
- **Agricultural** policies, strategies and programmes are increasingly reflective of integrating the use of climate and weather services in decision making in the overall agriculture sector. For example, in India the National Initiative for Climate Resilience in Agriculture (NICRA), supported by the Government of India with an investment of INR 3.5 billion (USD$55 million), mentions application of improved production and risk management, inter alia, using climate and weather services.
- Climate and weather services are also linked to national level policies on **energy and renewable energy**, designed to boost the economy in a substantial manner. This is in particular with reference to hydropower generation, transmission and distribution systems. Similarly, climate and weather services are linked to the **environmental policies** of countries of the region, especially those dealing with coastal zone policies/ regulations in countries such as India and Bangladesh.

SECTION 2

Supply of Climate Services in South Asia

There is a wide range of historical and real time weather and climate information available from global, regional and national centres. Most of the major centres are designated by the WMO but there are also other prominent research institutes operating in the region, such as APEC Climate Centre (APECCC) Korea, as well as private sector providers of climate information and services. Users can be confused as to the choice of data sets that would best serve their purpose (Prasad, *pers. comm.*) and most users receive information from intermediaries including other government agencies, NGOs and the private sector (Section 3 ‘Demand for Climate Information’).

There is a complex information chain (or web) with primary producers of climate and socio-economic information, intermediaries that process and add value to this information making it more relevant for different sectors and types of users. **This section is primarily focused on the supply of weather and climate information over a range of spatial and temporal scales; the demand side will be introduced in Section 3 and is the subject of ongoing consultation with users.**

Figure 3 Selected WMO designated centres (marked with *) and other institutions providing climate information and services in South Asia (a full summary is provided in Annex 2)

Global	Regional	National
• *Responsible for provising global NWP products*. • NOAA National Center for Environmental Prediction * • Met Office (UK) * • BoM (Australia) * • KMA (Korea) * • JMA (Japan) * • *Also UN, World Bank and many others provide global climate, DRR information*	• Responsible for Regional Climate Outlook Forums* • India NCMRWF * (demo) • Beijing Climate Center* • Tokyo Climate Center* • APEC Korea • *The Asian Development Bank, universities and NGOs also provide information.* • *The private sector also supplying data in India e.g. Weather Risk Management Services*	• *Responsible for National Climate Forums** • NHMS * • Other Government agencies (agriculture, water, health) • Universities • Private sector meteorological data providers/brokers • Private sector consultants • NGOs (e.g. Christian Aid, Action Aid) to community level

2.1 Global Suppliers

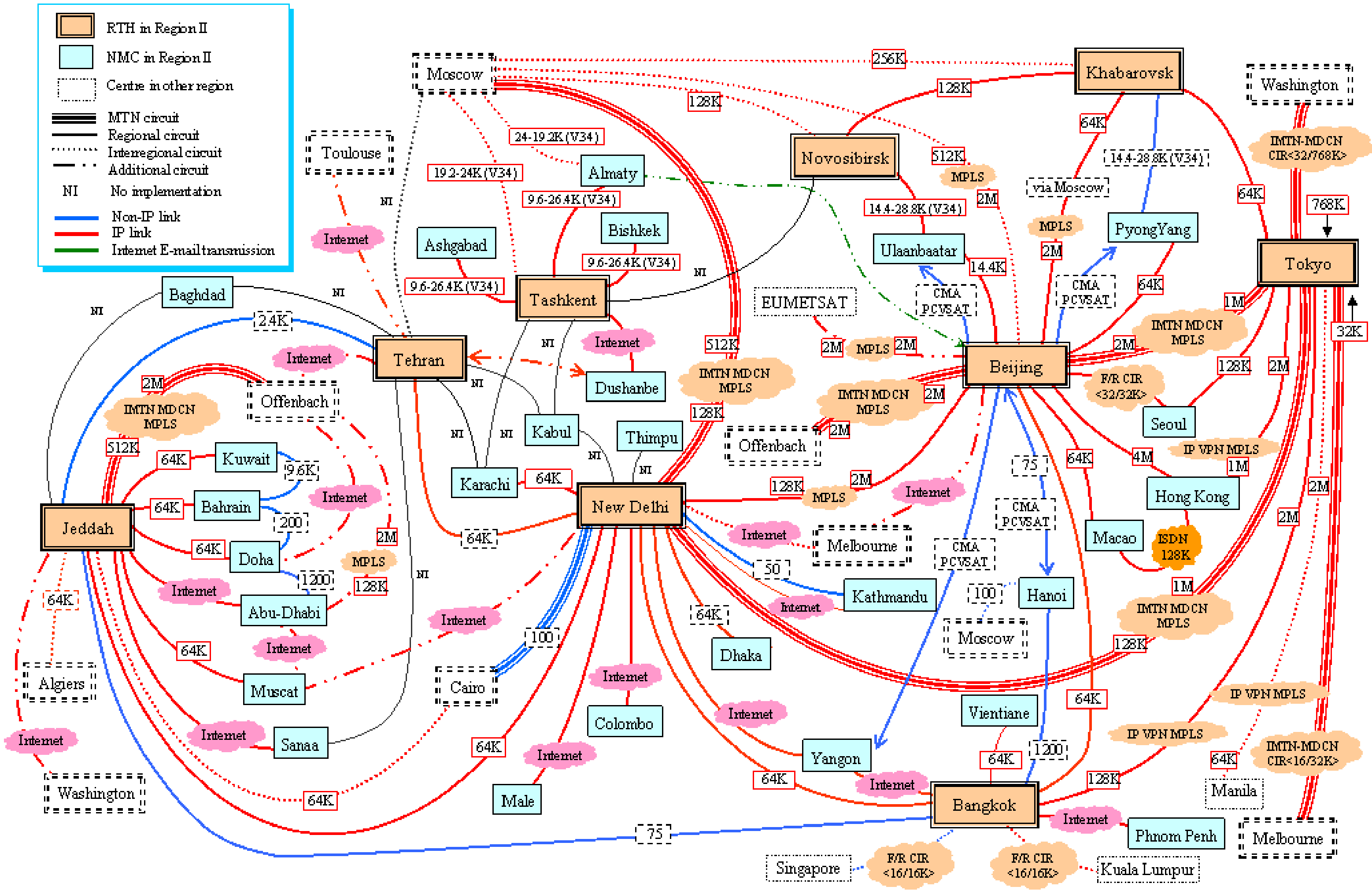
Observations of weather and climate parameters are essential ingredients for climate information and generating the climate products. Such data are gathered by the land based and remote sensing platforms and fed to the WMO’s Global Observing System. Observational networks are maintained by national meteorological and hydrological services. In addition to weather variables such as temperature and precipitation, climate information is built on data about levels of greenhouse gases, pollutants and aerosols, which can affect the climate, air quality, human health, and natural and human systems. The monitoring of atmospheric chemistry is coordinated by the WMO Global Atmosphere Watch.

Weather and climate observations are fed into computer models that simulate the global climate system. About a dozen national weather services and other organisations possess super computers with the capacity to run these models and produce global climate predictions and scenarios. WMO Global Producing Centres for Long Range Forecasts generate seasonal and other short-term climate predictions every month or quarter) (WMO 2014; World Bank 2009).

Data are disseminated through the WMO Global Telecommunication System (GTS), which connects all countries through their national meteorological services. The data and information that flow through the GTS are used for running weather forecasting models. Every country's meteorological service has free access to the output from global models, which can be used to provide boundary conditions for finer resolution regional and local forecasts. South Asia forms part of WMO Region II, Asia where the GTS connects national meteorological services with regional and global centres with different communications as outlined in Figure 4.

It is WMO's role to coordinate much of this activity and address challenges related to the sustainability of observing systems and access to data. There are opportunities for DFID to coordinate activities among global providers, for example by collaborating with GFDRR, and to leverage UK weather and climate expertise to support the uptake of global and regional climate services through research and development and NMHSs capacity building projects.

Figure 4 Regional Meteorological Telecommunication Network in Asia



Regional Meteorological Telecommunication Network for Region II (Asia)
Current status as of April 2009

2.2 Regional Suppliers

WMO Regional Climate Centres translate climate information received from WMO Global Producing Centres into regional predictions with higher spatial and temporal resolution. Regional Climate Outlook Forums then discuss trends and issue outputs such as seasonal forecasts, predictions of climate-driven outbreaks of malaria and climate scenarios for impact assessments. The only designated Regional Center in South Asia mandated to supply weather & climate information and services on an operational basis is the India Meteorological Department (IMD), described in Table 1 below. Regional climate data is also provided by other prominent research institutes operating in the region, such as APECCC Korea, as well as private sector providers of climate information and services.

The Regional Climate Outlook Forums (RCOFs) provide platforms for climate experts and climate information users to: discuss current climate status, exchange views on scientific developments in climate prediction, develop consensus-based regional climate outlooks that can feed into national climate outlooks produced by NMHSs, and engage in user-provider dialogue. An important aspect of RCOFs is the facility to bring together, at regular intervals, experts in various fields, operational climate providers and end users of forecasts in an environment that encourages interaction and learning. Regional agriculture and food security outlooks are now regularly produced based on the climate outlooks after the RCOFs in some regions. For example, the climate outlook in the Greater Horn of Africa from the GHACOF process is routinely used in combination with other information by the Famine Early Warning Systems Network (FEWS-NET) to prepare the food security outlooks.

The South Asia Regional Climate Outlook Forum (SASCOF) and the Forum on Regional Climate Monitoring-Assessment-Prediction for Asia (FOCRAII) are the most relevant for DFID target countries, although ASEANCOF may include Burma in model domain. The products produced by various regional centres are summarised in Annex 2.

Examples of regional climate services products produced by WMO regional and global centres are provided in Table 1 below. The performance, relevance and usefulness of these tools would need to be evaluated by consulting users since there appears to be no documented evidence of these factors. Expert opinion indicates that the Korean and Japanese centres appear more successful than the Indian centres, and that competition for staff with the higher paid IT sector is a problem for the Indian centres.[5] Again, these perspectives would need to be verified by consulting users, and there is an opportunity for DFID to coordinate this process if interested.

Regional centre	Product(s)	Description	Use
India IMD Pune RCC (Demonstration Phase)	Long range forecasting	1 and 4 months and seasonal forecasting for South Asia	Research use The centre hosts the South Asian Climate Outlook Forum (SASCOF)
India IITM	Long range forecasting	Modelling for the prediction of the onset on monsoon season	Research use
China, Beijing Climate Centre	Long range forecasting	Regional Outlook Forum Focus on East Asia and providing ensemble one month and seasonal forecasts	Research use. The Centre hosts the Forum on Regional Climate Monitoring-Assessment-Prediction for Asia (FOCRA II)
Korea APCC	APCC-Multi Model	Multi-model ensemble forecast using a large	Research

5 Assessment based on Met Office expert opinion

Regional centre	Product(s)	Description	Use
	Ensemble Service (MMES)	number of international NWP models	
Korea APCC	APCC Data Service System (ADSS)	Access to models and observational climate data to researchers and users.	Research use with potential for development of tailored applications for users.
Korea APCC	Climate Information Toolkit (CLIK)	Interface to Multi-Model Ensemble NWP models for forecasting purposes	Research use with potential for development of tailored applications for users.
Korea APCC	Climate Change Projections	Based on CMIP3 models used by IPCC in its Fourth Assessment global models. Presented as maps and country summaries.	Information for policy makers (out of date but may be updated in due course CMIP5 and CMIP6 in due course)
Tokyo	Long range forecasting	Long range forecasting over 1 and 3 months for East Asia (Includes Myanmar)	Research use. No evidence of practical application on RCC web site.
Tokyo	Climate monitoring	Range of global and regional products including access to monthly 'normals' and monthly data at individual stations globally.	Research use and potential applications for planning and climate studies in water and agricultural sectors.
Tokyo	Climate monitoring (extremes)	JMA monitors the global climate with CLIMAT and SYNOP reports from NMHSs through the GTS of WMO. Quality-checked data extreme events.	Post event reporting.
Tokyo	JRA-55	55 year reanalysis (1958-2012) at ~55 km resolution	Climate change and multi-decadal variability studies as well as for the monitoring of current climate systems.

Source: Based on information provided on each centre's web site.

Table 1 Example regional products produced by WMO regional and global centres (excluding additional products produced by NOAA, CSIRO and the Met Office)

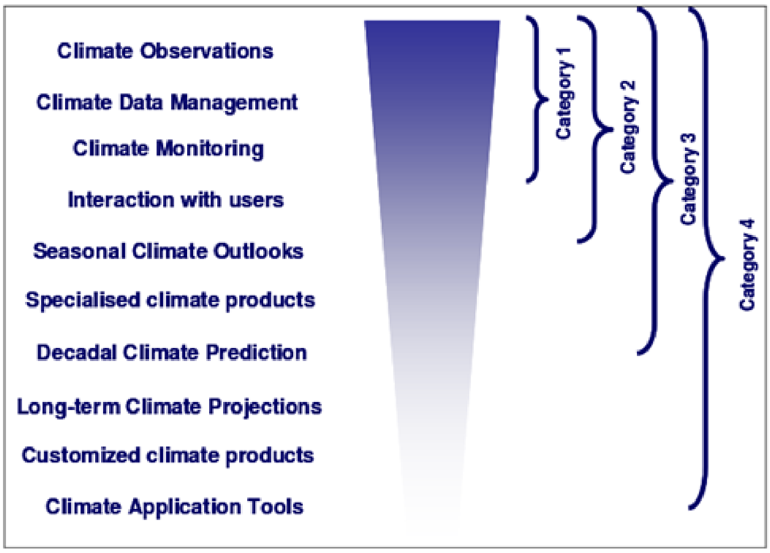
The regional distribution of forecasting and modelling skills and resources is uneven throughout South Asia. Furthermore, relatively few regional datasets exist for South Asia; even global downscaling partnership schemes such as CORDEX have limited data covering the region. Data is publically available through CORDEX only from the Met Office Hadley Centre, Max Planck Institute and Swedish Meteorological and Hydrographical Institute for South West Asia.

2.3 National Suppliers

The WMO-proposed National Climate Outlook Forums (NCOFs)/National Climate Forums (NCFs) adapt the global and regional scale forecasts to the national context and tailor products and translate key messages for users (Multidisciplinary Working Groups). They facilitate user-provider interaction and feedback and evaluate the impact of expected conditions (with existing vulnerabilities) (WMO, 2014b). There appears to be no evidence that the NCOFs exist and/or are operational in South Asia, and this information would need to be corroborated through further stakeholder consultation.

As part of the preparations for the GFCS, WMO experts reviewed the level of capability of national meteorological services in 191 countries in 2011. Each country was assessed according to four categories from 'basic' to 'essential', 'full' and 'advanced' related to the services provided and information supplied to users (Figure 5).

Figure 5 Hierarchy of national climate services capabilities. Categories 1, 2, 3 and 4 are referred to respectively as basic, essential, full and advanced services (Based on the same data as presented in WMO 2014).



Most of the 191 countries were assessed at the 'basic' and 'essential' levels of service provision, indicating that there was significant room for improvement. In South Asia, Afghanistan was classified as 'less than basic' reflecting the disruption caused by recent conflict. Burma and Nepal were classified as 'basic' and Bangladesh and Pakistan as providing 'essential' services. India was classified at the 'advanced' level.

Table 2 below presents a country level assessment of South Asian NMHSs capability based on the WMO 2011 assessment with additional comments based on a review of public web sites and expert opinion for this scoping study. Considerable progress may have been made since 2011 and this represents a snapshot of the level of capability. In general, the aspiration is to improve all NMHSs by at least one level so that all provide essential services or a full range of products. However, the more advanced NMHSs are also regional or global centres and play a very important role in supporting national services.

Country	Level of capability *	National Centre(s)	Comments
Afghanistan	**Less than basic**	Afghan Meteorological Service (within Ministry of Transport and Civil Aviation)	The AMS is responsible for producing climate information. Formerly a well-developed met service but declined during conflicts during the 1990s meaning that today its infrastructure, instruments and historical climate data have been severely depleted. Now the new Afghan government is trying to restore these services. A comprehensive ten-year capacity development programme for the AMS has been drawn up by UK Met Office in partnership with International Security and Assistance Force (ISAF) and DFID. This included facilitation of a stakeholder working group at the British Embassy in Kabul (Met Office 2012). Besides the AMS, the Famine Early Warning System Network (FEWSNET), in collaboration with US Geological Survey, is working on the use of satellite imagery to provide weekly reports on climate changes used to monitor variability and to signal impending changes/project crises. This system uses the limited available climate information for different areas of Afghanistan, however there is a need to generate real time climate data. A recent Met Office assessment indicated 'very limited operational capacity' and ad-hoc project by project capacity development as unsustainable (Met Office, 2012).
Bangladesh	**Essential**	Bangladesh Meteorological Department (BMD) under administrative control of the Ministry of Defence	The BMD's vision is to be a world-class meteorological centre providing excellent services nationally and internationally, as well as provide effective meteorological and seismological services for protection of life, property and the environment, increased safety on land, at sea and in the air, enhanced quality of life and sustainable economic growth. The BMD provides agromet, aviation and hydrological services and some centres provide flood warnings, although there is currently aa lack of trans-boundary data sharing to support this. Uses several NWP models and has made good advances in cyclone warning. Hosting SASCOF6 capacity building meeting.
Burma	**Basic**	Department of Meteorology and Hydrology (within the Ministry of Transport)	The mandate of DMH is: (i) to take precautionary measures against and minimize the effects of natural disasters; (ii) to promote safety, comfort, efficiency and regularity of air, land (rail & road), sea and inland water transportation; (iii) to bring sustainable development of natural resources (hydroelectric power, forest produce, water use, wind energy, etc.; (iv) to promote agricultural and food production; (v) to ensure efficient operation, planning and development of activities in natural defence, industry, health, social welfare and all sectors of national economy; (vi) to undertake international collaboration for all development activities and works of the DMH. The Meteorological Division is responsible for supply of meteorological information, warning, news, alerts and special outlook to prevent natural disasters. The DHM started a mini computer based river forecasting and flood warning system during 1978, which was upgraded during 1987 with UNDP/WMO assistance. The Hydrological Division is responsible for issuing daily river forecast and flood forecast along eight major rivers: Ayeyarwady, Chindwin, Sittaung, Thanlwin, Dokehtawady, Bago Shwegyin and Ngawun. In 2012, Burma's NAPA identified several priorities related to capacity of the NHMS including: • Improving weather observation capacity through a mobile/deployable weather radar system for providing early warning systems against extreme weather events • Assessing the status of dams for providing sustainable water supplies and withstanding flood risks under future climate change

Country	Level of capability *	National Centre(s)	Comments
			• Adaptation to climate change through Integrated Coastal Zone Management (ICZM) (RUM, 2012) Rapidly changing situation with large numbers of donor projects. Requires coordination as well as general capacity building and improvements in observations and communication networks.
India	**Advanced**	India Department of Meteorology, National Centre for Medium Range Weather Forecasting (NCMRWF), Demonstration Regional Climate Centre (RCC), Indian Institute of Tropical Meteorology (IITM)	Established in 1875, the IMD is the RCC with responsibility for South Asia. Under jurisdiction of the Ministry of Earth Sciences, the IMD has many divisions providing specialised services, including the Agricultural Meteorology Division, the Hydrometeorological Division, the Cyclone Warning Division, the Satellite Meteorology Division and the Climate Division. These centres of expertise are engaged in various international collaboration efforts. NCMRWF runs a version of the Met Office GloSea forecasting model. whereas IITM run NOAA CFS 2 models. A National Data Centre (NDC) provides the data rescue and data services. National Climate Centre (NCC) is responsible for long range forecast, climate monitoring, diagnostics, and development of climate data products. The Indian Council of Agricultural Research (ICAR) is an independent institution within the Department of Agricultural Research and Education (DARE), of the Ministry of Agriculture, which works in close coordination with the IMD to provide agromet advisories. The ICAR has its headquarters at New Delhi. Two leading research organisations of the Ministry of Earth Sciences providing development support are the National Centre for Medium Range Weather Forecasting (NCMRWF), a Centre of Excellence in Weather and Climate Modelling under the Ministry of Earth Sciences. The mission of the Centre is to continuously develop advanced numerical weather prediction systems, with increased reliability and accuracy over India and neighbouring regions through research, development and demonstration of new and novel applications, maintaining highest level of knowledge, skills and technical bases. Another organization is the Indian Institute of Tropical Meteorology (IITM), an independent research institute under the administrative control of the Ministry of Earth Sciences. IITM conducts research to generate scientific knowledge in the field of meteorology and atmospheric sciences that has potential application in various fields such as agriculture, economics, health, water resources, transportation, communications, etc.
Nepal	**Basic**	Department of Hydrology and Meteorology (DHM), Ministry of Science, Technology and Environment	The DHM has the mandate to monitor all the hydrological and meteorological activities in Nepal. The scope of work includes the monitoring of river hydrology, climate, agrometeorology, sediment, air quality, water quality, limnology, snow hydrology, glaciology, and wind and solar energy. General and aviation weather forecasts are the regular services provided by DHM. As a member of the WMODHM contributes to the global exchange of meteorological data on a regular basis. DHM actively participates in the programs of relevant international organisations, such as the UNESCO's International Hydrological Program (IHP) and WMO's Operational Hydrology Program (OHP). The department is also a focal point for the Intergovernmental Panel on Climate Change (IPCC) and for the meteorological activities of the South Asian Association for Regional Co-operation (SAARC). The International Civil Aviation Organization (ICAO) has recognized DHM as an authority to provide meteorological services for international flights. Operates forecasting systems and issues warnings. Meteorological, hydrological and climate data are available on the

Country	Level of capability *	National Centre(s)	Comments
			web-site. Significant donor activity related to natural hazards. Recent World Bank project terms of reference have highlighted priorities to: • Develop automated hydrological and meteorological networks • Improve transmission of data from the existing observation networks is also (as this mainly relies on mobile telephones with information redistributed through the internet) • Develop new systems to provide authoritative warnings for weather and weather extremes to government authorities and key user groups • To develop agro-meteorological information systems to manage agricultural drought The Dept. has access to various model output, GFS, low-res ECMWF. Training currently underway (Bangkok) on WRF high-resolution modelling (Skype conference 20 May), indicates some NWP in-house capability. Post-earthquake Nepal introduced to UKMO high-resolution modelling (possibly time-limited to earthquake support).
Pakistan	**Essential**	Pakistan Meteorological Department (PMD) Cabinet Secretariat (Aviation Division)	The PMD is the primary producer of climate information. PMD is both a scientific and a service department, and functions under the Cabinet Secretariat (Aviation Division). It is responsible for providing meteorological service throughout Pakistan to wide variety of interest and for numerous public activities and projects which require weather information. In its services to aviation the department's responsibility goes to some extent beyond national boundaries in fulfilment of accepted international agreements and obligations which include, among other things, the collection and rebroadcast of meteorological data. Apart from meteorology, the department is also extending services in the fields of Agro-meteorology, Drought Monitoring, Hydrology, Astronomy and Astrophysics, Seismology, Geomagnetism, and studies on Renewable Energies Resource potential across various parts of the country. The PMD provides a wide range of essential services including maintaining observations, forecasting and early warning systems for flood, droughts and other hazards. It is also a research organisation with expertise in Numerical Weather Prediction, pollen forecasting, climate change including the use of US and UK climate models. The PMD Operates a flood forecasting centre and set up the Drought/Environment monitoring and Early Warning Centre (NDMC)

*Based on WMO Experts Group, 2011

Table 2 A country level summary of NMHSs capability

2.4 Observational Networks

Effective climate services require observations of various types and of adequate quality and quantity and at the right place and at the right time[6]. Both surface-based and space observations are required of physical and chemical climate variables of the atmosphere, land, and oceans, including hydrologic and carbon cycles and the cryosphere. Existing capabilities for climate observation and data exchange provide a strong basis for improving climate services globally. However, there are major gaps in climate observations particularly in Least Developed Countries. The plan for the Observations and Monitoring Pillar of the GFCS aims to address these gaps and shortcomings, building on existing observational, data management, and exchange systems and initiatives, and adding enhancements where needed to support provision of climate services.

Observations needed for providing climate services include a range of Essential Climate Variables (ECVs) (Bojinksi et al. 2014) as well as those directly related to user needs such as measurement of precipitation, soil moisture and surface air temperature and observations of phenomena (e.g. thunderstorms, hail, fog, dust, cloud type and amount). The observational data record is fundamental for defining the initial states for model runs, for validating the numerical models used for weather and short-term climate forecasting, and for longer-term scenario-based projections of climate change. For many of these variables, enhancing observation collection, exchanging data, and/or funding stability are still required. Furthermore, the quality and duration of the time series of historical data held in global data centres show considerable variation from country to country.

Current coverage and use in South Asia

The observational network, particularly upper air, is generally poor in South Asia. For example, the Intergovernmental panel on Climate Change (IPCC) has observed in one case that Nepal, which lies in the Himalaya-Hindu Kush region, is a “white spot” – a location with little or no observed climate data. This makes it imperative that as much high-quality observational data as possible are obtained to develop and validate climate model projections as also to prepare down-scaled climate change projections in local scales (Prasad, *pers. comm*.; WMO 2014).

Table 3 details the observation network metadata for the different countries covered in this scoping study, as defined in WMO 2015., and an assessment of the data availability over the GTS (Global Telecommunication System) and as received in several recognised climate centres and archives. The definition of status in the left-hand column relates to a number of factors. These include extent of coverage, reliability of observations (a minimum of once every 24 or preferably 12 or 6 hours). Ideally, a small number of observations should be of acceptable consistency and quality to warrant input into numerical models. This latter factor would need a long-enough lead-in time to assure a defined quality/consistency is maintained and allow verification of NWP performance over these data-sparse regions. Whilst it may be unreasonable to expect a high coverage (location/topography/communications reliability), the basic minimum might be at least a consistent report from international airport serving the capital of the country.

6 The High Level Taskforce for the GFCS noted that to support climate services, high quality observations are required across the entire climate system and of relevant socio-economic variables.

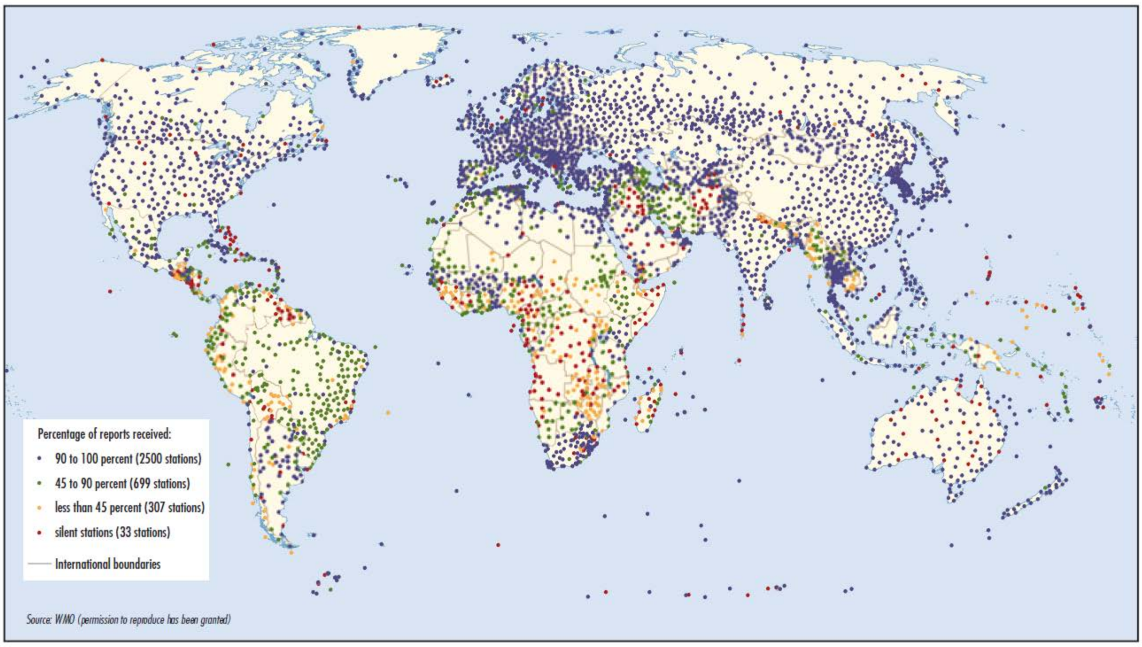
Country (and status)	Observation network (metadata)
Afghanistan **STATUS:** **POOR**	• 43 stations are defined in WMO metadata, including the following classifications: • 1 * GSN station (GCOS Climate Network) • 4 * RBCN stations (Regional Basic Climate Network) • 14 * RBSN stations (Regional Basic Synoptic Network) • 2 * Upper-Air RBSN stations
Bangladesh **STATUS:** **MODERATE**	• 54 stations are defined in WMO metadata, including the following classifications: • 10 * RBCN station • 12 * RBSN station • 2 * Upper-Air RBSN stations • CLIMAT reports (group 111 minimum req.) being received regularly from all 10 RBCN stations, with data going back until 2011. • Synoptic (3 Hr'ly) observations received by 40+ stations according to the data archives in the Met Office and OGIMET2. • Upper-Air TEMP data is available daily from Dhaka (41923) but only up to 100hPa, with 53 soundings in February 2015 according to National Centre Environmental Prediction (NCEP-US). • For Bogra (41883) only a few soundings are received each month, 5 in February according to NCEP.
Burma **STATUS:** **POOR**	• 64 stations are defined in WMO metadata, including the following classifications: • 3 * GSN station • 5* RBCN stations • 27 * RBSN stations • 5 * Upper-Air RBSN stations • CLIMAT reports being received regularly from 5 GSN/RBCN stations, with data going back for more 2 to 3 years. • Synoptic (3 Hr'ly) observations received by 40+ stations according to the data archives in the Met Office and OGIMET2. • No Upper-Air observations.
India **STATUS:** **GOOD**	• 496 stations are defined in WMO metadata, including the following classifications: • 21 * GSN station • 48 * RBCN stations • 84 * RBSN stations • 34 * Upper-Air RBSN stations • CLIMAT reports being received regularly from 36 GSN/RBCN stations, with data going back for more than 20 years. • Synoptic (3 Hr'ly) observations received by 90+ stations according to the data archives in the Met Office and OGIMET2. • Upper-Air TEMP data is available daily from 11 Radiosonde stations, with a number of other stations providing wind-only (PILOT) reports.
Nepal **STATUS:** **POOR**	• 15 stations are defined in WMO metadata, including the following classifications: • 1 * GSN station • 2 * RBCN stations • 15 * RBSN stations • No monthly CLIMAT reports are being received from any Nepal stations, despite this being a minimum requirement for a GSN and RBCN station, although some reports from 44453 & 44477 have been archived at NCDC for 2012 • Synoptic (3 Hr'ly) observations received by 15 stations according to the data archives in the Met Office and OGIMET2. • No Upper-Air observations.
Pakistan **STATUS:** **MODERATE**	• 80 stations are defined in WMO metadata, including the following classifications: • 6 * GSN station • 25 * RBCN stations • 56 * RBSN stations • 3 * Upper-Air RBSN stations (41780 also a GUAN, GCOS Upper Air Network)

Country (and status)	Observation network (metadata)
	• CLIMAT reports being received regularly from 24 GSN/RBCN stations, with data going back for more than 20 years. • Synoptic (3 Hr'ly) observations received by 40+ stations according to the data archives in the Met Office and OGIMET2. • Upper-Air wind-only (PILOT) data is available daily from 24 stations, but no TEMP reports from any of the nominated stations and notably 41780 (Karachi Airport) which is the only defined GUAN station in the target countries.

Table 3 Observation network metadata (A more complete table with comments on coverage from in-country consultation is included in Annex 2)

The WMO Regional Associations, including the South Asia Region, define the Regional Basic Synoptic Networks of surface and upper-air stations adequate to meet the requirements of Members and of the World Weather Watch. The WMO Regional Associations also define Regional Basic Climatological Networks necessary to provide a good representation of climate on the regional scale, in addition to global scale. Figure 6 shows areas of silent stations (red dots) and areas with poor reporting (yellow dots), which include much of Nepal, Bhutan and Burma.

Figure 6 Global weather stations assimilated into WMO systems (World Bank, 2009)



It is clear that there are significant gaps in observing networks for a range of reasons including poor communications or lack of operational maintenance. Afghanistan, Burma and Nepal have the highest concentration of 'silent' stations.

2.5 Research and Development

This section is primarily concerned with the *supply of information* and therefore the top-down research requirements. Some initial broad recommendations of potential options are made, however further testing and refinement of these will need to be completed through stakeholder engagement.

The research and development required to support climate services is wide ranging and includes top down or science driven developments in NWP and climate models as well as bottom up and 'decision focused' research on the use of weather and climate information (see Ranger, 2013 for a description of these different perspectives). For example, typical focal areas for climate services research include climate observations and monitoring; processing and archiving for national observations and climate risk information; reconstruction of high-resolution data; tailoring of climate information and climate scenarios; communication of weather and climate information and methods for incorporating climate risks into governmental and private sector decision making.[7]

In South Asia the **predictability and reliability of monsoon rainfall** and associated risks is the main focus for several regional research institutes (evidenced by publications produced by the IMD).[8] Regional centres and universities are working with other international institutes on the South Asian monsoon and its impacts, including NOAA, Met Office and the University of Reading. A second common area of research interest is the **prediction of tropical cyclones** in terms of both short term and seasonal prediction.

With respect to longer timescales, several NMHSs and technology institutes and universities are involved in climate change research including climate modelling and impacts, adaptation and vulnerability assessments. India has a large number of capable research institutes for climate research[9], which are able to utilise a range of Numerical Weather Prediction and climate models. In addition, some of these institutes have well established bi-lateral research collaboration with the UK (see below). Other countries in the region are active in climate research, through NMHSs and universities, for example:

- Pakistan Meteorological Department (PMD) uses several international climate models, including the Met Office PRECIS model to produce regional climate information (Ilvas 2012; see Annex 2).
- Bangladesh Meteorological Department (BMD) has been working closely with the Met Office Hadley Centre to create a downscaled HadCM3 17-member ensemble from CMIP3 data, at 25km resolution on a domain covering all of South Asia, which provides projections for future regional climate (see Annex 2).

In addition, research scientists from India and Bangladesh are heavily involved in the IPCC process across all working groups.

In terms of **translational science and action research**, there are several noteworthy initiatives underway in the region, for example:

- The Climate Change Agriculture and Food Security (CCAFS) Scaling Up Climate Services for Farmers in Africa and South Asia programme; The Global Flood Resilience Alliance and the Smart Information and Communication Technology for Weather and Water Information (IWMI); all three exploring strategies for translation and dissemination of weather and climate information to the 'last-mile' in the agriculture and food security, DRR and water sectors;
- University of Colombia research linking seasonal forecasting to food security and farming systems;
- The Asian Disaster Preparedness Center's work to improve the supply of science-based information and tools for DRR measures.

---

7 Based on KNMI's descrition of climate services research aims.

8 http://www.imdpune.gov.in/research/rnd/rnd_index.html

9 The National Centre for Regional Weather Forecasts (NCMRWF), The Energy Resource Institute (TERI), India Institute for Tropical Meteorology (IITM) and Universities such as Anna University's Centre for Climate Change and Adaptation Research.

There is significant recent and ongoing **DFID-funded research** into climate services in South Asia, particularly related to DRR, food security and health. For example, DFID's Building Resilience to Climate Extremes and Disasters (BRACED) programmes, The Himalayan Adaptation, Water and Resilience (HI-AWARE) project (part of the Climate Adaptation Research Initiative in Africa and Asia - CARRIAA), Climate Research and Information Services in South Asia (CRISSA); Return on Investment for Emergency Preparedness Study; Science for Humanitarian Emergencies & Resilience (SHEAR). These programmes position DFID as one of the lead investors in translational sciences and action research in the region, alongside USAID and others.

Besides these regional initiatives, individual governments have entered into agreements and memorandum of understanding with donors, other countries and multilateral development organisations for pursuing actions in the area of climate and weather services. The pattern of **bilateral collaboration on research projects** reflects the general level of research capacity in each of the countries as well as the interests of donor governments that provide development assistance to support research collaboration. For example, bi-lateral research collaboration between the UK and India is strong with several ongoing programmes, some of which are listed in Table 4. India also has bilateral research programmes with France, USA, Russia, Oman, Maldives, Indonesia, Bhutan and Nepal.

More recently, the Afghan Meteorological Service (AMA) signed an agreement with the India Meteorological Department, NCMRWF, RIMES and Ministry of Earth Science for a five year programme of rehabilitation but this was not yet coordinated with other international donors or Afghan ministries. There is anecdotal evidence that AMA and other departments are beginning to collaborative effectively with neighbouring countries, for example on transboundary water management issues.[10]

UK partner	South Asia	Type	Nature of research collaboration
NERC	MoES	Impacts	Newton-Bhabha Fund Atmospheric Pollution & Human Health in a Developing Megacity Sustaining water resource for food energy and ecosystem services (programme in development) Food security & land use change
NERC	MoES	NWP	The Drivers of Variability in the South Asian Monsoon research programme. http://www.nerc.ac.uk/press/releases/2014/19-monsoon/
NERC	MoES	Natural Science	The Changing Water Cycle research programme http://www.nerc.ac.uk/research/funded/programmes/cwc/
NERC **Univ of Southampton**	~	Hydraulics	River scour in Bangladesh (example project) http://www.nerc.ac.uk/latest/publications/planetearth/spr15-scouring.pdf

Table 4 Bi-lateral research partnerships between the UK and India

Research Gaps

Considering the landscape of existing donor programmes and the research focus on South Asian Monsoon and tropical cyclones, there are several options for supporting research in the region. These are summarised in Table 5 and will be discussed with key stakeholder during subsequent engagement activities.

