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BRACED aims to build the resilience of more than 5 million vulnerable people against climate extremes and disasters. It does so through 15 NGO-consortia working across 13 countries in East Africa, the Sahel and Asia.

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Climate information and services in BRACED countries

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Access to sound climate information is vital for anticipating climate-related risks and adapting to climate change. As such, it is recognised as an essential input to projects being funded by the Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme.

KEY MESSAGES

- Access to, use and application of weather and climate information in Africa and Asia is increasing.

- Yet end-users face various challenges in applying the information they receive. This is related to the quality of the information products, not having information at appropriate scales and difficulties in communicating and interpreting the information produced. Climate information should be service-orientated and integrated into decision making from national through to the community level.

- The success of resilience programmes will depend on their ability to create opportunities to strengthen climate services in country. Additional support is needed to (i) strengthen the capacity of information providers, so they are able to produce more localised, timely and accurate climate information; and (ii) institutionalise two-way communication, between producers and end-users, so those who need it can continue to use information over time to build resilience.

- BRACED presents an opportunity to integrate climate services into resilience programming. By adapting climate information to specific contexts but within an overall resilience programme, BRACED will create an enabling environment for better access, use and application of weather and climate information.

- The generation and communication of climate information to build resilience needs to be linked to development processes through its insertion in sectoral plans and decisions on basic service delivery.

1. INTRODUCTION

Key terms

WEATHER: the state of the atmosphere at a given time with respect to variables such as temperature, moisture, wind and barometric pressures

CLIMATE: the average weather over a long period of time

The seamless integration of weather and climate information in government, non-government and private sector decision making can help mitigate against the risks of disasters, weather and climate variability, climate extremes and other related events that threaten vulnerable communities around the world. Climate information is generated through monitoring and analysis activities conducted by meteorologists and climate science-related researchers. This information is becoming an integral part of risk management and resilience programming and is seen as vital to enhancing people's capacity to deal with the impacts of climate change (Hellmuth et al., 2011; Mitchell et al., 2010). Equally, the production of climate information for decision-making is increasingly being seen as an entry point for joining up work on climate change adaptation, disaster risk reduction and development in climate-sensitive places (Ahmed, 2013; Dutton, 2002; Foresight, 2012).

Climate and weather information is one of seven learning themes guiding research by the Knowledge Manager (KM) under the Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme. KM research is aimed at generating knowledge about the sources and characteristics of climate resilience and how these can most effectively be enhanced. The 15 consortia funded under the BRACED programme were clear from the beginning that climate information would be an essential input into their projects, to guide programming and identify areas of high risk.

The KM understands resilience to be a set of interrelated capacities: the capacity to absorb, anticipate and adapt to climate extremes and disasters (the 3As) (Bahadur et al., 2015). The 3As framework highlights the capacities that can be strengthened to help communities deal with climate extremes over the short term, when there is greater certainty over the types of events that can occur, and over the longer term, when uncertainty is higher.

Extreme events are already putting lives, livelihoods and assets at greater risk and these events are becoming more common in some places. Building resilience to the shocks that can be anticipated as well as those that cannot

relies on our ability to manage extreme events today and adapt to future changes. This involves decision-making on the basis of short-, medium-, and long-term scenarios, foreseeing the problems and opportunities associated with these – and the uncertainties. There are many starting points, but an obvious one is to improve the availability, quality and use of climate information.

The paper summarises and assesses existing weather and climate information for BRACED programme countries. It describes some of the drivers of weather (such as El Niño and the Asian monsoon), and how these contribute to variability in Africa and Asia. It then reviews information on existing climate services available in and/or for BRACED countries, highlighting state-of-the-art approaches and products in each area (Annex 1 provides a matrix of available weather and climate information sources). The paper highlights some problems in the use of this available information, including issues of quality, appropriateness of scale and how information is communicated and interpreted.