10 This is based on presentations by Tajikistan on the transboundary Panj river basin at the UNECE Second Workshop on Transboundary Flood Risk Management

Table 5: Preliminary options for R&D on climate services in South Asia

Climate service research area	Options	Who?	How? (Potential DFID involvement highlighted in red)	Why?
Climate observations and monitoring **Priority High**	Research into the effective use of satellite information for DRR and agriculture Research to support development of effective RADAR for EWS in Afghanistan, Burma and Nepal, including development of business cases Research into potential of space-based platforms to provide trans-boundary perspectives	DFID Indian Government SERVIR Research community (UK Space Catapult, NERC) Local universities World Bank WMO	Set up bi-lateral or regional research cooperation Jointly funded research calls Study of requirements in 2-3 pilot countries Liaison with World Bank Pilot projects and training	To make best use of information already available including new Indian satellites To support the development of improved rainfall, water and food security tools in place where ground based observation are poor To meet clear demand for short-term rainfall forecasting articulated by several country ministries. To ensure a ROI for hydromet investments Invaluable for more accurate weather forecasting, disaster risk reduction and projections of crop yields
Reconstruction of high-resolution data **Priority High**	Research to develop validated high resolution data of the past climate and tools for risk assessment (including downscaling of ERA-Interim data) Research to develop higher resolution Regional Climate Models (RCMs) for longer-term projections and policy planning. To understand RCM limitations when representing South Asia's complex topography at high resolution	DFID CORDEX Indian centres Met Office UK Univ of Reading Korea APCC IRI, GFDRR (Requires suitable IT and modelling infrastructure)	Coordination with current activities Development of climate service platform (aka Copernicus in Europe) Potential for additional modelling studies if gaps exist	To prevent major infrastructure development based on poor climate data (a couple of rain gauges for 2-3 years) To support emerging weather risk insurance markets To ensure data generated by CORDEX and others is put into use To develop higher resolution Regional Climate Models (RCMs) for longer-term projections and policy planning
Seasonal and sub-seasonal forecasting **Priority High**	Research into seasonal and sub-seasonal forecasting of the Indian Monsoon Seasonal forecasting of Tropical Cyclone activity and impacts of El Nino Seasonal forecasting of agricultural drought	DFID WMO Indian Gov SASCOF FOCRAII Met Office U. Reading NOAA	Research collaboration Liaison with WMO Improved ICT communications systems	Predicting the monsoon is key most sectors. TC forecasting key for DRR – floods, storm surge, wind damage Could provide useful information for farmers, agricultural risk assessment/insurance/food security
Tailoring of weather	Regional Model Downscaling to create	DFID	Support to CORDEX South Asia	Demand for higher resolution climate

EVIDENCE ON DEMAND
CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

Climate service research area	Options	Who?	How? (Potential DFID involvement highlighted in red)	Why?
and climate information and climate scenarios **Priority High**	national climate change scenarios Regional climate change risk assessment and multi-hazards assessment Strengthening mechanisms for derivation and distribution of climate information at regional level Working with users in specific sectors to define user requirements	CORDEX Regional Climate Centres NMHSs UK Met Office ADB GWP ICIMOD WCRP APN MAIRS (Monsoon Asia Integrated Regional Study) CCCR-IITM	Development of climate service platform (aka Copernicus in Europe) Coordinate user groups in DRR and/or agriculture (potentially linked to SASCOF or SAARC)	scenarios (e.g. Bangladesh). Benefit of consistent data sets for tackling cross-border issues (floods, droughts, food security) Understanding vulnerability and potential impacts, and responding through adaptation decisions and policy, requires climate information that is reliable, scale relevant and tailored to user needs
Communication of weather and climate information **Priority Medium**	Research into effective communication of climate services in priority sectors - such as agro-advisories and early warnings - especially for women and vulnerable groups	DFID WMO GWP CCAFS USAID Local authorities Research community Local universities NGOs Womens' groups and networks	Developing and testing ICTs Replicate/ scale-up successful initiatives Action research Research collaboration	To ensure last mile delivery of services To understand and overcome the barriers affecting access to climate services by different user communities
Processing and archiving for national observations and climate risk information **Priority Medium**	Research into the development of appropriate tools, e.g. National Climate Information Centre (NCIC, UK) National River Flow Archives, land use surveys for curating regional and national data sets. Research into the appropriate models for sustainable national information systems, including open data , cost recovery, cost:benefit of NHMS	DFID Research community Local universities World Bank	International research exchange and capacity building Provision of open software and tool boxes Improving ICT Scoping study at beginning of programme	To make best use of information already available and set up effective processes for maintaining and making national and regional data available.
Risk Insurance **Priority Medium**	Research and development of strategies for reducing insurance costs such as improving efficiency of insurance scheme management and developing appropriate products for low-income sectors	DFID Research community Local universities NGOs World Bank	Research collaboration and scoping studies Learning and knowledge exchange with SE Asia	To understand the prevailing enabling environment in South Asia To understand the potential for index based systems to contribute to poverty alleviation

Climate service research area	Options	Who?	How? (Potential DFID involvement highlighted in red)	Why?
	Research into physical characteristics of key infrastructure for estimating hazard risk Research and testing of risk models to determine links between weather indices and costs	ADB GFDRR Private sector	Coordinated research with GFDRR on risk assessment models	and build climate resilience. To test risk models, particularly for agricultural risks and tropical cyclones, which are under-developed and untested in some parts of South Asia.
Decision making **Priority Medium**	Research into how climate information can be effectively integrated into regional and national decision making	DFID Governments Basin authorities CDKN APAN	Link to existing programmes and networks e.g. APAN and CDKN	Promotion of climate service use in agriculture, DRR and water sectors (as well as other priority development sectors such as health and energy)

2.6 Intervention Mapping

The following section provides an overview of current and recent climate service interventions in South Asia. The focus of the intervention mapping has been on regional initiatives in order to identify potential opportunities for learning, collaboration and partnership with the proposed regional programme. A more complete list is provided in Annex 4.

An initial assessment indicates that while some users' needs are being met, there is significant opportunity for DFID to make a fundamental contribution to strengthening climate services in South Asia via a regional programme. The importance of regional level cooperation is reflected in both the stakeholders involved (see section 3.1) and the range of activities funded by donors, noteworthy examples of which are described below.

2.6.1 Donors

The main donors currently funding work to strengthen climate services in the region are:

- Asian Development Bank Climate Change Fund. It appears little has been invested in climate services to date.
- JICA's 2014 Cooperation for NMHSs Strategy aims to enhance the capacity for DRR and Climate Change Adaptation through modernisation of instruments and equipment and capacity building in operation and maintenance, and improvement of forecasting capacity in South Asia.
- USAID funds and partners in the Climate Services Partnership (CSP), Scaling Up Climate Services for Farmers in Africa and South Asia (CGIAR CCAFS) and SERVIR Himalaya initiatives, amongst others.
- The World Bank's South Asia Regional Integration Strategy (2014) identifies hydromet modernisation, disaster preparedness and climate resilience as high priority areas to support regional integration. Its Regional Weather and Climate Services Program in Nepal, Bangladesh and Bhutan are at planning stages and are expected to encompass improved meteorological information services, improved hydrological information services, strengthened forecasting and early warning systems, and improved dissemination of agro-meteorological information.
- UN agencies and Finnish, Norwegian and Australian governments are also engaged to a lesser degree
- DFID is one of the main investors in climate change science and social science research, for example through the Climate Development Knowledge Network (CDKN), SHEAR and co-financing programmes with the ADB, NERC, UNDP and the Dutch government
- The Global Facility for Disaster Risk Reduction (GFDRR) is investing in the modernisation of weather, climate and water information systems globally with significant activity in South Asia. By 2014 GFDRR grants have contributed to a $400 million investment from climate investment funds and the World Bank. Example projects include '*Support for Design and Implementation of Building Resilience to Climate Related Hazards'* in Nepal (with PPCR), India's Cyclone Risk Mitigation Project (with GoI) and *the 'Ayeyarwady Integrated River Basin Management Project and Information Systems Modernization Component'.*
- The WMO Regional Programme for Asia 2012-2015 has focused on: enhancing operation of the Regional Climate Outlook Forum; developing climate services to address the slow onset impacts of climate variability and climate change; establishing a

regional-wide multi-hazard early warning system for DRR and implementing the Integrated Drought Management Programme amongst others.

2.6.2 Programmes and Initiatives

The Evidence Review has identified numerous programmes and initiatives that the proposed programme should build on and/or engage with. A full list is provided in Annex 4. Highlights are mentioned below:

- For climate monitoring and information systems: The Establishment of a Regional Flood Information System in the Hindu Kush Himalayan Region (HKH-HYCOS), SERVIR Himalaya, Mountain Environment Regional Information System (MENRIS) and Regional Database Initiative all led by ICIMOD; the Integrated Drought Management Programme for South Asia (IDMP) implemented by the WMO and the Global Water Partnership; the World Bank's Regional Weather and Climate Services Program; FOCRAII.
- For multi-decadal timescales the WCRP Climate Model Inter-comparison Project (CMIP5), the Coordinated Regional Downscaling Experiment (CORDEX) and Decadal Prediction and Stochastic Simulation of Hydroclimate Over Monsoonal Asia (University of Colombia).
- Trans-boundary governance, DRR and natural resource management: the Global Water Programme in South Asia; ICIMOD; The South Asia Water Initiative; International Water Management Institute; the Climate Services Partnership; the World Bank South Asia Regional Hydromet Program; the International Bank for Reconstruction and Development; Global Flood Resilience Alliance (the International Red Cross, Practical Action, funded by Zurich Insurance).

Risk Insurance[11]

The Insurance Institute of India (III) along with the SAARC SDMC is in the process of building awareness on risk insurance across the region. A seminar was held in December 2014 by both organisations and included participation from insurance regulators and government agencies (Indiaprwire, 2015). Besides the III and SAARC alliance, there are no other regional level risk insurance initiative in South Asia. Two noteworthy initiatives have been implemented in the South East Asia region, and potential for replication/extension to South Asia should be explored. These are:

- The Disaster Risk Financing and Insurance (DRFI) Program, a joint initiative of the World Bank Group's Finance and Markets Global Practice and the Global Facility for Disaster Reduction and Recovery (GFDRR), was established in 2010 and is supporting governments in South East Asia to strengthen financial resilience along four main priorities, including sovereign disaster risk financing and insurance; agricultural insurance; property catastrophe risk insurance; disaster-linked social protection.
- The Integrated Disaster Risk Management (IDRM) Fund was established by Asian Development Bank (ADB***)*** in 2013 and supported by the Government of Canada as a resource to assist the development of regional DRM solutions in line with the disaster risk management priorities of ADB's South-east Asia developing member countries, namely Cambodia, Indonesia, Laos, Myanmar, Philippines, Thailand, and Vietnam (ADB 2013).

---

11 This section on risk insurance is provided at the request of DFID South Asia during the kick-off stage

National Risk Insurance Practices

Non-life forms of risk insurance play an important role in disaster risk reduction. There are various kinds of non-life risk insurance available in South Asia, such as agriculture insurance (crop insurance, livestock insurance), building/residential property insurance and assets (industrial and non-industrial) insurance. In all South Asian countries, the main form of disaster insurance coverage is as a voluntary endorsement to a homeowners' policy, which in most cases is declined by consumers (AIDMI 2011). Disaster insurance other than agricultural insurance cannot be bought separately in any South Asian country and has to be bundled with a homeowners policy.

Country	Risk Insurance Availability	Insurers	Re-insurers	State Met Service role	Private Met Service Role
Afghanistan	No	No	No	No	No
Bangladesh	Yes	Public and Community Based	No reinsurer	No	No
Burma	Yes	Public and Private	Private international	No	No
India	Yes	Public, Private and Community Based	Government, Private national / international	Yes	Yes
Nepal	Yes	Public, Private and Community Based	No reinsurer	No	No
Pakistan	Yes	Public and Private	Private international	No	No

Sources: FAO 2010 and other literature reviewed for this scoping study

Table 6 Institutional and structural characteristics of risk insurance in South Asia

Agricultural Risk Insurance

From the viewpoint of climate change, agriculture insurance has a direct link with weather parameters and as such offers the greatest potential to support disaster risk reduction efforts in the region. Yet at present agricultural risk insurance has limited spread in the region.

In India about 32 million farmers are enrolled in various crop insurance schemes, though a recent survey found 81% of Indian farmers were unaware of opportunities to insure their crops (Assocham 2015). The Indian National Agriculture Insurance Scheme (NAIS) has dominated with its crop insurance programme marketed exclusively by banks on behalf of AICI (Agriculture Insurance Co. of India Ltd). However, a poor claims record of such indemnity-based insurance schemes (where pay-out is linked to actual losses) has led to general low levels of trust in insurance agencies (AIDMI 2011). The Government of India is now piloting a modified National Agricultural Insurance Scheme, a market-based programme working with the private sector with the aim of settling claims more quickly and reducing distortion from subsidies.

In 2003 the first parametric (weather index-based) insurance scheme in a developing country was launched by the rural microfinance organisation BASIX, marketed by the rural bank KBS in India. Parametric Insurance is mostly used for crop risks, with pay-outs linked “to a physical trigger such as rainfall measured at a regional weather station” (IIASA 2011) rather than linked to actual losses. The BASIX scheme has received significant attention from the World Bank and the Asian Development Bank, both institutions having promoted knowledge transfer to stakeholders in Thailand, Bangladesh and Ethiopia. Furthermore, BASIX is working with Development International Desjardins to replicate the experience in Sri Lanka (BASIX 2010). In 2007 the Indian government launched a similar parametric ‘Weather Based Crop Insurance Scheme’.

Parametric insurance products may be effective in scenarios where hazard assessment data is scarce and indemnity assessments would be relatively expensive. However, research into the effectiveness of parametric schemes has found evidence that they “may not be appropriate for poor farmers that face a multitude or chronic levels of risk, or where agricultural services, supply chains, markets and infrastructure are weak (ProVention 2009).

Parametric insurance schemes are only effective if the trigger data are accurate and if the trigger threshold correlates with actual losses. There is a risk that inappropriate parametric products may not release insurance payments, despite substantial disaster losses. There is also a risk that consumers will not buy into the concept of parametric insurance if they are not convinced that the trigger reflects their own risk.

In 2009, Munich Re with GTZ and an Indonesian insurance company piloted a parametric flood insurance scheme, wherein insurance cards would pay out 5 times the original cost if waters rose to a pre-determined trigger level. This scheme was discontinued due to weak consumer demand as community members did not feel that the trigger (water level at Manggarai Water gate) reflected their individual risks/losses (World Bank 2011).

In Bangladesh agricultural crop insurance was introduced in 1977 by the state-owned insurance company Sadharan Bima Corporation (SBC). Parametric (index-based) crop insurance is not available. Currently, SBC is the only regulated company that has underwritten crop and livestock insurance with no such services offered by private commercial insurance companies (FAO 2011).

In Nepal, two cooperatives commenced pilot crop insurance schemes in 2007 in conjunction with the Department of Agriculture (FAO, 2011). In Pakistan risk insurance is relatively new, with crop insurance introduced in 2008 as part of a crop loan insurance scheme. Risk insurance products are not available in Afghanistan (FAO 2010).

2.6.3 Regional Networks

Four key networks benefiting from significant engagement and traction with different levels of government, the private sector, civil society and the donor community are the Asian Pacific Adaptation Network, the South Asian Disaster Knowledge Network, the SAARC Disaster Management Centre and the South Asian Climate Outlook Forum. The proposed programme will need to consider how to engage with these networks to maximise reach and impact.

2.7 Recommendations

The current status of climate service provision and the capability of regional and national suppliers opens up a range of potential intervention options that require discussion and validation with stakeholders during the next phase of this scoping study.

First Priority: Strengthen capability of NMHSs to supply demand-oriented climate services

i. There is a requirement for a clear roadmap for climate services in South Asia tailored to the GFCS Framework and oriented to meet the demand for information in the region.[12] A number of key questions need to be addressed to fill on-going knowledge gaps, including e.g. what level of capability is required to meet development objectives? What role should India play as a regional provider? What level of impact have existing centres (that have been established for some time) had?

ii. Strengthen the capability of NMHSs to utilise available climate products from GPCs and RCCs for end-user interests in their respective countries. Training programs should form a major component of this effort (there is evidence that a range of climate products are available but little evidence indicating whether these are currently being used. Further stakeholder consultations will validate this priority). Investigation is required to understand the existence/methodology/relative success being adopted by NMHSs in reaching out to user communities, like farmers, in product delivery and feedback mechanisms.

iii. Support the development of standard 'climate services toolkits' - sets of bespoke software products including data portals, data management systems, analysis and prediction packages - and accompanying training modules, that are specifically designed to support the generation and use of climate information and prediction products that meet user needs.[13] The purpose is to facilitate the production, communication, and application of climate information products and avoid the possibility of a proliferation of inconsistent, and possibly sub-standard, tools by implementing a set of standards, and establishing a certification process for new tools.

iv. There is limited evidence that National Climate Outlook forums exist or are operating effectively in the target countries. It is therefore recommended that DFID provide support to these platforms to strengthen their presence and capacity and improve two-way communication between NMHS and end users in priority sectors. It will also be important to provide support to link national forums more effectively to the South Asia Regional Center (IMD) for technical capacity building and knowledge sharing.

Second priority: Strengthen regional and national observational network capacity

---

12 The European road map attempts to organise research activities and to stimulate the climate services market. http://www.kowi.de/Portaldata/2/Resources/horizon2020/coop/A_European_research_and_innovation_Roadmap_for_Climate_Services.pdf

13 For example the UK National Climate Information Centre develops tools for manipulating point and gridded climate data and making national data sets available to the public and research community. http://www.metoffice.gov.uk/weather/uk/climate.html

i. A more complete regional network is required to support regional forecasting on various time scales and to provide better climate information for a range of applications, including climate change risk assessment. Options include enhancing the role of the more advanced Indian centres, supporting existing programmes like SAARC, SASCOF, FOCRAII, APAN (see Section 4.1 and Annex 4), alternatives would include more targeted activity supporting better regional integration of the “basic” NHMS (Burma, Afghanistan) and supporting their links with their own governments and bilaterally with neighbours and with regional initiatives. Finally there are other regional centres in East Asia and global producing centres (US, Japan, UK, France) and other developed NHMS (Finland, Sweden, UK, Denmark, Netherlands, China) that are already playing a significant role in supporting South Asian NHMS.

ii. Raise the capability of least developed NMHSs by at least one level: Afghanistan from ‘Less than Basic’ to ‘Basic’ and Nepal and Burma from ‘Basic’ to ‘Essential’ (based on WMO recommendations). Evidence indicates there are opportunities to rehabilitate silent stations (particularly in LDC NMHSs Afghanistan, Nepal and Burma to bring them as close as possible to RBSN/RBCN (World Bank, 2009), implement new networks and explore use of non-traditional observations (e.g. using data from other sectors and new technology, such as mobile phone communications, aircraft observations, private sector, other third parties and the general public) which may bring particular benefit in areas where the conventional network is sparse. Automatic weather stations are being, or proposed to be, installed as integral components of climate projects in several countries.[14] Similarly, the WMO Integrated Observing System (WIGOS) is working to increase sharing of observation networks that are not operated by the country NMHS.

iii. **Further research is required in regional climate modelling in South Asia, particularly with respect to modelling the monsoon, tropical cyclones and representation of complex topography**. There are a number of relevant recently completed and ongoing projects (Annexes 2 and 4) but initial learning should be drawn from the Met Office/Bangladesh project, which aims to produce downscaled 25km CMIP5 projections across the whole of South Asia. [15] Research could also draw on the South East Asia Climate Analysis & Modelling project (SEACAM), as well as relevant CORDEX initiatives. The outputs of this work should provide clear guidance on the information available, its strengths and weaknesses and examples of how it can be incorporated into decision making related to agriculture or DRR.

iv. Continuing efforts must be devoted to **recovering and analysing historical data in South Asia**. The Climate Data Management Systems (CDMS) initiative being developed through international efforts led by the WMO Commission for Climatology provides technological solutions for modern archiving and for quickly retrieving historical and near-real-time climate time series. NMHSs in developing and least developed countries should be assisted and encouraged in using modern CDMSs on a sustainable basis (WMO, 2014).

14 For example the World Bank funded projects and bi-lateral country projects from Finland (FMI) and Norway (Met Norway) in Nepal and Burma.

15 The Capacity Building in Climate Modelling in Bangladesh project was a collaborative venture between UK aid from DFID, the Met Office Hadley Centre and the Bangladesh University of Engineering and Technology (BUET). See: http://www.metoffice.gov.uk/services/climate-services/case-studies/bangladesh

Third Priority: Develop an innovative research programme that supports the generation, uptake and use of weather and climate services while building the capacity of the South Asia research community

i. Promote an interdisciplinary regional research programme to respond to various on-going gaps in the region. Priority areas include: Climate observations and monitoring; Reconstruction of high-resolution data; Seasonal Forecasting; Tailoring of weather and climate information and climate scenarios; and Communication of weather and climate information. This programme should aim to strengthen global-regional-national research partnerships as well as strengthen learning and exchange mechanisms. Action research and multi-stakeholder processes should be promoted to help close current gaps between information providers and users.

ii. Despite several initiatives to promote risk insurance in South Asia, key challenges include high insurance premiums, a lack of products suitable for low-income and at-risk communities, a lack of enabling policies and regulatory frameworks, a lack of precise risk information for designing a robust index based facility, and limited technical capacity. Against this backdrop, it is recommended that DFID promote research to explore the potential of index based insurance facilities in South Asia, in particular building capacity for estimating medium and long term hazard risk, and supporting the development and testing of risk insurance products for low income sectors. See Annex 6 for a complete list of recommendations relating to risk insurance.

SECTION 3

Demand for Climate Services

3.1 Users of climate information services

Users of climate information include a wide range of groups and individuals across sectors, livelihood groups and decision-making levels with widely varying levels of access to information and resources (Rogers and Tsirkunov 2013). Key regional and national level users for the DRR, agriculture and water sectors are listed in Table 7 below.

Level	Sector	Key Users of Climate Information
Regional	All	Asian Development Bank; European Commission; World Bank; Global Environmental Facility; Climate and Development Knowledge Network (CDKN) Asia; Red Cross Climate Centre; DFID Asia Regional Team; University of Colombia; South Asia Association for Regional Cooperation (SAARC); International Centre for Integrated Mountain Development (ICIMOD); IUCN; UNDP; UNEP; WMO; USAID; SDC; GIZ; CORDEX-Regional Climate Downscaling Experiment, Future Earth; SAARC Meteorological Centre; South Asia Climate Outlook Forum; ICRISAT-International Centre for Research in Semi-Arid Tropics, RIMES-Regional Integrated Multi-hazard Warning System
	Agriculture	Asia – Pacific Association of Agricultural Research Institutions; Agricultural Research for Development (ARD) in South Asia; The Borlaug Institute for South Asia (BISA); The International Food Policy Research Institute (IFPRI) mission in South Asia; South Asian Association for Regional Cooperation (SAARC); Asian-Pacific Weed Science Society (Pakistan); International Society for Tropical Ecology (ISTE) (India); The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)
	Water	South Asia Institute (Water and Climate Series Seminar); Remote Sensing Centres; South Asian Regional Meteorological Centres; Integrated Drought Management Programme for South Asia; International Centre for Integrated Mountain Development (ICIMOD); The South Asia Water Initiative; International Water Management Institute (IWMI); Mekong River Commission (Burma is a Dialogue Partner)
	DRR	UNISDR; Community Based Disaster Risk Management (CBDRM); Cyclone Preparedness Programme (CPP); Asian Disaster Preparedness Centre (ADPC); International Red Cross and Red Crescent Movement; Duryog Nivaran; SAARC Disaster Management Centre
National	Agriculture	Ministries of Agriculture, Food Security and Rural Development; Agricultural Research Councils; NGOs and civil society; risk insurance companies
	DRR	National Disaster Management Authorities; Military, naval and air forces; Coast guards; NGOs and civil society; Risk insurance companies

Level	Sector	Key Users of Climate Information
	Water	Ministries of Water Resources and Rural and Urban Development; NHMs; Water resource management authorities; Soil conservation agencies; Hydropower agencies; Industrial and urban water sectors; Nepal Red Cross Society (NRCS); Flood Forecasting and Warning Centre (Bang); Institute of Water Modelling (Bang); Federal Flood Commission (Pakistan); Ministry of Water and Power (Pakistan); Bangladesh Inland Water Authority; Bangladesh Water Development Board; Flood Forecasting and Warning Center (Bang); NGOs and civil society; private service providers

Table 7 Key users of climate information across priority sectors

3.2 Climate Information Requirements

For climate information to benefit climate-sensitive sectors and society in general, it must induce and facilitate changes in decision-making process and in the actions taken by stakeholders (Sonka et al 1992). There is a need to transform climate related data into customised products and services that have a societal and public use. Furthermore, fluid, proactive and transparent links between agencies producing climate information and end-users are required to improve the relevance and applicability of climate information for decision-making purposes (Jagtap *et al.* 2002).

Forecast information with different lead times is relevant to different sectors of human activity, decision making and early-warning systems. As per WMO's classification of forecast ranges, the time scales and products of weather and climate forecast systems vary from descriptions of current weather conditions – known as 'nowcasting' - to climate forecasting beyond 2 years (Table 8) (WMO 2015).

Forecasting Range		Definition
Nowcasting		A description of current weather parameters and 0 -2 hours description of forecasted weather parameters
Very short-range		Up to 12 hours description of weather parameters
Short-range		Beyond 12 hours and up to 72 hours description of weather parameters
Medium-range		Beyond 72 hours and up to 240 hours description of weather parameters
Extended-range		Beyond 10 days and up to 30 days description of weather parameters, usually averaged and expressed as a departure from climate values for that period.
Long range	Monthly Outlook	Description of averaged weather parameters expressed as a departure (deviation, variation, anomaly) from climate values for that month (not necessarily the coming month).
	Three month or 90 day outlook	Description of averaged weather parameters expressed as a departure from climate values for that 90 day period (not necessarily the coming 90 day period).
	Seasonal outlook	Description of averaged weather parameters expressed as a departure from climate values for that season.
Climate forecasting	Climate variability prediction	Description of the expected climate parameters associated with the variation of inter-annual, decadal and multi-decadal climate anomalies.
	Climate prediction	Description of expected future climate including the effects of both natural and human influences.

Table 8 WMO Definitions of Meteorological Forecasting Ranges (WMO 2015)

Forecasting day-to-day weather is primarily an atmospheric initial condition problem, although there can be an influence from ocean and land conditions. Forecasting at the seasonal to inter-annual range, in contrast, depends strongly on slowly-evolving components of the Earth system, especially the sea-surface temperatures (SST). In between these two time scales is the sub-seasonal variability, which is considered as the time range between two weeks and two months. Sub-seasonal to seasonal forecasting is at a relatively early stage of development.

Extending downward from a seasonal forecast, which might influence crop-planting choices, a sub-seasonal forecast could help orientate decision around optimising irrigation scheduling and pesticide/fertilizer application. In situations where seasonal forecasts are already in use, sub-seasonal ones could be used as updates, such as for estimating end-of-season crop yields. Extending upward from user-applications of numerical weather predictions, there is a potential opportunity, for example, to extend flood forecasting with rainfall-runoff hydraulic models to longer lead times. On the other hand, the agricultural community would need daily and seasonal forecasts, city planners may require more real-time information and forecasts for shorter periods of time, while, central planners may require climate projections for the next decade or two (Dinshaw *et al*., 2012).

Major issues from a climate perspective include the occurrence of extreme events, from heat waves to hurricanes, how seasonal-to-interannual variability affects their probability of occurrence, and whether such climatic variations are usefully predictable. Many of the extreme events with the largest impacts have a strong sub-seasonal/weather character, reinforcing the importance of sub-seasonal time scales for advancing both understanding and predictions of extreme events in a variable and changing climate. Assessing how sub-seasonal to seasonal variations may alter the frequencies, intensity and locations of high impact events will be a high priority area of research from the societal decision-making perspective. The sub-seasonal to seasonal time range falls within the remit of the GFCS.

Through the intersection with disaster risk management, food security and markets, the sub-seasonal timescale is of relevance to development agencies such as the World Bank, USAID, UK Department for International Development, and food security organizations such as the World Food Programme, and the Consultative Group on International Agricultural Research's Program on Climate Change, Agriculture and Food Security. Improved forecasts of extremes on this timescale have the potential to mitigate disasters, and thus improve resilience of vulnerable communities to climate shocks, and help them better adapt to climate change. Importantly, the two-way flow of information between development/food security organizations and the climate community will be crucial to the creation of meaningful climate services through the GFCS. Sub-seasonal forecasting has not received as much attention as weather forecasting or seasonal forecasting because it was thought to be a difficult time range that is not as well defined as weather and seasonal forecasting. However, there are reasons to think that there are opportunities for making forecasts for this time range that would be very useful to society (Vitart et al 2012).

Table 9 provides examples of the requirements of climate services information for different sectors in South Asia. Some of the most prominent uses of climate information in the priority sectors of this scoping study are described below.

Use	Information Requirement	Geographical Area
Disaster risk reduction		
Hazard mapping	Relevant climate services and hydrological data	Region
Relief payments	Dense network of rain gauges to calculate drought indices	India, Sri Lanka
Seasonal outlooks	Seasonal climate forecast model; sea surface temperatures; remotely sensed snow cover; in situ snow depths; monthly rainfall	Region
Flood Risk Management		
Early warning systems for fluvial, glacial and tidal hazards	Real-time meteorological data; remotely sensed snow data	Region
Glacial lake outburst floods	Local meteorological data	Nepal
Water Management		
Rainwater and groundwater harvesting schemes	Meteorological data	Afghanistan, Bhutan, Pakistan
Long-range reservoir inflows	Seasonal climate forecast; sea surface temperature; remotely sensed snow cover; ; in situ snow depths; multi-decadal rainfall	India, Nepal, Pakistan
Agriculture and Food Security		
Crop selection, timing of planting, irrigation scheduling	Long-term forecasts of monsoon onset; seasonal drought	Region
Soil moisture conservation	Satellite monitoring of vegetation cover; meteorological data	Region

(Source: Based on Wilby 2009)

Table 9 Examples of climate information required for different uses in priority sectors

3.2.1 Disaster Risk Reduction

Information Requirements

Effective disaster preparedness and disaster risk reduction hinges upon decision makers (of all kinds) having access to the right information at the right time. Accurate risk information should enable “the prioritization of investments in disaster risk reduction” (OECD 2012), however, accurate risk information alone is insufficient. Numerous studies (CDKN 2014) have highlighted the challenges of translating effective risk information into effective decision making. Risk assessments “do not automatically translate into a set of recommendations or plan of action to be taken up by decision-makers” (CDKN 2014) and even when they do, such recommendations are not always implemented.

In the DFID Science for Humanitarian Emergencies and Resilience (SHEAR) scoping study (see Lumbroso et al., 2014) research priorities with respect to risk assessments and early warning systems for weather-related hazards were identified (from highest to lowest priority) as droughts, landslides, floods and cyclones. This prioritisation was based on the following two factors:

i. The humanitarian impact of the hazard in terms of the total number of people affected

ii. The effectiveness of the risk assessments and early warning systems that have been implemented previously, based on the analytical framework and stakeholder engagement that have been undertaken as part of this study (Lumbroso et al., 2014)

Under future climate change scenarios it is likely that the frequency of extreme events such as cyclones, storms, floods and droughts will increase which will affect almost all economic and social sectors. For example, an increase in the melt rate of glaciers is likely to increase the frequency of glacial lake outburst floods which pose serious risks to parts of Bhutan, Nepal, India and Bangladesh.

Interview with stakeholders (see Annex 1) reveals that climate information is required for national and regional DRR decision-making shown in Box 2 below.[16]

Box 2: Climate information required for DRR decision making

Regional level decision making	National level decision making
➢ Developing and implementing regional sectoral management/climate change/DRR plans ➢ Emergency planning ➢ Strengthening early warning system design ➢ Guiding research priorities	➢ Development of national DRR strategies, regulations and policy ➢ Risk assessment and hazard analysis ➢ DRR training and awareness raising ➢ Coordinating emergency response

Climate information and tools available

The Global Data-Processing and Forecasting System (GDPFS) produces and disseminates weather and climate predictions to enable NMHSs to provide high-quality meteorological forecasts and other information services on a 24/7 basis. It is a three-level system with World Meteorological Centres (WMCs), Regional Specialized Meteorological Centres (RSMCs), including Regional Climate Centres (RCCs), and National Meteorological Centres (NMCs) supporting NMHSs and their early warning capacities. The Severe Weather Forecasting Development Project, has been successfully rolled out in the Bay of Bengal (South Asia). It uses a "Cascading Forecasting Process" (global to regional, to national) that provides Forecasters of the NMHS with improved access, as well as effective utilization of existing and newly developed products and tools available through the advanced GDPFS centre (World Bank 2014). Improvements in cyclone early warning systems in Bangladesh (IRIN 2007) and India (UNDP 2014a) have saved hundreds of thousands of lives in recent times.

On-going initiatives working to improve the links between climate information and DRR include:

- The Global Flood Alliance (Zurich Insurance, Practical Action, the International Federation of the Red Cross (and national chapters), the International Institute for Applied Systems Analysis (IIASA) and the Wharton Risk Management and Decision

16 This table will be validated during subsequent stakeholder consultations

Processes Center) is a 5 year programme focusing on South Asia (as well as SE Asia and Latin America), looking at building flood resilience through work in Nepal at community, sub-national and national level. They are working with the Nepal DHM on forecasting and early warning, and are focusing on translation and dissemination of weather and climate information to the 'last-mile' (user groups at sub-national level including farmers, community disaster risk reduction task forces, community level governance structures). The Alliance aims to test, evaluate and replicate successful approaches to flood resilience. The Alliance is also focusing on cross-border challenges in an integrated trans-boundary river basin approach including links to India and Bangladesh and is interested in improving region-wide cooperation. Key challenges facing the Alliance include lack of regional leadership and momentum behind improving cross-border collaboration (including restrictions on access to data in classified rivers in India).

- The DFID-funded SHEAR research programme which aims to integrate disaster risk assessment, sub-seasonal to seasonal forecasting and disaster risk monitoring into practical decision making. The work in Asia focuses on landslides and links to floods and earthquakes. It will look at how forecasting and EWS can be developed for specific hazards, especially linking risk models and forecasting to develop impacts based forecasting and multi hazard risk assessment. The focus will be in Nepal and Bangladesh.
- The SAACR SDC South Asian Disaster Knowledge Network (SADKN) portal which provides:

  - Access to clear, understandable and user-friendly information about real time, impending and historical disasters, details of hazards, vulnerabilities and risks of disasters in structured layers of digitized maps in WebGIS platform, and wealth of resources, references, images and videos.
  - Instant geospatial support for assessing risks and communicating about hazards and the exposure that vulnerable people and infrastructure have to these hazards and assist them in locating disaster occurrences and probable fall outs, and taking important decisions regarding evacuation, damage and loss assessment, recovery and risk reduction.[17]

Are User's Needs Being Met?

Principal challenges to the uptake of climate information into DRR decision-making in South Asia are:

- Lack of conceptual clarity and methodological consistency for risk assessments creates "confusion for decision makers" (CDKN 2014)
- Ineffective tailoring and targeted dissemination of climate and weather services to specific DRR user groups / decision makers
- Low technical capacity of public sector agencies with responsibilities for DRR to understand, interpret and apply risk information. Data is often presented in technical language and a mismatch between scales is also often experienced.
- Low perceived relevance of generic risk assessment information for sectoral agendas (health, employment, housing etc). Without sectoral interpretation, "planners and policy-makers tend to disregard studies prior to making investment decisions" (CDKN 2014).
- Short-sightedness of decision-makers

17 See Section 4: Are Users' Needs Being Met and Annex 4 for more information

- Limited sharing and dissemination of data and information concerning early warning and weather/climate forecasts in South Asia
- Limited lead-times - NMHSs need to be upgraded to produce early forecasts rather than relying on observational data. Bangladesh is one country in the region that has moved towards this model, however upstream data availability from India, Bhutan and China is an issue. For Nepal, topographical constraints and limited automatic hydro-met hinder observation and forecast ability.

3.2.2 Agriculture

Information requirements

The agriculture sector in all South Asian countries is the chief user of climate information and services. In general, community livelihood practices and their long-term experiences influence the extent to which and how they use climate and weather information (Macharia et al., 2012). For agriculture, climate forecasts must be interpreted in terms of production outcomes at the right scale (e.g. at the local geographical level and seasonal time scale) for farmers and other agricultural decision-makers to benefit (Kumar 2013).

Interviw with stakeholders (see Annex 1) reveals that climate information is required for national and regional decision-makingin the agricultural sector as shown in Box 3 below.[18]

Box 3 Climate information required for agricultural decision-making

Regional level decision making	National level decision making
➢ Developing plans, programmes strategies and initiatives regarding agriculture and food security ➢ Regional trends in the status, quality and quantity of crop productivity ➢ Forecasting and crop productivity modelling ➢ Scientific research priorities	➢ Emergency / contingency planning and coordination with aid agencies ➢ Sector planning ➢ Strategic framework for agricultural management ➢ Preparing agricultural advisories for farmers ➢ Risk assessment

Climate information and tools available

The climate forecast community is now capable of providing a multi-scale (in space and time) integrated prediction system that provides useful predictions of variables with socio-economic interest in South Asian countries. Currently improved availability of data and rapid advances in numerical modeling are enhancing the reliability of climate forecasts on the sub-seasonal to seasonal scales. On average, a five-day weather forecast today is more reliable than a two-day weather forecast 25 years ago.

Regional approaches are often employed to support national capacity by linking with neighbouring regional and global centres of excellence for data, forecast and expertise sharing,

18 This table will be validated during subsequent stakeholder consultations

for example through a system of "cascading forecasts" for snowmelt runoff and severe weather in Central Asia, supported by IDA and the PPCR.

India and Bangladesh have made considerable progress in developing their agricultural advisory networks and extension systems in reaching the farmers through the Internet and mobile phones (Sivakumar et al. 2014). For example, a novel mobile-based project initiated by NGO SRIJAN (Self Reliant Initiatives Through Joint Action) in Rajasthan state of India is not only helping soya farmers enhance their harvest but also connecting them to the experts and enabling them to access valuable information instantly. This simple mobile based service is almost doubling the soya harvest of women farmers in Rajasthan. The mobile service dispatches information on price and weather forecasts and prediction or forecasts on harvests, which help farmers in harvest collection and better managing the allocation of warehouses. NGOs can thus play a very significant and useful role in this effort (Pareek 2015).

Are Users' Needs Being Met?
Although the timely availability of improved climate information can help farmers to plan their agricultural activities and achieve improved agricultural productivity, enhanced farm incomes and better livelihoods, this information is not currently reaching the majority of agricultural producers in the region. Limited interaction of the NMHSs with farmers, inadequate dissemination of weather and climate products and services in a timely manner to end users, language barriers in understanding the climate products and services, weak agricultural extension services and poor communication infrastructure, remain as some of the main barriers in the provision of weather and climate information to the agricultural sector, chiefly smallholder farmers.

In 2012, the CGIAR CCAFS, USAID, the WMO, and the Climate Services Partnership (CSP) organised an international workshop on scaling up climate services for farmers in Africa and South Asia. Over 100 experts, representing 30 countries and some 50 institutions, collectively identified critical gaps in the design, delivery and effective use of climate-related information for risk management among smallholder farmers in sub-Saharan Africa and South Asia, and the strategies for addressing them (Sivakumar et al. 2014). For South Asia, the regional priorities identified as:

- Creation of appropriate mechanisms to promote greater interaction between smallholder farmers, agricultural research agencies, and NMHSs in the generation of climate information and its dissemination
- Development of more robust infrastructure and capacity of NMHSs through increased national, regional and international collaboration, to enable them to provide more effective climate services
- Identification of appropriate ICT tools, and make better use of them for more effective and efficient dissemination of climate information for smallholder farmers.
- Build the capacity of smallholder farmers, women, poor and socially marginalized groups to use ICT tools.
- Strengthen the collaboration between different agencies involved in the production and communication of climate services through better networking and improved institutional frameworks.

(Sivakumar et al. 2014)

Other gaps include:

- Users currently face difficulties in accessing real time data and/or climate services are not regularly updated with new information (Dinshaw, 2012). In some countries, such as Nepal, short and medium term forecasts are unavailable meaning that strategic decision-making is made around seasonal predictions.
- Agro-meteorological infrastructure, services, and human capacity are still inadequate and unevenly distributed across the region (Tall et al. 2013).
- Farmers generally require information that is crop-specific (Ramakrishna, 2013). In South Asia this information is limited or absent, except in regions where rice, cotton or wheat is a predominant crop over a large area and crop status information is available (Sivakumar et al. 2014).
- Many users of agricultural/climate information find it difficult to understand probabilistic forecasts and their inherent uncertainties (Rajeevan et al., 2004).
- Existing data are not translated into formats that are useful and can be understood easily by users in the agricultural sector, particularly small-scale farmers (Dinshaw *et al*, 2012).
- Stronger relationships are required between information suppliers and end users will help guide processes towards transforming climate information into usable tools for agricultural decision making (Weiss, 2000).

3.2.3 Water

Information requirements

Weather, climate and hydrologic monitoring and forecasting are essential to inform decision making in the water sector for climate resilience and provide critical inputs to early warning systems (WMO, 2015). In Afghanistan, recent wars and political instability have led to the loss of much of the institutional data and knowledge relating to water resources and climate. As such, decision makers and water managers are unable to understand the causes of water excess and deficit and, in turn, are unable make informed decisions around water resource management, or understand the socio-economic benefits of climate information and services.

Climate data and information underpin the planning and management of surface freshwater supplies and mitigation of damage from high and low water flows. Long records of catchment rainfall and river flows provide the basis of planning for sustainable freshwater harvesting, but it is the hydrological extremes of flood and drought that pose significant problems for water resource managers (WMO 2015b).

In 2014 a needs and capacity assessment survey on drought monitoring was conducted in South Asia with the assistance of Global Water Partnership (GWP) country partnerships in early 2014. The assessment revealed that there is no validated system of early warning on drought that could meet the requirement for a high spatial resolution in any of the surveyed countries (GWP, 2015). Table 10 shows a summary of South Asian countries' responses to a needs assessment on drought carried out by GWP (GWP, 2014).

Country	Existence of a drought early warning system	Capability to contribute to drought monitor/early warning	Requirement for infrastructural support	Rating of usefulness of drought monitoring/early warning system
Afghanistan	No	Very low – No prediction capability	Very high – Technical and training support needed	"Essential"

Country	Existence of a drought early warning system	Capability to contribute to drought monitor/early warning	Requirement for infrastructural support	Rating of usefulness of drought monitoring/early warning system
Bangladesh	No	Medium – Experience in flood warning, usage of drought prediction tools	High – Technical support and training needed	"Essential to ensure food security"
India	Yes - Especially good in certain regions	Very high – Experience in usage of different drought indices	Medium – Nationalized institution needed who can run a drought early warning system	"Extremely useful and essential"
Nepal	No	Low – Experience in collecting post-drought information	Very high – More hydro-met stations required	"One of the best initiatives in the region and my country"
Pakistan	Yes	Very high – Weather radar and GIS spatial integration systems capability to identify drought	Medium – Information for specific drought prone areas needed	"Moderate in own country, strong in South Asia"

Source: GWP 2014 Note: Burma not included in the report

Table 10 Requirements for drought monitoring systems

South Asia's water supplies are vulnerable to shifts and changes in melting of glaciers located in the Himalayas, which feed major rivers such as the Indus, Ganges, and Brahmaputra. More information and a better understanding of glacier dynamics and hydrology is vital for the region's water policies and management (Jaitly, 2009). For example, in the "short term" (i.e. the next 25 to 50 years) and increased glacial melt rate would supply more water to the dependent perennial rivers in India and Pakistan. However, the same process could increase the sedimentation rate of reservoirs, reducing their economic life.

Interview with stakeholders (see Annex 1) reveals that climate information is required for national and regional decision-making in the agricultural sector as shown in Box 4 below.[19]

[19] This table will be validated during subsequent stakeholder consultations

Box 4 Climate information required for water sector decision-making

Regional level decision making	National level decision making
➢ Developing strategies and initiatives regarding trans-boundary water and natural resource management ➢ Regional trends in the status, quality and quantity of water resources and improving access to water ➢ Developing and implementing basin management plans ➢ Real time water flow data collection and sharing of information ➢ Scientific research	➢ Developing and implementing national water management and flood protection plans ➢ Flood forecasting and warning systems ➢ Real-time climate data collection ➢ Provision of in-situ networks for climate services ➢ Scientific research ➢ Capacity building

Climate information and tools available
Many South Asian countries share large river basins and therefore it becomes vital to share the climate data and information for each country to monitor the available water on regular basis and to take precautionary measures regarding floods. Yet a lack of trans-boundary collaboration currently hinders water management in the region.

Notwithstanding, a number of recent and on-going regional programmes are strengthening links between climate information and services and the water sector. For example:

- The South Asia Regional Hydromet Program (World Bank) is building the capacity of participating countries and institutions to respond to water related hazards and climate risks at the national and regional levels, by supporting improvements in monitoring, weather and flood forecasting, community based early warning systems and delivery of climate services.
- Similarly, the DFID-funded South Asia Water Governance Programme (SAWGP) is creating space for seven countries sharing the 3 Himalayan rivers to collaborate. It is working through multiple activities (total budget £23.5 million) including the South Asia Water Initiative Phase II (SAWI-II), the Mount Kailash Sacred Landscape Conservation and Development Initiative.
- Finally, the Establishment of a Regional Flood Information System in the Hindu Kush Himalayan Region (HKH-HYCOS) project (funded by Finland and USAID) ran until 2014 and promoted the timely exchange of flood data and information for the reduction of flood vulnerability within and among the participating countries (Bangladesh, Bhutan, China, India, Nepal and Pakistan) (See Annex 4).

In 2011, the Global Framework for Disaster Risk Reduction (GFDRR) launched a hydro-meteorological initiative to support and leverage World Bank investments to strengthen weather, climate and hydrological services, while at the same time adhering to international norms and standards established by the WMO and the Global Framework for Climate Services (GFDRR, 2011).

Are User's Needs Being met?
A range of gaps need to be addressed to improve the effectiveness of climate information and services for the water sector. These include:

- Lack of hydrological/meteorological measurement stations, missing access to satellite data (SADMS, 2015)
- Insufficient rainfall prediction capability, or shortage of well-trained staff (SADMS, 2015)
- Conditions of vegetation and soil moisture are not yet monitored at all (SADMS, 2015)
- Reliable detection of drought emergence and progression at regional level remains challenging (SADMS, 2015)
- Lack of understanding of glacier dynamics and hydrology
- There is need to develop relationships between the NMHSs and water management authorities to apply climate information to water resource management policy and practice (Jon Campbell, 2015).

3.2.4 Health

Information Requirements
The health impacts of increased climate variability and extreme weather events are projected to be significant in South Asia by 2050 (IPCC, 2014) The health sector in South Asia needs to understand and quantify the specific effects of climate variability and change both on the overall disease burden and on opportunities and effectiveness in the public health response. For example in Bangladesh "*measures to mitigate the adverse health impacts of climate change need to be considered beyond the health sector: for example, integrating health sector, water and sanitation, urban planning, a weather early warning system, and a disaster management system. Resources should be spatially targeted to reach the most vulnerable locations that are likely to be at high climate and health risk to ensure cost-effectiveness*" (World Bank, 2014).

The health sector can use climate information effectively in epidemic early warning systems. Seasonal forecasts of temperature and rainfall, which are useful indicators of the likely occurrence of malaria outbreaks, can be used to implement epidemic surveillance, while real-time temperature and rainfall estimates can be used to initiate selective interventions and to support the early detection of disease outbreaks (Ghebreyesus et al. 2008).

Climate information needs to be geographically specific and readily available on the time-scales relevant to public health decision-makers. Achieving this depends on a high level of collaboration between environmental and health experts. Institutionally, this will only occur if there is an effective working relationship between the providers of climate information and the Ministry of Health, and down-stream to local health providers.

Climate information and tools available
The health sector can use climate information very effectively in epidemic early warning systems. Seasonal forecasts of temperature and rainfall, which are useful indicators of the likely occurrence of malaria outbreaks, can be used to implement a programme of heightened epidemic surveillance; while real-time temperature and rainfall estimates can be used to initiate selective interventions and to support early detection of disease outbreaks (Ghebreyesus et al., 2009).

Projections of climate change related health impacts use different approaches to classify the risk of climate sensitive health determinants and outcomes. For malaria and dengue, results from projections are commonly presented as maps of potential shifts in distribution. Health-impact models are typically based on climatic constraints on the development of the vector and/or parasite, and include limited population projections and non-climate assumptions (IPCC, 2007).

The recent World Health Assembly reinforced the need for countries to develop health measures and integrate them into plans for adaptation to climate change; to strengthen the capacity of health systems for monitoring and minimizing the public health impacts of climate change through adequate preventative measures, preparedness, timely response and effective management of natural disasters; and for the health sector to effectively engage with all of the relevant sectors, agencies and key partners at the national and global levels in order to reduce the current and projected health risks from climate change. One approach is to build on existing decision-support and other tools, such as surveillance and monitoring, to include the capacity to assess vulnerability and the health impacts of climate change, and to develop new responses as appropriate.[20]

Are User's Needs Being Met?

- Across South Asia there is a lack of coordination and interactions between climate information producers and the health service. In Pakistan, for example, the absence of a pollution monitoring system, particularly in the urban areas, has led to uncertainty around the quality of drinking water and it is difficult for researchers to understand the relationships between pollution, water borne diseases and the changing climate. Similarly, cases of Malaria and Hepatitis – two diseases highly associated with climate change - are on the rise in Pakistan yet a lack of coordination between the climate information producers and health practitioners means there is little understanding around the causes of these, and others, emerging diseases (Information gathered from country experts during initial stakeholder consultations)
- Health sector strategies do not currently consider the role of climate in affecting disease incidence and the need for preventative health care. Since the health sector is not usually engaged in climate and environmental monitoring, acquiring and using this type of information successfully depends on developing partnerships between health practitioners and the gatherers and providers of climate and environmental information.
- At present there is little or no coordination between climate information producers and health practitioners to tackle disease outbreaks (WHO, 2004). Establishing a regional task force of climate information producers and health practitioners could serve to identify vulnerable areas and causes of health problems associated with climate. Collaborative work and networking between NHMS and Ministries of Health should be encouraged.

3.2.5 Energy

Information requirements

Several South Asian countries are facing energy crises due to climate change impacts. For example, changes in precipitation, ice pack and snow melt patterns, combined with climate change-related land use change, is having a significant impact upon the variability and

[20] Sixty-First World Health Assembly, 19-24 May, 2008

availability of water flow, severely affecting large and small scale hydropower schemes in Afghanistan (Jajavid Laghari, 2013).

Historical climate data is key to determining the nature, location and design of sustainable energy infrastructure. Day-to day-weather variations have an impact on load demand and energy production, transport and distribution management, as well as energy prices. Weather forecasts are required for monitoring energy usage and predicting future demand.

Climate statistics are one of the key factors for planning the energy generation and distribution systems. In South Asia, running 2,000Km from east to west and comprising more than 60,000 Km^2 of ice, the Hindu Kush–Karakoram–Himalayan glaciers are a source of water for domestic and industrial consumption, energy generation and irrigation for a quarter of the total population living in South Asia. Flow of water in the river depends upon the prevailing weather conditions and it is estimated that a 1% reduction in stream flow could reduce electricity output by roughly 3% (Javid Laghari, 2013). Climatic records on year-to-year variability and the duration and intensity of past drought events are essential to the design process and are crucially important in effective operation of energy infrastructure.

Climate information and tools available

In most of the South Asian countries, climate information is not specifically generated for the use of energy / power industry. Indications are that some energy companies in South Asia are investing in understanding the interactions between climate variability and energy demand for supply planning to guard against shortages during the most critical times.

For example, the Earth System Science Organization, the India Meteorological Department (IMD) and the Power System Operation Corporation, an arm of Power Grid Corp have inked an agreement to use weather information to forecast requirements in the power sector over the short term. "*All weather information provided by Earth System Science Organization (ESSO-IMD) shall be used by the power system operators across India for better management and for the purpose of analysis*" (Government of India Ministry of Earth Science 2015). Awareness creation among the power industry on the usefulness of climate information in planning for sustainable supply is also under way in India (Information gathered from discussion with IMD officials).

Some weather service providers in private sector like Delhi based Skymet and Weather-Risk Ltd. provide customized weather data and forecasts to a few power distribution companies (Archita Bhatta and Rohini Rangarajan, 2009).

Are Users' Needs Being Met?

- The energy sector is highly affected by changing climate, particularly by weather extremes. Unfortunately, during extreme winters and summers, climate information is not used effectively in decision making. For example, in India, power distribution companies estimate the demand for the next day and buy power from the generating companies a day in advance. A sudden change in temperature can upset their calculations.
- More accurate information is required on water resources, as described above, as is increased coordination between NHMS and the energy sector to understand information needs and develop information packs and tools to support sustainable energy planning.

3.2.6 Gender and Vulnerability

Information Requirements

Given that in South Asia women often constitute the majority of the work force in the agriculture, water resource management and forestry sectors, and are often the main providers of food for their families, climate services must designed with women's needs, priorities, experience, livelihood activities and knowledge in mind (Kapoor 2011). Yet very little is currently known in South Asia about what kind of climate services women require.

Producing accurate climate information is fundamental, but how this is communicated, its relevance on a local scale, whether users feel it is legitimate, and equitability of access are all equally important if women and vulnerable groups are to use this information effectively for critical decision-making purposes (Agrawal et al. 2014).

Climate information and tools available

At present, climate services and information are "gender blind" and thus are unable to respond to the specific and differential needs of women and vulnerable groups.

Some work has been undertaken to assess barriers to climate services facing marginalised groups and potential strategies for overcoming these. The Scaling Up Climate Services for Farmers in Africa and South Asia project led by the CGIAR CCAFS is trying to identify what women need in terms of climate services in order to reduce their vulnerability to flooding, droughts and other disasters. The project has collected evidence showing that women farmers are overwhelmingly left out of many forms of communication channels (McOmber et al. 2013). Likewise, the report "Identifying Gaps, Challenges and Limitations of Access of Women, Children and PWD of Nijhumdwip to Cyclone Early Warning Towards Rendering Improved Early Warning Services through CPP Dissemination Mechanism/System" based on a study in a remote part of Bangladesh indicates that that women have difficulty accessing information on cyclone warnings (BRCS 2013).

The CCAFS research concludes that the use of 'hybrid' communication methods - traditional information sharing channels, such as social networks, complemented by simple and affordable ICTs - is the most effective way of increasing women's access and use of climate information services. CCAFS research in India found that the use of climate information is higher in villages where women are fully involved as key partners in its production and delivery (CCAFS 2013). An example of successful hybridization can be observed through a mobile phone programme in Bangladesh called Help Line, which offers health, legal and agricultural advice to women in rural communities through a call-in hotline. It is attention to local norms and conditions that allows for effective implementation of ICT usage and access (McOmber et al. 2013).

Are women and vulnerable groups' needs being met?

- There is currently a lack of evidence around whether climate services are meeting the needs of women and vulnerable groups in South Asia, although the little information that does exist indicates that this is not the case.
- Weak interaction between climate information producers, women and vulnerable groups resulting in low capacity amongst regional and national information providers to deliver climate services relevant for these groups.
- Discussions at the 2014 WMO conference on the gender dimensions of climate services pointed to the on-going technological, social and economic barriers that limit the effective use of ICTs in delivering weather and climate services to women (WMO 2015).

- The CCAFS and WMO both emphasise the need for education programmes that support women farmers to connect to new sources of information (CCAFS 2013 and WMO 2015).

See Annex 5 for a more complete analysis of gender and vulnerability in South Asia.

3.4 Communicating Climate Information to Priority Sectors[21]

Communicating weather and climate information is critical for informed decision-making and disaster response (see Section 3.2). Regional forums and NMHSs' need to supply information for a range of applications in different sectors as described in the previous chapter. While some data is shared proactively by NMHSs and government agencies, these links are generally weak and limited.[22] Information is not transferred efficiently or in understandable formats to policy makers and other decision makers and this is impacting on the effectiveness of early warning systems, public sector response/management, as well as the capacity of communities and individuals to make informed decisions about their livelihoods and welfare.

Several of the NMHSs provide climate information via their web sites, including the commercial sale of data (Bangladesh, Nepal). Anecdotal evidence indicates that some NMHSs sell data to other departments within their own country, which may promote the development of separate observation networks in different sectors. Where NMHSs are currently producing raw data only (e.g. Bangladesh Meteorological Department) there is a lack of helpful climate related products available to priority development sectors which could aid sustainable planning and disaster risk reduction efforts. Communication of data to users and amongst the scientific community is limited. High capacity and robust communication links are a pre-requisite for improved regional collaboration.

One of the primary constraints affecting climate and related data access and data exchange is the restrictive data policies of some data providers. Agencies responsible for data management and exchange have generally developed their own data policies, often based on national legislation, and many are not able to provide free and unrestricted access to their data. As a fundamental principle of data sharing within the GFCS, an open door policy should be pursued, as expressed by GFCS Principle 6. Thus countries should continue to be encouraged to adopt free and unrestricted (non-discriminatory and without charge) international exchange of climate-related data and products. The WMO Congress, for example, has adopted WMO Resolutions 40 and 25 to guide its Members concerning access and exchange of meteorological and hydrological data. These Resolutions provide a useful model for developing broader, overarching data access and exchange policies addressing all components of the climate system across geographical and time scales, including biological, environmental, and socio-economic data requirements under the GFCS. Nevertheless, where exchange of socio-economic and other data is sensitive, as it often will be, the availability of such data at the national level is still crucial for developing national climate services.

3.4.1 Regional Communications Capability

The SAARC has acknowledged the risks posed by regional and trans-boundary hydro-meteorological hazards and has reiterated the need to strengthen and intensify regional

---

21 The relevant components of the GFCS are User Interface Platforms and Climate Information Systems.

22 Information provided by national consultants supporting the production of this case study. See Annex 3 Supplementary Data on Demand

cooperation “*to address the challenges posed by climate change and natural disasters*” (World Bank, 2015). In November 2014 SAARC members agreed to establish a cross-border information sharing and regional cooperation mechanism to fight climate change and to minimize the risks of natural disasters. It was agreed to establish a SAARC Environment and Disaster Management Centre (SEDMC) to spearhead this regional effort. South Asian countries also collaborate through other forums, notably the South Asian Climate Outlook Forum (World Bank, 2015). Although there has been a small shift in the willingness of the countries in the region to engage in discussions related to regional integration, generally South Asia has struggled to establish effective communications despite the multitude of common resources and risks the region is facing (World Bank 2015). The need for effective regional communications is pronounced and urgent to mitigate risks and strengthen disaster preparedness (Memom, 2012; World Bank, 2015).

The two sectors where regional communications regarding climate information is most important are hydropower and floods.

Hydropower

South Asia has significant technical and economically feasible hydropower, which in most countries has only been exploited to a small degree (<20%). In the next three decades to meet the energy needs of the region numerous large hydropower schemes will be developed. There are numerous major issues influencing hydropower development in the region (e.g. the distance of hydropower resources from load centres; construction costs, social and environmental issues); however, amongst these is the quality and quantity of climate and hydrological data. New hydropower schemes should be considered in the context of the whole catchment taking into account how climate change will influence flows, and how future river flows must meet competing demands made for energy, the environment, and water supply for domestic, agriculture and industrial uses (Lumbroso et al., 2014). This is challenging given the current state of regional cooperation.

Meetings with the Nepal Hydrology and Meteorology Department have indicated that there is some, albeit limited, cooperation with Bangladesh and India with respect to climate services for the operation of existing hydropower schemes. However, there is a clear need for improved regional cooperation in order to assessing dam safety and sustainability of hydropower production under climate change (Wilby, 2009).

Flooding

Although South Asia is at risk from frequent flooding, disunity amongst the countries for mostly political reasons hinders the effectiveness of flood warnings (Haq and Nibanupudi, 2013). The lack of trans-boundary co-operation was highlighted by Price et al. 2014 who carried out around 500 interviews in Afghanistan, Bangladesh, India, Nepal and Pakistan. Many of the major river basins in the region are trans-boundary ones. The most important ones are shown in Figure 7. China is South Asia's most important upstream riparian country (He et al., 2014) and hence plays an important part in regional flood risk management and water allocation. The Government of India has signed memorandums of understanding with China for the provision of hydrological information of Chinese Stations on the Yaluzangbu/Brahmaputra and Langquinzangbu/Sutlej rivers during monsoon season. Both the countries have also set up an Expert Level Mechanism for addressing the issues pertaining to trans-boundary rivers (Government of India, 2015). With regards to new infrastructure schemes that affect river flows such as hydropower plants, the Chinese government’s new mandate is that “*new projects on* *trans-boundary rivers must go through scientific planning and study, with the consideration of the interests of both downstream and upstream riparian countries*" (He et al., 2014)

Figure 7 Important trans-boundary rivers in South Asia (Source: ACDP and UNDP 2006)

The lack of cohesive communication at times of flooding between China, India, Pakistan, Nepal, Bangladesh and Afghanistan results in delayed evacuation procedures (Haq and Nibanupudi, 2013). It has been reported that a lack of co-operation between South Asian countries is thwarting timely flood warnings that could save lives and decrease damage property during the monsoon season (Khadka, 2013). For example, in July 2013 heavy rainfall caused serious flooding in north-west India and Nepal (Khadka, 2013). However, because the sharing of hydrological data is a sensitive issue owing to disputes over water use, warnings were not issued in a timely manner (Khadka, 2013).

In western South Asia, the Kabul River with its headwaters in Afghanistan a major contributor to the serious floods in Pakistan in 2010. However, it was reported that there was no communication related to flood forecasting and warning between (Khadka, 2013). Bangladesh is one of the most flood prone counties in the region; however, it receives relatively little hydrological data from Nepal which is located upstream (Khadka, 2013). Officials at Nepal's Department of Hydrology and Meteorology said they used to send the information to Dhaka by fax before but now staffing constraints have limited this recently.

Pakistan has a mechanism for receiving some limited hydrological data from India; however, these data are not deemed adequate enough to provide "meaningful" flood warnings (Khadka, 2013). Another issue is that hydrological data for trans-boundary rivers such as the Indus, Ganges, and Brahmaputra are particularly sensitive and are often considered "classified information" on the grounds of national security (Surie and Prasai, 2015). Many stakeholders in the region state that a network is required to share data across borders.

3.4.2 National Communications Capability

Floods

In most South Asia countries the river basins are large (i.e. greater than 1,000 km^2). Forecasting and warning systems for both floods and cyclones have been established in Bangladesh and India for several decades (Lumbroso et al. 2014). Various authors (see Islam and Dhar 2000; Mirza et al. 2003; Haque et al. 2011; Habib et al. 2012) have indicated that improvements in flood forecasting and warning have reduced the number of fatalities from these hazards in Bangladesh and India, despite the exposure to these hazards increasing (WMO 2013; Shankar 2013).

In Bangladesh early warning systems and Cyclone Preparedness Programmes (CPP) were initiated in Bangladesh after the 1970 cyclone. There are around 43,000 CPP volunteers, stationed in the coastal districts, who are responsible for disseminating cyclone warnings among villagers via megaphones and by house-to-house contact. The number of cyclone shelters has also increased significantly (Paul, 2009).

In Nepal there is a web-based, real-time data acquisition based on 44 stations in major river catchments in Nepal (Gautam, 2011). Real-time water levels for these gauges are available on the Department of Hydrology and Meteorology's web page. However, these do not form the basis of an effective national flood forecasting system. The DHM does have informal agreements with various countries as they receive real time satellite data and information from Indian and Chinese counterparts. However, there is no formal mechanism for sharing of data and the impacts of this became evident during the 2013 Mahakali/Uttarakhand Floods, the Hud-Hud Cyclone and West Nepal floods in 2014. Despite sophisticated mechanisms to generate climate and weather forecasts, huge gaps exist regarding interpretation of the information and transmission to the local level.

In Pakistan the National Flood Forecasting Centre was established in 1992. Flood forecasting and warning activities are carried out during the monsoon season; however, there has been some criticism of the failure of the Pakistan government to make use of European Centre for Medium-Range Weather Forecasts, as has been the case in Bangladesh (see Webster, 2013).

In India the Central Water Commission (CWC) has a website that makes hydrological and hydro-meteorological information available to the public. CWC started flood-forecasting services in 1958 using information from upstream water level gauges (Jha et al., 2012). Most of the techniques for formulating the real time flood forecast are based on statistical approaches. There is a need for significant improvement of the real time flood forecasting systems including the establishment of automatic communication systems to allow the transmission of data in real time (Singh, 2012).

Agriculture

In South Asia agriculture is the largest user of water (Price et al., 2014). Access to reliable, timely and relevant information to assist farmers in reducing their risk and improving their decision making is important. The preparation and dissemination of agricultural advisories is at different stages of development across the South Asian region (Sivakumar et al., 2014). Countries like India and Bangladesh have made considerable progress in developing their agricultural advisory networks and extension systems in reaching the farmers through the Internet and mobile phones. In these more advanced countries, the major concern is the content of these agricultural advisories and their usefulness in minimizing the climate risks and increasing agricultural production. Agricultural advisory services in other countries in the region, including Nepal, are still in preliminary stages of growth (Ramakrishna 2013).

Mittal and Mehar surveyed 1,200 farmers in the five major states (Bihar, Haryana, Punjab, Uttar Pradesh and West Bengal) of the Indo-Gangetic Plains of India to assess farmers' information needs and methods via which they received data (Mittal and Mehar, 2013). The survey found that 99% of the farmers had access to mobile phones; however, only 41% used them for purposes relating to agriculture (Mittal and Mehar, 2013). The impact of mobile phones as a source of information for farming depends on how mobile networks are able to link the farmers to required information in a timely and accurate manner.

It is important to deliver information in local languages because of low literacy levels that limit farmers' ability to read and type messages on mobile phones in English. Only 51% of the 1,200 farmers surveyed could read text messages and only 28% could reply back in text form (Mittal and Mehar, 2013). Many of these farmers were unable to read or access the information/messages themselves. However, someone in their family or neighbourhood is able to read it to them. In India, many Mobile Based Information Service (MBIS) providers have been operational since 2007. However, they had poor penetration and low awareness amongst the surveyed farmers (Mittal and Mehar, 2013). Mittal and Mehar found that 90% of farmers said that they were interested in receiving the information on their mobile phones. However, although these numbers contradicted the actual usage, they also highlighted the potential for their usage. Involving farmers in the process of designing and delivering climate services can enhance the relevance of information and farmers' trust in it. Developing institutional capacity to include gender analysis in the design and implementation of climate services projects is another major priority (see Section 3).

3.5 Recommendations

The following could help to improve the various issues related to meeting demand for and improving communication of climate services. These will be explore and validated through stakeholder consultations during the next phase of this scoping study.

First Priority: Strengthen relationships between climate information providers and intermediaries with priority sector authorities

i. There is a need to increase and improve interactions along the complex information chain with primary producers of climate and socio-economic information (e.g. WMO designated GPCs and RCCs), intermediaries (NMHSs, NGOs etc.) that process and add value to this information making it more relevant for different sectors and types of users. Given there is no way a direct interface can exist between the primary producers and end users, it is the intermediaries who need to be strengthened and brought into the loop. Formal mechanisms between institutions could be pursued, in particular relating to flood early warning systems and disaster preparedness be strengthened (Khadka 2013; World Bank 2015). DFID could also promote collaboration among scientific communities, policy makers and practitioners to identify knowledge gaps, to co-design, to co-produce knowledge and make science more readily available and accessible.

ii. Strengthen inter-country communication systems, in particular for establishing early warning systems and disseminating this information to priority users such as monsoon forum groups and the health and agricultural sectors.

iii. There is a need to “desecuritise” and declassify trans-boundary water and climate data and information in South Asia to enhance public access to this information throughout the region (Surie and Prasai 2015). DFID could play a key role promoting the proactive disclosure of climate services information by government departments in the region. Funding research into experiences where this has led to improved efficiency of early warning systems, for example, including cost-benefit analysis, would help strengthen the business case.

iv. Build capacity to translate and interpret risk assessments into clear recommendations or plans of action in priority sectors

v. DFID could support Pakistan and Afghanistan to negotiate a bilateral treaty on the use and management of the Kabul River’s water resources for their mutual benefit. This agenda could be pursued by establishing a joint, multi-disciplinary, scientific fact-finding working group to build a climate and hydrological evidence base on the Kabul River basin. A bilateral Afghanistan-Pakistan water resources commission could also be established to negotiate hydro-power development plans.

Second Priority: Strengthen regional networks to generate and knowledge on climate products and services

i. Promote cross-regional cooperation between Farmers Associations, DRR practitioners and water user groups of member countries of South Asia by establishing a regional network to enhance the sharing and use of knowledge on climate products and services

ii. Support the establishment of regional advisory teams comprising subject matter specialists in priority sectors and NMHSs to interact with end users on a regular basis to help improve the relevance of climate information and services to their decision making needs

iii. Support collaboration and knowledge transfer between the regional CORDEX so as to strengthen the capabilities of stakeholders in each country in providing efficient and useful climate services to the end-user communities.

Third Priority: Promote more effective use of ICTs

i. Data and information management practices could be improved by integrating national data and ICT initiatives into the everyday functioning of government while at the same time investing in new and cost-effective information and communication technologies (Surie and Prasai, 2015)

ii. Support the scaling-up of successful experiences where ICT tools have been used for more effective and efficient dissemination of climate information to end users. Insufficient infrastructure and poor institutional links constrain the potential of ICTs for delivery of climate information. Thus DFID could help strengthen collaboration between different agencies involved in the production and communication of climate services through better networking and improved institutional frameworks. Leveraging the full potential of

ICTs for climate services, particularly agro-meteorological advisories to smallholders, would bring significant improvements in supporting livelihoods in South Asia.

SECTION 4

Conclusions and Recommendations

In the above chapters, we have attempted to present and critically analyse available evidence on climate and weather information services in South Asia, both from the demand and supply point of view and everything in between. We are hopeful of validating the information and gathering additional perspectives and insights during the course of the stakeholder consultation and engagement workshops scheduled to be held in all six countries of the region during June 2015.

During the Evidence Review we have already commenced our interactions and engagements with key stakeholders who are either producers, processors, intermediaries, users or those who are interested in promoting effective sharing of relevant and demand-based climate and weather information on a timely basis, towards disaster risk reduction, early warning, climate adaptation and climate compatible development. This engagement drew on contacts provided by the DFID Asia Regional Team, as well as our team's national and regional associates and networks. In this final section, we wish to reiterate and highlight our conclusions and recommendations together with possible interventions options for the proposed programme.

While there has been a small but perceptible overall shift in discourses relating to regional integration in South Asia, the region has struggled to arrive at a common ground for regional cooperation towards coordinated information and knowledge sharing and policies and programmes in disaster risk reduction and early warning systems. All the countries of the region are prone to natural disasters and vulnerable to the multiple impacts of climate change. Accurate, relevant, needs-based, timely and effective climate information produced on a regional basis will help reduce lead times, promote trans-boundary synergies and complementarities, thus providing significant benefits to disaster preparedness and early warning as well as in climate adaptation, towards overall economic development. The need for effective regional cooperation, therefore, is pronounced and urgent to mitigate risks and strengthen disaster preparedness and early warning systems and the various recommendations below are to be seen in that light.

The South Asia region is hugely diverse in terms of the availability and effective use of climate related information. Understanding vulnerability, potential impacts and responding through adaptation decisions, both at the policy and practice levels, requires climate information that is relevant, timely, accurate, defensible, tailored to user needs and demands and delivered at a time when user desires it. Unfortunately, the current state of regional climate and weather information in South Asia presents users with a confusing array of data sources that are often contradictory and delivered with minimal understanding of how it could be understood, interpreted and applied for decision making at different levels.

The current status of climate service provision and use and the capacity of national and regional players open up a range of potential intervention options that will require further discussion, elaboration, validation and prioritisation in consultation with the stakeholders during the next phase of the scoping study. These have been summarised into **two sets of intervention**

options, the first focused on **strengthening and understanding demand for climate services** and the second on **improving the supply and delivery of climate information and services, including the interface**. For both sets of intervention options, activities have been ranked as either **first**, **second** or **third** priority. This exercise was undertaken at the request of DFID and now needs testing and validating during stakeholder engagement workshops. Sections 4.1 and 4.2 provide a description of first and second priority options for strengthening the supply and demand of climate services in South Asia, while Tables 11 and 12 that follow provide an overview of all three categories of priority activities, including geographical scope, timescales, opportunities, challenges, factors governing implementation and an ease of implementing rating.

For any regional programme in South Asia to be effective, meaningful and relevant it will need to simultaneously address regional, sub-regional (multi-country), national and in a few cases even sub-national elements**.**

For example:

At the **regional level** (historical to climate change scales – broad and shallow):

a. Strengthen the supply of climate services/disaster risk assessment that brings together the best data sets, builds capacity in met services and increases interactions between intermediaries and end users
b. Work with existing organisations such as SASCOF, including establishing regional advisory groups
c. Promote regional data sharing through existing mechanisms and on selected pilots (see below)
d. Promote cross-regional research, learning and exchange to address on-going knowledge gaps e.g. index based insurance and linked to other programmes like SHEAR etc.

And at the **national level** (historical, sub-seasonal, seasonal scales – deep and narrow):

a. 3-5 national or local pilots in selected countries that require access to regional/cross-border data e.g. Afghanistan/Pakistan or Nepal/India/Bangladesh or Burma/India/China
b. Targeted improvements in observations in selected countries including the use of satellite data and reanalysis, as part of the same pilots. This could focus on the weaker NMHSs (Afghanistan, Burma, Nepal) and/or on building cooperation with stronger centres, particularly India
c. Demonstrate impacts of climate services tailored to vulnerable and marginalised sectors
d. Develop user groups, including NGOs

Types of activity cover the entire spectrum from information supply to communications, regional cooperation and decision-making responses. Both research and programmes are required because there are ongoing knowledge gaps, but also some good practice that is already showing effective and could be replicated/scaled-up (see Annex 4).

It is suggested that the sector focus could be on agriculture and DRR, bringing in health and floods where needed.

4.1 Strengthening the Supply of Climate Services

As far as strengthening the supply of climate information is concerned, the **first priority** relates to **building the capability of NMHSs to produce and deliver demand-led climate services** (p. 33-34). Some of the key activities that are part of this action include:

- **Supporting a clear roadmap for climate services in South Asia,** tailored to the GFCS Framework and oriented to meet the demand for information in the region. This will be a logical first step, especially considering the fact that many countries of the region are in the process of evolving strategies and actions towards clear articulation of the weather and climate services at the national and sub national levels. Before steps are initiated to design the road map, several questions will need to be answered to fill on-going knowledge gaps, including for example:

    i. What level of impact have existing centres, which have been established for a while now, created?
    ii. What level of capability is required to meet the development objectives?
    iii. What role should India be expected to play as an important regional provider of climate information.

    One key challenge towards developing a South Asia regional framework will be the huge diversity of standards and quality of climate information that the countries are in a position to generate and process.

- **Strengthening the capacity of NMHSs to utilise available climate products from Global Producing Centres and Regional Climate Centres for end user interests in the respective countries.** A range of potentially useful climate products are available from GPCs and RCCs, however little evidence exists indicating whether these are currently being put to good use. While the stakeholder consultations will validate this priority, what is clear is that capacity building and communication programmes will form major components of this effort, meaning there is significant potential for high-value adding with modest investments. Further investigation will be required at the national level to understand the existence of such efforts, methodologies adopted and the outcomes achieved by NMHSs in reaching out to the user communities with this information, together with the relative merits of any feedback mechanisms. Another important question is whether available products from GPCs and RCCs are sufficient to meet the current and emerging future needs of climate services in the countries of the region, especially those with a basic or sub-basic level of climate services (see Sections 2.1 and 2.2).

- **Supporting the development of standard 'climate services toolkits'** - sets of bespoke software products including data portals, data management systems, analysis and prediction packages, together with accompanying training modules - that are specifically designed to support the generation and use of climate information and prediction products that meet the needs. The purpose will be to facilitate the production, communication and application of climate information products and avoid the possibility of proliferation of inconsistent and possibly sub-standard tools by implementing a set of standards and establishing a certification process for new tools. While this activity offers an excellent opportunity to set up uniform standards and enforce the same at the regional level, the efforts involved in producing toolkits relevant to the South Asian region cannot be underestimated.

- Another key element under this action for DFID will be to provide **support to Regional and National Climate Outlook forums**. There is limited evidence that these forums exist or are operating effectively in the target countries. DFID could consider providing support to these platforms to strengthen their presence and capacity, thus improving two way communication processes among NMHSs and end users in priority sectors. It will also be important to provide support to link the regional and national forums more effectively to South Asia Regional Centre of IMD, for technical capacity building and knowledge sharing (see p.17).

The **second priority** is to **strengthen regional and national observation network capacity.** When addressing observational requirements we suggest first concentrating the existing (or recent) networks, with a priority on those that have a climate record. Given the likely funding available, the programme should focus on the basic networks (i.e. surface manual observations) and then look to complement these with more automated measurements. Upper-air measurements are expensive and more difficult to sustain, but consideration should be given for areas with very sparse U/A observations on a regional scale. Projects to utilise observations from ‘new’ technology (i.e. aircraft) and from other institutes (i.e. agriculture) should be encouraged, as these often do not need additional infrastructure and staff, just money and a good data policy. We would not propose the installation of more complex instrumentations (i.e. weather radars) at this time, as the likelihood is that the NMHS is not capable of operating and maintaining these systems over the longer time periods. Unless the funding is going to provide ongoing support and maintenance (10+ years).

Some of key activities to operationalise the action are:

- **Support regional forecasting on various time scales through a more complete regional network, to provide better information for a range of applications,** including climate risk assessment. This appears pragmatic and constitutes a step wise approach towards enhancing regional cooperation on climate services. Options in this regard involve enhancing the role of the more advanced centres based in India, to support existing programmes under SAARC, SASFOF, FOCRAII, APAN etc. Alternatives would include more targeted activities supporting better regional integration of basic level NMHSs (Afghanistan, Burma, Nepal) and supporting their links with their own governments and bilaterally with neighbours and regional initiatives. There are other regional centres in East Asia and global producing centres (US, Japan, UK, France) and other developed NMHSs (Finland, Sweden, Denmark, Netherlands) that are already playing significant roles in supporting South Asian NMHSs.

- **Raise the capability of least developed NMHSs by at least one level.** In many of the target countries, the in-situ observations are insufficient in order to meet user needs and also the NMHSs services lack the infrastructure, resources and skills to operate these networks in an efficient and effective manner. So as an underpinning requirement we would suggest that any national and/or regional activity needs to assess the observational need (Satellite and In-Situ) and attempt to address the gaps, as far as resources allow. Based on WMO recommendations, raising the capacity of the least developed NMHSs by at least one level would requiring raising Afghanistan from ‘less than basic’ to ‘basic’ and Nepal and Burma from ‘basic’ to ‘essential’. Evidence indicates that there are opportunities to rehabilitate silent stations in these countries to bring them as close as possible to RBSN/RBCN. Support could also be extended for implementation of new networks and explore use of non-traditional observations such as using data from other sectors and new technologies such as mobile phone communications, aircraft communications, initiatives from other third parties, including general public. This may bring benefits to areas where conventional networks are sparse. This activity will have to be in tune with the respective current national plans for strengthening NMHSs and the ongoing collaborations. Automatic weather stations are proposed to be installed as integral components of climate projects in several countries. Similarly, the WMO's Integrated Observing Systems is working towards increase the sharing of observation networks that are not operated by country NMHSs (see Section 2.4).

- **Further research is required in regional climate modelling in South Asia, particularly with respect to modelling the monsoon, tropical cyclones and representation of complex topography.** There are a number of relevant recently completed and ongoing projects (Annexes 2 and 4) but initial learning should be drawn from the Met Office/Bangladesh project, which aims to produce downscaled 25km CMIP5 projections across the whole of South Asia. Research coul;d also draw on the South East Asia Climate Analysis & Modelling project (SEACAM), as well as relevant CORDEX initiatives. The outputs of this work should provide clear guidance on the information available, its strengths and weaknesses and examples of how it can be incorporated into decision making related to agriculture or DRR.