2. KEY CONCEPTS

2.1 Weather and climate information

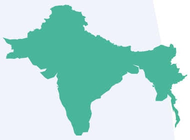
Climate information and forecasts can cover varying timescales, such as short-range (e.g. up to a few days), medium-range (e.g. from weeks up to a month) and long-range (e.g. greater than one month, including seasonal time scale). Climate information also includes projections and scenarios (e.g. decadal and longer) (World Meteorological Organisation, 1992). While the term 'weather' is the state of the atmosphere at a given time and place with respect to variables such as temperature, moisture, wind and barometric pressure, the term 'climate' is typically defined as the average weather over a long period of time. Initially, information products and predictions were based on empirical and statistical techniques, but they are being increasingly derived from more complex dynamic* models including those that couple representations of the atmosphere, oceans, land interface, sea ice and atmospheric aerosols and gases (WMO, 2011a).

* Prediction techniques could be empirical/statistical or dynamical. Empirical/Statistical information derives from relationships identified in observations or experiments while dynamical techniques use physical principles and numerical methods or models.

2.2 Climate services

Climate services disseminate climate information to the public or a specific user (WMO, 2011a). A global framework has started to emerge, led by the World Meteorological Organization (WMO) and the UN High Level Task Force, called the Global Framework for Climate Services (GFCS), which provides a structure for the development and application of future weather- and climate-related information. GFCS encourages a service-oriented approach to climate services – it is the use rather than the production of information that is important.

For climate information products to be interpreted and applied in decision-making, they need to be developed through strong partnerships between information providers (or source agencies) and government (e.g. line agencies, departments and local governments), private sector and research entities and directly affected users. What is referred to now as the 'climate services approach' also calls for improvements in the weather and climate information



Nowhere are the challenges of climate extremes and variability more apparent than in Sub-Saharan Africa and South Asia

itself to link it to information on impacts and make it more relevant for decision-making in particular contexts. The GFCS suggests:

> *'[…] to be useful, climate information must be tailored to meet the needs of users… Users need access to expert advice and support to help them select and properly apply climate information. Climate services often do not reach "the last mile", to the people who need them most, particularly at the community level in developing and least developed countries' (WMO, 2011b).*

2.3 Sub-Saharan Africa and South Asia

Nowhere are the challenges of climate extremes and variability more apparent than in Sub-Saharan Africa and South Asia – two regions that face high levels of exposure to drought, floods, heatwaves and cyclones, and that will likely suffer from increases in the frequency and magnitude of some of these events. The higher frequency of tropical cyclone formation in the Bay of Bengal and the Western Pacific region in 2015 and the record summer temperature highs in the Indian subcontinent, which took the lives of more than 2,500 in India and Pakistan, are two examples of transcending normal thresholds. This is the 'new normal' (Ahmed, 2015; National Climatic Data Center, 2011). Yet the limited numbers and capacity of observational networks, plus constraints in availability, access, communication and interpretation of data have limited the use of climate services in these regions.

Improving capacities to take appropriate action in light of expected trends and uncertainties will help equip communities to deal with climate changes. To do this, we need reliable, relevant, accessible, useable, credible and understandable climate information.

3. CLIMATE VARIABILITY AND DRIVERS OF WEATHER

Understanding the forces that control our daily, weekly or monthly weather patterns helps us to use climate information more effectively. The atmospheric general circulation is driven by uneven heating (an energy imbalance) between the equator and the poles, while local effects are driven by the differential heating of the Earth's surface due to the varying heat capacities of the different materials on the surface. Other continental- and regional-scale forces are also at play generating more location-specific climates.