Priority Activities[23]	Scope	Timeframe	Opportunities	Challenges	Factors governing implementation	Complexity of implementation[24]
Strengthen capability of NMHS to supply demand oriented climate services						
Promote the development of a clear roadmap for climate services in South Asia tailored to the GFCS Framework and oriented to meet demand for information in the region	Regional	Long term	This will provide a useful bridge between the global and national frameworks Considerable scope for value addition and contribution to regional cooperation	Huge diversity (in infrastructure, technology, knowledge, capacities, human resources) in the state of development of climate services in different countries in the South Asia region Translating concept to operational reality has enormous challenges	Most challenging as geo political barriers are involved	3
Strengthen the capability of NMHSs to utilise available climate products from GPCs and RCCs for end-user interests	National	Short to medium term	High potential for value addition with modest investment (a 'low-hanging fruit') Can be effectively combined with other activities to strengthen NMHSs Existing standard tools publicly available, such as those from the UK National Climate Information Centre.	Not enough existing knowledge about whether products from GPCs and RCCs meet current and future needs , especially in countries with least developed NMHSs	A number of actors engaged in this area already, with a number of ongoing programmes and interventions Complexities of interventions are manageable Geo-political factors do not offer any serious barriers	1
Promote the development of standard climate services toolkits together with accompanying training modules designed to support the generation and use of climate information	National and Regional	Short to medium term	Good opportunity as this paves the way for effective regional exchanges and collaboration Helps set up standards and enforce the same at the	Efforts required to produce tool kits relevant to the South Asian region as a whole Requires complementary activities	Number of actors already engaged is possibly small An unexplored area No major geo-political	2

23 First, Second, Third

24 1 to 3 (Easy – Difficult – Most Challenging)

Priority Activities[23]	Scope	Timeframe	Opportunities	Challenges	Factors governing implementation	Complexity of implementation[24]
and prediction products that meet user needs, especially women and vulnerable groups			regional level Contributes to building gender equality and supporting the empowerment of women and vulnerable groups in decision making processes Avoid proliferation of substandard and inconsistent tools by implementing set of standards and establishing certification process for new tools	Deep rooted gender bias in countries of the region	barriers Can capitalise on the lessons already available and ongoing work at the regional (i.e. CCAFS) and global levels	
Support National Climate Outlook Forums and similar platforms to strengthen their presence and capacity and improve two-way communication between NMHSs and end users in priority sctors	National	Short to medium term	Is in the nature of improving interface between producers and users This is fundamental to effective functioning of regional climate outlook forums	No major challenge at the national level	No major geo political barriers at the national level Political will is required for effective functioning of the regional forums	1
Strengthen Regional and National Observational Network Capacity						
Support a more complete regional network for regional forecasting on various time scales and to provide better climate information for a range of applications including climate risk assessment	National/ Regional	Short to medium term	Closely linked with and complementary to the first priority action Offers good potential for enhancing the role of advanced regional Indian centres Opportunities to support existing programmes like SAARC, SASCOF,	Will need to be preceded by an assessment of the ground situation with regards to current infrastructure and capacity Will have to be in tune with national plans for strengthening NMHS and ongoing interventions This alone will not automatically lead to	A number of actors engaged in this area already, with a number of ongoing programmes and interventions Complexities of interventions are manageable Geo-political factors do not offer any serious barriers	2

Priority Activities[23]	Scope	Timeframe	Opportunities	Challenges	Factors governing implementation	Complexity of implementation[24]
			FOCRAII, APAN etc. Opportunity to strengthen regional integration of basic NMHSs like Afghanistan, Burma and Nepal, through regional and bi-lateral initiatives, as well as strengthening links with national governments Other regional and global providing centres, as well as other more developed NMHSs in the region, can be brought in as key partners	enhanced regional cooperation on climate services Considerable capacity building involved at the national level		
Raise the capability of least developed NMHSs (Burma, Afghanistan and Nepal) by at least one level, including the revival of silent stations, implementing new networks and exploring the use of non-traditional observations	National	Short to medium term	Opportunity to strengthen the base for a meaningful regional initiative towards effective and demand-based climate services Helps in integration of non-traditional observations and private sector networks Opportunities to join hands with the WMO, World Bank, JICA, ADB, USAID and others who are active in weather and climate services (including in strengthening infrastructure) in the region	Will have to be preceded by an assessment of the ground situation with regards to current infrastructure and capacity Will have to be in tune with current national plans for strengthening NMHSs and ongoing initiatives Resource intensive This step alone will not automatically lead to enhanced regional cooperation Considerable capacity building will be involved at	A number of actors are already engaged in this area, with ongoing programmes and interventions Complexities of actions are manageable No significant geo-political barriers	1

Priority Activities[23]	Scope	Timeframe	Opportunities	Challenges	Factors governing implementation	Complexity of implementation[24]
				the country level		
Support research to better understand RCM limitations when representing South Asia's complex topography at high resolution	Regional	Long term	Better application of regional models in weather forecasting and climate scenarios Initial learning should be drawn from the Met office / Bangladesh project	Long time to yield impact	Global climate research and development organisations better placed to support this research	3
Support innovative research programme that strengthens all aspects of weather and climate services, while building capacity of South Asia research community						
Launch an interdisciplinary research programme to respond to major knowledge gaps and build global-regional-national partnerships, learning and exchange. Priority areas include climate observations and monitoring, reconstruction of high resolution data, seasonal forecasting, and downscaling regional information and scenarios	Regional	Long Term	Inter-disciplinary research caters to knowledge gaps relating to both supply and demand side of climate information	Vast scope Take long time to yield meaningful results	Essentially a technical research area, better left to the global research and technical organisations working in climate sciences and services	1
Promote research to explore potential of index based insurance facilities in South Asia. In particular, building capacity for estimating medium and long term hazard risks and supporting development and testing of risk insurance products for low income sectors.	National / Regional	Long Term	Good 0opportunity to understand and address issues of risk transfer mechanisms to benefit the poor Can draw on work being undertaken in South East Asia, funded by the World Bank, GFDRR and ADB	Long time frame to yield results Index based insurance is effective only if backed by good functional infrastructure to provide information on indices Needs to be backed up by adequate re-insurance facilities	No significant geo-political barriers	1

Priority Activities[23]	Scope	Timeframe	Opportunities	Challenges	Factors governing implementation	Complexity of implementation[24]
				Appetite for climate/weather insurance in South Asia region still poor.		

Table 11 Preliminary Intervention Options for Strengthening the Supply of Climate Services

4.2 Strengthening Demand for Climate Services

A number of actions have been identified to improve various constraints related to meeting demand for and improving communication of climate services. These will be further explored, deliberated, validated and prioritised during the next stage of stakeholder consultations.

Based on the Evidence Review, the **first priority** is to **strengthen interface and relationships between providers of climate information and the intermediaries consisting, among others, of priority sector departments.** Key actions to operationalise this priority action include:

- **Increase and improve meaningful interactions among actors of the complex information** chain involving primary producers of climate and socio-economic information (e.g. WMO designated GPCs and RCCs), intermediaries (NMHSs, NGOs etc.) that process and add value to this information, making it more relevant and useful for different sectors and types of users. Given the fact that there is no way that a direct interface can exist between the primary producers and the end users, it is the intermediaries who will need to be strengthened and brought effectively into this loop. Formal mechanisms between institutions could be pursued, in particular relating to flood early warning systems and disaster preparedness be strengthened. DFID could also promote collaboration among scientific communities, policy makers and practitioners to identify knowledge gaps to co-design and co-produce knowledge and make science more readily available and accessible. Such a measure will enable better sectoral integration (as against generic level) of risk assessment, apart from enhancing relevance and enabling tailoring and targeting of the products. However, an important challenge in this area will be the current level of governance at the national and sub-national levels in different countries, necessitating considerable investments in capacity building and thinking in systems involving producers of climate information, priority sector authorities and users.

- Another crucial measure would be to **strengthen inter-country communication systems**, in particular for establishing early warning systems and disseminating information to priority users such as monsoon forum groups and the agriculture and health sectors. This activity offers potential of high dividend as it involves promotion of information and knowledge sharing on a regional basis, which is the basis of cooperation in DRR and effective early warning systems. There is considerable potential to join hands with efforts of SDMC (SAARC Disaster Management Centre), SAARC Met Research Centre and other initiatives, notably that of the World Bank. This measure, of course, will call for political commitments at the highest levels in the countries concerned.

- **Promoting 'de-securitisation' and declassification of trans-boundary water and climate and data information in South Asia** will be yet another key measure, to enhance public access to this information throughout the region. DFID could play an important role in promoting proactive disclosure of climate services information by government departments in the region. Funding research into experiences where this has led to improved efficiency of early warning systems, for example, including cost benefit analysis would strengthen the business case. However, this activity has high chances of running into geo-political barriers, as the countries of the region consider the flow details of trans-boundary rivers as sensitive information, in order to ensure that their bargaining power is not compromised during bilateral discussions on water sharing arrangements.

- **Building capacity to translate and interpret risk assessments into clear recommendations or plans of action in priority sectors**, including describing processes that generate exposure and vulnerability to current and future hazards. This activity offers considerable scope for influencing both climate information and generator and the intermediaries/ users with capacity building activities. Yet governance issues at different level could prove to be a key challenge, apart from diversity in terms of infrastructure, capacities, knowledge, skills, expertise, technologies, and institutions among countries.

The **second priority** will be to **strengthen regional networks to generate and disseminate knowledge on climate products and services**. Some of the key activities under this priority action will include:

- **Establish a region network to encourage cross-regional cooperation involving farmers associations, DRR practitioners and water user groups** to enhance the sharing and use of knowledge on climate products and services.
- Similarly, support could be extended for **establishment of regional advisory teams** comprising subject matter specialists in priority sectors and NMHSs to interact with end users on a regular basis, to help improve the relevance of climate information and services to their decision-making needs.
- On the same vein, **close collaboration and knowledge transfer between regional CORDEX** can be supported to strengthen the capabilities of stakeholders in each country, in providing efficient and useful climate services to the end-user communities.

Priority Activities[25]	Scope	Timeframe	Opportunities	Challenges	Factors governing implementation	Complexity of implementation[26]
Strengthen interface and relationships between providers of climate information, intermediaries and users, especially from priority sectors						
Increase and improve meaningful interactions among actors in complex information chain involving primary producers, intermediaries that process and add value add to this information, making it more relevant and useful for different sectors and types of users (p.	National	Short to Medium Term	Enables sectoral (rather than generic) risk assessment Enhances relevance and applicability of climate services, if made available on a timely basis Comprehensive risk information for effective decision making Helps in tailoring and targeting products Potential for linking into and benefiting from ongoing activities and programmes such as SHEAR, Global Flood Alliance, South Asia Disaster Knowledge Network	Weak governance at the national and sub-national levels in different South Asian countries Will involve considerable investments in capacity building and communication systems	Work already in progress in various countries at the national/ sub-national level Can capitalise on global experiences on the subject No major geo-political barriers anticipated	1
Strengthen inter-country communication systems and dissemination of climate information and services to priority users such as monsoon forum groups and the agriculture and health sectors	Regional	Medium to Long term	Facilitates regional cooperation on information sharing Essential for coordination of DRR and effective and sustainable early warning systems Potential to join hands with SAARC Disaster	Will require political commitment at the highest level and sustained engagement at a regional level Equal participation of all South Asian countries required for success	Complexities involved in design and implementation Geo-political barriers represent a considerable challenge Initial efforts could be limited to a few countries along trans-boundary	2

25 First, Second, Third

26 1 to 3 (Easy – Difficult – Most Challenging)

			Management Centre, SAARC Met Research Centre and other initiatives including those proposed by the World Bank (in Nepal, Bangladesh and Bhutan)		river basins (e.g. China, Nepal, India and Bangladesh) Lessons and experiences gained could be put to use for scaling-up into region-wide efforts	
Promote de-securitisation and declassification of trans-boundary water and climate and datea information in South Asia to enhance public access to this information and increase regional collaboration	National	Short Term to Medium Term	Offers immense potential for improving the effectiveness of early warning systems and disaster risk reduction, and eventually towards climate compatible development	Mistrust and extreme reluctance of the governments of the region to share water flow related information as regards trans-boundary rivers This information is treated as confidential and sensitive by governments to protect national interests during water sharing conflicts and negotiations Political will and transparency required at the highest level	Will involve considerable political will and sustained engagement	3
Support capacity building amongst priority user groups to translate and interpret risk assessments into clear recommendations or plans of action	National	Medium to Long Term	Offers considerable opportunity to improve take-up and use of existing tools by target user communities, as well as influence the design of future products Potential for creating a meaningful space for exchange and learning between producers of climate information together with users and intermediaries	Weak governance issues at different levels Diversity in terms of infrastructure, capacities, knowledge, skills, expertise, technologies and institutions in different countries among the key users of climate information and services	No major geo political constraints involved Would mean working with national and sub-national actors and capitalising on global experiences and lessons Part and parcel of National and Sub-National Climate Change Action Plans in many countries of the	1

			Fundamental for building the effectiveness of early warning, disaster risk reduction and climate adaptation efforts Twin benefits of DRR in the short term and climate adaptation in the long run Many potential partners could be brought on board e.g. World Banks, USAID, CGIAR, CSP		region	
Strengthen regional networks to generate knowledge on climate products and services						
Establish regional networks between farmers' associations, DRR practitioners and water user groups to enhance the exchange and use of climate knowledge products and services	National/ Regional	Short to medium term	Opportunities for promoting regional cooperation in climate services, on a sectoral basis, which is more effective Formation of regional user networks will help strengthen feedback mechanisms, thereby influencing the provision of climate services in such a way that they are in tune with the needs and priorities of different user communities ICTs available to facilitate networking	Regional networks are effective when they involve face-to-face meetings in addition to virtual exchanges. Travel regulations between countries of the regions (especially visa requirements) represent an important constraint.	Some experiences and lessons available on regional cooperation, especially in the area of water governance can feed into the design and planning of initiatives Otherwise, it is an area where not much information is currently available	2
Support the establishment of regional advisory teams comprising subject matter specialists in priority sectors and NMHSs to help	National/ Regional	Short to medium term	Opportunity to improve coordination with end users and enable service providers to design/modify their products their outputs	The interface and interactions between government departments and the NMHSs in most countries of the region are	Some experiences and lessons available on regional cooperation, especially in the area of water governance can	2

improve the relevance of climate information and services to priority sector decision making needs			in tune with the needs of users in priority sectors Will support cross-regional collaboration Regional advisory teams could provide an excellent platform for	weak and ineffective, even at the national level	feed into the design and planning of initiatives Otherwise, it is an area where not much information is currently available No significant geo political barriers	
Support collaboration and knowledge transfer between the regional CORDEX so as to strengthen the capabilities of stakeholders in each country in providing efficient and useful climate services to the end user communities	National/ Regional	Short to medium term	The CORDEX model is showing strong buy-in from the science community and is gaining momentum internationally Opportunity for DFID to support an on-going programme of work, especially building understanding around the value of regional climate information for decision making, building the pool of available data for downscaling and supporting sub-regional pilot studies (see Annex 4) CORDEX South Asia represents a key research partner		Opportunity to build on the successes and learning from CORDEX Africa No significant geo political barriers	2
Promote more effective use of ICT						
Supporting the integration of national climate information and ICT initiatives into everyday functioning of government, while at the same time investing in new and cost	National	Short to medium term	Opportunities in this area include high level of growth/innovation of ICTs for development in some countries of the region such as Bangladesh and India (e.g. Climate Services	High level of capacity building required ICT infrastructure will involve financial investments	A number of actors are already engaged in this area, with ongoing programmes and interventions that DFID could build on	1

effective information and communication technologies			through Community Radios)	High bandwidth connectivity will be required for some ICTs Rate of obsolescence of technologies is high	Complexities of actions are manageable No significant geo-political barriers	
Support scaling up of successful experiences where ICT tools have been used for more effective and efficient dissemination of climate information to end users	Regional/ National	Long term	Good opportunities for information and knowledge sharing on methods and methodologies Experiences are available in the region on effective use of ICT tools in dissemination of climate information Leveraging the full potential of ICTs for climate services, particularly agro-meteorological advisories to smallholders, would bring significant improvements in livelihoods in South Asia	Current capacity and infrastructure constraints will need to be dealt with High bandwidth connectivity required for some ICTs	Global climate research and development organisations better placed to support this research No significant geo-political barriers	2

Table 12 Preliminary Intervention Options for Strengthening Demand for Climate Services

4.3 Implications for the Proposed Programme

For any regional programme in South Asia to be effective, meaningful and relevant it will need to simultaneously address regional, sub-regional (multi-country), national and in a few cases even sub-national elements.

For example:

At the **regional level** (historical to climate change scales – broad and shallow):

a. Strengthen the supply of climate services/disaster risk assessment that brings together the best data sets, builds capacity in met services and increases interactions between intermediaries and end users
b. Work with existing organisations such as SASCOF, including establishing regional advisory groups
c. Promote regional data sharing through existing mechanisms and on selected pilots (see below)
d. Promote cross-regional research, learning and exchange to address on-going knowledge gaps e.g. index based insurance and linked to other programmes like SHEAR etc.

And at the **national level** (historical, sub-seasonal, seasonal scales – deep and narrow):

a. 3-5 national or local pilots in selected countries that require access to regional/cross-border data e.g. Afghanistan/Pakistan or Nepal/India/Bangladesh or Burma/India/China
b. Targeted improvements in observations in selected countries including the use of satellite data and reanalysis, as part of the same pilots. This could focus on the weaker NMHSs (Afghanistan, Burma, Nepal) and/or on building cooperation with stronger centres, particularly India
c. Demonstrate impacts of climate services tailored to vulnerable and marginalised sectors
d. Develop user groups, including NGOs

Types of activity cover the entire spectrum from information supply to communications, regional cooperation and decision-making responses. Both research and programmes are required because there are ongoing knowledge gaps, but also some good practice that is already showing effective and could be replicated/scaled-up (see Annex 4).

It is suggested that the sector focus could be on agriculture and DRR, bringing in health and floods where needed.

References

Agrawal, S. Davis, A. and Tall, A. 2014. Does climate information matter? An innovative tool to measure the value of climate services for farmers. News blog on the CCAFS/CGIAR website accessed April 2015.

AIDMI/IIASA. 2011. Impact Assessment of Disaster Microfinance for Pro-Poor Risk Management: Evidence from South Asia. AIDMI, Ahmedabad.

AIDMI. 2014. Summary Report on Reducing Underlying Risk Factors: Assessing the Effectiveness of Risk Insurance Post--- Cyclone Phailin in Odisha, India. AIDMI, Ahmedabad.

AIDMI. 2014. Briefing note from Summary Report on Reducing Underlying Risk Factors: Assessing the Effectiveness of Risk Insurance Post--- Cyclone Phailin in Odisha, India. AIDMI, Ahmedabad.

Alfani, F., Dabalen, A., Fisker, P., Molini, V. 2015. Can We Measure Resilience? A Proposed Method and Evidence from Countries in the Sahel. World Bank, Washington DC.

Arnold, M. / ProVention Consortium. 2008. The Role of Risk Transfer and Insurance in Disaster Risk Reduction and Climate Change Adaption. ProVention Consortium, Geneva.

ASEAN. 2015. ASEAN Shares Experience to SAARC in Setting up Regional Disaster Response Mechanisms. Accessed online May http://www.asean.org/news/asean-secretariat-news/item/asean-shares-experience-to-saarc-in-setting-up-regional-disaster-response-mechanisms 2015:

Asian Development Bank (ADB). 2013. Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific. Asian Development Bank, Manila.

Assocham India. Only 19 pc farmers are insured, exposing vast majority to weather vagaries: assocham-skymet study. Accessed April 2015: http://www.assocham.org/newsdetail.php?id=4923

Bangladesh Red Crescent Society. 2013. 2013 Identifying Gaps, Challenges and Limitations of Access of Women, Children and PWD of Nijhumdwip to Cyclone Early Warning Towards Rendering Improved Early Warning Services through CPP Dissemination Mechanism/System. BDRCS, Dhaka.

BASIX. 2010. Index Based Insurance. BASIX Experience. Workshop on developing index-based livestock insurance to reduce vulnerability due to drought-related livestock death. Addis Abbaba, Ethiopia, 12th July 2010.

CCAFS. 2013. Climate services for smallholder farmers: helping farmers cope with risk. CCAFS, Frederiksberg

CDKN/Wilkinson (2014) Risk-Informed Decision-Making: An Agenda for Improving Risk Assessments under HFA2. CDKN, London.

Chintan, G.S. 2011. Trans-boundary River Basins in South Asia: Options for conflict resolution. International Rivers, Berkeley. (http://www.internationalrivers.org/files/attached-files/transboundaryriverbasins.pdf)

Climate and Development Knowledge Network (2012). Managing Climate Extremes and Disasters in the Water Sector: Lessons from the IPCC SREX Report. CDKN, London.

Cramer, L. 2015. What do Women Farmers Want? Cramer, L. 2015. What do Women Farmers Want?

Dhungana, R. R. 2012. Status of Gender Inequalities in South Asia. Published on My Public Health blog, accessed April 2015.

Duryog Nivaran. 2014. Towards Post-2015 Agenda for DRR (HFA2) Women as a force in resilience building, gender equality in DRR Report of the Consultations in Asia Pacific. Duryog Nivaran, Colombo.

Economist Intelligence Unit (EIU). 2014. The South Asia Women's Resilience Index: Examining the role of women in preparing for and recovering from disasters. The Economist, London.

Emergency Events Database (EM-DAT: The OFDA/CRED International Disaster Database) (http://www.em-dat.net)

G20/OECD. 2012. Disaster Risk Assessment and Risk Financing A G20 / OECD Methodological Framework (http://www.oecd.org/gov/risk/G20disasterriskmanagement.pdf)

GCFS. 2015. Global Framework for Climate Services – Priority Areas. WMO, Geneva. (http://www.gfcs-climate.org/priority-areas)

Ghesquiere, F.,Mahul, O., Forni, M. and Gartley, R., 2006. Caribbean Catastrophe Risk Insurance Facility: A solution to the short-term liquidity needs of small island states in the aftermath of natural disasters. World Bank, Washington DC.

Gine, X., Townsend, R. and Vickery, J., 2007. Statistical Analysis of Rainfall Insurance Payouts in Southern India. In: American Journal of Agricultural Economics. 89 (5).

Global Water Partnership (GWP). 2014. Drought monitoring system for South Asia - Summary report of the need assessment survey on the development of South Asian Drought Monitoring System (SA DMS). (http://www.droughtmanagement.info/literature/GWP_SA_Summary_Report_Need_Assessment_Survey_2014.pdf)

Goh, A. H. X. 2012. A Literature Review of the Gender–differentiated Impacts of Climate Change on Women's and Men's Assets and Well-being in Developing Countries. Collective Action and Property Rights (CAPRi) Working Paper No. 106. CAPRi, Washington DC.

Government of India Ministry of Earth Science. 2015. India Meteorological Department and Power System Operation Corporation Ltd. (POSOCO) Signed MoU to Increase the Efficiency of Power Sector & to Make them Weather Proof. Press release, accessed May 2015: http://pib.nic.in/newsite/PrintRelease.aspx?relid=121836

HR Wallingford (2014) Caribbean and South Asian regional frameworks for water security and climate resilience: South Asia - Assessment and recommendations report, Climate Development Knowledge Network, March 2014

IPCC. 2007. limate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability. Projections of climate-change-related health impacts. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch8s8-4-1.html

IRIN. 2007. BANGLADESH: Megaphones save thousands. http://www.irinnews.org/report/75470/bangladesh-megaphones-save-thousands

Jay, A. and Hansen, J. 2013. Providing Climate Services that make Sense to Farmers. CCAFS News blog, accessed online April 2015.

Jones, S., Oven, K. J., Manyena, B., & Aryal, K. 2014. Governance Struggles and Policy Processes in Disaster Risk Reduction: A case study from Nepal. Geoforum, 57, 78-90.

Kapoor, A. 2011. Engendering the Climate for Change: Policies and Practices for Gender-Just Adaptation. Alternative Futures, New Delhi.

Kunreuther, H. and Erwann, M. K. 2008. Framework for Reducing Vulnerability to Natural Disasters: Ex Ante and Ex Post Considerations. Risk Management and Decision Process Centre, The Wharton School, University of Pennsylvania, Philadelphia.

May, S., Hansen, J. and Tall, A. 2013. Workshop Report: Developing a Methodology to Communicate Climate Services for Farmers At Scale. CCAFS, Frederiksberg

McOmber, C., Panikowski, A., McKune, S., Bartels, W-L. and Russo, S. 2013. Investigating Climate Information Services through a Gendered Lens. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) Working paper No. 42. CCAFS, Frederiksberg.

Mitchell, T., Tanner, T. and Lussier, K. 2007. We Know What We Need: South Asian Women Speak Out on Climate Change Adaptation. Action Aid, London.

MUNICH RE, 2010. Topics Geo - Natural catastrophes 2009: Analyses, assessments and positions. Munich Re, Munich.

MUNICH RE. 2011. Protecting Cooperatives and their Low-income Members in the Philippines against extreme weather events through micro-insurance. Press release: http://www.munichre.com/en/media_relations/press_releases/2010/2010_10_11_press_release.aspx>

National Research Council (NRC). 2010. Informing an Effective Response to Climate Change. America's Climate Choices: Panel on Informing Effective Decisions and Actions Related to Climate Change. National Research Council, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies. National Academies Press, Washington DC.

O'Connor, P.M. 2005. Recent Trends in the Catastrophic Risk Insurance / Reinsurance Market. OECD, Paris.

OECD. 2012. Disaster risk assessment and risk financing: A G20/OECD methodological framework. Paris: Organisation for Economic Co-operation and Development. OECD, Paris.

Pareek, S. 2015. How A Mobile Phone is Revolutionizing the Lives of Soya Farmers in Rajasthan. Accessed May 3015: http://www.thebetterindia.com/23501/a-mobile-based-initiative-to-monitor-soya-harvest-is-changing-the-lives-of-farmers-in-rajasthan/#sthash.bXNVS3Qg.dpuf

Prabhakar, S.V.R.K., G. S. Rao, K. Fukuda, and S. Hayashi. 2012. "Promoting risk insurance in the Asia-Pacific region: Lessons from the ground for the future climate region under UNFCCC". In Schmidt-Thome, P. and Knieling, J. *Implementing Climate Change Adaptation Strategies*. Blackwell Publishers, London.

Prabhakar, S.V.R.K., A. Abu-Bakar, C. Claudio and H.V. Hung. 2013. Scaling up Risk Financing in Asia and the Pacific Region: Bottom-up Lessons from Agriculture Insurance in Malaysia, Philippines and Vietnam. Asia Pacific Adaptation Network and Institute for Global Environmental Strategies, Hayama.

Prabhakar, S.V.R.K. 2014. "Evidence for Disaster Risk Reduction & Climate Change Adaptation Effectiveness of Insurance", IGES Workshop at Malaysia Proceeding.

Press Trust of India. 2015. Less than 20% farmers take crop insurance: Atudy. Accessed April 2015: http://www.business-standard.com/article/pti-stories/less-than-20-farmers-take-crop-insurance-study-115041200181_1.html

ProVention Consortium. 2009. Practice Review on Innovations in Finance for Disaster Risk Management. ProVention, Geneva.

Royal Society. 2014. Resilience to Extreme Weather. The Royal Society Science Policy Centre report 02/14. Royal Society, London.

Tall, A., Jay, A., Hansen, J. 2013. Scaling Up Climate Services for Farmers in Africa and South Asia Workshop Report. CCAFS Working Paper no. 40. CCAFS, Frederiksberg.

Tall, A. and Vaughan. C. 2013. Developing a Methodology to Evaluate Climate Services for Farmers. CCAFS News blog accessed online April 2015.

Tsuji, H., 1986. An Economic Analysis of Rice Insurance in Japan. In: P. Hazell, C. Pomareda and A. Valdez, eds. 1986. *Crop insurance for agricultural development: Issues and experience.* John Hopkins University Press, Baltimore.

UK Met Office. 2012. Developing Afghanistan's Meteorological Service. UK Met Office, London

UN. 2007. *Developing Index-Based Insurance for Agriculture in Developing Countries*. Sustainable Development Innovation Briefs 2. UN, New York.

UN. 2015. Global Assessment Report on DRR: Making Development Sustainable, the Future of DRM. UN, New York.

UNDP. 2014. 2014 Human Development Statistical Tables: Gender Inequality Index. UNDP, New York

UNDP. 2014a. Early Warning: Saving Lives in India. http://www.in.undp.org/content/india/

en/home/ourwork/crisispreventionandrecovery/early-warning--saving-lives-in-india.html

UNFCCC. 2011. Cancun Adaptation Framework. UNFCCC, Bonn.

UNISDR. 2005. Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. UNISDR, Geneva.

UNISDR. 2012. Disaster Risk and Resilience. Thematic Think Piece, UN System Task Force on the Post-2015 UN Development Agenda. UNISDR, Geneva.

UNISDR. 2013. Global Assessment Report 2013. UNISDR, Geneva.

UNISDR. 2015a. Concept Note for Working Session of UN World Conference on DRR (Sendai) on Applying Science and Technology to DRR Decision-Making. UNISDR, Geneva.

UNISDR. 2015b. Science and Technical Advisory Group Report: Science Is Used For Disaster Risk Reduction. UNISDR, Geneva.

Vitart, F, Andrew W. Robertson and David L. T. Anderson, WMO Bulletin, Volume 61(2), 2012

WCDRR. 2015. Sendai Framework for Disaster Risk reduction 2015-2030. (www.wcdrr.org/uplads/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf)

WEDO. 2008. Gender, Climate Change and Human Security. Lessons from Bangladesh, Ghana and Senegal. WEDO, New York.

World Economic Forum (WEF). 2009. The Global Gender Gap Report. WEF, Geneva.

WMO. 2014. Implementation plan of the Global Framework for Climate Services WMO (2014b) Meeting on the Implementation and Coordination of the GFCS. Geneva 29th September to 1st October 2014.

WMO. 2015. Definitions of Meteorological Forecasting Ranges. Accessed May 2015: http://www.wmo.int/pages/prog/www/DPS/GDPS-Supplement5-AppI-4.html

World Bank. 2005. Natural Disaster Hotspots, A Global Risk Analysis. World Bank, Washington DC.

World Bank. 2008. Risk transfer options for poor and vulnerable. Workshop on Building Community-Based Risk Management and Responses to Natural Disasters, Bangkok, Thailand, June 10-13, 2008.

World Bank. 2009. Natural hazards, unnatural disasters: the economics of effective prevention. The World Bank and United Nations, Washington DC.

World Bank. 2011. Innovation in Disaster Risk Financing for Developing Countries: Public and Private Contributions.

World Bank. 2012. Disaster Risk Management in South Asia: A Regional Overview. World Bank, Washington DC.

World Bank. 2015. Bangladesh Regional Weather and Climate Services Project. World Bank, Washington DC.

World Meteorology Organization (WMO). 2011. Report of the high-level taskforce for the global framework for climate services: a global framework for climate services empowering the most vulnerable climate knowledge for action. WMO, Geneva.

WMO. 2015. Empowering Women Strengthens Climate Response: WMO, Related material based on Conference on Gender Dimensions of Weather and Climate Services. WMO, Geneva.

Yee, A. 2013. In Bangladesh, More Shelter from the Storm. Opinionator blogspot accessed April 2015.

Email correspondence with Kamala Gurung, Gender and Social Inclusion Expert, Practical Action South Asia

Section 3: Demand for Climate Information

Ashok Kumar. 2013. Timely weather info to improve farm incomes. One World South Asia. http://southasia.oneworld.net/news/weather-info-to-help-indian-farmers-raise-their-income#.VRjm5M0rAT8. Accessed April 2015.

Ghebreyesus, T.A., Z. Tadese, D. Jima, E. Bekele, A. Mihretie, Y.Y. Yihdego, T. Dinku, S.J. Connor and D.P. Rogers. 2008. Public health and weather services–climate information for the health sector, WMO Bulletin 57 (4): 256 – 261.

Human Health: http://www.climate.org/topics/health.html.

Jagtap, S.S., J.W. Jones, P. Hildebrand, D. Letson, J.J. O'Brien, G. Podesta, D. Zierden, F. Zazueta. 2002. Responding to stakeholder's demands for climate information: from research to applications in Florida, Agricultural Systems 74: 415–430.

Kumar K. K., Kumar K. R., Ashrit R. G., Deshpande N. R., Hansen J. W. 2004. Climate Impacts on Indian Agriculture. Int. J. Climatol. 24, 1375–1393.

Rogers, D., and Tsirkunov, V. 2013. Weather and Climate Resilience: Effective Preparedness through National Meteorological and Hydrological Services. Directions in Development. World Bank, Washington DC.

Sivakumar M. V. K., Das H. P., Brunini O. 2005 Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics. Clim. Change 70, 31–72

Sonka, S.T., Changnon Jr., S.A., and Hofing, S.L., 1992. How Agribusiness Uses Climate Predictions: Implications for climate research and provision of predictions. Bull. Am. Meteor. Soc. 73, 1999–2008. USDA, 1997. Georgia County-Level Data. In: Census of Agriculture, 1(10).

WMO – Agriculture: https://www.wmo.int/pages/themes/climate/applications_agriculture.php

WMO – Water sector: https://www.wmo.int/pages/themes/climate/applications_water.php

Section 2: Supply of Climate Information

APCC Asia Pacific Economic Cooperation Climate Center brochure.

Asian Disaster Preparedness Center (ACDP) and United Nations Development Programme (UNDP) (2006) A primer for integrated flood risk management in Asia

Bangladesh Telecommunication Regulatory Commission (BTRC) (2013). Mobile phone subscribers in Bangladesh.

BBC news, 4th August 2013: Pakistan and Afghanistan monsoon floods kill dozens. www.bbc.co.uk/news/world-asia-23568689 [accessed 01 April 2015]

Bharati, L., G. Lacombe, P. Gurung, P. Jayakody, C.T. Hoanh, and V. Smakhtin, 2011: The Impacts of Water Infrastructure and Climate Change on the Hydrology of the Upper Ganges River Basin. *IWMI Research Report 142, International Water Management Institute (IWMI), Colombo, Sri Lanka,* 36 pp.

Boos, W.R. and Kuang, Z., 2010: Dominant control of south Asian monsoon by orographic insulation versus plateau heating. *Nature*, **463,** 218-222.

Cai, X., B.R. Sharma, M.A. Matin, D. Sharma, and S. Gunasinghe, 2010: An Assessment of Crop Water Productivity in the Indus and Ganges River Basins: Current Status and Scope for Improvement. *IWMI Research Report 140, International Water Management Institute (IWMI), Colombo, Sri Lanka*, 22 pp.

Chaudhary, A. (2013). India flood forecast spending may rise five-fold after deaths. Available at: http://www.livemint.com/Politics/TIwKygeMrbw6Zom7Y632jL/India-flood-forecast-spending-may-rise-fivefold-after-death.html Accessed [21 November 2013]

DRR Working Group Myanmar (2014) Strategic Framework 2013-18.

Dulal, H.B., 2014: Governing climate change adaptation in the Ganges basin: assessing needs and capacities. *INTERNATIONAL JOURNAL OF SUSTAINABLE DEVELOPMENT AND WORLD ECOLOGY,* **21(1)**, 1-14.

Gautam, D.K. (2011). Web-based real time data acquisition system for flood early warning. National stakeholders workshop on weather forecasting and flood early warning system in Nepal, 8 April 2011, Kathmandu.

Ghawana, T. and Minoru, K. (2015) Indian flood management: a report on institutional arrangements, January 2015 Available at: http://whrm-kamoto.com/assets/files/TARUN%20MINORU-ICHARM%20REOPRT%20ON%20INDIAN%20FLOOD%20MANAGEMENT%20INSTITUTIONS%20JANUARY%202015.pdf [Accessed 31 March 2015]

GoN (2009) Government of Nepal Ministry of Home Affairs National Strategy for Disaster Risk Management, 2009

Government of India (2015) India - China co-operation: Memorandum of understanding on hydrological data sharing on River Brahmaputra/Yaluzangbu Available at: http://wrmin.nic.in/forms/list.aspx?lid=349 [Accessed 31 March 2015]

Gunawardene, N. (2014) South Asia analysis: Space diplomacy can boost development, 23 July 2014, SciDevNet Available at: http://www.scidev.net/south-asia/enterprise/analysis-blog/south-asia-analysis-space-diplomacy-can-boost-development.html [Accessed 31 March 2015]

Habib, H., Shahidullah, M. and Ahmed, D. (2012) *The Bangladesh cyclone preparedness programme: A vital component of the nation's multi-hazard early warning system*, in: Golnaraghi, M. (eds.) *Institutional partnerships in multi-hazard early warning systems,* Springer, New York.

Haq, R. and Nibanupudi, H.K. (2013) South Asia: The need to enhance cross border risk communication, Journal of Risk and Crisis Communication

Haque, U., Hashizume, M., Kolivras, K., Overgaard, H., Das, B. and Yamamoto, T. (2011). *Reduced death rates from cyclones in Bangladesh: what more needs to be done?* Bulletin of the World Health Organization. Available at: http://www.who.int/bulletin/volumes/90/2/11-088302/en/ [Accessed 21 November 2013].

Hassell, D., and Jones, R., 1999: Simulating climatic change of the southern Asian monsoon using a nested regional climate model (HadRM2). Hadley Centre Tech. Rep. HCTN 8, 46 pp

He, D., Wu, R., Feng, Y., Li, Y., Ding, C., Wang, W., and Yu, D. W. (2014) China's transboundary waters: New paradigms for water and ecological security through applied ecology, Journal of Applied Ecology, Volume 51, Issue 5, pages 1159–1168, October 2014

Heeks, R. and Ospina, A.V. (2012a) ICTs, climate change and development: Themes and strategic actions

Heeks, R. and Ospina, A.V. (2012b) ICTs, climate change and development: Case evidence Available at: https://www.escholar.manchester.ac.uk/api/datastream?publicationPid=uk-ac-man-scw:176883&datastreamId=FULL-TEXT.PDF [Accessed 31 March 2015]

Hewitt, C., Mason, S. and Walland, D. 2012. The Global Framework for Climate Services. Nature C Nature Climate Change 2,831–832. doi:10.1038/nclimate1745

Hijioka, Y., E. Lin, J.J. Pereira, R.T. Corlett, X. Cui, G.E. Insarov, R.D. Lasco, E. Lindgren, and A. Surjan, 2014: Asia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1327-1370.

Hussain, S.S. and M. Mudasser, 2007: Prospects for wheat production under changing climate in mountain areas of Pakistan – an econometric analysis. *Agricultural Systems*, **94(2)**, 494-501.

Immerzeel, W.W., van Beek, L.P.H., Bierkens, M.F.P., 2010: Climate Change Will Affect the Asian Water Towers. *Science*, **328**, 1382-1385. doi: 10.1126/science.1183188

Christensen, J.H., K. Krishna Kumar, E. Aldrian, S.-I. An, I.F.A. Cavalcanti, M. de Castro, W. Dong, P. Goswami, A. Hall, J.K. Kanyanga, A. Kitoh, J. Kossin, N.-C. Lau, J.

Renwick, D.B. Stephenson, S.-P. Xie and T. Zhou, 2013: Climate Phenomena and their Relevance for Future Regional Climate Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Islam, A.S., Attwood, S.; ,Braun, M., Kamp, K. and Aggarwal, P., 2013: Assessment of capabilities, needs of communities, opportunities and limitations of weather forecasting for coastal regions of Bangladesh. WorldFish, Penang, Malaysia. Project Report 2013-35.

Islam, S.R., and Dhar, S.C. (2000) *Bangladesh floods of 1998: Role Of flood forecasting and warning centre*, BWDB, Dhaka.

Jay, A. and Hansen, J. (2013) Providing climate services that make sense to farmers, 13 April 2013, Available at: http://ccafs.cgiar.org/blog/providing-climate-services-make-sense-farmers [Accessed 31 March 2015]

Jha, A., Bloch, R. and Lamond, J. (2012) Cities and flooding: A guide to integrated urban flood risk management for the 21st Century. World Bank, Washington. ISBN (electronic): 978-0-8213-9477-9

Jones, L. and Boyd, E. (2011) Exploring social barriers to adaptation: insights from Western Nepal. Global Environmental Change, 21 (4). pp. 1262-1274. ISSN 0959-3780 doi: 10.1016/j.gloenvcha.2011.06.002

Khadka, N.S. (2013) South Asia disunity 'hampers flood warnings', 19 July 2013, Available at: http://www.bbc.co.uk/news/science-environment-23358255 [Accessed 31 March 2015]

Knox, J., T. Hess, A. Daccache, and T. Wheeler, 2012: Climate change impacts on crop productivity in Africa and South Asia. *Environmental Research Letters*, **7(3)**, 034032, doi:10.1088/1748-9326/7/3/034032.

Kumar, R., Naja, M., Pfister. G.G., Barth, M.C., Wiedinmyer. C. and Brasseur. G.P., 2012: Simulations over South Asia using the Weather Research and Forecasting model with Chemistry (WRF-Chem): chemistry evaluation and initial results. *Geosci. Model Dev*., **5**, 619—648.

Lal, M., 2011: Implications of climate change in sustained agricultural productivity in South Asia. *Regional Environmental Change*, **11**, S79-S94.

Lasco, R.D., C.M.D. Habito, R.J.P. Delfino, F.B. Pulhin, and R.N. Concepcion, 2011: Climate Change Adaptation for Smallholder Farmers in Southeast Asia. *World Agroforestry Centre, Laguna, Philippines*, 65 pp.

Lasco, R.D., R.V.O. Cruz, J.M. Pulhin, and F.B. Pulhin, 2010: Assessing Impacts, Vulnerability and Adaptation: The Case of Pantabangan-Carranglan Watershed. *Nova Science Publishers, New York, NY, USA,* 167 pp.

Lumbroso, D., Hurford, A., Winpenny, J., and Wade, S. (2014) Harnessing hydropower: Literature review, August 2014

Lumbroso, D., Rance, J., Pearce, G. and Wade, S. (2014) Science for Humanitarian Emergencies and Resilience (SHEAR) scoping study: Final report, Evidence on Demand, March 2014

Memon, N. (2012) Disasters in South Asia – A regional perspective, ISBN 978-969-9153-12-9

Met Office (2012). Islamic Republic of Afghanistan. A Sustainable and Independent National Meteorological Service.

Mirza Q., Dixit A. and Nishat A. (2003) *Flood problems and management in South Asia*. Kluwer Academic Publishers, Dordrecht.

Mittal, S. and Mehar, M. (2013) Agricultural information networks, information needs and risk management strategies: A survey of farmers in Indo-Gangetic Plains of India, Socio-economics, Working paper 10, October 2013

Ngoundo, M., C.E. Kan, Y.C. Chang, S.L. Tsai, and I. Tsou, 2007: Options for water saving in tropical humid and semi-arid regions using optimum compost application rates. *Irrigation and Drainage*, **56(1)**, 87-98.

Ortiz, R., K.D. Sayre, B. Govaerts, R. Gupta, G.V. Subbarao, T. Ban, D. Hodson, J.M. Dixon, J. Iván Ortiz-Monasterio, and M. Reynolds, 2008: Climate change: can wheat beat the heat? *Agriculture, Ecosystems & Environment*, **126(1-2)**, 46-58.

Pal, J.S., Giorgi, F., Bi, X., Elguindi, N., Solmon, F., Rauscher, S.A., Gao, X., Francisco, R., Zakey, A., Winter, J., Ashfaq, M., Syed, F.S., Sloan, F.C., Bell, J.L., Diffenbaugh, N.S., Karmacharya, J., Konaré, A., Martinez, D., da Rocha, R.P. and Steiner, A.L., 2007: Regional climate modeling for the developing world: the ictp regcm3 and regcnet. *Bull. Amer. Meteor. Soc.*, **88**, 1395–1409. doi: http://dx.doi.org/10.1175/BAMS-88-9-1395

Paul, K.M. (2009) Why relatively fewer people died? The case of Bangladesh's Cyclone Sidr, Natural Hazards, August 2009, Volume 50, Issue 2, pp 289-304

Peras, R.J.J., J.M. Pulhin, R.D. Lasco, R.V.O. Cruz, and F.B. Pulhin, 2008: Climate variability and extremes in the Pantabangan-Carranglan Watershed, Philippines: assessment of impacts and adaptation practices. *Journal of Environmental Science and Management*, **11(2)**, 14-31.

Price, G., Alam, R., Hasan, S. Humayun, F., Kabir, M., Karki, C. Mittra, S. Saad, T., Saleem, M., Saran, S. Shakya, P., Snow, C. and Tuladhar, S. (2014) Attitudes to water in South Asia, Chatham House Report, ISBN 978 1 78413 012 1

Rai, N. and Smith, B. (2013) Climate Investment Funds: Pilot Programme for Climate Resilience (PPCR) in Bangladesh – a status review. IIED Country Report.

Ramakrishna, Y.S. (2013) Current status of agrometeorological services in South Asia, with special emphasis on the Indo-Gangetic Plains. CCAFS Working Paper No. 53., Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available at: http://cgspace.cgiar.org/handle/10568/33842 [Accessed 31 March 2015]

Ranger, N., S. Hallegatte, S. Bhattacharya, M. Bachu, S. Priya, K. Dhore, F. Rafique, P. Mathur, N. Naville, F. Henriet, C. Herweijer, S. Pohit, and J. Corfee-Morlot, 2011: An assessment of the potential impact of climate change on flood risk in Mumbai. *Climatic Change*, **104(1)**, 139-167.

Rao, D. B., Ashok, K. and Yamagata, T., 1994: A numerical simulation study of the Indian summer monsoon of 1994 using NCAR MM5. J. *Meteor. Soc. Japan*, **82**, 1755–1775.

Ratnakumar, P., V. Vadez, L. Krishnamurthy, and G. Rajendrudu, 2011: Semi-arid crop responses to atmospheric elevated CO2. *Plant Stress*, **5(1)**, 42-51.

Republic of the Union of Myanmar (RUM) (2012) Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change

Royal Haskoning (2014) Myanmar IWRM Strategic Study December 2014 Research and Analysis, Strategies and Measures. A report prepared by Dutch government as part of bilateral collaboration with Myanmar. http://nwp.nl/_docs/nieuwsbrief_bijlagen/2014dec_myanmarstudy.pdf

Rahmat, R., Archevarahuprok. B., Kang, C.P.,Xiang, C.J., Hein, D., Gunawan, D., Buonomo, E., Redmond, R., Sidup, H., Sirabaha, H., Swe, H., Dash, I., Yee, J.L.S., Rizal, J., Sitthichivapak, K., Subramaniam, K., Dagar, L., Neng, L.J., Kwok; L.J., Ho, L., Khiem, M.V., Palmer, M., Im, M.S., Mazuki, M.Y.A., Tieh, N.S., Thanh, N.D., Husain, S.A.H., Shahid, S., Tucker, S, Srivatsan, V., Chinvanno, S., Cinco, T.A., Thanh, T.T., Hoa, V.V. and Soe, W., 2014: A Regional Climate Modelling Experiment for Southeast Asia: Using PRECIS regional Climate Model and selected CMIP3 Global Climate Models.

Shankar, M. (2013). *India beats a cyclone*. Available at: http://www.ipsnews.net/2013/10/india-beats-a-cyclone/ [Accessed 28 November 2013].

Singh, R. (2012) Real time flood forecasting - Indian experiences Available at: http://gwadi.org/sites/gwadi.org/files/Singh_L11.pdf [Accessed 31 March 2015]

Sivakumar, M.V.K., Collins, C., Jay, A., and Hansen, J. (2014) Regional priorities for strengthening climate services for farmers in Africa and South Asia, CCAFS Working Paper no. 71. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark

Srivastava, A., S. Naresh Kumar, and P.K. Aggarwal, 2010: Assessment on vulnerability of sorghum to climate change in India. Agriculture, *Ecosystems and Environment*, **138(3-4)**, 160-169.

Surie, M. and Prasai, S. (2015). Strengthening transparency and access to information on transboundary rivers in South Asia, The Asia Foundation, New Delhi.

Syed, F.S., Iqbal, W., and Syed, A. and Rasul, G., 2014: Uncertainties in the regional climate models simulations of South-Asian summer monsoon and climate change. *Climate Dynamics*, **42**, 2079-2097. doi: 10.1007/s00382-013-1963-x

Webster, P. (2013) Meteorology: Improve weather forecasts for the developing world. Nature 493, pp17–19

Webster, P. J., Magana, V.O., Palmer, T.N., Shukla, J., Tomas, R.A., Yanai, M, and Yasunari, T., 1998: Monsoons: Processses, predictability, and the prospects for prediction. *J. Geophys. Res.,* **103,** 14 451–14 510.

Wilby, R. (2009) Climate for Development in South Asia (ClimDev-SAsia): An inventory of cooperative programmes and sources of climate risk information to support robust adaptation, 7 September 2009

World Bank (2009) Natural hazards, unnatural disasters: the economics of effective prevention. The World Bank and United Nations, Washington DC.

World Bank (2012). Disaster Risk Management in South Asia: A Regional Overview. World Bank, Washington DC.

World Bank (2014) Ganges strategic basin assessment: A discussion of regional opportunities and risks, Report no. 67668-SAS, World Bank, Washington DC, USA

World Bank (2015) Project information document concept stage, Bangladesh regional weather and climate services project, Report no: PIDC18262

World Meteorological Organization (WMO) (2014) Implementation plan of the Global Framework for Climate Services WMO (2014b) Meeting on the Implementation and Coordination of the GFCS. Geneva 29th September to 1st October 2014.

World Metrological Organisation WMO (2013). Early warning systems saves millions of lives. A WMO factsheet. Available at: http://www.wmo.int/pages/prog/drr/events/GPDRR-IV/Documents/FactSheets/FS_nhews.pdf. [Accessed 21 November 2013].

Annex 1 Stakeholder Engagement

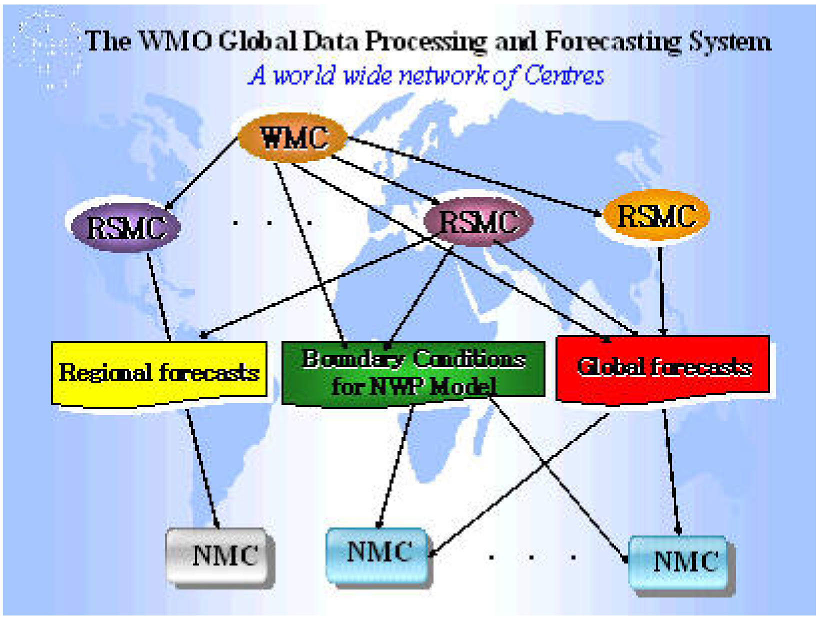
Stakeholders consulted/contacted for the Evidence Review (consultation pending in green)

Name	Position/Institution
Dr. Vidhisha Samarasekara	Senior Climate Change Specialist, ADB
Arif Md. Faisal	Environment Specialist, ADB
Prof Dr Syed Anwarul Huque	Professor (Retired), Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh. Formerly Senior Agriculture Specialist, Bangladesh Centre for Advanced Studies (BCAS)
Tohidul Islam	Associate Specialist Engineer Flood Management Division Institute of Water Modelling (IWM)
Dr Kamala Gurung	Gender and Social Inclusion (GESI) Coordinator, Practical Action South Asia Regional Office
Farhana Shamin	Programme Manager, Practical Action Bangladesh
Nicola Jenns	Climate and Environment Advisor, DFID
Tim Waites	Senior Livelihoods Advisor, DFID
Sarah Brown	Lead Consultant and International Projects Manager, Climate Change Adaptation and Disaster Risk Reduction, Practical Action Consulting
Nicola Ranger	Climate and Environment Advisor, DFID
MVK Shivakumar	World meteorological Organization, Geneva
LS Rathore	Director General, India Meteorological Department
BP Yadav	Scientist, India Meteorological Department
KK Singh	Director, Agromet Unit, India Meteorological Department
Leo Sebastian	Regional program leader, CCAFS, Southeast Asia
Udaya Regmi	International Federation of Red Cross and Red Crescent Societies (IFRC) Burma
Catriona Clunas	DESA Livelihoods Advisor, DFID Burma
Noriko Takagi	Deputy Representative, UNHCR Burma
Mr.Kyaw Lwin Oo	Director, Name and type of organisation1 Department of Meteorology and Hydrology, Burma
Ahmed Kamal	Member, National Disaster Management Authority (NDMA), Pakistan
Dr. Qazi Talat	Director, Federal Flood Commission (FFC), Pakistan
Zahid Mahmood	Director, Water and Power Development Authority (WAPDA), Pakistan
Dr. Azmat Hayyat	Director, National Drought Monitoring Centre, PMD, Pakistan
Adil Naseer	Coordinator, APGA, All Pakistan Geoscientists Association, Pakistan
Dr. Sajidin Hussain	Senior Programme Officer, Area Development and Management Consulting (ADMC), Pakistan
Dr. Bushra	Associate Professor, Department of Environment International Islamic University, Pakistan
Chaudhry M. Aslam	Director, Agro-Meteorological Centre, Pakistan
Mr. Muhammad Munir Sheikh	Head, Climatology & Environment Section, Global Change Impact Studies Centre (GCISC), Pakistan
Dr. Muhammad Mohsin Iqbal	Head, Coordination & Agriculture Section, Global Change Impact Studies Centre (GCISC), Pakistan
Mr. Mujahid Hussain	Director, People Empowering & Development Alternatives (PEDA), Pakistan
Peter Burgess	ECHO New Delhi
Ned Garnett	NERC
Lizzie Garett	NERC
Dr Nafees Meah CChem	Director, Research Councils UK (RCUK) India
Mr. Davide Zappa	DRR Technical Expert Asia/Pacific, EU
Edward Turvil	EU

Name	Position/Institution
Juliet Field	BRACED, DFID
Undala Alam	Water and SAWG programme, DFID
Fergus McBean	CHASE, DFID
Peter D'Souza	CHASE, DFID
Sam Rose	DFID Nepal
Dan Acycliffe	DFID Bangladesh
Helene O'Connor	DFID Bangladesh
Amirtham Ganguly	DFID India
Susil Perera	Red Cross Climate Change
Ariana Pelham	DFID Pakistan
Poppy Whitfield	DFID Pakistan
Louise Horner	DFID Afghanistan
Elaine Jepsen	DFID Afghanistan
James Purcel	DFID Afghanistan
Ashley Sarangi	DFID Burma
Aloke Barnwal	DFID India
Edward Turvill	ECHO EU Bangkok
Ali Sheikh	CDKN Pakistan
Catharine Vaughan	IRI Colombia University
Lisa Goddard	IRI Colombia University
Haresh Bhojwani	IRI Colombia University
Rob Wilby	UK
Rob Wilby	UCT
Walter Immerzeel	Future Water Group the Netherlands
ADPC	Bangkok
ODI/CDKN	London
Roger Street	Oxford University
Kai Kim Chiang	CPGD Project, OPML New Delhi
Ancha Srinivasan	Asian Development Bank
Cindi Malvicini	Asian Development Bank
Charles Rodgers	Asian Development Bank
Arnaud Cauchois	Asian Development bank
Arghya Roy	Asian Development Bank
Cinzia Losenno	Asian Development Bank
Bill Young	World Bank
Marcus Moench	ISET USA

2.1 Global Data Processing and Forecasting

The Global Data-Processing and Forecasting System



Purpose

The main purpose of the Global Data-processing and Forecasting Systems (GDPFS) shall be to prepare and make available to Members in the most cost-effective way meteorological analyses and forecast products. The design, functions, organizational structure and operations of the GDPFS shall be in accordance with Members' needs and their ability to contribute to and benefit from the system.

Organization

It is organized as a three-level system of: World Meteorological Centres (WMCs), Regional Specialized Meteorological Centres (RSMCs) and National Meteorological Centres (NMCs), which carry out GDPFS functions at the global, regional and national levels, respectively. The GDPFS shall also support other WMO Programmes and relevant programmes of other international organizations in accordance with policy decisions of the Organization.

Real-time Functions

- Pre-processing of data, e.g. retrieval, quality control, decoding, sorting of data stored in a database for use in preparing output products;
- Preparation of analyses of the three-dimensional structure of the atmosphere with up-to-global coverage;
- Preparation of forecast products (fields of basic and derived atmospheric parameters) with up-to-global coverage for one to 10 days ahead;
- Preparation of specialized products such as limited area very fine-mesh

Non-real-time Functions

- Preparation of special products for climate-related diagnosis (i.e. 10-day or 30-day means, summaries, frequencies and anomalies) on a global or regional scale;
- Intercomparison of analysis and forecast products, monitoring of observational data quality, verification of the accuracy of prepared forecast fields, diagnostic studies and NWP model development;
- Long-term storage of GOS data and GDPFS products, as well as verification results for operational and research use;

short-, medium-, extended-, and long-range forecasts, tailored products for marine, aviation, environmental quality monitoring, and other purposes;

- Monitoring of observational data quality.
- Post-processing of NWP data using workstation and PC based systems with a view to producing tailored value added products and generation of weather and climate forecasts directly from model output.
- Maintenance of a continuously updated catalogue of data and products stored in the system;
- Exchange between GDPFS centres of ad hoc information via distributed data bases;
- Conduct of workshops and seminars on the preparation and use of GDPFS output products.

WMO has officially designated 12 GPCs of Long-Range Forecasts:

1. Beijing: China Meteorological Administration (CMA) / Beijing Climate Center (BCC)
2. Center for Weather Forecasts and Climate Studies (CPTEC) / National Institute for Space Research (INPE), Brazil
3. European Centre for Medium-Range Weather Forecasts (ECMWF)
4. Exeter: Met Office, United Kingdom
5. Melbourne: Bureau of Meteorology (BOM), Australia
6. Montreal: Meteorological Service of Canada (MSC)
7. Moscow: Hydrometeorological Centre of Russia
8. Pretoria: South African Weather Services (SAWS)
9. Seoul: Korea Meteorological Administration (KMA)
10. Tokyo: Japan Meteorological Agency (JMA) / Tokyo Climate Centre (TCC)
11. Toulouse: Météo-France
12. Washington: Climate Prediction Center (CPC) / National Oceanic and Atmospheric Administration (NOAA), United States of America

In addition to the institutions referenced above, WMO has also designated the following Lead Centres:

1. WMO Lead Center for Long-Range Forecast Multi-Model Ensemble (LC-LRFMME) jointly coordinated by KMA and CPC/NOAA
2. WMO Lead Center for Standard Verification System of Long-Range Forecasts (LC-SVSLRF) jointly coordinated by BOM and MSC

GPCs provide the following products as a minimum:

- Predictions for averages, accumulations, or frequencies over 1-month periods or longer (typically anomalies in 3-month-averaged quantities is the standard format for seasonal forecasts, and forecasts are usually expressed probabilistically)
- Lead time: between 0 and 4 months
- Issue frequency: monthly or at least quarterly
- Delivery: graphical images on GPC website and/or digital data for download
- Variables: 2m temperature, precipitation, Sea Surface Temperature (SST), Mean Sea-Level Pressure (MSLP), 500hPa height, 850hPa temperature
- Long-term forecast skill assessments, using measures defined by the SVSLRF.

2.2 Regional Climate Centres in Asia

Regional Association II (RA II – Asia) is served by a collection of RCCs having pan-Asian as well as sub-regional interests, which have established a joint portal (http://www.rccra2.org/) that provides links to the various RCC products and services in RA II. The portal also includes a link to the APEC Climate Center (APCC), another key institution providing regional climate monitoring and prediction products. The following are the basic details of the two formally designated WMO RCCs in RA II:

RCC Beijing
Beijing Climate Center (BCC)
http://bcc.cma.gov.cn
Location: Beijing, China
Domains of interest: East Asian Monsoon and all Asia for monitoring extremes.

RCC Tokyo
Tokyo Climate Center (TCC)
http://ds.data.jma.go.jp/tcc/tcc/index.html
Location: Tokyo, Japan
Domain of interest: All Asia and Western Pacific (40N-20S, 30E-180)

India Meteorological Department (IMD)
http://www.imdpune.gov.in/climateoutlook/cli_index.html
Location: Pune, India

India Meteorological Department (IMD) commenced the demonstration phase in 2014 to seek designation of its National Climate Centre (NCC) as a WMO RCC, with the domain of responsibility covering the South Asian countries. IMD RCC is presently in DEMO stage and is likely to be declared as designated RCC shortly.

RCCs perform the following minimum set of functions:

- Interpret and assess relevant LRF products from Global Producing Centres (GPCs)
- distribute relevant information to RCC Users; and provide feedback to GPCs;
- Generate regional and sub-regional tailored products, relevant to RCC User needs, including seasonal outlooks etc.;
- Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data;
- Generate 'consensus' statement on regional or sub-regional forecasts
- Provide on-line access to RCC products/services to RCC Users;
- Assess use of RCC products and services through feedback from RCC Users.
- Operational Activities for Climate Monitoring:
- Perform climate diagnostics including analysis of climate variability and extremes, at regional and sub-regional scales;
- Establish an historical reference climatology for the region and/or sub-regions;
- Implement a regional Climate Watch.
- Operational Data Services, to support operational LRF and climate monitoring:
- Develop regional climate datasets, gridded where applicable;
- Provide climate database and archiving services, at the request of NMHSs.

ADDITIONAL 'HIGHLY RECOMMENDED' FUNCTIONS OF DESIGNATED WMO RCCs OR WMO RCC-NETWORKS:

- Climate Prediction and Climate Projection (beyond 2 years timeframe)

- Assist RCC Users in the access and use of WCRP-CMIP climate model simulations
- Perform downscaling of climate change scenarios
- Provide information to RCC Users for use in development of climate adaptation strategies
- Generate, along with warnings of caution on accuracy, seasonal forecasts for specific parameters where relevant, such as: onset, intensity and cessation of rainy season; tropical cyclone frequency and intensity
- Perform verification on consensus statements for forecasts;
- Perform assessment of other GPC products such as SSTs, winds, etc.

- Non-operational data services
  - Keep abreast of activities and documentation related to WMO WIS, and work towards WIS compliance and DCPC designation;
  - Assist NMHSs in the rescue of climate data from outmoded storage media;
  - Assist NMHSs to develop and maintain historical climate datasets;
  - Assist RCC Users in the development and maintenance of software modules for standard applications;
  - Advise RCC Users on data quality management;
  - Conduct data homogenization, and advise RCC Users on homogeneity assessment and development and use of homogeneous data sets;
  - Develop and manage databases, and generate indices, of climate extremes;
  - Perform Quality Assurance/Quality Control on national datasets, on request of an NMHS;
  - Provide expertise on interpolation techniques;
  - Facilitate data/metadata exchange amongst NMHSs, including on-line access, through an agreed regional mechanism;
  - Perform Quality Assurance/Quality Control on regional datasets.

- Coordination Functions
  - Strengthen collaboration between NMHSs on related observing, communication and computing networks including data collection and exchange;
  - Develop systems to facilitate harmonisation and assistance in the use of LRF products and other climate services;
  - Assist NMHSs in user liaison, including the organisation of climate and of multidisciplinary workshops and other forums on user needs;
  - Assist NMHSs in the development of a media and public awareness strategy on climate services.

- Training and Capacity building
  - Assist NMHSs in the training of users on the application and on implications of LRF products on users;
  - Assist in the introduction of appropriate decision models for end-users, especially as related to probability forecasts;
  - Promote technical capacity building on NMHS level (e.g. acquisition of hardware, software, etc.), as required for implementation of climate services.
  - Assist in professional capacity building (training) of climate experts for generating user-targeted products.

- Research and Development
  - Develop a climate Research and Development agenda and coordinate it with other relevant RCCs;

- Promote studies of regional climate variability and change, predictability and impact in the Region;
- Develop consensus practices to handle divergent climate information for the Region;
- Develop and validate regional models, methods of downscaling and interpretation of global output products;
- Promote the use of proxy climate data in long-term analyses of climate variability and change;
- Promote application research, and assist in the specification and development of sector specific products;
- Promote studies of the economic value of climate information.

2.3 Observations

Observation network metadata and comments on coverage in each country (from in-country consultation

Country	Observation network (metadata)	Comments
Afghanistan	43 stations are defined in WMO metadata, including the following classifications: 1 * GSN station (GCOS Climate Network) 4 * RBCN stations (Regional Basic Climate Network) 14 * RBSN stations (regional Basic Synoptic Network) 2 * Upper-Air RBSN stations	Monitoring of the data availability during March (2015) shows: No monthly CLIMAT reports are being received from any Afghanistan stations, despite this being a minimum requirement for a GSN and RBCN station. No Synoptic, or hourly, surface observations are being received over the GTS, according to the data archives in the Met Office and OGIMET2. However, in checking the climate monitoring archives of NCDC (National Climatic Data Centre), which can be accessed through GOSIC3, there is recent data from a limited number of stations. Upper-Air TEMP data is available daily from Kabul Airport (40948) only, with 55 soundings in February 2015 according to National Centre Environmental Prediction (NCEP-US). In-country consultation: Due to wars and political instability, much of the institutional data was lost; most of the country's weather observational equipment was destroyed. No data of last 2-3 decades is available. Synoptic data of land and upper air is not produced to date due to absence of any observational network in Afghanistan. Security and financial constraint are the major issues and challenges - it is not possible to establish such observational network in the remote areas of the country. It is suggested to support Afghanistan to establish a network of observatories. Network of AWS (automatic weather stations) with GSM/GPRS data communication system will be more suitable in current situation. There is also need to build the capacity of AMS (Afghan Met service) providing technical and financial support.
Bangladesh	54 stations are defined in WMO metadata, including the following classifications:	At present, BMD only issues a 24 hour general weather forecasts as it does not have the required observational capability to allow for

Country	Observation network (metadata)	Comments
	10 * RBCN station (Regional Basic Climate Network) 12 * RBSN station (regional Basic Synoptic Network) 2 * Upper-Air RBSN stations CLIMAT reports (group 111 minimum req.) being received regularly from all 10 RBCN stations, with data going back until 2011. Synoptic (3 Hr'ly) observations received by 40+ stations according to the data archives in the Met Office and OGIMET2. Upper-Air TEMP data is available daily from Dhaka (41923) but only up to 100hPa, with 53 soundings in February 2015 according to National Centre Environmental Prediction (NCEP-US). For Bogra (41883) only a few soundings are received each month, 5 in February according to NCEP.	issuing accurate short term weather or longer range seasonal forecasts. The key deficiencies/challenges are as follows: The country's meteorological observation network managed by BMD is primarily manual. Even though BMD operates doppler radars (established through JICA support) it does not have a sufficiently dense rainfall monitoring network to calibrate the radars. The network density of upper air observation and ground monitoring stations is not adequate as per WMO standards to address tropical microclimates. Monitoring of the ocean system and land/ocean interface is critical for BMD to assess cyclone strength and storm surges. Limited reliable bathymetric data for the 700 kilometre coastline and its marine meteorological observation network is inadequate. Further, the hydrological network, managed by the Hydrology Division of the BWDB, remains primarily manual with manual data collection, transmission and storage with only limited real time hydrological and flood forecasting. Constrains BWDB's capacity for real time flood forecasting and early warnings. Network capacity is mainly along the major rivers and relatively insufficient on smaller rivers, urban catchments, remote areas and trans-boundary rivers.
India	496 stations are defined in WMO metadata, including the following classifications: 21 * GSN station (GCOS Climate Network) 48 * RBCN stations (Regional Basic Climate Network) 84 * RBSN stations (Regional Basic Synoptic Network) 34 * Upper-Air RBSN stations CLIMAT reports being received regularly from 36 GSN/RBCN stations, with data going back for more than 20 years. Synoptic (3 Hr'ly) observations received by 90+ stations according to the data archives in the Met Office and OGIMET2. Upper-Air TEMP data is available daily from 11 Radiosonde stations, with a number of other stations providing wind-only (PILOT) reports.	A separate 14 page summary was provided.

Country	Observation network (metadata)	Comments
Nepal	15 stations are defined in WMO metadata, including the following classifications: 1 * GSN station (GCOS Cilmate Network) 2 * RBCN stations (Regional Basic Climate Network) 15 * RBSN stations (Regional Basic Synoptic Network) No monthly CLIMAT reports are being received from any Nepal stations, despite this being a minimum requirement for a GSN and RBCN station, although some reports from 44453 & 44477 have been archived at NCDC for 2012 Synoptic (3 Hr'ly) observations received by 15 stations according to the data archives in the Met Office and OGIMET2. No Upper-Air observations.	
Pakistan	80 stations are defined in WMO metadata, including the following classifications: 6 * GSN station (GCOS Cilmate Network) 25 * RBCN stations (Regional Basic Climate Network) 56 * RBSN stations (regional Basic Synoptic Network) 3 * Upper-Air RBSN stations (41780 also a GUAN, GCOS Upper Air Network) CLIMAT reports being received regularly from 24 GSN/RBCN stations, with data going back for more than 20 years. Synoptic (3 Hr'ly) observations received by 40+ stations according to the data archives in the Met Office and OGIMET2. Upper-Air wind-only (PILOT) data is available daily from 24 stations, but no TEMP reports from any of the nominated stations and notably 41780 (Karachi Airport) which is the only defined GUAN station in the target countries.	In country consultation: During last few years, the observational network of PMD has increased from 40+ stations to 60+ stations, producing 3 hourly synoptic weather observations that are not communicated unfortunately. More than 40 AWS in the remote areas have also been installed and their data will be available soon. Pakistan Meteorological Department (PMD) is still not producing regular upper air data due to financial constraints. PMD has a technical unit to maintain the available equipment. Due to security issues, the establishment of new weather observational network in western provinces (along Afghan Iran Border) is difficult. It is suggested to install AWS in such areas with GSM/GPRS communication system to fill the gap. According to the policy, all met data is achieved in CDPC (Climate Data Processing Centre) of PMD, located in Karachi. The historical data is provided to concerned organizations, research institutes and academia according to the requirement.
Burma	64 stations are defined in WMO metadata, including the following classifications: 3 * GSN station (GCOS Climate Network) 5* RBCN stations (Regional Basic Climate Network) 27 * RBSN stations (regional	

Country	Observation network (metadata)	Comments
	Basic Synoptic Network) 5 * Upper-Air RBSN stations CLIMAT reports being received regularly from 5 GSN/RBCN stations, with data going back for more 2 to 3 years. Synoptic (3 Hr'ly) observations received by 40+ stations according to the data archives in the Met Office and OGIMET2. No Upper-Air observations.	

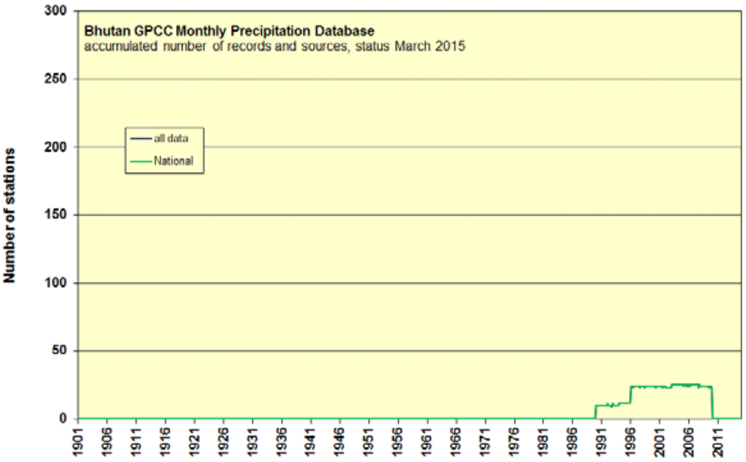
2.4 Additional Notes

Datasets

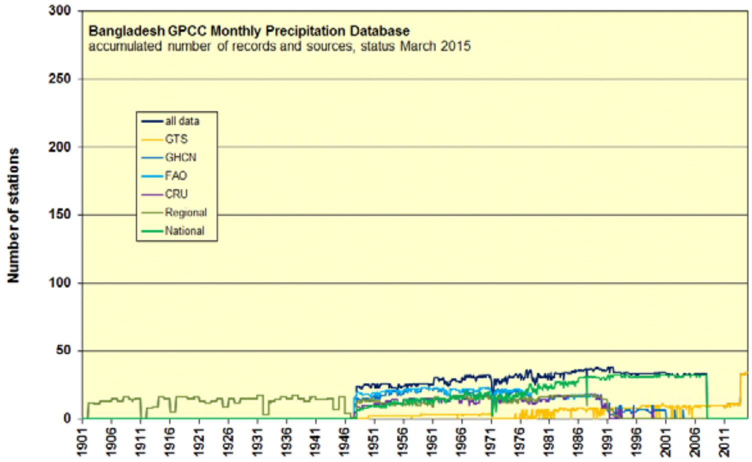
Since 1989, the Global Precipitation Climatology Centre (GPCC) has built up its unique capacity to assemble, quality assure, and analyse rain gauge data gathered from all over the world. The resulting database has exceeded 200 yr in temporal coverage and has acquired data from more than 85 000 stations worldwide. A more detailed description of the GPCC is given in the following paper published in 2013, with Appendix B showing a breakdown of data time series at a National level (http://www.earth-syst-sci-data.net/5/71/2013/essd-5-71-2013.pdf). For the target countries the rain-gauge data is summarized as follows:

Country	Superior	Half-Sufficient	Minor (too few)
Afghanistan		TH: 1976–1980	TM: 1958–1984
Bangladesh		TH: 1948–2008	
Bhutan	TS: 1990–2009		
India			TM: 1961–2000
Myanmar			TM: 1961–2000
Nepal	TS: 1947–2007		
Pakistan			TM: 1961–2007

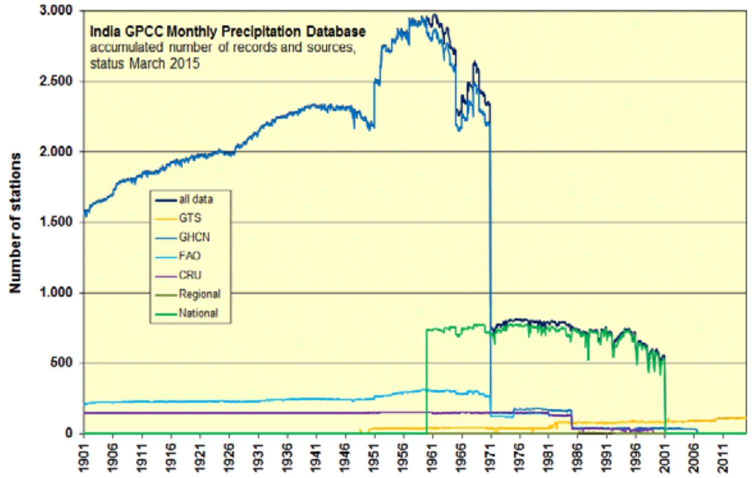
The following plots are the accumulated number of records and sources, for each country, in the GPCC Monthly Precipitation Database, as of March 2015.



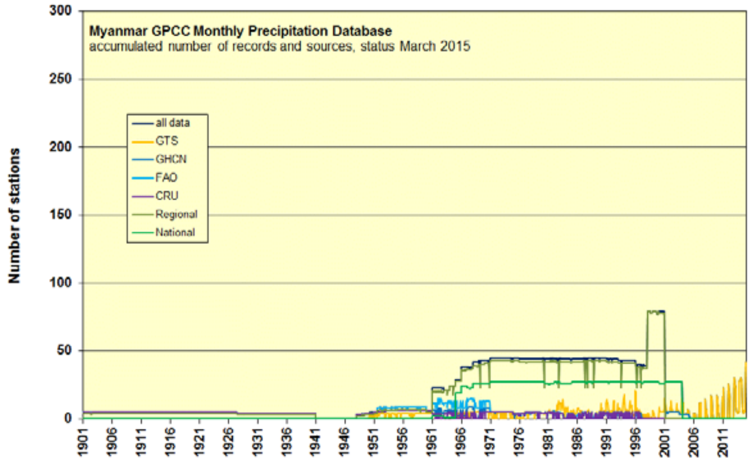
Plot 1



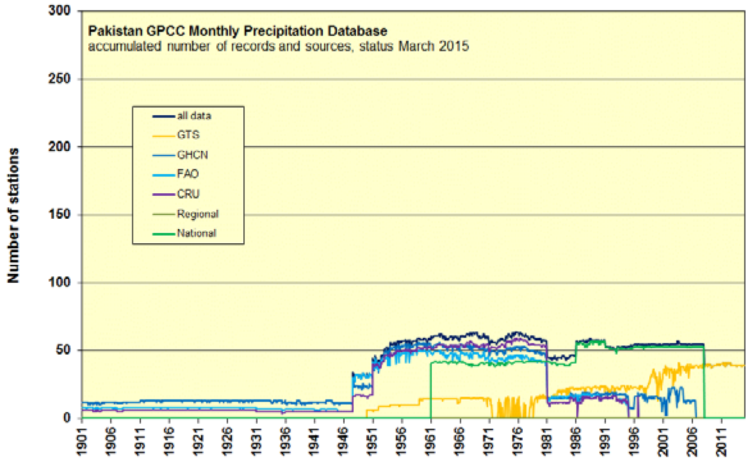
Plot 2



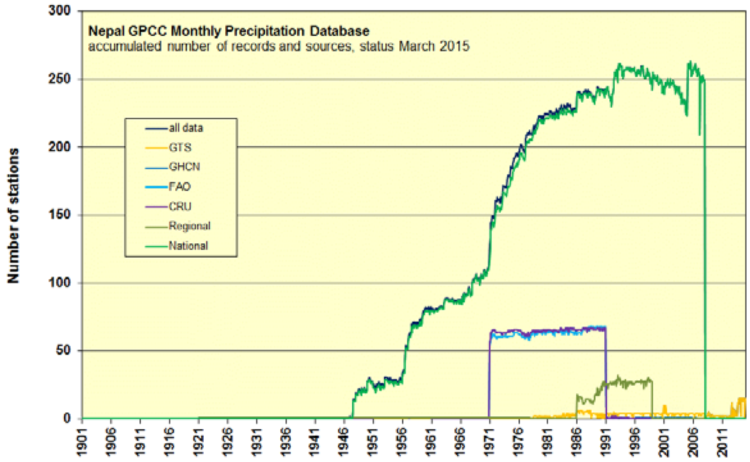
Plot 3



Plot 4



Plot 5



Plot 6

2.5 Review of Current / Future Initiatives

Regional

The $1.2 billion Pilot Program for Climate Resilience (PPCR), a funding window of the $8.1 billion Climate Investment Funds, assists developing countries in integrating climate resilience into development planning. Building on National Adaptation Programs of Action (NAPAs) and other existing efforts, the PPCR also offers additional funding to pilot innovative public and private sector solutions to pressing climate-related risks. Currently the largest adaptation fund in the world, the PPCR focuses on a smaller number of countries and transactions to maximize impact and possibility for replication. It is active in 9 pilot countries and 2 regional programs, which includes 9 small island nations. At present this includes Bangladesh, where the focus so far has been on coastal protection[27] (Rai and Smith, 2013), and Nepal[28], where the focus is on managing hazards, particularly in mountain

[27] https://www.climateinvestmentfunds.org/cifnet/?q=country-program-info/bangladeshs-ppcr-programming
[28] https://www.climateinvestmentfunds.org/cifnet/?q=country-program-info/nepals-ppcr-programming

regions[29]. (Note that programme information and contact points are available on the Climate Investment Fund web site listed in the footnotes).

National

Nepal

Ongoing project **BRCHN (Building Resilience to Climate Related Hazards for Nepal)** managed by Finnish Met Institute (FMI), using World Bank funding under the PPCR. Resourcing of 30 million USD, of which 10 million is for observing networks and 20 million for Met Service infrastructure. Key points:

- Improving Hydrological Networks, building on existing stations + manual to auto + new technology.
- Meteorological networks; 15 RBSN stations, 1 Radar, 1 Upper-Air and 27 Agro.
- Updated network, new technology, mixture of manual/auto observations.
- New calibration facility for Temperature, Pressure and Humidity.
- 8 High altitude AWS (ICIMOD)
- Completion mid-2017 with all data available on GTS.

(Source – Stuart Goldstraw, Met Office – Obs Consultant for BRCHN project)

Most of the hydrological and meteorological information (e.g. water levels, rainfall and weather forecasts) are available via the department's web site. There is a climate portal. Discharge and water level data are available in real-time. In the high mountain areas the hydro-meteorological network is limited. There is a need to improve this in order to have weather information available to tourists trekking in the Himalayas, especially after the incident that occurred in October 2014. Data are collected via two different methods as follows:

- Telemetry – These data are placed on line although this is some doubt as to whether these data are stored in a database. The automatic stations have solar panels so that they continue to operate should the electricity supply fail.
- Manual data collection – The aim is to upgrade these to automatic stations.

The long-term aim is to have all the data on the internet. The data are currently stored in a GIS-based system. There is also a plan to put another 20 or so meteorological stations in the high mountain areas. Two to three months of data are available via the internet. Data are archived in a "standard" database. There is a "nominal" charge for data. There is a 75% discount for researchers and students. The only condition with respect to the use of the data is that it cannot be transferred to third parties and that the Department must be acknowledged. It usually takes one to two days to collate the data that users need.