3.1 Africa

The main large-scale systems affecting rainfall in eastern and western Africa include the Inter-Tropical Convergence Zone (ITCZ) (Sharon and Nicholson, 2009; Suzuki, 2011; Yi Song et al., 2004), sub-tropical anticyclones (Manatsa et al., 2014), monsoon winds and ocean currents (Barry and Chorley, 2009; Janicot et al., 2009; Tierney et al., 2011), jet streams (Nicholson, 2009), easterly waves (Lafore et al., 2011), tropical cyclones and teleconnections including El Niño

El Niño

El Niño is a part of natural climate variability – a driver of weather, acting on a shorter temporal timescale than climate change, affecting seasonal weather patterns. The effect of El Niño on weather patterns in a region is important for planning, because the effects of expected longer-term trends in climate (e.g. more rainfall and floods) may be reversed in El Niño years. El Niño events lead to a variety of impacts across the globe; these are different for each region, depending on the timing of the event (WFP, 2014). El Niño typically results in more rainfall during October–December in East Africa and drier conditions during June–September in West Africa. While an El Niño can go unnoticed or even have beneficial impacts in many parts of the world, it can also be disruptive or cause extensive problems when some areas get too much or too little rainfall. (Red Cross/ Red Crescent Climate Centre, n.d.)

The progress and strength of El Niño can be monitored through near-real-time El Niño Southern Oscillation (ENSO) observing systems, making it possible to generate probabilistic seasonal climate forecasts months in advance (IRI, 2015). Seasonal forecasts can be used to predict whether too much or too little rainfall is expected as they take factors from El Niño and other climate elements into account. (Red Cross/ Red Crescent Climate Centre, n.d.). Such forecasts may be useful for planning in agriculture and for disaster prevention, including the mitigation of malaria outbreaks (IRI, 2015).

El Niño can provide an opportunity for climate scientists to generate more accurate seasonal forecast information, for more locations across the world, compared with non-El Niño years. El Niño predictions can be used to trigger actions such as moving livestock to higher ground based on a flood forecast (Singh, 2015).

and the Southern Oscillation Index. Regional factors also modify rainfall including the large water bodies like Lake Victoria, complex topographies such as the Great Rift Valley, high mountains such as Mount Kenya and Mount Kilimanjaro and local influences such as land-sea breezes and vegetation.

3.1.1 Inter-Tropical Convergence Zone

The ITCZ is a zone of low pressure near the equator where two easterly trade winds (monsoons), originating from the Northern and Southern Hemispheres, converge. The ITCZ breaks into two components over Central Africa (Suzuki, 2011) to form a zonal component and the meridional component. This division is attributed to the geography of the Great Rift Valley and the mountain chains of East Africa. The zonal part of the ITCZ migrates seasonally north and south following the highest concentration of the sun's energy, creating bimodal rainfall patterns (two rainy seasons) over most parts of East Africa. The first peak or season, the 'long rains', occurs from March to May (MAM) and the second season, the 'short rains', is observed from September to December (SOND). Areas near the equator in western and southern Africa have a single intense rainy season from July to September (JAS).

3.1.2 Tropical cyclones

The BRACED projects located in East Africa may be affected by tropical cyclones. These are storm systems characterized by a large low-pressure centre and numerous thunderstorms that produce strong winds and heavy rain. These systems usually affect the southern parts of the eastern coast of Africa by increasing or decreasing the intensity of precipitation and by interfering with the normal flow of winds. Tropical cyclones do not usually directly hit the northern part of eastern Africa, but their passage changes the weather across the region by redirecting the wind flow pattern to their intense low pressure centres and hence denying the land areas precipitation. For example, the 1984 drought in some parts of the region was partially blamed on the high frequency of cyclones (Okoola, 1998).

3.1.3 Regional modifying features

The position, strength and orientation of the subtropical high-pressure systems (the 'sub-tropical anticyclones') are crucial to the weather of Africa. These include the Mascarene High in the Southwest Indian Ocean, St Helena High in Southeast Atlantic Ocean (both in the Southern Hemisphere), the Azores/Saharan High in North Atlantic Ocean and the Arabian High to the northeast (both in the Northern Hemisphere). These anticyclones are strong during their respective winter and weak during their respective summer seasons. The differential strengths between the Northern and the Southern Hemispheres determine the relative positions of the ITCZ and the associated weather systems. Some seasons in specific areas have been known to fail when sea surface temperatures (SSTs) around the area of the dominant anticyclone are above normal, causing weaker than normal pressures, with the resultant displacement of the ITCZ from its normal position.

3.1.4 Climate change

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment (Niang et al., 2014) report indicates increasing trends in observed temperature for Africa. These trends are projected to continue into the future and rise faster than the global average (James and Washington, 2013). In the case of precipitation, the projections are uncertain (Rowell, 2012) and depend more on seasons and locations than temperature projections. This uncertainty makes it difficult to base climate change adaptation planning on precipitation scenarios.

3.2 Asia

The BRACED countries in the Asia region (Nepal and Myanmar) are significantly influenced by the regional weather and climate system of South Asia, the Bay of Bengal and the Himalayas. Nepal is highly affected by the mountain systems of the Himalayas and the Indian subcontinental monsoon. Myanmar is influenced by

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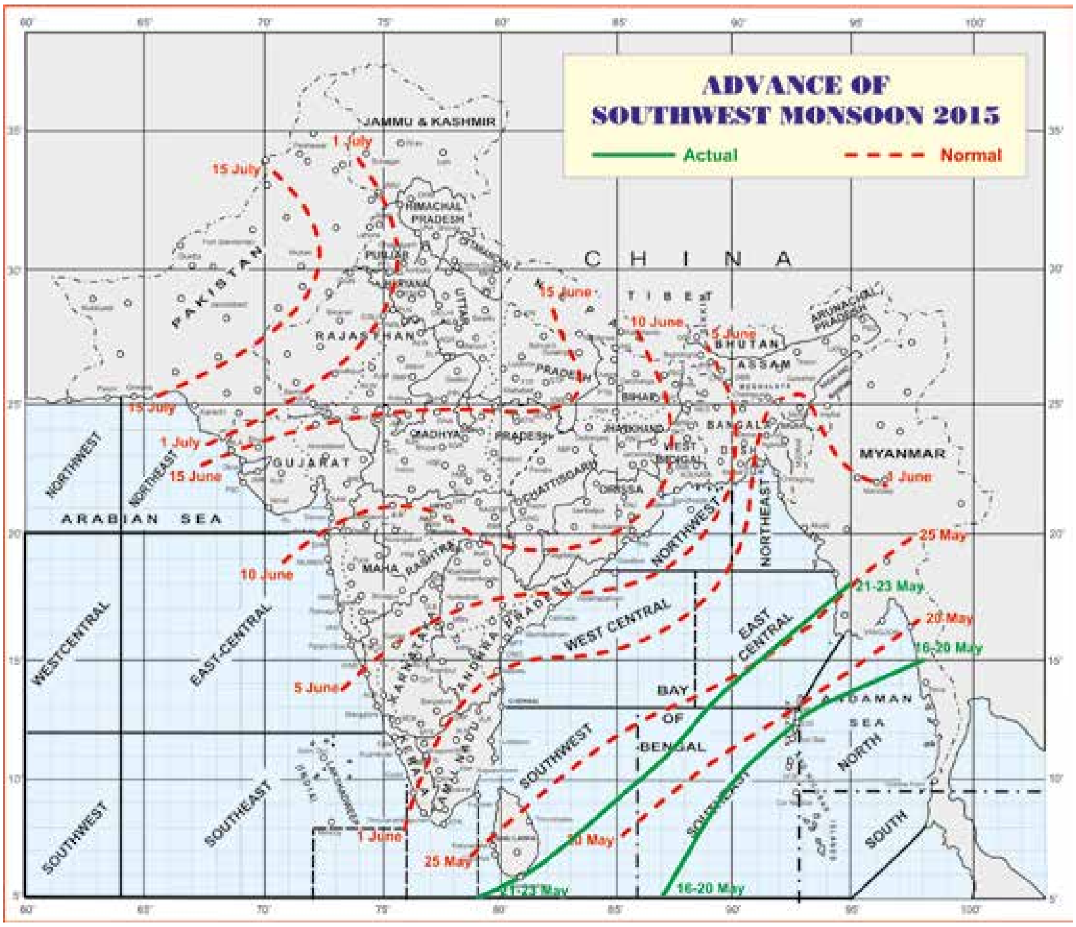
Figure 1: The advance of the south-west Monsoon in India, 2015