(Source – Director General, Department of Hydrology and Meteorology, visit Feb15, see Annex A)

GFCS Projects in Nepal being carried out by Partners include: Building Resilience to Climate Related Hazards (World Bank); Reducing vulnerability and increasing adaptive capacity to respond to impacts of climate change and variability for sustainable livelihoods in agriculture sector in Nepal (FAO); Finnish-Nepalese Project for Improved capability of the Government of Nepal to respond to the increased risks related to the weather-related natural disasters caused by climate change, Phase 2; Climate Service Learning Lab - Rupandehi site

29 http://www.worldbank.org/en/news/press-release/2013/10/07/building-climate-resilience-for-nepals-vulnerable-populations

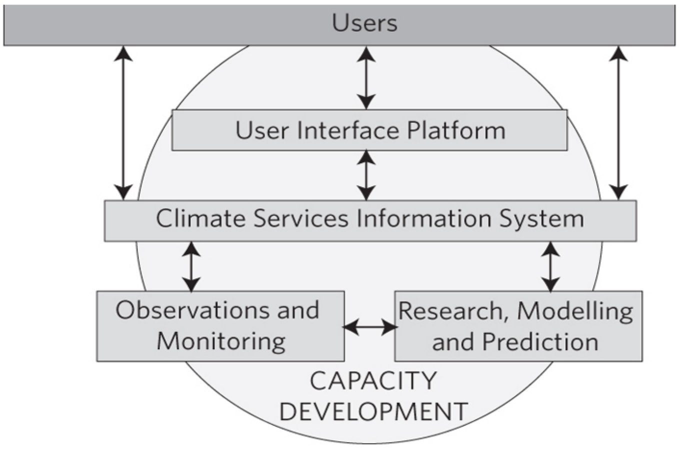
(CCAFS); Scaling up Climate Services for Farmers in Nepal (CCAFS); Building adaptation to climate change in health in least developed countries through resilient water, sanitation and hygiene (WHO); Global flood EWS for early rapid mapping activations: case study Nepal (UNITAR\UNOSAT); and Community Based Flood and Glacial Lake Outburst Risk Reduction (UNDP).

Bangladesh

In **Bangladesh,** for example, a flash-flood early warning system developed through the Adaptation for Smallholder Agriculture Programme (ASAP)-funded activities would buy farmers more time to raise defenses and harvest crops.

3. Capacity assessment

The Global Framework for Climate Services (Hewitt et al., 2012)



The capacity building areas of GFCS relevant to the supply of climate information include:

- **Human resource capacity** – equipping individuals with the knowledge, skills and training to enable them to generate, communicate and use decision-relevant climate information;
- **Infrastructural capacity** – enabling access to the resources that are needed to implement infrastructure to generate, archive, quality control, communicate, exchange and use climate data and decision-relevant information and products, including on the supply side instruments for observing networks, data management systems, computer hardware and software, internet access, communication tools, manuals and scientific literature.
- **Procedural capacity** – defining, implementing and advancing best practices for generating and using climate information;
- **Institutional capacity** – on the supply side elaborating management structures such as defining the position and terms of reference of NMHSs for climate services, processes, policies and procedures that enable effective climate services, not only within organizations but also in managing relationships between the different organizations and sectors (public, private and community, including international collaboration).
  Source: WMO (2014)

WMO defines eight steps in the capacity development of NMHSs: defining requirements; establishing baseline; analyzing gaps; elaborating a strategic plan; ensuring national commitment and support; mobilizing resources; implementing a capacity development response; and monitoring and evaluation. Focus areas include strengthening regional offices, regional economic groupings and partnerships. In general, financing for CD activities of NMHSs comes from the regular budget of WMO, voluntary contributions, WMO Voluntary Cooperation Programme (VCP) and UN and other partnerships (WMO, 2014).

Sustainability of NHMS requires long term funding and national government commitment is a key requirement. A common message is that strong coordination is required across the different pillars of GFCS and that a clear explanation of benefits and current scientific limitations must be presented. According to a GFDRR/WB study (2013), large-scale modernization national programs should typically include three components:

- Institutional strengthening, capacity building, and implementation support;
- Modernization of observation infrastructure and forecasting;
- Enhancement of the service delivery system.

Modernization of NMHSs should be considered within the wider regional and global context (WMO, 2014b).

Strategic goals highlighted in the WMO GFCS Annex of Capacity Development include:

1. Strengthening of the observing network in developing and least developed countries (this is particularly relevant for Afghanistan, Myanmar, Nepal).
2. Improvement of meteorological telecommunications and communication systems for rapid data collection, exchange and dissemination of data and information (this is likely to be important for promotion of regional climate services programmes).
3. Improvement of level of technical capacities (resources, expertise to generate appropriate policy-relevant climate information and operational warning services for the priority sectors) including procedural issues.
4. Improvement of products generation and use through collaboration with various users and other stakeholders.
5. Improved institutional capacity of national and regional centres to provide relevant, reliable and timely climate and weather services.
6. Strengthening capacity of the global, regional and national climate centres such as the GPCs, WMO RCCs and NMHSs to function as efficient network of coordination, development and dissemination centres.

Different aspects on capacity

Human resource capacity

Equipping individuals with the knowledge, skills and training to enable them to generate, communicate and use decision-relevant climate information

Although WMO literature focuses on the capacity of NHMS and research scientists, this clearly needs to include boundary organisations and intermediaries involved in the production and communication of weather and climate information. This includes NGOs and private sector organisations, such as those outlined in Section 2.

The development of research scientists

The World Climate Research Programme (WCRP) have developed a strategy to promote greater involvement of developing-country scientists, early career professionals and students in climate science activities. DFID have been active in this area sponsoring raining of scientists in South Asia[30].

The development of capacity in NGOs

A wide range of NGOS are involved in climate services provision in the DRR, water, food security, health and energy in South Asia including International Federation of Red Cross and Red Crescent Societies, Global Water Partnership, Oxfam, Action Aid, Practical Action, Christian Aid and many more.

NGOs are well placed to support the two way communication between scientists and local communities and to deliver services that may use outputs from global, regional or national weather and climate models.

The development of capacity in the private sector

The private sector is involved in climate services provision in the insurance, engineering, water, agricultural, environmental consultancy and international development markets. This is a highly complex, emerging and largely unregulated market which includes large global companies, universities, national meteorological and hydrological services and 'boutique' consultancies offering a wide range of forecasting, insurance and risk management products as well as consultancy services. The private sector may play a useful role as intermediaries in adding value to weather and climate information and translating information for different sectors. From a private sector perspective, open access to the best available weather and climate information is required in order to consider weather or climate risks and to develop risk products. However there can be a lack of transparency and scrutiny of proprietary weather and climate information products.

Infrastructural capacity

Enabling access to the resources that are needed to implement infrastructure to generate, archive, quality control, communicate, exchange and use climate data and decision-relevant information and products, including on the supply side instruments for observing networks, data management systems, computer hardware and software, internet access, communication tools, manuals and scientific literature. (WMO, 2014)

Observing networks

As highlighted in Section 4, there are significant gaps in observing networks for a range of reasons including poor communications or lack of operational maintenance. Afghanistan, Burma and Nepal have the highest concentration of 'silent' stations. A more complete regional network would support regional forecasting and climate change assessments.

IT hardware

It is clear that NHMS and other government departments in several other the target countries (Bangladesh, Nepal, Myanmar) lack the IT infrastructure to manage national data, for example Bangladesh only uses numerical weather prediction models for research purposes rather than operational purposes due to lack of IT resources (Abdur, pers. comm.).

Procedural capacity

30 http://www.ids.ac.uk/idsproject/support-to-improve-climate-research-and-information-services-in-south-asia-sicrisa

Defining, implementing and advancing best practices for generating and using climate information.

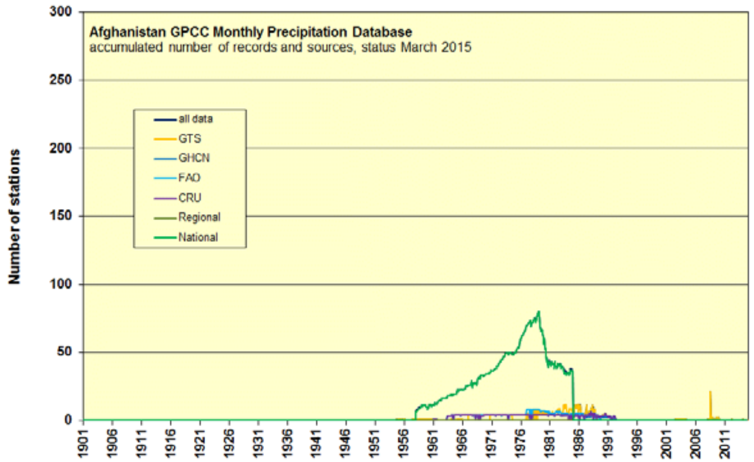
The important gaps at the national level are sector-specific services, including tailored information; decision support; locally-specific information; and information to bridge current timescale gaps (decadal, and extended-range weather forecasts, plus intra-seasonal information). There are increasing expectations for climate services both domestically as well as regionally and globally, but there is a minimal increase in capacity to provide climate services. The question then is how the NMHSs can provide climate services while minimizing additional workloads? (WMO, 2014b)[31]

Institutional capacity

On the supply side elaborating management structures such as defining the position and terms of reference of NMHSs for climate services, processes, policies and procedures that enable effective climate services, not only within organizations but also in managing relationships between the different organizations and sectors (public, private and community, including international collaboration).

[31] This part of the report and the subsequent text was based on a presentation from Simon Mason, IRI, Columbia.

Strategic goals	Strategic direction/development	Expected Results	Areas addressed of the capacity development Pillar
1.Strengthening of the Observing Network in developing and least developed countries	1.1 Revive/establish rainfall and climate stations at national level to increase the network available for monitoring climate and have more data for applications and research.	1.1.1 Increased rainfall and climate data base for different parameters such as rainfall and temperature	Infrastructural
2. Improvement of Meteorological Telecommunications and communication systems for rapid data collection, exchange and dissemination of data and information	2.1 Acquire new and replace the aging Automatic Message Switching Systems at NMHSs.	2.1.1 Improved efficiency of data exchange between national centres and other centre through Global Telecommunication System (GTS)	Infrastructural

Strategic goals	Strategic direction/development	Expected Results	Areas addressed of the capacity development Pillar
3. Improvement of level of technical capacities (resources, expertise to generate appropriate policy-relevant climate information and operational warning services for the priority  **sectors) including procedural issues**	3.1 National and regional centres develop new innovative products, through initiating pilot projects at regional and some national centres, replicating to others later on. Human resources, infrastructural, and procedural 3.2 Support training on new product development and packaging techniques involving regional centres in collaboration with national climate centres, research communities such as the WRCP activities and development Partners. 3.3 Support acquisition of relevant hardware and software for data analysis and generation of tailored products at regional and national climate centres.	3.1.1 Improved communication and information exchange between national and local centres. Improved local skills and buy-in to support themselves in the future 3.2.1 Improved technical capacity. Improved engagement across regional to local research organisations 3.3.1 Improved availability of well packaged policy relevant and sector specific products	Human resources, infrastructural, and procedural
4. Improvement of products generation and use through collaboration with various users and other stakeholders	4.1 Implement pilot applications projects at regional and national level to demonstrate economic benefits of climate services 4.2 Conduct capacity building workshops involving global, regional and national centres, stakeholders and users of climate information and	4.1.1 Improved awareness of economic benefits of climate and related services 4.2.1 Improved capacity for generation of relevant user-friendly tailor made products 4.2.2 Availability of more	Human resources and user interface

Strategic goals	Strategic direction/development	Expected Results	Areas addressed of the capacity development Pillar
	products on best practices for generation and of effective use of climate products and information. 4.3 Support and strengthen the already ongoing providers and users interface activities such as RCOFs and NCOFs, Malaria Outlook Forums (MALOFs) etc.	sector tailored-made products 4.3.Strengthen effectiveness and capacity of relevant regional and national forums.	
5. Improved institutional capacity of national and regional centres to provide relevant, reliable and timely climate and weather services	5.1 Develop policy and institutional framework for the climate services providers sector/institution at regional and national level. 5.2 Improve funding base of the national institution and centres through strengthened status of the organizations and financial management. 5.3 Improve human resources capacity in the national/regional climate centres to ensure improved quality services. climate and weather services 5.4. Facilitate development of Memorandums of Understanding (MOUs) to facilitate smooth operation of climate services between countries and institutions.	5.1.1 Availability of policy framework for meteorology sector 5.2.1 Enhanced efficiency and accountability of national centres 5.3.1 Smooth access of national and regional institutions 5.4.1 Support common understanding of roles and responsibilities and long terms commitments between countries and institutions on provision of climate information and services.	Institutional and human resources

Strategic goals	Strategic direction/development	Expected Results	Areas addressed of the capacity development Pillar
6. Strengthening capacity of the global, regional and national climate centres such as the GPCs, WMO RCCs and NMHSs to function as efficient network of coordination, development and dissemination centres	6.1 Develop coordination and management mechanisms to ensure efficient regional coordination and cooperation between climate services institutions and stakeholders. 6.2 Support Implementation of relevant regional events and networking. Improve funding base for the regional and national climate centres to ensure efficient functioning of the institutions.	6.1.1 Improved coordination and cooperation between climate services provider institutions and stakeholders 6.2.1 Increased awareness and use of services by stakeholders 6.2.2 Improved efficiency of functioning and quality of service delivery of institutions	Institutional and infrastructural

Table 1 Example activities considered by WMO GFCS as building capacity (WMO, 2014)

4. Research Modelling and Prediction

4.1 The GFCS Research, Modelling & Prediction pillar

The GFCS framework includes an annex on Research, Modelling and Prediction (RMP, WMO, 2014). The document sets out the importance of including the fundamental links through from science to services as well as the need for science to be more interactive and targeted to user needs.

The aims of the pillar are summarised as:

- Developing and improving practical science applications;
- Enhancing cooperation in research communities and interaction between climate information providers and users;
- Improving climate information products, and
- Improving understanding of Earth's climate system.

In terms of what is defined as 'climate services' and therefore what research towards them should capture, there is some debate in the community whether this should also include weather research and services. However, in general the GFCS Implementation Plan (WMO, 2014a) supports a seamless approach, stating **"**Stakeholders' needs often cover both weather and climate timescales and there are therefore likely to be considerable benefits, and synergies, in developing and delivering services in a seamless cross-timescale way".

The seamless approach is also supported in the Annex to the GFCS Implementation Plan – Climate Services Information System (CSIS) Component (**WMO, 2014e**) which states "From a user perspective, an integrated body of services that spans all timeframes... is the ideal mechanism", and although much of the focus of research objectives in the RMP Annex are focussed on longer timescales and climate change, there is acknowledgement that extreme climate and weather events need to be addressed.

The nature of atmospheric processes and modelling supports the need for a seamless approach to research collaborations, and recent projects such as TRANSPOSE-AMIP (**Williams et al., 2013**) have shown the advantages in using climate models in weather mode to investigate errors and ultimately improve skill.

4.2 Weather/climate modelling basics – short, medium and longer term, regional NWP and climate models

The weather and climate of different regions varies hugely, caused by differing atmospheric composition, topography and meteorological processes. It is for this reason that high resolution regional or provincial forecasts and climate models are utilised, to provide local people with the most useful information. Unfortunately the availability of weather and climate information is unevenly distributed, with information on South Asia largely being poorly represented or scarce.

Seasonal forecasting:

Seasonal forecasting is possible in some areas of the world. Unlike short term weather forecasting, initial conditions do not need to be known in detail. Rather, we need to know the conditions at the surface and how they might change (Houghton, 2009).

In the tropics, the atmosphere is particularly sensitive to sea surface temperature.

Atmospheric prediction is primarily done using numerical models which rely on the fundamental equations of physical motion and thermodynamics. These models integrate forward in time from a set of initial conditions; initial analyses of the state of the atmosphere which are generated from a combination of model representation and observations. The process by which the observations are combined with the model is referred to as data assimilation.

The newest generation of NWP models can explicitly represent convection due to very high grid resolutions, such as UKV which runs a 1.5km grid length model over the United Kingdom. However, even with a perfect analysis, numerical weather prediction (NWP) models struggle to represent convection with parameterisation.

Medium range forecasting:

Prediction from days 2-15 is referred to as 'medium range weather forecasting'. However there are some large scale influences on trends in rainfall events such as the East Asian Summer Monsoon.

Medium range and seasonal forecasts are generally provided by externally with the exception in India that has two centres producing medium range forecasts (see Section 4.4).

The lack of medium range forecasting is potentially due to a lack of knowledge, lack of model skill or access for in-country forecasters to data and information.

Prediction for longer than 2 days is available from the American GFS model, providing 50km resolution simulations over South Asia. These are utilised by National Meteorological Agencies such as the Pakistan Meteorological Service who focus these forecasts on their specific country and publish this on their website. Similarly, the Bangladesh Meteorological Department receives its seasonal forecasts from Tokyo Climate Centre (TCC).

Regional Climate Models:

Regional Climate Models (RCMs) provide longer term projections of the 'general trends' of weather or climate using a resolution of perhaps 25 or 50km. This can be used to generate projections from intra-seasonal to inter-decadal timescales. RCMs are generally nested into global climate models which have a much courser resolution; usually 200 or 300km (Houghton, 2009), which is far too large a scale to accurately represent small scale weather patterns such as precipitation. The output from an RCM should be largely in line with that of the driving GCM results but may deviate slightly as a result of the RCM's higher resolution of complex topography or land surface representation.

Regional Climate Models are validated by running simulations of past climates and notable weather events (e.g. aerosol generating volcanic eruptions) and then comparing the model output with observations from reality. A model's ability to accurately represent observations from the past improves our confidence that its future projections should be reliable.
A model's output is closely monitored against the developing observations. This is especially true for Numerical Weather Prediction on short timescales (hours to days), where present observations can be fed back into the model to keep the projection in line with the unfolding present weather events.

As RCMs run at a much higher resolution than GCMs and run for longer timescales than short-term forecasts, they are more computationally expensive. This computational cost means that each nation cannot necessarily run their own RCM, so the responsibility of generating regional climate models lies largely with developed nations.

<u>PRECIS and RegCM4 RCMs:</u>

Developing countries can and do utilise tools such as PRECIS (Providing Regional Climates for Impacts Studies www.metoffice.co.uk/PRECIS) or RegCM4 (Regional Climate Model v4, International Centre for Theoretical Physics http://www.ictp.it/research/esp/models/regcm4.aspx) to run RCMs at comparatively little computer cost – these tools can be run using a modern laptop. The Pakistan Meteorological Department uses PRECIS and RegCM4 to downscale GCM data for seasonal forecasts and future climate projections. http://www.pmd.gov.pk/rnd/rndweb/rnd_new/index.php

PRECIS training has been delivered throughout South and South East Asia, with local scientists attending workshops in Bangladesh (2010), India (2005) and Bhutan (2004). Representatives of the Department of Meteorology and Hydrology (Myanmar) participated in one such large scale training event; the SEACAM (Southeast Asia Climate Analyses & Modelling) project, which enabled local scientists to create and analyse RCM data. This training helps to facilitate inter-country collaboration and data sharing, provides a platform to produce their own scientifically rigorous climate models and trains early-career scientists on how to analyse the output – all challenges highlighted in the SEACAM framework's assessment of end-user's needs (Rahmat et al., 2014).

4.2.3 Country specific Research, Modelling and Prediction:

Pakistan Meteorological Department (PMD) uses PRECIS and RegCM4 to downscale GCM data for seasonal forecasts and future climate projections. PMD are currently creating experimental seasonal precipitation forecasts by downscaling China Meteorological Administration's Global Atmosphere-Ocean Coupled Model (CGCM) and validating this against the past 30 years of observation data (Ilvas, 2012).

India can boast a relatively abundant cluster of research and regional modelling capability compared with other countries in South Asia, boasting institutes such as The National Centre for Regional Weather Forecasts (NCMRWF), The Energy Resource Institute (TERI), India Institute for Tropical Meteorology (IITM) and Universities such as Anna University's Centre for Climate Change and Adaptation Research. India has been able to utilise the Weather Research and Forecasting (WRF) model to dynamically downscale CMIP5 simulations.

The National Centre for Regional Weather Forecasts (NCMRWF) in India runs real-time global data assimilation and forecast systems on sub-daily to seasonal timescales. NCMRWF uses the T80L18 Global Model ensemble (8 ensemble members) to create forecasts. This model has a systematic tendency to increase rainfall amount in forecasts over India and the Central Bay of Bengal as the forecast length increases (Kar et al., 2007). Ensemble spread also increased over the same region as forecast length increases, as would be expected.

Since 2012 the Bangladesh Meteorological Department (BMD) has been working closely with the Met Office Hadley Centre to create a downscaled HadCM3 17-member ensemble from CMIP3 data, at 25km resolution on a domain covering all of South Asia, which provides projections for future regional climate. At present BMD provides only raw data rather than climate related products. This data will be freely accessible through the British Atmospheric Data Centre (BADC) in the future. There is also an intention to produce similar data using CMIP5 runs over the same region over the coming years. BMD has also recently immersed itself in weather prediction and risk management; it is in the second phase of establishing its Numerical Weather Prediction system, supported by human capacity development of weather analysis and forecasting. BMD signed a bilateral agreement on Regional Integrated Multi-Hazard Early Warning System (RIMES) in March 2012 and contributed to the 'Severe Thunderstorm Observation and Regional Modeling' (STORM) Project with the South Asian Association for Regional Cooperation (SAARC) Meteorological Research Centre (SMRC) in

2009.

Information on regional climate models utilised in other South Asian countries appears to be scarce, however access to RCMs which use the wider South Asia domain is available to be utilised. See table below.

High resolution limited area models run operationally over South Asia for short-range prediction

Region / country specific domain	Modelling Centre	Model, resolution	Availability of output
South Asia	Met Office Hadley Centre	PRECIS 25km or 50km	CORDEX / BADC website.
South Asia	Met Office Hadley Centre	HadCM3 CMIP3 model data 25km resolution	Will be put onto BADC in the future. Available on request from MOHC. CMIP5 update will be available in the future.
South Asia	China Meteorological Agency	Global Spectral Model (GSM), 30km resolution	Short and medium range forecasts for one week ahead, published on PMD website
Pakistan / South Asia	Abdus Salam International Centre for Theoretical Physics (ICTP)	RegCM4 50km resolution	Unknown.
Pakistan / South Asia	Pakistan Meteorology Department (PMD)	COsahedral Nonhydrostatic model (ICON) 13km resolution	Numerical weather prediction model at DWD. Operational since 20th Jan 2015. 24 hourly and 3 hourly charts published on PMD website.
Pakistan / South Asia	NOAA	Global Forecast system (GFS) 50km resolution	GFS produces a short-medium range weather forecast for 7-16 days, published on PMD website
India and surrounding region	National Centre for Medium Range Weather Forecasts (NCMRWF)	NCMRWF model, 25km resolution	Free access to operational forecast products on NCMRWF ftp site ftp://ftp.ncmrwf.gov.in/pub/outgoing/IND_REGION
India	NCMRWF	Seasonal Prediction and Application to Society (SeaPrAS)	Forecasts output through NCMRWF.
India	NCMWRF	T80L18 Global Model 8 model ensemble	Unkown
India	The Energy Research Institute (TERI)		Unknown
India		Weather Research and Forecasting (WRF) model, CMIP5	Peer-reviewed published papers.
Nepal	Met Office UK	12km model	Not publically available
Bangladesh	Met Office Hadley Centre	PRECIS model; downscale to 25 km resolution from GCM boundary data	can produce outputs for more than 150 parameters

4.3 Key scientific challenges in weather and climate research for the South Asia region

As previously explained, Global Climate Models do not contain the complexity of information to accurately represent regional level processes. The South Asian domain presents a number of challenges when it comes to improving a model's skill.

Regional modelling of the South-Asian Summer Monsoon: Climate models have long struggled to accurately simulate the mean structure and ENSO relationship of the South Asia Summer Monsoon (SASM) (Webster, 1998), which is a fundamental characteristic of South Asian climate dynamics. This failure to represent the SASM results in systematic biases of RCM outputs relating to inter-annual variability of temperature, precipitation and circulation (particularly June-September). Although the RCMs are not able to capture this inter-annual variability, the annual cycle of temperature is however well represented. Furthermore the spatial gradients and topographically-induced structure of climate are generally captured and simulated values are within a few degrees of the observed values (Pal et al., 2007). RCM biases relating to the SASM are largely independent of those from the driving GCMs; downscaling different global datasets using the same RCM provides similar spatial patterns. Instead, the biases appear to be caused by the RCM's physics parameterisations (Syed et al., 2014), which are set up differently for each RCM. Even when a model does reasonably represent the SASM, it may be for the wrong reasons; such as the land-sea temperature gradient.

Simulated Precipitation levels: There is low confidence in future precipitation projections at a sub-regional scale and thus in future freshwater availability in most parts of Asia. (IPCC c24,1330). There is little inter-model consistency in the representation of precipitation. High precipitation areas are generally difficult to simulate accurately in terms of both intensity and location. For example, RegCM3 simulates the precipitation peak in central eastern India well, although a few degrees to the south. It accurately locates the high precipitation areas over the western Ghats, Nepali upslopes and Indo-China Peninsula coastal areas, but overall the model gives a positive precipitation bias (Pal et al., 2007).

Orography: Debate exists around the extent to which the Tibetan plateau impacts on the south-west summer monsoon. The plateau heats up in the summer and establishes an atmospheric circulation which is conductive for the monsoon. It also acts as a barrier to the cold, dry air from the northern latitudes, which would otherwise subdue the warm moisture-filled ocean air that drives the monsoon (Boos & Kuang, 2010). Using ECMWF Reanalysis 40 (ERA40) data, they found that even when removing the Tibetan plateau, the Himalayas would still cause this barrier effect; essentially rendering the Tibetan plateau inconsequential to the monsoon.

Whilst we are still unsure of which physical processes are occurring in relation to this complex topography, it is unsurprising that the regional climate models struggle to produce realistic and consistent simulations over the region. Higher resolution models (greater than 25km resolution) are not yet able to add significant value to regional climate models over parts of south Asia; due to the complex topography of the Himalayas, a 12km model of Nepal simulated unrealistic valley cooling (Moufouma-Okia, 2013). To counteract this effect and create realistic results from a model with this resolution, significant amounts of orographic smoothing must be applied, rendering the topography of the RCM little more informative than that of the original GCM.

Temperature bias: Higher-than-observed temperatures are simulated in semi-desert and desert regions, particularly over eastern Pakistan. The overall bias is again in line with previous RCM studies over South Asia that include comparisons to surface temperature observations (e.g., Hassell and Jones 1999; Rao et al. 1994)

Sea Level Rise and Flash flooding: Future rates of sea level rise are expected to exceed those of recent decades (see WGI AR5 Section 13.5.1), increasing coastal flooding, erosion, and saltwater intrusion into surface and groundwater. In Bangladesh, 20% of habitable land would be lost and roughly 15 million people would be displaced as a result of one meter of sea-level rise (SLR). Estimates suggest that one meter of SLR could occur by 2050 (compounded of 70cm due to subsidence because of land movements and groundwater subsidence and 30cm from the effects of global warming) (Houghton, 2009).

Diseases: More frequent and intense heat waves in Asia will increase mortality in vulnerable groups. Increases in heavy rain and temperature will increase the risk of diarrheal diseases, dengue fever, and malaria (Hijioka et al., 2014).

Urbanisation: Rapid urbanization, industrialisation and economic development will be compounded by climate change. Development of sustainable cities in Asia with fewer fossil fuel-driven vehicles and with more trees and greenery will have a number of co-benefits including improved public health. New cities will need to implement drainage systems capable of managing more intense precipitation patters and buildings which can withstand stronger storms. These improvements should also be investigated for current densely populated areas. Estimates suggest that, by upgrading the drainage system in Mumbai, losses associated with a 1-in-100 year flood event today could be reduced by as much as 70% and, through extending insurance to 100% penetration, the indirect effects of flooding could be almost halved, speeding recovery significantly (Ranger et al., 2011).

3.1 Users of climate information and services / Information requirements

The users of climate information include a wide range of groups and individuals across sectors, livelihood groups and decision-making levels, with widely varying levels of access to information and resources to use this information appropriately[32]. Key activities and decisions dependent on climate related information and it has long been recognized that if society could have advance information on weather, the adverse effects associated with it could be minimized[33]. For climate information to benefit climate-sensitive sectors and society in general, it must induce changes in the decision-making process and in the actions taken by stakeholders[34]. There is a need to transform climate related data into customized products and services that have a societal and public use and sensitise the policy makers in order to make all climate services mandatory in all sectors. The communication of information between service providers and the end users remains a real challenge since there is a gap between the source and the end of the information available. Information requirement and users of climate information in priority sectors viz., Agriculture, Water, Disaster Risk Reduction (DRR), Health and Energy are dissed in this section.

Agriculture sector

Agriculture is strongly influenced by weather and climate in south Asian countries[35], [36]. For agriculture, climate forecasts must be interpreted in terms of production outcomes at the right scale (e.g. at the local geographical level and seasonal time scale) for farmers and other agricultural decision-makers to benefit[37].Climate variability, climate change, weather extremes, rainfed agriculture with low productivity, deteriorating soil quality and weak extension services are all challenges that the farmers in South Asia are facing and that they impact negatively the agricultural productivity in the region. Most farmers in South Asia are resource-poor smallholder farmers often with limited access to technologies and resources, which leaves them increasingly vulnerable to weather and climate fluctuations. In spite of advances in plant breeding and soil and crop management; seasonal climate variability, impacts of climate change and weather and climate extremes continue to impose serious limitations on the realization of potential crop yields in South Asia with negative ramifications for other sectors of agriculture. The resulting food insecurity and social instability across South Asia is threatening the livelihoods of people and economies of all countries in this region[38].

32 APAN. Rogers, D., and V. Tsirkunov. 2013. Weather and Climate Resil- ience: Effective Preparedness through National Meteorological and Hydrological Services. Directions in Development, World Bank, Washington, DC.

33 Chattopathyay, N. and B. lal. 2008. Agrometeorological risks and coping strategies – Prespective from Indian sub continent. In. Managing weather and climate risks in agriculture. Edited by M.V.K.Sivakumar and R.P.Motha. Springer Publications. P: 83 - 98.

34 Sonka, S.T., Changnon Jr., S.A., Hofing, S.L., 1992. How agribusiness uses climate predictions: implications for climate research and provision of predictions. Bull. Am. Meteor. Soc. 73, 1999–2008. USDA, 1997. Georgia County-Level Data. In: Census of Agriculture, Vol. 1: Part 10, Chapter 2.

35 Kumar K. K., Kumar K. R., Ashrit R. G., Deshpande N. R., Hansen J. W. 2004 Climate impacts on Indian agriculture. *Int. J. Climatol.* **24**, 1375–1393.

36 Sivakumar M. V. K., Das H. P., Brunini O. 2005 Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics. *Clim. Change* **70**, 31–72.

37 Ashok Kumar. 2013. Timely weather info to improve farm incomes. One World South Asia. http://southasia.oneworld.net/news/weather-info-to-help-indian-farmers-raise-their-income#.VRjm5M0rAT8

38 Workshop proceeding on "Improving Climate Services for Farmers in Africa and South Asia". 2015. https://www.wmo.int/media/sites/default/files/Kampala%20Declaration.pdf

The forestry sector uses historical climate data to develop strategic plans from planting to harvesting. These decisions cover practices such as zoning land for commercial forestry based on climate suitability, site preparation, regeneration, thinning and fertilizing. Information on potential climate change is equally important. If the climate changes as the trees grow, the yield could be significantly different to what was expected. Similarly the monitoring of monthly and seasonal variations in sea surface temperatures is enhancing the tactical planning of operations for ocean fishing fleets (e.g. by minimizing time and costs in locating and travelling to fish) and could improve the overall management of the world's fisheries. Also, the detailed knowledge of such climate events such as El Niño or La Niña can lead deep-ocean Pacific fishing fleets to fishing feeding areas[39].

Water Sector

Climate data and information underpin the planning and management of surface freshwater supplies and mitigation of damage from high and low water flows. Long records of catchment rainfall and river flows provide the basis of planning for sustainable freshwater harvesting, but it is the hydrological extremes of flood and drought that pose significant problems for water resource managers[40]. These hydrologic data are essential for calculating quantities such as frequency of heavy rainfall, the Probable Maximum Precipitation for given periods and flood events, flood forecasting and water resources assessment. To assist water sector decision-making in the changing climatic condition, we need climate change scenario information. This data, collected on weekly, seasonal and annual timescales and at national, regional and local levels, are now more essential than ever to provide the foundation upon which operational water management strategies can be developed.

Group	Data Details	Possible Source
Weather Data (Rainfall)		
Predicted Data	Rainfall (Catchment)	IMD, NCMRWF, PMD, DHM, DMH
Real-time Data	Rainfall (Dam and Catchment)	CWC, Irrigation Dept., IMD, PMD, DHM, DMH
Historical Data	Rainfall (Catchment)	CWC, Irrigation Dept., IMD, PMD, DHM, DMH
Weather Data (Temp.)		
Predicted Data	National, Sub National, Local/District Level	IMD, NCMRWF, PMD, DHM, DMH
Real-time Data	National, Sub National, Local/District Level	IMD, PMD, DHM, DMH
Historical Data	National, Sub National, Local/District Level	IMD, PMD, DHM, DMH
Weather Data (RH)		
Predicted Data	National, Sub National, Local/District Level	IMD, NCMRWF, PMD
Real-time Data	National, Sub National, Local/District Level	IMD, PMD, DHM, DMH
Historical Data	National, Sub National, Local/District Level	IMD, PMD, DHM, DMH
Stream Gauge Data		
Historical Data	Stream Gauge Data	CWC, Irrigation Dept., BWDB
Real-time Data	Stream Gauge Data	CWC, Irrigation Dept., BWDB,
Reservoir Data		
Historical Dam	Discharge (Water Release) Data	CWC, Irrigation Dept., BWDB

39 WMO – Agriculture: https://www.wmo.int/pages/themes/climate/applications_agriculture.php
40 WMO – Water sector: https://www.wmo.int/pages/themes/climate/applications_water.php

Group	Data Details	Possible Source
Real Time Dam	Discharge (Water Release) Data	CWC, Irrigation Dept., BWDB
Other Data		
Collection and Collation of Climate Change Data (PRESIS)	Data of Various Scenario Data	IITM
Sea Level Rise Data: Tide Table	Past and Future Data	NIO, Hydro Survey of India

Table 13 Hydro-Meteorological data for climate services[41],[42],[43]

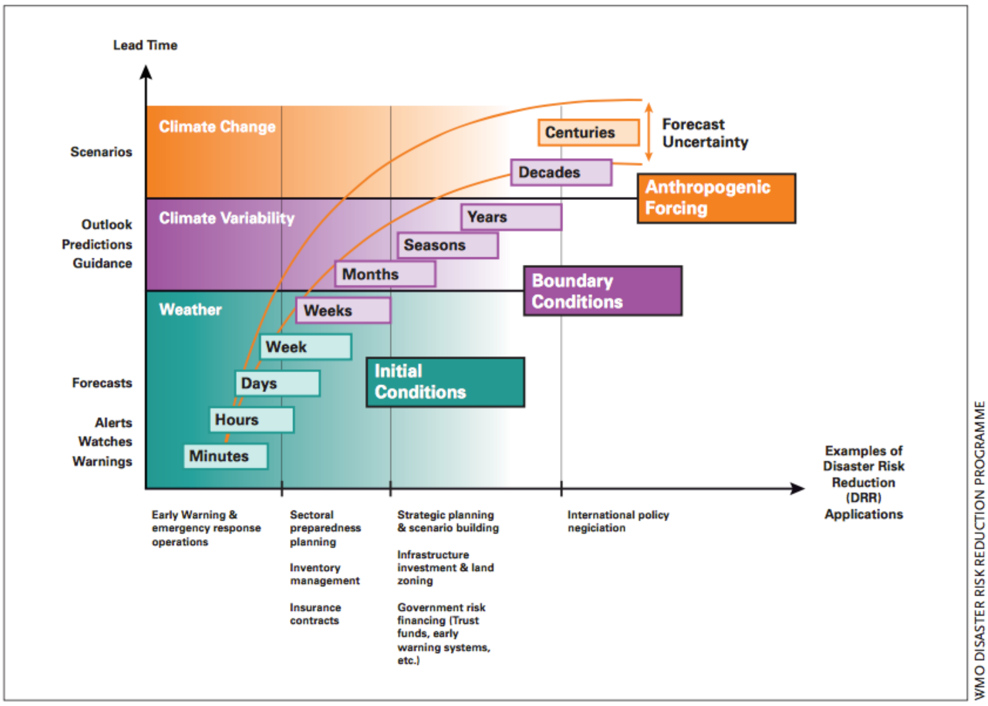
Disaster risk reduction

Increasing the frequency of extreme events such as cyclones, storms, floods and droughts impacts almost all the sectors. Early warning of extreme events is crucial for developing and implementing preparedness and response strategies. Among issues hampering Disaster Risk Reduction efforts is a lack of data concerning a country's past climate to quantify hazard characteristics (e.g., frequency, severity and location) of local climatic extremes in the future. Rising sea levels increase the risk of coastal flooding, and may necessitate population displacement, as well as inundating fresh water supplies.

The hazard side of the equation uses historical data and forward looking modeling and forecasting about environmental conditions e.g., tropical cyclones, rainfall, soil moisture and hill slope stability, mountain weather patterns and river basin hydrology. The emergence of climate prediction provides opportunities to increase the lead times of early warnings. For instance, seasonal climate outlooks help governments predict – and manage – excessive or deficient rainfall. Historical data has traditionally been used for analysis of hazards patterns. But this is no longer sufficient, because hazard characteristics are changing as a result of climate change. For instance a 100-year flood or drought may become a 30-year flood or drought or, simply said, more severe events could happen more frequently in the future. Weather and climate services with forecasts from the next hour to seasonal through to decadal time scales are therefore needed to inform long-term investments and strategic planning on, for instance, coastal zone management, development of new building codes and the retrofitting of infrastructure to withstand more frequent and severe hazards.

41 http://worldweather.wmo.int/en/home.html
42 http://dmh-cdp.wowspace.org/team/homex.php
43 http://wxmaps.org/pix/forecasts.html

Figure 1 Seamless hydro-meteorological and climate services for various risk management applications



Seamless hydrometeorological and climate services for various risk management applications.

Health sector

Climate is a key variable in managing the overall burden of disease and the health sector needs to understand and quantify the specific effects of climate variability and change both on the overall disease burden and on opportunities and effectiveness in the public health response. Information on frequencies of heat waves is needed for prediction of vector borne diseases. To ensure food security and to reduce the malnutrition, information on rising temperatures and variable precipitation are essential[44]. The health sector can use climate information effectively in epidemic early warning systems. Seasonal forecasts of temperature and rainfall, which are useful indicators of the likely occurrence of malaria outbreaks, can be used to implement a programme of heightened epidemic surveillance, while real-time temperature and rainfall estimates can be used to initiate selective interventions and to support the early detection of disease outbreaks[45]. Climate change is high on the agenda of public health services worldwide. The recent World Health Assembly of the World Health Organization (WHO)[46] reinforced the need for countries to develop health measures and integrate them into plans for adaptation to climate change.

Energy sector

Energy is at the heart of economic and social development and historical climate data is key to determining the nature, and help locate and design, better energy infrastructure. Weather forecast information are required for monitoring of energy usage and prediction. Energy companies use seasonal climate forecasts through link between climate variability and energy demand for supply planning to guard against shortages during the most critical times in the season. Direct solar conversion, harnessing of hydro, wind and wave energies can in

44 Human health: http://www.climate.org/topics/health.html.

45 Ghebreyesus, T.A., Z. Tadese, D. Jima, E. Bekele, A. Mihretie, Y.Y. Yihdego, T. Dinku, S.J. Connor and D.P. Rogers. 2008. Public health and weather services–climate information for the health sector, WMO Bulletin 57 (4): 256 – 261.