Source: India Meteorological Department (2015).

multiple factors including the Indian subcontinental monsoon, the Bay of Bengal system and partly the East Asian monsoon. This is regarded as one of the most dynamic regions in Asia because it is affected by hydro-meteorological hazards such as tropical cyclones, flooding (including riverine floods, glacial lake outburst floods (GLOF) and flash floods), landslides, drought, erratic temperatures and other rainfall-related phenomena.

3.2.1 Monsoon

Several monsoons are active in the Indian subcontinent (Chang et al., 2005). The region is influenced by the south-western summer monsoon, which is generally expected to begin around early June and fade away by the end of September but is only partially understood and notoriously difficult to predict (WCRP, 2011; Webster et al., 1998). On reaching the southernmost point of the Indian peninsula, the moisture-laden winds divide into two parts owing to the topography: the Arabian Sea Branch and the Bay of Bengal Branch (see Figure 1). The distinct difference between winter and summer winds and precipitation patterns is what characterises the monsoon over this region (Turner and Annamalai, 2012). The Bay of Bengal Branch of the south-western monsoon flows over the Bay of Bengal heading towards north-east India and Bengal, picking up more moisture from the Bay of Bengal. The actual advance of the southwest monsoon can vary from the normal climatology, as shown in the figure above for 2015.

The region is also influenced by the north-east monsoon starting around September. During this time, the northern land mass of the Indian subcontinent begins to cool off rapidly as the angle of the Earth tilts the Northern Hemisphere away from the sun. As a result, air pressure begins to build over northern India, as the Indian Ocean and its surrounding atmosphere continue to retain its heat. This causes cold wind to sweep down from the Himalayas and the Indo-Gangetic Plain towards the vast spans of the Indian Ocean (Chang et al., 2005).

The Indian monsoon is remarkably stable as a whole, with a mean total rainfall of around 850 mm in the months of June to September and an inter-annual (year-to-year) variation of only around 10% in most cases. Yet even these relatively small variations in the Indian monsoon can influence things like agricultural production and the stocks and commodities market, so a 5–10% change on top could have significant impacts (Turner, 2015; Turner and Annamalai, 2012).

3.2.2 Tropical cyclones

The Bay of Bengal region is regarded as a 'funnel of disaster' and has been the location of many devastating tropical cyclones in the region. Although less than 5% of the total number of tropical cyclones worldwide occur in the Bay of Bengal, these account for over 90% of global damage and death owing to tropical cyclones (Webster, 2013). The precipitation at the centres of tropical cyclones will likely be more extreme in West, East, South and Southeast Asia in the future due to climate change (Hijioka et al., 2014).

3.2.3 Climate change

The IPCC's Fifth Assessment Report has already indicated various signals of change for the region, including warming trends and increasing temperature extremes, water scarcity, increasing drivers of coastal and marine hazards (i.e. cyclones, sea level rise, rising SSTs), multiple stresses caused by rapid urbanisation and manifestation of extreme climate events, among others (Hijioka et al., 2014).

4. AVAILABILITY OF CLIMATE INFORMATION IN BRACED COUNTRIES

4.1 Africa

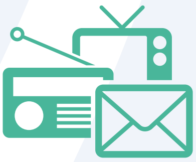
Climate information in BRACED African countries comes from several sources, principally the National Hydrological and Meteorological Services (NHMSs), which provide information to their governments and other users within their countries. The NHMSs run observational networks and can provide raw data on request, usually at a cost. They often give free daily, five-day, seven-day, monthly and seasonal weather/climate forecasts.

In addition, these services provide regular agro-meteorological bulletins, reference information for aviation and WMO El Niño updates. The NHMSs are continually developing their services, improving their products and ensuring the products are used. The Regional Climate Outlook Forums (RCOFs) (discussed below), and even National Climate Outlook Forums have been developed to further improve climate information products and their dissemination.

Mid-range forecasts: Regional Climate Outlook Forums (RCOFs) in Africa

The Climate Information and Prediction Services (CLIPS), a WMO project, initiated the RCOFs at a workshop on Reducing Climate-Related Vulnerability in Southern Africa in October 1996 at Victoria Falls, Zimbabwe. The workshop identified priorities for forecasting and applications, including a series of pilot projects to be developed into a framework for responding using climate forecast information in agriculture, food security, water resources, public health and forestry. The RCOFs are charged with producing an assessment (ideally, a consensus) on the state of the climate for the upcoming season, for developing improvements in communications and connectivity, training programmes, educational opportunities and fellowship possibilities that cross political and sectoral boundaries.

The RCOFs have grown to be the main regional mechanism for the formulation and dissemination of seasonal climate forecasts, bringing together climate scientists, policymakers, operational forecasters and climate information users. The involvement of users has helped to disseminate the forecasts and obtain feedback on their usefulness. These forums are now active in several parts of the world, routinely providing real-time regional climate outlook products. In Africa, ICPAC coordinates the Greater Horn of Africa Climate Outlook Forum (GHACOF); ACMAD coordinates Prévisions Saisonnières en Afrique de l'Ouest (PRESAO) for West Africa; and the Southern African Development Community (SADC) coordinates the Southern African Regional Climate Outlook Forum (SARCOF).



Information is usually disseminated through radio, TV, bulletins and email. In Ethiopia, Kenya and Sudan information is also shared on well-developed climate information websites

Information is usually disseminated through radio, television, bulletins and, in some cases, email. In three BRACED countries – Ethiopia, Kenya and Sudan – the services are fairly advanced, with well-developed websites for information dissemination. They have some products based on more complex methods that require advanced modelling skills and powerful computers.

All BRACED countries in Africa also have access to climate information from the African Centre of Meteorological Application for Development (ACMAD), which produces information for the whole of Africa. Information on food security integrating climate information is also available from the Famine Early Warning Systems Network (FEWS NET).

BRACED countries in the eastern Africa region have access to information from the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC), while those in West Africa and the Sahel region can also get information from the Agrometeorology, Hydrology, Meteorology (AGRHYMET) Regional Centre.

4.2 Asia

BRACED projects in Asia have access to different types of climate information with varied scales and resolution. The NHMSs are again the main climate information providers to government departments, line agencies, administrations, the private sector, communities and others. In Nepal, the Department of Hydrology and Meteorology (DHM) functions under the Ministry of Science, Technology & Environment. In Myanmar, the Department of Meteorology and Hydrology (DMH) operates under the Ministry of Transport.

NHMSs in Asia provide daily/hourly weather forecasting for the general public; hourly weather information for civil aviation; weekly/monthly weather reports; seasonal outlooks; hazard-specific severe weather bulletins, advisories and warnings to the public and institutions. They also provide hydrological and meteorological data, water quality and air pollution data, climate projections/scenarios and other types of advisories for government departments and other end users.

In terms of long-range and decadal scenarios, in the past three years Nepal and Myanmar have developed two climate data portals with support from regional partners. These are web-based portals, providing a digital resource for sharing decadal scenarios and related data. Both the portals are publicly shared and further data can be requested. Downscaled scenarios have been developed in these portals, but not yet at a level of spatial resolution required for local planning. Myanmar has also developed a stakeholder forum more popularly known as the Myanmar Monsoon Forum. Prior to the monsoon season, the NHMS invites all the sectors to join the forum and share their seasonal forecasts to initiate a dialogue. This has extended beyond climate information providers and collaborators, to include the users. The NHMS in Nepal, on the other hand, often collaborates with the RSMC in New Delhi for seasonal forecast information and looks for agreements in the RCOFs.