46 World Health Assembly, 2008: Climate Change and Health. 61st WHA Resolution, May 2008, Geneva. (http://www.who.int/gb/ebwha/pdf_files/A61/A61_R19-en.pdf)).

certain circumstances, replace significant quantities of non-renewable energy sources. A major challenge for managers of hydroelectric facilities is to match energy generation to seasonal and long-term water supplies, and often to competing water demands for urban and irrigation needs[47]. During periods of drought the demand for electricity has to be balanced against the need to conserve scarce water supplies. Long climatic records on the year-to-year variability and the duration and intensity of past drought events are essential to the design process and are crucially important in effective operation of water infrastructure. Large wind generators now offer economic power supplies in climatologically favourable locations. Long records describing the diurnal and seasonal patterns of local winds are essential for planning the economics of a wind generation project such as the off shore wind farm pictured above. Large-scale solar systems have demonstrated the feasibility of photovoltaic conversion and their location is determined be the use of solar climate data. Key users of climate / weather information across priority sectors are given in Annexure 1.

3.2 Links between climate scientists / information users/ policy makers

Active and early involvement of agencies with strong established relationships and trust with end-users is required to improve chances of delivering operational applications of climate information [48]. Links between climate information generators and users in identified sectors are described below.

Agriculture

Frequent interaction between climate information producers, farmers and policy makers will be helpful to understand the needs of end users and such interaction will also strengthen the feedback mechanism. Regional approaches are often employed to support national capacity by linking with neighboring regional and global centers of excellence for data, forecast and expertise sharing, for example through a system of “cascading forecasts” for snowmelt runoff and severe weather in Central Asia, supported by IDA and the PPCR. Building capacity of the agencies involved across the service delivery chain improves early warning and preparedness, as well as coordination and information exchange. Hydro-meteorological support emphasizes the role of the ultimate information users as demand drivers and ultimate beneficiaries of quality weather, climate and hydrologic services. Presently, the climate information and products are based on advanced approaches such as probabilistic forecasts based on ensemble methods. Most of the farmers in South Asian countries are unable to understand the probabilistic forecasts and uncertainties in the forecasts. A strong inter regional relationship will be helpful to guide the end-users about the importance of climate information in decision-making.

Water

Weather, climate and hydrologic monitoring and forecasting are essential to inform decision making for climate resilience and provide critical inputs to early warning systems. In 2011, Global Framework for Disaster Risk Reduction (GFDRR) launched a hydro-metrological initiative to support and leverage World Bank investments to strengthen weather, climate and hydrological services, and ensure that World Bank investments support and contribute to international norms, standards, systems and efforts under the auspices of the World Meteorological Organization (WMO) and the Global Framework for Climate Services.

In India, water sector managers use information including historic climate records, monitoring of the current season, prediction at a range of lead times, and value-added information, which integrates and translates raw climate data into impacts and management

47 WMO – Energy Sector: https://www.wmo.int/pages/themes/climate/applications_energy.php.

48 Jagtap, S.S., J.W. Jones, P. Hildebrand, D. Letson, J.J. O’Brien, G. Podesta, D. Zierden, F. Zazueta, 2002. Responding to stakeholder’s demands for climate information: from research to applications in Florida, Agricultural Systems 74 : 415–430.

implications within agricultural and hydrological systems. Seasonal prediction is a particularly promising, provide a degree of predictability of rainfall at a seasonal (i.e., ! 3 months) lead time. The lead time of seasonal forecasts matches the period between the many climate-sensitive decisions (e.g., allocation of land, technologies to a local environment including choice of crop and variety, land configuration, level of fertilizer application, etc.).

In Afghanistan, according to a report on "Trans-boundary Water Policy of Afghanistan," the country uses only a small portion (about 30%) of the water that originates in the country. The primary source of water is snow melt in the Hindu Kush Mountains with runoff peaking in early summer. Pakistan and Afghanistan share some river basins. Afghanistan relies on winter snowfall in the mountains to replenish the snowfields and glaciers that supply water to its perennial and ephemeral rivers and streams. Due to wars and political instability, much of the institutional data and knowledge relating to water resources was lost. Most of the Afghanistan's water monitoring equipment was destroyed, and the abilities of Afghan water scientists stagnated. Its scientists had been isolated from the international scientific community and from on-going technological advancements in the field of climate. Due to, non-availability of historical data and climate information for water sector, the decision makers and water managers are unable to grasp the socio-economic benefits of climate information and services.

Pakistan is a water scarce country due to low water storage capacity. The high population growth in the region will put in more pressure on water sector in the future. Water scarcity includes both available amount and quality of water. Human security is on risk due to water scarcity and climate change. Due to lack of coordination between climate information producers, water managers and end users, a huge amount of snow-melt water is wasted during dry summer months (Apr-Jun) and rain-water during monsoon season (Jul-Sep). Water related disasters such as floods and droughts are also increasing gradually in Pakistan and other south Asian countries but water managers are unable to understand the causes of excess and deficient water in the region. There is need to develop a relationship between the NMHS and the water management authorities to use the available water more judiciously by proper application of climate information.

Disaster Risk Reduction

Current actions on early warning and disaster risk reduction are mostly based on indigenous knowledge at the community level. However, if people have access to timely and relevant information on weather and climate, they would be able to prioritise and diversify their livelihood options. Considering the context of increasing uncertainty, "planning for the worst" must assume a central role in development. For Disaster Management and Recovery, local contingency and emergency preparedness plans need to be developed and linked to the existing early warning system plans to strengthen community-based preparedness planning.

Box: Indian case study on Disaster Risk Reduction

In October 1999, a Category 5 cyclone devastated the eastern coastline of India. The strongest cyclone on record in the North Indian Ocean left 10,000 people dead and about 1.7 million homeless, and caused disaster losses estimated at US$4.5 billion. Fourteen years later in October 2013, Category 4 Cyclone Phailin hit the same stretch of coastline around Andhra Pradesh and Odisha (formerly known as Orissa). This time, a different story unfolded: fewer than 40 people died (0.4% of the 1999 casualties) and initial estimates of economic losses stood at US$700 million. What changed? Essentially, years of disaster risk prevention and preparedness paid off. After 1999, the Odisha State Disaster Management Authority (OSDMA) invested heavily in improving capacity to manage disaster risk through early warning systems and preparedness simulations, including annual storm drills and the involvement of local community and volunteer organizations. OSDMA also invested in new cyclone shelters, evacuation routes and strengthening coastal embankments. With improved forecasting, the Indian Meteorological Department was able to provide accurate advance warning (72+ hours) and tracking forecasts before Phailin made landfall, allowing about a million people to evacuate. Improvements in communication technology also played a central role in enabling the network of community and volunteer organizations to mobilize the larger population; currently, 60% of the population in Odisha own mobile phones, compared to just 2 million handsets in all of India in 1999.

Continued and increased support is necessary to ensure that Andhra Pradesh, Odisha and other similar jurisdictions with well- developed disaster management structures do not become victims of their own success, due to the perverse incentives surrounding disaster response. The widespread devastation in 1999 captured global media attention and catalyzed a humanitarian relief effort that extended well into the 2000s. This financial assistance is equally important in 2013 to ensure that the fragile success is not undone. The Government of India and the World Bank continue to support climate and disaster resilience in Odisha and Andhra Pradesh through Phase 1 of the National Cyclone Risk Mitigation Project. The project, totaling US$255 million, has been under implementation since March 2011, and aims to extend the early warning system to the community level, build multi-purpose cyclone shelters and evacuation roads, and strengthen existing coastal embankments. Early indications reveal that project investments are contributing to India's larger efforts to help communities become more resilient to the impacts of natural disasters and the changing climate[49].

Country like Afghanistan is extremely vulnerable to natural meteorological and hydrological disasters such as flash floods, torrential rains, landslides, avalanches, dust-storm and droughts. The frequency of such disasters has substantially increased as witnessed during last few years. The climate models suggest that a range of new and increased climatic hazards will confront Afghanistan. The most likely adverse impacts of climate change in Afghanistan are drought related disasters such as desertification and land degradation. Floods due to untimely rainfall and a general increase in temperature are of secondary importance. Improving weather forecasts and early warning systems must be effectively linked to action on the ground, to save both lives and property. Preparedness activities, therefore, must include strengthening the capacity of local organizations to plan for and respond to the effects of disasters. Afghan Meteorological Authority (AMA) is the mandated NHMS in Afghanistan based in Kabul. AMA is closely working with various international agencies. e-Afghan Ag "provides credible relevant information to those helping farmers in Afghanistan." The project is supported by USDA and managed by UC Davis (e-Afghan Ag, 2015). FEWS NET (Famine Early Warning Systems network) is a USAID-funded activity that collaborates with international, regional and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. It includes food security updates, weather hazards, and agro-climatic monitoring, among others. By the Agro-Meteorology Project, scientists with the USGS (United State Geological Survey) Agro-Meteorology (Agromet) Program assist the Afghan Government in the collection and analysis of agricultural and meteorological data as it relates to crop production, irrigation, water supply, energy, and aviation.

49 World Bank Project staff, World Bank's blog and NPR blog.http://blogs.worldbank.org/endpovertyinsouthasia/never-again-story-cyclone-phailin; http://www.npr.org/blogs/parallels/2013/10/15/234679285/how-india-has-learned-to-deal-with-majorcyclones?utmmedium=Email&utmsource=share&utm campaign.

Bangladesh Meteorological Department (BMT), also known as Abohawa Office (Weather Office) is the national meteorological organization (NHMS) of Bangladesh. It is responsible for maintaining the network of surface and upper air observatories, radar and satellite stations, agro-meteorological observatories, geomagnetic and seismological observatories and meteorological telecommunication system of Bangladesh. BWDB is national hydrological agency, which uses various weather and climate information for disaster risk reduction. BWDB also established Flood Forecasting and Warning Center (FFWC) for early warning in Bangladesh.

In Burma, links among the climate scientists, information users and policy makers is missing. DMH is the sole responsible body to collect and process all required information. However, the mode of dissemination is an area that needs to be worked upon. Further the information available is not transferred efficiently to policy makers or climate scientists from development organisations like CCAFS etc. for appropriate decision making. Development partners would like to have more general information related to priority investment areas on climate change by national partners along with sectors and available funding by donors. Alongside, organisations more specifically focused on DRR would appreciate pro active sharing and dissemination of climate related information guidance and learnings from responsible global, national and local agencies with trainings provided so that information meets the minimum quality and are available. (Joshi, Milan, Personal Communication).

In Nepal, DHM (Department of Hydrology and Meteorology) is mandated NHMS agency of Government of Nepal. There is limited link between DHM and Insurance Board (national insurance providers). The Ministry of Agriculture and Cooperatives who provides limited ad-hoc disaster relief for crops and livestock. Compensation for catastrophe events (e.g. floods) is usually paid in kind in the form of free seeds or other crop inputs. In Nepal, International Centre for Integrated Mountain Development (ICIMOD) is also working and supporting DHM to improve its capacity on weather prediction but no linkage with insurance agencies.

Pakistan, like other south Asian countries, is historically prone to meteorological and hydrological disasters such as flash floods, river floods, urban floods, torrential rains, landslides, dense fog, droughts, tropical cyclones, windstorms, severe heat and cold waves. Hence, DRR got high attention in the region during the last decade and Disaster Management Authorities have been established at national levels in Pakistan during the last decade but there is still a need to do much by using the available climate information services to minimize the risk of disasters. Disaster risk reduction interventions are being carried out in isolation in the country till date by different departments / agencies at national, province and district levels. Due to lack of coordination, lack of understanding of climate information and effective early warning systems, a blame game normally starts after the occurrence of any disaster.

In the case of approaching cyclones, for example, local authorities use early warnings to evacuate large numbers of people to safer locations or to protect them in situ. Long lead times enable people to protect property and infrastructure; reservoir operators, for example, can reduce water gradually to accommodate incoming floodwaters. Early warning can also provide information on the occurrence of a public health hazard and enable a more efficient response to seasonal drought and food insecurity. Effective systems, therefore, require a combination of government leadership, multiagency coordination to ensure effective responses based on pre-agreed operating procedures, and community participation[50]

Health

[50] Rogers, D., and V. Tsirkunov. 2013. Weather and Climate Resil- ience: Effective Preparedness through National Meteorological and Hydrological Services. Directions in Development, World Bank, Washington, DC.

From the health sector's perspective, climate information needs to be geographically specific and readily available on the time-scales relevant to public health decision-makers. Achieving this depends on a high level of collaboration between environmental and health experts. Institutionally, this will only occur if there is an effective working relationship established between the providers of climate data and information and the Ministry of Health The climate information could be used in planning for the purchase of drugs; identifying where and when to implement more epidemiological surveillance; focusing vector control more accurately in space and time; raising community awareness of epidemic risk; and warning relevant players of any potential emergency as necessary[51].

It is obvious that there should be a good public health intervention strategy to cope with climate-sensitive diseases. Lack of understanding of the relationship between climate and disease often results in health services discounting its importance. This strategy must consider the role of climate, as well as other factors affecting disease incidence and preventative health care. Since the health sector is not usually engaged in climate and environmental monitoring, acquiring and using this type of information successfully depends on developing partnerships between health practitioners and the gatherers and providers of climate and environmental information.

Due to poor industrial waste management and sanitation system, the quality of available water is causing health problems in Pakistan. Malaria and Hepatitis are the growing deceases in Pakistan that are highly associated with climate. Dengue has recently emerged in Pakistan. Unfortunately, there is no coordination between the climate information producers and the health practitioners so far. The health practitioners are unable to understand the causes of emerging diseases that are obviously associated with climate. The science of climate change and human health is totally uncared in developing countries of south Asian region. Hence by establishing a task force of climate information producers and the health practitioners on priority basis will be very useful to identify the vulnerable areas and causes of health problems associated with climate.

Climate-sensitive diseases do not respect borders and, thus, collaborative work between National Meteorological Services and Ministries of Health should be implemented throughout the region. There should also be networking among these partnerships to extract the maximum from the information generated. It should also form the basis for cross-border collaboration on climate-sensitive diseases. In this context, The South Asian Climate Outlook Forum (SASCOF)[52] established during 2009 with representation from Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka play a vital role. The World Health Organization and World Meteorological Organization play a crucial role to ensure collaboration among different countries in the region.

Energy

Energy sector is highly affected by changing climate, particularly by weather extremes. Unfortunately, during extreme winters and summers, the climate information is not used properly in the decision making. Pakistan like other developing countries of this region is facing energy crises since last few years due to industrial growth and high population growth. The lack of coordination between information producers and energy sector has further deteriorated the issue. In Afghanistan, the availability of secure energy supplies has been significantly disrupted by conflicts and resulting under-investment over the past two decades. The impacts of changing climate are already felt in hydro-electricity production,

51 Connor, S.J., T. Dinku, T. Wolde-Georgis, E. Bekele and D. Jima, 2008. A collaborative epidemic early warning and response initiative in Ethiopia. In: Proceedings of International Symposium on PWS: A Key to Service Delivery, 3-5 December 2007, WMO, Geneva.

52 SASCOF, South Asian Climate Outlook Forum. http://www.imdpune.gov.in/consensus%20statement_2014_23apr14_final.pdf

although large thermal power plant and transmission infrastructure are also susceptible to flash flooding and heat stress. Changes in precipitation, ice pack and snow melt patterns, combined with climate change-related land use change has significant impact upon the variability and availability of water flow. Smaller hydropower plants are particularly vulnerable because the average water discharge at many lowland hydro plants is already declining, partly due to lack of climate information and lack of coordination between agriculture and water sector.

3.3 Initial assessment of whether and to what extent users' decision making needs are currently being met

Every year natural hazards cause significant loss of life, and erode or destroy development gains. From the ten most commonly reported disasters, nine are directly or indirectly related to weather or climate. Vulnerability to disasters is increasing as more people and assets locate in areas of high risk. Since 1970, the world's population has grown by 87 per cent. During the same time, the proportion of people living in flood- prone river basins increased by 114 per cent and on cyclone-exposed coastlines by 192 per cent. Rapid urbanization and the growth of megacities will increase exposure to natural hazards. Climate change is expected to increase the frequency and intensity of the most severe weather related hazards in the decades to come.

Over the past five decades, economic losses related to hydro- meteorological hazards have increased, but the human toll has fallen dramatically. This is because of scientific advances in forecasting, combined with proactive disaster risk reduction policies and tools, including contingency planning and early warning systems in a number of high risk countries. In 2005, governments endorsed the Hyogo Framework for Action 2005 – 2015 to build the resilience of nations and communities to disasters. The paradigm shift from post disaster response to a proactive risk reduction approach requires meteorological, hydrological and climate services to support science-based risk management decisions, as well as investments in early warning systems.

Agriculture sector in all south Asian countries is the chief user of climate information that can grasp the benefits of climate information and services to contribute in economic growth of the country. The climate forecast community is now capable of providing a multi-scale (in space and time) integrated prediction system that provides skillful, useful predictions of variables with socio-economic interest in south Asian countries. Currently the improved availability of data and the rapid advances in numerical modeling are enhancing the reliability of climate forecasts on the sub-seasonal to seasonal scales. On average, a five-day weather forecast today is more reliable than a two-day weather forecast 25 years ago. The timely availability of such improved weather and climate products and services that address pertinent seasonal weather and climate challenges will help farmers plan their agricultural activities and achieve improved agricultural productivity, enhanced farm incomes and better livelihoods. The limited interaction of the National Meteorological and Hydrological Services (NMHSs) with farmers, the inadequate dissemination of weather and climate products and services in a timely manner to the end users, language barriers in understanding the climate products and services, weak agricultural extension services and poor communication infrastructure, remain as some of the main barriers in the provision of weather and climate information to smallholder farmers.

Many south Asian countries share large river basins and therefore it becomes vital to share the climate data and information for each country to monitor the available water on regular basis and also to take precautionary measures regarding floods. The collaboration and climate information sharing across boundary would be the strength of each other.The reliable short, medium and long-term information of temperatures and rainfall, based on probabilistic approach, is always an essential need of water sector for a better management of supply and demand side of water. Summertime temperature's trend may be helpful to estimate the snow-melt water by glaciers. The quantitative forecast of monsoonal rainfall would be helpful for the planning purpose i.e., water management for agriculture and energy sectors.

Increasing number of countries are taking steps at national to local levels to reduce risks associated with natural hazards. Among issues hampering these efforts is a lack of data concerning a country's past climate to quantify hazard characteristics (e.g., frequency, severity and location) of local climatic extremes in the future. Disaster risk reduction is therefore one of the high priorities for the development of the Global Framework for Climate Services, to meet both the growing needs and opportunities to increase disaster resilience. With appropriate use of meteorological, hydrological and climate information as part of a comprehensive multi-sector, multi-hazard, and multi-level (local to global) approach, considerable achievements can be realized. An essential starting point for reducing risks is a quantitative assessment which combines information about the hazards with exposures and vulnerabilities of the population or assets (e.g., agricultural production, infrastructure and homes, etc). The hazard side of the equation uses historical data and forward looking modeling and forecasting about environmental conditions e.g., tropical cyclones, rainfall, soil moisture and hill slope stability, mountain weather patterns and river basin hydrology. This must be augmented with socio-economic data that quantifies exposure and vulnerability (for instance, casualties, construction damages, crop yield reduction and water shortages).

Investment in meteorological services and early warning systems have been demonstrated to help with reducing loss of life associated with meteorological hazards. Meeting today's climate-related risks is a pre-condition to being able to adapt to future climate-related challenges including more intense precipitation and storm surges, droughts, heat waves as highlighted by the Intergovernmental Panel on Climate Change [53]. The climate related diseases such as malaria, dengue, hepatitis, allergy etc are common problems of south Asian countries. There is need to develop a common research group on "impact of climate change on human health" at SAARC forum, to explore the causes of diseases and to identify the vulnerable areas.

In a majority of countries of the South Asia region, there is lack of capacities among producer institutions to provide a suite of services (collection and update of climate data, development of climate products and services and promotion of uptake and use of products). Also, there is lack of meaningful partnerships and interface among the producer and user institution. Also, within the user institution, there is often no multi-disciplinary team to assess climate related risks and communicate results (together with the uncertainties involved) and periodically maintain good quality socio economic data in order that climate risks are quantified. There is overall lack of understanding among communities on climate variability and change, along with associated risks and opportunities. The investments, both in infrastructure (monitoring stations and equipment) and soft systems (data base management, information sharing) are sub optimal (Dagar, Sumit Personal Communication). Current status of climate information services in South Asian countries are discussed below:

AFGHANISTAN

Agriculture sector of Afghanistan has a potential to produce several local crops, fruits and vegetables. Presently, the agriculture productivity is lower than potential. Climate information providing system will prop up the agriculture sector of Afghanistan. First, there is need to strengthen the capability of AMA by providing a network of automatic weather stations and building a capacity of staff and scientists through basic trainings in the neighboring countries like Pakistan, Iran and Qatar. The capacity of AMA may also be developed according to

53 World Meteorological Organization report on "Climate Information for Disaster Risk Reduction"

new development and advances in the field of climate such as weather and climate modeling with the support of regional institutes and organizations. Before the capacity building of AMA and establishment of climate information producing system, the available products and information by the regional institutes may be provided to the agriculture sector of Afghanistan through a reliable dissemination system. Like other parts of the region, the agricultural productivity in Afghanistan is also affected by deficient and unusual rains during peak cultivation seasons. Due to lack of climate information, the crop choice availability is limited and sometimes the potentially productive land is left uncultivated. By providing a support in the shape of climate information and services, the poor farmers can be motivated to grow local crops and vegetables on regular basis to accomplish the needs of communities. Without any support and significant investment in field of public weather and climate service delivery, the agricultural economy is likely to become marginal resulting food insecurity in Afghanistan.

The existing climate information producing system is deprived to date. In the absence of climate information, the end-users who are mostly small farmers are unable to understand the impact of weather on agriculture productivity. Most of the small and poor farmers and the policy makers are not aware about the agriculture potential of the country and about the changing climate. Lack of historical climate data and information is a main stumbling block to provide any support to end-users in decision-making.

A critical unknown factor in Afghanistan's water future is the influence of a changing climate. Decision support on water management in the aspect of amount and quality, is not possible without climate information producing system and building a relationship with the water managers in decision support in Afghanistan.

At present, no DRR policy of Afghanistan exists, however the disaster preparedness law was developed three decades ago. Recently, ANDMA (Afghanistan National Disaster Management Authority) has been established to cope the disasters related issues in the country. Due to absence of historical data, scientific knowledge of return periods of floods and droughts, lack of climate information, it becomes difficult to reduce the vulnerability through prevention, mitigation and preparedness. Due to non-availability of climate information and early warning systems, a proactive approach by the disaster managers cannot be adapted. Hence, there is need to strengthen the capacity of concerned organizations and institutes of Afghanistan by providing funding, technical assistance and trainings by regional organizations. NDMA of Pakistan is building the capacity of ANDMA by providing technical support and trainings. The United Nations Assistance Mission in Afghanistan (UNAMA) and the Asia Development Bank has collaborated with the Government of Afghanistan and other partners to develop a National Plan for Disaster management as well and Strategy for Institutional Strengthening in Risk Management. Organizations working at the community level such as the Afghan Red Crescent Society have provided training in hazard assessment and mapping to community volunteers in order to assist in the preparation of plans.

A Famine Early Warning System Network (FEWSNET), in collaboration with USGS are working on the use of satellite imagery and provide regular weekly reports on climate changes that are used to monitor changes or to signal impending changes/projecting crises. However, there is need to generate the real time climate data in Afghanistan to calibrate the information based on remote sensing. The existing low profile climate information and services cannot provide any support in decision making, particularly to produce affective early warnings regarding the occurrence meteorological and hydrological hazards in Afghanistan.

In Afghanistan, climate change is likely to compound health problems. The distributional effects of climate change are more likely to fall upon women and children. A large proportion of the Afghan population live just above the poverty line, climatic shocks have the potential to tip a large percentage of population into poverty resulting increased prevalence of diseases. No system of coordination and interactions between climate information producers and health practitioners exists in Afghanistan. Limited climate information is produced for some other sectors, not for the health sector in Afghanistan. The existing limited climate information and lack of coordination with stakeholders is not useful in decision making regarding the identification of health related issues among vulnerable communities, particularly women and children.

BANGLADESH

In Bangladesh, there is lack of coordination among the different climate data provider, seeker and climate service provider. This makes efforts and investments overlap during any research. Hence, there is a need for coordinated efforts in research. ADB supports BMD for numerical climate and weather data project through funding and technical support (Abdur Rob, Personal Communication). Soil fertility, drought related information, flood information, disaster trends, flood data, water level data, water resources data are used for efficient energy management, transportation planning and market Access (Abdur Rob, Personal Communication).

BURMA

Department of Meteorology and Hydrology (DMH) is the mandated national NHMS agency in Myanmar. DMH provides meteorological service for aviation, meteorological and hydrological service for shipping and inland water transport, meteorological services to agriculture, hydrological services, and also seismological services. No existing linkages between DMH and insurances agencies in Myanmar. Climate information to some extent is used by agriculture sector for appropriate practices and planning; but no validation established. Data claimed to be used for disaster risk reduction planning; again no authenticated documents available readily. (Milan Joshi, Personal Communication).

Though ten days forecast available in the web portal of DHM is being used for general decision making, data related to extreme and severe events are missing. It is important to note that in compliance with UNFCCC, Burma claims to have paid special attention to enhance education and awareness of public on climate change through trainings and various means. However, the first phase of consultation reveals that the field reality is different as general public are not aware of the same (Joshi, Milan Personal Communication).

INDIA

In India, IMD (Indian Meteorological Department), NCMRWF (National Centre for Medium Range Weather Forecasting) and CWC (Central Water Commission) are mandated NHMS agencies of Govt. of India. The prime object of Agricultural Meteorology Division, India Meteorological Department (IMD) is to minimize the impact of adverse weather on crops and to make use of crop-weather relationships to boost agricultural production. It is also the centre for research programmes in agricultural meteorology and has field units in various parts of the country. Besides, forecasts and advisories for farmers are issued by IMD's Forecasting Offices located at different State capitals. IMD is also one of the six Regional Specialized Meteorological Centers (RSMC) of the World Meteorological Organization (WMO). It has the responsibility for forecasting, naming and distribution of warnings for tropical cyclones in the Northern Indian Ocean region, including the Malacca Straits, the Bay of Bengal, the Arabian Sea and the Persian Gulf.

In India, different states are taking initiatives to establish automatic weather station (AWS) network to provide weather information along with value added weather services such as weather based agro advisory, market intelligence, etc., for improving the decision making capacity of the stakeholders at various levels. In Tamil Nadu, 385 AWS have been installed on different blocks and weather information with agro advisory are provided online at hourly basis (tawn.tnau.ac.in). Similar initiatives have been taken in other states like Karnataka, Maharashtra and Andhra Pradesh.

In India, many private weather services agencies to fill the information gap and hence playing a big role. Sky-Met and WRL (Weather Risk Limited) are well known private weather service providers to various insurance as well as to media (print and electronic) agencies. Sky-met have been working on customizing weather forecast information for farmers. Skymet has built very precise algorithms for forecasting temperature, rainfall, humidity at the village level. Skymet have also established network of over 1,800 automatic weather stations spread across 15 states of India. For the first time in India, these weather stations are streaming live data to crop insurance companies to hasten settlements. Skymet also provides data mining support and remote sensing based data services to crop insurance companies that will help them create new products and settle yield based claims under Modified National Agriculture Insurance Scheme (MNAIS) (Skymet, 2015). Apart from Sky-Met, WRL also working on risk assessment with their own network of weather stations.

NEPAL

Most of the organizations within Nepal do not have access to useful and relevant climate data/services. The critical barrier is the cost of such scientific data/information and the other important barrier is the lack of technical expertise within the country to effectively generate reliable information and effectively translate it into easily understandable form. Existing climate services from the government level are very ineffective and are not updated frequently. Capacity of the government to generate and effectively use such data and information is lacking. Dialogue, outreach and feedback process is just a virtual within the government system, and there are challenges to take advice and make necessary changes.

Lack of skilled expertise to handle sophisticated climate data and services is also a constraint, which would require capacity building of the national hydrological and meteorological services. Barriers are also there in terms of medium and short-term forecasts, which is not available for Nepal, and even if it is available the spatial and temporal resolution cannot capture the heterogeneity of the climate and weather of the various topographical regions. Also, users face difficulties in accessing real time data due to lack of sufficient human resources at the sub-regional level who have the capabilities to process the data and disseminate it to the end users. Linkage to agro-meteorological information to the farmers is missing – and there is no mechanism in place to test whether the forecasted data or information has been utilised by the end users or how effective it has been. Under the Building Resilience to Climate Induced Hazards (BRCH) – PPCR project, Ministry of Agricultural Development (MoAD) is working to create an Agricultural Management Information System (AMIS). The portal aims to provide timely agro-climate and weather information to the farmers to aid farmers and relevant stakeholders. However, progress has been slow towards developing a user friendly agro-portal, that would ultimately support making rational decisions in the agricultural sector to negate the impacts of droughts and floods.

Seasonal outlook is critical for crop planning, crop production, crop protection, harvesting, disaster risk reduction, early warning systems (Dagar, Sumit Personal Communication). Many organisations in Nepal do not have access to useful and relevant climate data and services. One of the critical barriers relates to costs of generating such scientific data and information and the other being lack of technical expertise within the country to effectively generate reliable information and translate the same into easily understandable forms and formats. Similarly, existing climate services from the government are ineffective in that they are not updated frequently. Capacity of the government to generate and effectively use such data and information is a key constraint. Dialogue, outreach and feedback system in government ministries and departments, especially in the agriculture and water sectors, are weak and non-existent. Lack of skilled expertise to handle sophisticated climate data and services is a constraint which will require capacity building of the NHMS.

Barriers also exist in terms of medium and short term forecasts which are not available for Nepal and even if available, spatial and temporal resolutions cannot capture the heterogeneity of the climate and weather of the various topographical regions. Also users face difficulty in aaccessing real time data due to lack of sufficient human resources at the sub regional level who have the capabilities to process the data and disseminate it to the end users. Linkage to agro meteorological information to the farmers is missing and there is no mechanism in place to test whether the forecast data or information has indeed been utilized by the end users and how effective this has been. (Dagar, Sumit Personal Communication)

PAKISTAN

Pakistan Meteorological Department (PMD) is the NHMS agency and also a scientific, service department. It is responsible for providing meteorological service throughout Pakistan to wide variety of interest and for numerous public activities and projects which require weather information. Apart from meteorology, the department is also extending services in the fields of agro-meteorology, drought monitoring, hydrology, astronomy and astrophysics, seismology, geomagnetism, and studies on Renewable Energies Resource potential across various parts of the country. Pakistan Meteorological Department shoulders the responsibility to investigate the factors responsible for global warming, climate change its impact assessment and adaptation strategies in various sectors of human activities. There is no link with NHMS and insurance agencies in Pakistan.

Agriculture sector is the priority sector in Pakistan where changing climate has serious threats to local crops and productivity. Therefore the demands for climate services in this sector are also very high. Farmers of Pakistan are not fully aware about the misery of climate change resulting low agricultural productivity than potential. In Pakistan, the overall extent of negative impact of temperature is greater than the positive effect of rainfall in the country. The climate information can be used to convert the negative impacts of rising temperature and rainfall into an opportunity. Presently, the provided climate information to the agriculture sector is not very useful in decision making because (i) only general weather forecasts for next 2-3 days (for all areas and crops) are provided to the agriculture sector through a traditional dissemination system; (ii) the climate information or products are not produced according to the needs and farmers of remote and isolated vulnerable areas are not receiving the climate information timely; (iii) SASCOF provides the information about monsoon rainfall only that is very general, not area or country specific. Pakistan and Afghanistan also receive significant winter precipitation by mid-latitudinal weather systems; hence both countries should also be members of NEACOF.

Due to lack of data, knowledge and information sharing, the feedback mechanism is not effective to understand the impacts of climate change on local crops. The climate information producers do not understand the needs and requirements of farmers and therefore the provided information cannot be very useful for the farmers in decision making. Based on changing climate and the demands of farmers, it is suggested that (i) reclassifying the climatic zones of Pakistan that will be more beneficial for both, the climate information producers and the end-users; (ii) producing probabilistic weather forecasts with the uncertainties in forecasts for decision making by the farmers; (iii) climate information or products should be produced according to the needs and demands of farmers i.e., weather forecasts of major climate variables (temperatures, rainfall, winds) for existing crops of different areas (rain-fed & irrigated); (iv) effective dissemination system for climate information by NMHS is a demand of agriculture sector that will be helpful to minimize the risk and crop damages; and (v) awareness of new farming techniques by Agriculture Department including new irrigation methods, new methods of crop farming and adapted cropping pattern would be the appropriate derivatives of paradigm shift required in the agriculture sector.

The water sector gravely accepts the climate information in Pakistan. Water sector has no mechanism to measure the exact availability of available water due to lack of water level gauges along rivers. The water managers mostly depend on estimated amount of water in the two major reservoirs (Mangla Dam & Tarbela Dam). There is no system with water sector to estimate the snow-melt water and underground water availability. Pakistan is not as much water scarcity country as painted by the water managers. Most of the time, Pakistan has excess water that cannot be managed by the water managers due to low storage capacity. The trust deficit of water managers on climate information producers results poor decision making in water management.

There is a strong need to give directions and sound guidelines to different departments / agencies working in isolation to align their activities in line with the true spirit of National Disaster Management to counter the threats of disasters by using the climate information and early warnings. A proactive and anticipatory approach through wider consultations with all stakeholders by focusing on risk assessment, prevention, mitigation and preparedness, as mentioned in National Disaster Risk Reduction Policy will be more effective to use the climate information and services. Disaster Management Authorities are responsible to reduce the disasters vulnerability and they have a right to demand reliable and impact based climate information and effective early warnings with appropriate lead time. It is difficult to cop any disaster at national level, hence the organizational set up of NDMA should be expanded at local and district level to cop the disasters. Historical past long term data should be used to recalculate the return periods of major disasters such as floods and droughts.

The initial assessment based on available early warnings and climate information during recent flood disaster in Pakistan revealed that vulnerability could not be reduced so far. It also indicates that the climate information and services available to some extent could not be used and adapted to reduce the vulnerability in the communities. Most of the disaster managers in NDMA and PDMA are not relevant persons who are appointed on contract or temporary basis from other organizations. They have no capability to understand the impact of climate information and early warnings produced by NMHS. Such irrelevant persons could not establish a strong relationship with the climate information producing organization in Pakistan that should be helpful in their decision support system. There is also lack of lesson learning process i.e., lessons are identified by the past extreme events but not adapted/learned.

There is a strong need to give directions and sound guidelines to different departments / agencies working in isolation to align their activities in line with the true spirit of National Disaster Management to counter the threats of disasters by using the climate information and early warnings. A proactive and anticipatory approach through wider consultations with all stakeholders by focusing on risk assessment, prevention, mitigation and preparedness, as mentioned in National Disaster Risk Reduction Policy will be more effective to use the climate information and services. The initial assessment based on available early warnings and climate information during recent flood disaster in Pakistan revealed that vulnerability could not be reduced so far. It also indicates that the climate information and services available to some extent could not be used and adapted to reduce the vulnerability in the communities. Most of the disaster managers in NDMA and PDMA are not relevant persons who are appointed on contract or temporary basis from other organizations. They have no capability to understand the impact of climate information and early warnings produced by NMHS. Such irrelevant persons could not establish a strong relationship with the climate information producing organization in Pakistan that should be helpful in their decision support system. There is also lack of lesson learning process i.e., lessons are identified by the past extreme events but not adapted/learned.

Due to lack of pollution monitoring system in the country, particularly in the urban areas and uncertain quality of drinking water, it is difficult for the researchers to develop any relationship between the water/pollution borne diseases and changing climate of Pakistan. Lack of interest and investments by the government and donors in the sector of “climate and health”, it is not possible to develop any decision-support system in this regard. However, the climate information and data can be used to surmount this major issue related with the human health.

Annex 4 Intervention Mapping

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Asian Pacific Adaptation Network (APAN)	Institute of Global Environmental Strategies (IGES), Regional Resource Centre for Asia and the Pacific (RRC.AP) located at Asian Institute for Technology (AIT), and Stockholm Environment Institute (SEI)	Network	On-going	UNEP	The mission of APAN is to build climate change resilient and sustainable human systems, ecosystems and economies through the mobilisation of knowledge, enhanced institutional capacity and informed decision making-processes, and facilitated access to finance and technologies. The APAN organises the Asia Pacific Climate Change Adaptation Forums which are among the biggest climate adaptation events in the region attracting over 500 participants from all levels of government, the private sector and the donor community. USAID sponsored a forum in September 2014 on adaptation finance.	Climate services have not been explicitly addressed to date, despite being a prominent topic in recent regional policy. DFID could consider sponsoring a forum in order to stimulate debate and cross-regional (Asia-wide) knowledge sharing and learning on different elements of climate services thereby strengthening the enabling environment required to move from planning to implementation. Other donors could be interested in co-sponsoring such an event. Also important to engage with the South Asian node of the APAN, the Climate Action Network South Asia (CANSA). Members include organisations from Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka
Asian Disaster Preparedness Center (ADPC)	ADPC	Programme	On-going	ASEAN, SAARC, UN agencies, World Bank, ADB and other bilateral donors and regional organisations	ADPC's 2020 Strategy approaches DRR through enhancing capacity of countries by utilizing science-based information; strengthening government systems for effective risk management at all levels; and by improving grounded application of risk reduction measures in development. Runs mostly national level and some regional programmes and training courses related to climate services, e.g. *End-to-end Multi-hazard Early Warning Systems*.	ADPC represents a potential channel for funding / implementation partner in climate services and DRR work across Afghanistan, Bangladesh, Burma, India, Nepal and Pakistan. Not currently running many regional programmes so could be interested in engaging with DFID to scale-up its work in this respect.
Can Seasonal Climate Forecasts Improve Food	IRI University of Colombia and CSIRO	Research	Completed 2012-2014	AusAid	Project in India and Sri Lanka to enhance food security by reducing agricultural production risks associated with climate variability and climate change, and by developing a blueprint for improved climate information usage	Support scaling-up of testing seasonal climate forecasts in farming systems across South Asia

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Security in Indian Ocean Rim Countries?					across case study regions in the Indian Ocean Rim. IRI's role and involvement focuses on improving seasonal climate forecasts, and testing their value in farming systems based on hindcasts.	

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Climate Adaptation Research Initiative in Africa and Asia (CARRIAA)	HI-AWARE is confirmed by ICIMOD, Bangladesh Centre for Advanced Studies, The Energy and Resources Institute, India, Climate Change, Alternate Energy and Water Resources Institute of the Pakistan Agricultural Research Council Alterra, Wageningen University and Research Centre, the Netherlands	Research	On-going to 2019	IDRC and DFID	A seven-year, $70 million initiative, CARIAA focuses on three global "hot spots": deltas in Africa and South Asia; semi-arid regions in Africa and South and Central Asia; and Himalayan river basins. The Himalayan Adaptation, Water and Resilience (HI-AWARE) project builds on current research on adaptation in the Hindu Kush Himalayan region to look at short- and long-term climate trends and adaptation strategies, while taking into account local and seasonal impacts and responses. The project will identify: • "critical moments"—times of the year when specific climate risks are highest and when specific adaptation interventions are most effective; • "adaptation turning points"—when current policies and management practices are no longer effective and alternative strategies have to be considered; and • "adaptation pathways"—sequences of policy actions that respond to adaptation turning points by addressing both short-term responses to climate risks and longer-term planning. Research will take place in the Indus, Ganges, and Brahmaputra river basins, with research and pilot intervention sites in Pakistan, India, Nepal, and Bangladesh.	Ensure effective linkages so that regional programme options build on and feed into this research.
Climate	Asian	Funding	On-going	ADB	Established in 2008 to facilitate greater	It does not seem that much on climate services

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Change Fund (CCF)	Development Bank	mechanism			investment to effectively address the causes and consequences of climate change. Activities targeted include development of knowledge products and services related to climate change, although it is not clear what has been funded in this respect to date.	has been funded to date. Opportunity for DFID to explore future synergies for funding regional work through this mechanism.
Climate and Development Knowledge Network (CDKN)	Various	Funding mechanism for Programmes and Research	On-going	UK AID and the Ministry of Foreign Affairs of the Netherlands	Priority countries in Asia are Bangladesh, India, Indonesia, Nepal, Pakistan. Most relevant area of work is Disaster Risk Management, including *Disaster Risk Insurance For Vulnerable Communities In Pakistan*. The National Disaster Management Authority (NDMA), Government of Pakistan has requested CDKN to support its cause to develop a risk transfer mechanism to protect the lower income population group against extreme events that are expected to increase in frequency due to climate change impacts. Five options of a potential fund design have been prepared for the NDMA to choose from. Under the ongoing phase 2, CDKN is supporting the NDMA in designing an insurance strategy by undertaking a 6 months Demand Study in 5 districts of Pakistan. The detailed insurance strategy will help the NDMA in moving towards consensus on the Fund design. Other projects in the region include seasonal forecasting for farming in Bundelkhand, India to vulnerability of slum dwellers to extreme heat in India and Pakistan.	DFID options should build on learning generated by CDKN projects in the region. Research into risk insurance is required for the South Asia region and the CDKN could provide the appropriate mechanism for generating evidence in this area through, for example, multi-country studies.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Climate Research and Information Services in South Asia (CRISSA)	DFID South Asia Research Hub with collaboration from ADB, British Geological Survey; Institute for Social and Environmental Transition; IDS; International Alert; Livelihoods Resource Centre; ODI Rural Support Programmes Network; University College London; World Resources Institute	Research	On-going 2011-2015	DFID and International Alert	This programme aims to improve coordination among funders of climate research and information services to support a more coherent response to the needs in the region. DFID is funding a range of research programmes with a variety of partners. These include: • Research into the 2010 floods in Pakistan; • Research into operationalizing integrated flood risk management in Eastern India; • Groundwater vulnerability to climate change in the Indo-Gangetic plain; • Strengthening the Response to Climate Variability in Fragile States; Information for Climate Adaptation in South Asia - Identifying User Needs; • Support to improving climate research publications in South Asia; • Calibrating the relationship between above and below snow-line precipitation	There has been significant progress in developing agreement among international research funders on the need for coordination on research and this is being followed up with approaches to DFID from other research funders for discussions on cooperation on key new programmes.
Climate Services Partnership (CSP)	Secretariat conformed by Earth Institute and the International Research Institute for Climate and Society (IRI), both at the University of Colombia	Network, Programme , Research	On-going	USAID	The CSP is a platform for knowledge sharing and collaboration aimed at promoting resilience and advancing climate service capabilities worldwide. The fourth International Conference on Climate Services is planned for December 2015 in Uruguay. The conference will explore the theme of decision support systems; it will also engage a range of other topics	Potential partner for implementing regional research and programmes. Has not done too much focused on South Asia to date so could be interested in expanding operations in collaboration with the proposed regional programme. The CSP has developed several tools that could be tested in the region, such as economic analysis of climate services, climate service evaluation methodologies

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					including health, water, disasters, grassland management, and the evaluation of climate services. Has provided a webinar on the SERVIR project.	
The Coordinated Regional Climate Downscaling Experiment (CORDEX) Regional Downscaling	World Climate Research Programme	Research programme	On-going	Various	The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships. As demonstrated at the recent International Conference on Regional Climate - CORDEX 2013**,** co-sponsored by WCRP**,** the European Commission and IPCC, the CORDEX concept has gained maturity and is showing strong buy-in from the science community and VIA practitioners.	In order to meet stakeholders' expectations, plans are now underway to follow-up on the **conference outcomes** so as to improve the experimental framework leading into the second phase of CORDEX (CORDEX-II). Key outcomes for consideration when developing options for the proposed regional programme include: 1. Tailoring regional climate information and in particular towards updated regional climate assessments and truly operational regional climate services 2. Understanding the added value of regional climate information for decision making, and the challenges of uncertainty 3. A critical mass of multi-model multi-method experiments is needed to encourage uptake of CORDEX data for regional climate analysis and VIA assessment 4. End-to-end pilot studies over selected subregions are needed to provide test - beds to explore a range of critical issues

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Decadal Prediction and Stochastic Simulation of Hydroclimate Over Monsoonal Asia	University of Colombia, LDEO Tree Ring Laboratory, University of California	Research	Completed 2011-2014	US Dept of Energy	Project Goals: • Develop new tree-ring based streamflow reconstructions for rivers in monsoonal Asia; • Improve understanding of hydrologic spatio-temporal modes of variability over monsoonal Asia on interannual-to-centennial time scales; • Assess decadal predictability of hydrologic spatio-temporal modes through new development and testing of statistical for decadal prediction of river flows over monsoonal Asia; • Further develop Monte Carlo stochastic simulation methods to merge the decadal predictions with GCM climate change projections, thus creating downscaled future climate scenarios to 2050, together with estimates of uncertainties via quantification of the full probability density function; • Develop stochastic reservoir simulation and optimization for scheduling hydropower, irrigation and navigation releases through hydrologic modeling case studies for two major reservoir systems over Asia, namely that of the Bhakra Beas Management Board (BBMB) that manages one of the largest reservoir operations in India (in Punjab), and the Yangtze River Three Gorges Dam	The proposed work will deliver urgently needed methodologies to enable more effective planning and adaptation to near term climate change and variability to 2050. While these methods will be tested using the primary reservoir management case studies in India and China, as well in Indonesia, they will be broadly and geographically applicable and DFID could support further testing. All results and software will be made easily accessible to the public via wiki pages and other means.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					reservoir in China.	
The Establishment of a Regional Flood Information System in the Hindu Kush Himalayan Region (HKH-HYCOS)	Led by ICIMOD. Partners were Bangladesh Water Development Board and Bangladesh Meteorological Department; Department of Hydromet Services in Bhutan; China Meteorological Administration and Bureau of Hydrology; Central Water Commission and India Meteorological Department; Department of Hydrology and Meteorology in Nepal; Pakistan Meteorological Department, Water and Power Development Authority and Federal Flood Commission	Information system	2009-2014	Ministry of Foreign Affairs, Government of Finland First Phase (2001-2005) – USAID Office for Foreign Disaster Assistance (USAID/OFDA) and United States Department of State, Regional Environment Office for South Asia	The Establishment of a Regional Flood Information System in the Hindu Kush Himalayan Region (HKH-HYCOS) project promotes the timely exchange of flood data and information for the reduction of flood vulnerability within and among the participating countries though and established and agreed platform which is accessible and user friendly. Project activities worked to: • Strengthen the framework for cooperation for sharing regional flood data and information among participating member countries • Establish a flood observation network in selected river basins in the participating countries • Establish regional and national flood information systems to share real time data and information and increase lead time • Enhance the technical capacity of partners on flood forecasting and communication with end users • Develop a full-scale, fully integrated regional project as planned and agreed among participating countries	Build on learning, explore possibilities for replication and scaling-up.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Flood Hazard Model in Index-based Flood Insurance (IBFI) in South Asia	International Water Management Institute with AIC, Aon Benfield, Indian Council of Agricultural Research (ICAR), International Food Policy Research Institute, IWM,	Programme	On-going 2015-2018	Info not available	The project will develop meso-level IBFI scheme using flood hazard model and remote sensing data - to pre-determine flood thresholds that trigger speedy compensation payout. The project will involve national stakeholders like Disaster Management Centre, Ministries of Water Resources and Agriculture and private sector in particular insurance industry. At the local/village, the programme leverages from the field level experience of the CBOs, local civil society members, implementing NGOs, local government offices and local media to implement IBFI scheme.	
Forum on n Regional Climate Monitoring-Assessment-Prediction for Asia (FOCRAII)	Hosted by the Beijing Climate Center of CMA	Forum	On-going	WMO and CMA, cosponsored by State Administration of Foreign Expert Affairs, National Development and Reform Commission of China and WMO East Asian Monsoon Activity Center/BCC	The main objectives of the Forum are: 1. To review the progress made in the CliMAP programs and the activities both within RA II and the world with a specific focus on the challenges and opportunities in seasonal to inter-annual climate prediction methodologies and systems unique to the RA II region. 2. To provide a platform for the members of RA II to share and exchange experience and knowledge on CliMAP. 3. To build collaborations and partnerships among the members of RA II in the CliMAP programs as well as other international partners and activities. 4. To discuss collaborations among the members of RA II and other international partners to build an Asia-Pacific network of climate	Tentative agenda for the 2015 Forum includes technology and climate services; user demands in the energy and/or agriculture and food security, and/or urban environments; and seasonal climate predictions

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					extreme events monitoring and assessment.	
Global Flood Resilience Alliance	Practical Action, the International Federation of the Red Cross (and national chapters), the International Institute for Applied Systems Analysis (IIASA) and the Wharton Risk Management and Decision Processes Center	Programme	On-going 2013-2018	Zurich Insurance	A 5 year programme focusing on South Asia (as well as SE Asia and Latin America), looking at building flood resilience through work in Nepal at community, sub-national and national level. They are working with the Nepal DHM on forecasting and early warning, and are focusing on translation and dissemination of weather and climate information to the 'last-mile' (user groups at sub-national level including farmers, community disaster risk reduction task forces, community level governance structures). The Alliance aims to test, evaluate and replicate successful approaches to flood resilience. The Alliance is also focusing on cross-border challenges in an integrated trans-boundary river basin approach including links to India and Bangladesh and is interested in improving region-wide cooperation. Key challenges facing the Alliance include lack of regional leadership and momentum behind improving cross-border collaboration (including restrictions on access to data in classified rivers in India).	Practical Action has indicated that the alliance would welcome engagement with DFID and other actors on improving South-Asia region-wide cooperation and collaboration.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
ICIMOD	ICIMOD and partners	Research and programmes	On-going	Various	Over the past five years, ICIMOD has fostered regional and trans-boundary dialogue to promote integrated water and land management and has acted as a resource centre for information on water resources and climate change. ICIMOD has worked to develop and institutionalise remote sensing and geographic information systems in support of development policies and to assist science-based decision making at many levels. In particular, it has worked with international and regional partners to provide access to data and information, to integrate analysis and modelling, and to develop interactive mapping and spatial visualization. The result is that ICIMOD is now internationally regarded as a regional resource centre for geo-information and earth observation application with a specific mountain focus. ICIMOD is also committed to capacity building in this area; the regional member countries have benefited from ICIMOD's short courses and training programmes and have gone on to establish GIS hubs in their own countries. Over the next five years, ICIMOD will: • provide innovative approaches to support the Regional Programmes through integrated data management and a spatial analytical frameworks • customize new technologies in geospatial science to adapt them to mountain-specific situations within ICIMOD's Thematic Areas; and	A number of the ICIMODs regional projects have recently come to an end. Explore potential for scaling-up development and testing of climate service applications and products/rapid response mapping across the region, in particular supporting usage for decision making in priority sectors. ICIMOD has strong capacity implementing transboundary and river basin initiatives in the region.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					• continue to build capacity with regional member countries and to promote partnerships and regional cooperation for information sharing and exchange.	
Integrated Drought Management Programme for South Asia (IDMP)	GWP South Asia and the International Water Management Institute, national authorities in Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka, the Country Water Partnership and others	Programme and information system	On-going	WMO and Global Water Partnership	Launched in 2013 to develop a regional drought monitor for South Asia covering Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. A Needs and Capacity Assessment Survey for the development of a South Asian Drought Monitoring System revealed that there is no validated system of early warning on drought that could meet the requirement for a high spatial resolution in any of the surveyed countries. GWP representatives attended the WMO co-sponsored 5th South Asian Climate Outlook Forum in Pune, India, in April to present the Assessment Report. Based on these discussions a clear way forward for the South Asian Drought Monitoring System (SA DMS) has been agreed with IWMI and additional co-funding secured. The system will be developed for the whole South Asian region, with a few countries in a first phase as a pilot to tailor the system to national needs.	Recommendations made at the South Asian Climate Outlook Forum concerned the involvement of users and relevant government agencies, as the key to the drought monitor's success and particularly for the housing and ownership of the system nationally and regionally. DFID could support complementary measures to this work, focused on overcoming the challenges identified in the Needs and Capacity Assessment, namely: 1. Improving hydrological/meteorological measurement stations 2. Improving access to satellite data 3. Strengthening rainfall prediction capability 4. Improving staff training

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Mountain Environment Regional Information System (MENRIS)	ICIMOD	Information system	On-going	ICIMOD	The MENRIS programme encompasses long-term monitoring, database development, and uptake of knowledge for the region. The system will use the concept of trans-Himalayan transects to help address the information gaps across the Hindu Kush Himalayan region. ICIMOD will work with partners to employ the information at community, national, regional, and global levels. Initiatives of this programme are SERVIR Himalaya and The Regional Database Initiative (RDI) both listed separately in this table.	
JICA	JICA	Programme	Recent and on-going	JICA	JICA has supported various national projects to strengthen capacity and infrastructure for climate services in different countries of South Asia. Completed project: The Project for Development of Human Capacity on Operation of Weather Analysis and Forecasting In the People's Republic of Bangladesh: i) Improved capacity of observation & forecasting ii) Quantitative rainfall estimation of Radar iii) Trend analysis of climate change iv)1-3 days weather forecasting by NWP on trial v) Promotion of understanding of weather information among the stakeholders vi) Proper/efficient operation and maintenance of meteorological radar Ongoing project: Establishment of End to End Early	Explore interest in collaboration on regional level capacity building and infrastructure improvement options

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					Warning System for Natural Disaster in Burma Planned projects: 1. Establishment of Disastrous Weather Monitoring System in Burma 2. Establishment of Specialized Medium Range Weather Forecast Center and Strengthening of Early Warning and Dissemination Network in Pakistan 3. Installation of Weather Surveillance Rader at Karachi (Pakistan) 4. Project for Establishment of S-Band Doppler Radar System in Dhaka and Rangpur (Bangladesh)	
Regional Database Initiative	ICIMOD along with national and regional centres for remote sensing applications; national statistical bureaus	Information system	On-going 2013 -	ICIMOD	The Regional Database Initiative (RDI) ensures the integrated management of centre-wide data and information incorporating geospatial, socioeconomic, and multi-thematic data at different levels. This initiative will develop appropriate policies for facilitating data and information sharing and technical specifications for the design, development, and management of data and information systems.	RDI is proactively forging partnerships with a range of institutions and with other Regional Programmes and Initiatives for the development and operationalization of information systems. The Initiative is also interested in collaborating with national, regional, and global partners for product development and dissemination using emerging technologies

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Regional Weather and Climate Services Program	World Bank	Programme	Planned	World Bank	The proposed Regional Weather and Climate Services Program will be implemented as a Series of Projects over a five to eight year period. The approach is to start from the bottom up and strengthen national capacity for weather and climate services which are required for sub-regional and regional level collaboration. The project interventions are expected to encompass improved meteorological information services, improved hydrological information services, strengthened forecasting and early warning systems, and improved dissemination of agro-meteorological information. The Nepal Building Resilience to Climate Related Hazards project, which supports similar objectives and investment activities, would be considered the first project in the series. The Bangladesh Regional Weather and Climate Services Project would be the second while the proposed Bhutan Regional Disaster and Climate Resilience Project, which has been requested by the Royal Government of Bhutan, is expected to follow. Its amount/timing/scope is under discussion. Collaboration with the India Meteorological Department (IMD) will be strengthened. Total budget approximately USD 75 million.	Poonam Pillai at World Bank is keen to discuss possible collaboration and future synergies
Return on Investment for Emergency Preparedness	UNICEF and WFP	Programme	Completed	DFID	£5.6 million. One of the first research initiatives to quantify the cost and time benefits of a large and diversified investment "portfolio" of emergency	The ambition is for the model to have continued future use within UNICEF/WFP and potentially other interested humanitarian agencies for all humanitarian contexts. Complementary

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Study					preparedness interventions undertaken by UNICEF and WFP in 2014. Covered Pakistan in Asia.	research areas identified by the Final Report (2015) include: • Further research into Early Warning system investments at a later stage of implementation or in other countries to demonstrate the cost savings from these interventions • Similar ROI calculations could be developed for preparedness interventions at the regional or global level • The differentiation between slow-onset emergencies (e.g., drought) and sudden onset (e.g., earthquake) and the relevant impact on preparedness approaches requires further exploration.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
Scaling Up Climate Services for Farmers in Africa and South Asia	CGIAR Climate Change and Food Security Initiative (CCAFS) with support from USAID, Climate Services Partnership, WMO	Programme	On-going	CGIAR	The CCAFS is leading a process of South-South learning and planning towards defining priorities for strengthening and scaling-up climate information and advisory services for agriculture and food security in Africa and South Asia. The process began at the international workshop on "Scaling up Climate Services for Farmers in Africa and South Asia" in December 2012, where participants collectively identified critical gaps in the design, delivery and effective use of climate services for smallholder agriculture. Working groups prioritised improving the scientific capacity of NMHSs to develop location specific seasonal climate forecasts at the subnational scale, and enhancing institutional frameworks for collaboration between the different agencies involved in the production and communication of climate services. In 2014, the programme published *Scaling up climate services for farmers: Mission Possible. Learning from good practice in Africa and South Asia,* which presents lessons learned from 18 case studies that have developed and delivered weather and climate information and related advisory services for smallholder farmers including India's Integrated Agrometeorological Advisory Service (AAS) Program.	DFID could support this programme to fund region-wide replication and scaling-up of best practices, incorporating the following five key elements identified in the 2014 report, namely: 1. Involve farmers in the co-design, co-production and co-evaluation of climate services. 2. Establish partnerships that bridge the gap between climate, agricultural research and farmers. 3. Exploit scalable communication channels to reach "the last mile." 4. Continuously assess to improve quality of service delivery, in particular to understand costs and benefits of climate services can be used to build a case to governments and donors for continued and perhaps increased investment 5. Proactively engage, and target the needs of, the most vulnerable and marginalized, particularly women.
SERVIR Himalaya	USAID, NASA and ICIMOD	Information system	2010-2014	USAID, NASA and ICIMOD	SERVIR is a regional visualization and monitoring system that integrates earth observation information, such as	Support scaling-up of training, testing and use of the SERVIR system. Explore how SERVIR can supported planned options through the provision

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					satellite imagery and forecast models, together with in situ data and other knowledge for improved and timely decision-making. The SERVIR initiative strengthens ICIMOD's capabilities as an established regional resource centre on geospatial information and earth observation applications for the Hindu Kush Himalayan (HKH) region. In 2015, community members in Nepal were trained in the use of satellite imagery for forest monitoring. Also in 2015, the SERVIR Hub Exchange Programme provided a space for participants to discuss and share experiences in cloud-based automated flood mapping.	of geospatial information and earth observation applications.
Smart Information and Communication Technology for weather and water information	IWMI and WaterWatch B.V	Programme	Completed 2011-2014	IFAD	The objective of this project was to promote innovative approaches and ICT based technologies for weather, water and crop-related information and advice to relevant end users in China, Egypt, Ethiopia, India, Mali and Sudan for informed decision-making and enhanced negotiation capacity with water- and farm-related service providers.	Ensure option build on learning and support replication and scaling-up of best practice.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
The South Asia Water Initiative (SAWI)	World Bank with partners including ICIMOD, IUCN, IWMI, Commonwealth Scientific and Industrial Research Organization, universities, Institute of Water Modeling, Center for Environment and GIS and Indian Institutes of Technology	Programme	On-going 2013-2017	ADB, DFID, UNDP, the Royal Norwegian Embassy, Australian DFAT, SDC, FAO, JICA and IFAF	The overarching objective of SAWI is to increase regional cooperation in the management of the major Himalayan river systems in South Asia to deliver sustainable, fair and inclusive development and climate resilience. The initiative has four geographic Focus Areas (Indus Basin, Ganges Basin, Brahmaputra Basin, Sundarbans Landscape), together with a cross-cutting Knowledge, Dialogue and Cooperation component. Knowledge related activities include: • analyses in support of regional cooperation in particular on flood early warning systems and the data sharing required to operationalize these. • host a biennial knowledge forum to build stronger collaborative relationships across the research community	Support SAWI to explore opportunities to provide the knowledge and dialogue support to specific new cooperative agreements between countries, in particular on flood early warning systems and the data sharing required to operationalize these.
Science for Humanitarian Emergencies & Resilience (SHEAR)	Various	Research	On-going 2015-2020	DFID, NERC and ESCR	£19 million 5 year research programme, SHEAR focuses on four areas: disaster risk assessment (mapping and analyses), sub-seasonal to seasonal forecasting, disaster risk monitoring, and the integration of these into practical decision making. The programme is targeting lower and lower-middle income countries across sub-Saharan Africa and south Asia, focusing on the co-production of knowledge using a multi-disciplinary and problem-centred approach.	The gaps that SHEAR leaves are seasonal to sub-seasonal forecasting (a real gap). There are also significant gaps in bringing existing knowledge and tools into operation.[54]

54 Interview with Nicola Ranger, Climate and Environment Advisor, DFID

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					The work in Asia focuses on landslides and links to floods and earthquakes. It will look at how forecasting and EWS can be developed for specific hazards, especially linking risk models and forecasting to develop impacts based forecasting and multi hazard risk assessment. The focus will be in Nepal and Bangladesh. SHEAR also has a "challenge fund" joint with GFDRR and World Bank seeking to "catalyse" innovation in Asia.	

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
SAARC Disaster Management Centre (SDMC)	SDMC	Programme and regional collaboration mechanism	On-going		The Centre has the mandate to serve eight Member Countries - Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka - by providing policy advice and facilitating capacity building services including strategic learning, research, training, system development and exchange of information for effective disaster risk reduction and management in South Asia. Runs a range of relevant training programmes, for example on geoinformatics for disaster management and incident command systems. The Centre is implementing the South Asian Disaster Knowledge Network (SADKN) portal which provides: • Access to clear, understandable and user-friendly information about real time, impending and historical disasters, details of hazards, vulnerabilities and risks of disasters in structured layers of digitized maps in WebGIS platform, and wealth of resources, references, images and videos. • Instant geospatial support for assessing risks and communicating about hazards and the exposure that vulnerable people and infrastructure have to these hazards and assist them in locating disaster occurrences and probable fall outs, and taking important decisions regarding evacuation, damage and loss	With considerable political traction and engagement with different levels of government, scientific and technical organisations as well as local communities, the SAARC SDMC is a key partner for developing actions related to the DRR sector, particularly the development, dissemination and testing of risk management tools. DFID could explore opportunities to co-fund with USAID activities resulting in the implementation of the regional Natural Disaster Response Mechanism.

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
					assessment, recovery and risk reduction. In 2008, SDMC members agreed to creating a Natural Disaster Response Mechanism to adopt a coordinated and planned approach to meet emergencies. Draft agreement signed in 2009. In 2015, a visit supported by USAID took place to the ASEAN Coordinating Centre for Humanitarian Assistance (AHA Centre) to learn about ASEAN's regional disaster response mechanisms and promote larger cooperation between the two regions.	
South Asian Climate Outlook Forum (SASCOF)	Hosted by the India Meteorological Department (IMD) in collaboration with the Indian Institute of Tropical Meteorology (IITM) and supported by Ministry of Earth Sciences, Government of India	Network/ Forum	On-going	WMO and Government of Canada	The fifth session of the SASCOF (SASCOF-5), convened to generate the climate outlook for the summer monsoon season of 2014, was held at Pune, India, in April 2014 with the participation of eight South Asian countries. It was preceded by a capacity building training workshop on seasonal prediction.	Potential to sponsor future events, organise special forums on climate services

Initiative	Lead / Partners	Type	Status	Funding	Activities related to climate services	Opportunities for DFID to build on this work
South Asia Regional Hydromet Program	World Bank	Programme	On-going	World Bank	The South Asia Regional Hydromet Program seeks to strengthen disaster preparedness and climate resilience through cross-border/regional dialogue, and the capacity of participating countries and institutions to respond to water related hazards and climate risks at the national and regional levels, by supporting improvements in monitoring, weather and flood forecasting, community based early warning systems and delivery of climate services.	Poonam Pillai at World Bank is keen to discuss possible collaboration and future synergies.
South Asia Water Governance Programme (SAWGP)	International Bank for Reconstruction and Development, NGOs and other civil society organisations	Programme	On-going 2012-2017	DFID	SAWGP is creating space for 7 countries sharing the 3 Himalayan rivers to collaborate. It is working through multiple activities (total budget £23.5 million) including the South Asia Water Initiative Phase II (SAWI-II), the Mount Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI) and the Third Pole Project (TPP), with other activities still being designed. SAWGP's work on dialogue and investment preparations are contributing towards improved regional cooperation.	Key recommendations from the 2014 review include aligning closer with existing DFID, World Bank and donor partner water/energy programmes. The review also found that collaboration amongst SAWGP's delivery partners is contributing towards enhanced delivery at no additional cost, thereby, improving Value for Money. Worth considering as a delivery model.

Annex 5 Gender and Vulnerability in South Asia

Gender Relations in South Asia

Gender gaps are among the widest in the world in South Asia. Recent data shows that the average Gender Inequality Index (GII)[55] of South Asian countries lies around 0.54[56], which is considered 'medium' human development comparable to the Arab States and Sub-Saharan Africa (UNDP 2014). The constellation of high poverty, low literacy rates among women, long rooted gender biased beliefs and practices, social stigma, cultural taboos, and patriarchal social systems remain the major constrains for equality in the region (Dhungana 2012 and WEDO 2008). Yet the situation is not same across all of South Asia. According to the World Economic Forum in 2009, Pakistan was ranked at 132 out of 134 world nations, India at 114, behind Nepal (110) and Bangladesh (94), indicating that women in these last two countries share resources with men on a more equitable basis. Notwithstanding, "*While India, Iran and Pakistan perform very poorly on the economic, education and health sub-indexes, their overall scores are partially bolstered by relatively good performances on political empowerment*" (WEF 2009).

Gender, Climate Change and DRR

South Asia has been affected by a number of disasters in recent years - natural, economic and conflict-related. At the same time, the region is grappling with the multiple impacts of climatic change – from rising temperatures, to rising sea levels and changing rainfall patterns. These environmental, economic and social conflicts invariably affect women and marginalised groups the most. Gender inequality can create significant burdens for women to overcome in the context of climate change. For example, social inequities regarding women's control over assets, as well as their inability to accumulate and control financial savings in many developing countries, inhibits their ability to adapt in the midst of changing weather patterns and increased climate variability, thus making them vulnerable to the impacts of climate change in ways that men are not (McOmber et al. 2013).

A recent report by the International Food Policy Research Institute (Goh 2012) shows that climate change affects women's and men's livelihoods, assets and wellbeing differently in six key areas: (i) agricultural production, food security, (iii) health, (iv) water and energy resources, (v) climate-induced migration and conflict, and (vi) climate-related natural disasters. Although the case study evidence collected for the IFPRI research is highly context specific and varied, it does demonstrate that women across the world are often more negatively affected by climate change. Thus, it is crucial that any regional programme aimed at reducing the vulnerability of women and girls through the delivery of climate services must be sensitive to the gender-differentiated impacts of climate change and disaster events alike. In addition, given that women often constitute the majority of the work force in the agriculture, water resource management and forestry sectors, and are often the main providers of food for their families, climate services must designed with women's needs, priorities, experience, livelihood activities and knowledge in mind (Kapoor 2011).

The Policy Environment

While the importance of mainstreaming gender considerations into the design and delivery of climate services is beginning to be recognised in South Asia, and there have been some sporadic attempts made to do this, applying a gender lens in this arena is still very new. In the Hyogo Framework for Action 2005-2015, gender was been included as a cross-cutting issue and gender concerns were integrated as one of the components of community resilience building. However, this commitment so far has been poorly translated into action

55 Gender Inequality Index: A composite measure reflecting inequality in achievement between women and men in three dimensions: reproductive health, empowerment and the labour market.

56 The higher the GII, the greater disparities between females and males.

and most of the programmes and initiatives implemented on ground have often been ad hoc and inconsistent. The recently developed Sendai Framework for DRR (2015-2030) also prioritises gender-sensitive approaches to DRR, however it is clear that concerted efforts will be required in the South Asia region (as elsewhere) in order to ensure these commitments materialise into concrete actions. One key regional player, in that sense, is the SAARC Disaster Management Centre (SDMC), which has led efforts to advocate for specific actions and gender mainstreaming across national DRR policy.

A review of national climate change and disaster risk reduction policy in the focus countries of this scoping study reveals that in general the current status of gender considerations is weak; however there is increasing awareness of the need to pay special attention to vulnerable groups and to promoting the participation of women in decision making processes. Nepal is a regional leader in this sense having mainstreamed gender into its climate change policy and decision making processes, albeit without specific targets. The Pakistan 2013 National Climate Change Policy sets out measures to ensure that the elderly, the disabled, children and women get particular focus in evacuation strategies and specifies that there should be disaster management training especially for vulnerable groups of people. In general, though, government programmes in South Asia tend to overlook the specific vulnerabilities and needs of women when disasters strike (EIU 2014).[57] In terms of women's participation in DRR and resilience building efforts, most South Asia countries fare poorly (EIU 2014). Furthermore, South Asian women have not been specifically targeted in adaptation activities funded as part of bilateral and multilateral programmes (Mitchell et al. 2007). There is also a lack of monitoring and evaluation indicators and processes to measure the potential benefits of promoting women as leaders or the extent of women's empowerment (Duryog Nivaran 2014 and EIU 2014). For example, women now account for 30% of the volunteers in Bangladesh with respect to cyclone warning (Yee 2013).

There is disproportionate emphasis in policy and practice on women as vulnerable victims, and a proper exploration of their capacities for leadership and their rights to be included in DRR and CC efforts is long overdue (EIU 2014). The intimate "front-line" knowledge that women have of their local environment suggests enormous capacity for them to be transformational agents in community disaster planning and preparedness, and to play a significant role in bolstering resilience. Yet in South Asia women's perspectives are seldom incorporated into national disaster management and climate change adaptation strategies, and their participation in project planning and execution is at best poor.

A recent report by the International Food Policy Research Institute (Goh 2012) shows that climate change affects women's and men's livelihoods, assets and wellbeing differently in six key areas: (i) agricultural production, food security, (iii) health, (iv) water and energy resources, (v) climate-induced migration and conflict, and (vi) climate-related natural disasters. Although the case study evidence collected for the IFPRI research is highly context specific and varied, it does demonstrate that women across the world are often more negatively affected by climate change. Thus, it is crucial that any regional programme aimed at reducing the vulnerability of women and girls through the delivery of climate services be sensitive to the gender-differentiated impacts of climate change and disaster events alike.

Are women accessing climate services in South Asia?

There is little evidence indicating whether women are or are not accessing climate services in South Asia, however some work has been undertaken to assess barriers facing women and potential strategies for overcoming these. For example, the report "Identifying Gaps, Challenges and Limitations of Access of Women, Children and PWD of Nijhumdwip to

57 In partnership with The Economist Intelligence Unit (EIU), Action Aid has developed the South Asia *Women's Resilience Index* (WRI) which maps capacity in eight countries for risk reduction in disaster and recovery, and the extent to which women are considered in the national rebuilding efforts.

Cyclone Early Warning Towards Rendering Improved Early Warning Services through CPP Dissemination Mechanism/System" based on a study in a remote part of Bangladesh indicates that that women have difficulty accessing information on cyclone warnings (BRCS 2013). One major challenge that women face in accessing climate services has been identified as relating to communication methods and channels. Producing accurate climate information is fundamental, but how this is communicated, its relevance on a local scale, whether users feel it is legitimate, and equitability of access are all equally important if women and vulnerable groups are to use this information effectively for critical decision-making purposes (Agrawal et al. 2014).

The *Scaling Up Climate Services for Farmers in Africa and South Asia* project led by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is trying to identify what women need in terms of climate services in order to reduce their vulnerability to flooding, droughts and other disasters. The project has collected evidence showing that women farmers are overwhelmingly left out of many forms of communication channels (McOmber et al. 2013). The CCAFS research concludes that the use of 'hybrid' communication methods - traditional information sharing channels, such as social networks, complemented by simple and affordable ICTs - is the most effective way of increasing women's access and use of climate information services. An example of successful hybridization can be observed through a mobile phone programme in Bangladesh called Help Line which offers health, legal and agricultural advice to women in rural communities through a call-in hotline. It is attention to local norms and conditions that allows for effective implementation of ICT usage and access (McOmber et al. 2013).

Discussions at the 2014 World Meteorological Office (WMO) conference on the gender dimensions of climate services pointed to the technological, social and economic barriers limit the effective use of ICT in delivering weather and climate services to women (WMO 2015). CCAFS research in India found that the use of climate information is higher in villages where women are fully involved as key partners in its production and delivery (CCAFS 2013). Thus, the CCAFS and WMO both emphasise the role of education in supporting women farmers to connect to new sources of information (CCAFS 2013 and WMO 2015)

Recommendations

First Priority: Mainstream gender approaches to policy and programming of climate change and DRR strategies, of which climate services is an important component

i. Gender integration and mainstreaming are relatively new to South Asian policy. Most work in climate change and DRR is either "gender blind" or adopts a perspective of gender that focuses almost entirely on women ("men blind") without considering broader gender relations. As such, it is recommended that DFID promotes the mainstreaming of gender issues across climate change and DRR policy and planning, particularly amongst key regional agencies, such as the SAARC and the SDMC and also at national and sub-national levels.

ii. Given low levels of gender awareness in South Asian policy and programming, capacity building of key institutions (regional actors, national/sub-national governments, agricultural research institutes, NMHSs) to mainstream gender approaches into policy and programming for climate change and DRR strategies is also a priority area. Caution should be exercised so that the interventions do not reinforce existing gender inequalities.

Second Priority: Improve the relevance, quality, timeliness and uptake of climate information by women and other vulnerable groups

i. At present, climate services and information are "gender blind" and thus are unable to respond to the specific and differential needs of women and vulnerable groups. As such, it is recommended that DFID supports regional and national climate information providers to improve the relevance of information/products for women and vulnerable groups, including promoting multi-stakeholder co-production processes.

ii. Appropriate feedback mechanisms should also be developed and tested to understand the timeliness, quality, applicability and uptake of climate services by these groups. Similarly, DFID could play a key role incentivising NMHSs to develop education and outreach programmes with a particular emphasis on science education for girls and women.

Third Priority: Support research initiatives that increase the evidence base around climate services and gender

i. Promote cross-disciplinary research to strengthen the evidence base for improving the relevance of climate services for women and vulnerable groups. Building on the current CCAFS work, further research and innovation is required to understand:

   a. How women's strengths, experience, skills and knowledge can feedback into and strengthen climate service delivery for women and other vulnerable groups
   b. The most effective ways of reaching out to women and marginalised groups to overcome technological, economic, cultural and linguistic barriers in accessing climate services

Annex 6 Risk Insurance in South Asia

Across South Asia high exposure to natural hazards combined with low ability to manage the costs of disasters based on previous events contributes to financial vulnerability. Risk financing and/or risk transfer, combined with risk reduction hold the potential to manage risks on an ex ante basis, reducing vulnerability to disaster (G20/OECD 2012). The Hyogo Framework for Action 2005 – 2015 prioritises the development of financial risk-sharing mechanisms, particularly insurance against disasters (ISDR 2005). Similarly, the 2010 UNCCC Cancun Adaptation Framework also calls for insurance and climate risk insurance including "options for micro-insurance, and resilience building, including through economic diversification" (UNFCCC 2011).

Various types of risk insurance exist, and their appropriateness for different contexts relies on a range of important factors. For example, savings or reserves are useful where disaster risk exposures are relatively low, but for higher exposures contingent credit may be more useful as it can be difficult to build up the required funds (particularly for the poorest groups), and funds may be more effectively invested in growth/development focused activities. (G20/OECD 2012). On the other hand, where hazards are frequent, accessing loans to cover disaster losses may lead to increasing, unsustainable levels of debt (ProVention 2009).

Recommendations

Despite several initiatives to promote risk insurance in South Asia, key challenges include high insurance premiums, a lack of products suitable for low-income and at-risk communities, a lack of enabling policies and regulatory frameworks, a lack of precise risk information for designing a robust index based facility, and limited technical capacity. Against this backdrop, the following recommendations are set forth:

First Priority: Encourage the development and open sharing of accurate risk information/ knowledge, provided as a regional public good.

i. Availability of reliable medium and long range weather information and associated losses is a prerequisite for designing a robust parametric (index based) risk insurance facility (Prabhakar, 2012). Similarly, comprehensive information on physical characteristics of key infrastructure is required for estimating hazard risk. Such information is not readily available in most South Asian countries, hindering expansion of index based insurance facilities. Support is required to build technical capacity and information sharing in this respect.

Second Priority: Promote development of an integrated vision at regional and national levels on need to regulate risk insurance and support application of complementary risk mitigation measures

i. Insurance is most effective (and most affordable) when "coupled with actions by the local or national government to establish building codes and land use regulations" (Wharton 2008). Well-enforced building codes are important to ensure mitigation opportunities are broadly acted upon, reducing vulnerability across the board, enabling reduced insurance premiums to be offered. In South Asia, as in many low and middle income countries, building code and land use regulation and enforcement is often poor.

Third priority: Towards reducing insurance costs by developing products for low income groups, improving efficiency. Complement the risk insurance initiatives

already under implementation by DFID

i. In South Asia, there is need to explore strategies for reducing insurance costs through a combination of approaches such as improving efficiency of insurance scheme management, developing appropriate products for low-income at-risk sectors and reducing basic risks through risk mitigation measures such as enforcing structural standards and land use planning regulations. This agenda can be promoted in partnership with other regional initiatives, such as those being run by the Disaster Risk Financing and Insurance Program (World Bank), the Global Facility for Disaster Reduction and Recovery, and the ADB Integrated Disaster Risk Management Fund. These institutions represent strategic allies for further work to explore and develop the potential of risk insurance as a tool to support DRR efforts in the region.

ii. In countries where assessment information is scarce or of poor quality, insurance agencies are forced to undertake detailed individual risk assessments or adopt extremely conservative risk estimates, raising insurance costs to a level where they may not be viable. However, provision of public goods such as open source risk modelling initiatives (eg the Global Earthquake Model (GEM)), can contribute to reducing assessment costs, lowering barriers to entry for selling insurance in developing countries (World Bank 2011).

Appendix A A Framework for Stakeholder Consultation

Objectives and approach

The team will undertake broad stakeholder consultations at international, regional, national and sub-national levels across South Asia and in India, Nepal, Bangladesh, India, Pakistan, Afghanistan and Burma. We shall also make some initial inquiries into South East Asia. Where required stakeholders based in other regions (UK, USA etc.) will also be engaged in this process, which is in addition to the one-to-one stakeholder/expert consultations which have already been initiated during the Evidence Review period (see Annex 1).

The principal objectives of these consultations are:

1. To present and validate the findings and recommendations of the Evidence Review
2. To discuss a set of options for the regional programme, including identifying opportunities and challenges for implementation
3. To identify opportunities for scaling-up initiatives and enhancing regional approaches and collaboration

The workshops will provide a forum for us to leverage our regional and national networks and facilitate multi-disciplinary and multi-level interaction between a range of users and climate information providers together with intermediaries.

Consultations will take the form of **seven half-day national workshops** in the capital cities of India, Nepal, Bangladesh, India, Pakistan, Afghanistan and Burma, organised and facilitated by our team of in-country experts. Regional and national stakeholders to be invited to attend these workshops include:

- DFID in country teams
- Donors, international financing agencies
- Inter-governmental institutions
- NMHS
- National level government ministry/department officials (particularly from the five priority sectors)
- National universities
- Development banks/ financial institutions
- Para-statal entities
- Private sector providers of weather information
- Academic, research and resource/knowledge organisations
- NGOs, civil society organisations and other ‘practice’ organisations, with special attention paid to inviting those who work with vulnerable groups

We will also carry out **telephone interviews** with sub-national stakeholders, in particular gaining feedback from users working directly with the most vulnerable groups and ensuring coverage of our five priority sectors (agriculture & food security, DRR, water, energy and health, with emphasis on the first three). Care will be taken to select users with interests across the range of timescales associated with climate information: from historical records and monitoring to predictions from sub-seasonal to multi-annual timescales and beyond (for example government ministries with a remit for adaptation planning will be engaged as well as organisations more concerned with next season’s operational agricultural activities).

Workplan

Workshops and interviews will be organised to take place between mid-May and the beginning of June, leaving sufficient time for data analysis by the core team.