Forecasting capabilities

DMH in Myanmar and DHM in Nepal have recently improved the quality of short-range weather forecasts and are now developing their numerical weather prediction capacity through hands-on learning and by institutionalising the Weather Research Forecast (WRF) model, which is a state-of-the-art numerical weather prediction tool openly available. Both countries are still in the early stages of operationalising WRF on a daily basis. However, capacity for seasonal forecasts remains relatively low and NHMS professionals have not yet significantly developed their skills levels. At present, the NHMSs are largely dependent on regional (e.g. the WMO Regional Specialised Meteorological Centre (RSMC)) and international organisations for accessing seasonal forecast products. Seasonal prediction products need to be developed and customised for sectoral applications.

Nepal and Myanmar have developed separate publicly available web-based climate data portals sharing decadal scenarios and related data

Short-range forecast: increased capabilities for tropical cyclone forecasting in the Bay of Bengal

Communities in Myanmar, particularly those on the coast, are highly exposed to tropical cyclones developing in the Bay of Bengal. In July 2015, tropical storm Komen hit coastal communities on the eastern rim of the Bay of Bengal but the DMH, in collaboration with the WMO's RSMC in New Delhi, was able to provide a warning ahead of time. This was possible because of recent enhancements in the cyclone detection systems, increased skills and collaboration with neighbouring NMHSs (Bangladesh and India's Meteorological Departments) and the support of RSMC in the Bay of Bengal region. It is likely that countries in the Bay of Bengal will face increased risk associated with tropical cyclones in the future as a result of climate change and population dynamics, but by increasing the ability of the NMHSs to forecast tropical cyclones communities can be alerted and prepare better.

Long-range forecasts: Nepal Climate Data Portal

The forward-looking GFCS initiative is encouraging sector-wide sharing and distribution of climate information in Asia. One promising example is the Nepal Climate Data Portal, maintained by DHM in collaboration with various regional partners such as the Asian Disaster Preparedness Center, the Asian Development Bank and others. This portal is a good example of how long-range climate information products such as downscaled scenarios for precipitation, temperature and other parameters can be shared with the public. Practitioners from diverse sectors such as agriculture, transportation, business, private enterprise, tourism, local government and others, can use this portal and integrate future climate scenarios into their planning.

4.3 Available data sources

Annex 1 gives a summary of the different sources of climate information that exist in Asia and Africa (with a particular focus on BRACED countries). The matrix outlines prominent weather and climate information sources that BRACED programme countries and partners can access. It is categorised by three types of weather and climate information products: (i) short range; (ii) medium range; and (iii) long range, and further classified by national, regional and international/global sources relevant for Asia and Africa. The national sources may provide more information for the subnational level and for places where BRACED projects are being implemented.

Where the hazards are more cross-boundary in nature, such as tropical cyclones or seasonal predictions for drought or monsoon, regional sources often come into play. In many cases, planners and practitioners may require access to international sources of climate information, particularly in contexts where either the information is not available in the country or the in-country sources are not very reliable. Familiarisation with multiple sources and the triangulation of information for verifying and cross-checking are needed to make robust decisions on the ground. It should also be kept in mind that short-range weather-related information has a greater level of temporal and spatial accuracy (i.e. low uncertainty) compared with medium-range seasonal predictions or long-range outlooks or scenarios of climate, which may have relatively low-level temporal or spatial accuracy (or higher levels of uncertainty).

5. CONSTRAINTS ON THE USABILITY OF CLIMATE AND WEATHER INFORMATION

End-users of climate and weather information produced by national, regional and international agencies face various challenges when it comes to applying the information they receive to decision-making. Some of these challenges are related to factors such as quality of the information products, not having information at appropriate scales and difficulties in communicating and interpreting the information produced. These challenges are summarised in this section.

5.1 Quality

Good-quality data should be relevant, accurate, timely, comparable and complete (Herzog et al., 2007). Often climate information has limitations due to the quality of the data. NHMS climate information is normally based on observational data collected from a network of weather stations. Given the cost of installing and maintaining these, African countries have very few stations, often with poor spatial distribution. The resultant information may therefore not be relevant to specific local-level use. The sparseness of the networks also makes validation of data from each station almost impossible, since the nearest stations are very far removed and may even be in different climate zones.

Some stations are manned by permanent meteorological department employees, but the majority in the NHMS networks are staffed by volunteer observers from other government ministries and agencies, schools and even farmers. This raises issues on accuracy of the data since the observers are not under the direct supervision of the NHMS. The timeliness of transferring data from these stations may also be compromised. Finally, for several reasons, including lack of stationery, civil unrest, breakdown of equipment and closure of stations, there are gaps in the historical records, which limits statistical analyses.

5.2 Appropriateness of scale

It is instructive to note that, although national, regional and global meteorological services have been developing climate information with reasonable accuracy over the years, use is very limited at community level. Although information is available, farmers seldom use it (DIE, 2012; Githungoa, n.d.). This may be because it is not relevant for decision-making at the community level where adaptation decisions should ideally be taken, as information with low resolution covering large geographic areas does not reflect localised patterns of rainfall (DIE, 2012).

Downscaling seasonal forecasts to locally homogeneous rainfall zones or to weather station level, so small-scale local variations in rainfall patterns can be taken into account, would enable smallholder farmers to take decisions at the farm level (DIE, 2012; Githungoa, n.d.). For example, the Sakai research project in Makueni in Kenya has shown that seasonal forecasts can be downscaled to local areas with very good results for farmers (Opondo, 2012). Experience in Zambia also shows that downscaling station-scale seasonal forecasts can trigger overwhelming responses from farmers (Hansen et al., 2011).

The temporal scale of the data can also be very important. This is usually a factor in data derived from satellites, whose repeat observation durations vary depending on the orbital altitude. If an application requires more frequent data updates, for example when monitoring floods, data with monthly repeat observations are of little use.

5.3 Communication

In recent years, climate forecast applications for early warning systems in the Asia Pacific region have grown significantly. Training and capacity development programmes, innovation of multi-hazard early warning systems and a focus on needs of end users have improved meteorological and hydrological forecasting in many parts of the world and in particular in the Asia Pacific countries (Ahmed, 2015).

Despite improvements in the products however, they are not widely utilised owing to a lack of communication and familiarisation (Hellmuth et al., 2011; WCRP, 2011; WMO, 2015). This often occurs when the information producers lack adequate communication processes and are not focussed on providing a service. A recent example is the lack of preparedness for the South Asian monsoon. Experts suggest South Asia 'reacts slow' to monsoon forecasts in spite of availability of such forecast products in the region (Perera, 2015).

Communication of forecasts has been taken more seriously in recent years however, with improvements in public weather services, by creating awareness and education programmes, campaigns, targeted initiatives and media outreach. Communication of uncertainties is also important but end users require processes that show them how to manage these uncertainties. Closer interaction between

Problems in communicating early warning in Myanmar

On 2 and 3 May 2008, the Ayeyarwady Delta region of Myanmar was battered by tropical cyclone Nargis (UNISDR, 2009). During the Village Tract Assessment (VTA) carried out under the Post-Nargis Joint Assessment, more than a quarter of those interviewed at the community level cited late or incomplete warnings as one of the primary reasons for widespread destruction. At the same time, Myanmar's DMH indicates that it was continuously tracking the tropical cyclone and that it issued timely warnings of an impending landfall. However, the warning never reached the communities at risk. Delta residents can access only one radio channel and most do not even have a radio, let alone money for expensive batteries, when the electricity supply broke down. As a result, on the eve of the tropical cyclone making landfall, most residents were asleep when the last warning was issued on national radio. This suggests that, despite information being available, the population at risk is not receiving it.

Nine years later, in 2015, these circumstances were repeated, as heavy rains caused floods and landslides in several parts of Myanmar, beginning in June (OCHA, 2015). The month of extreme monsoon weather was worsened by the arrival of cyclone Komen at the end of July (FAO, 2015). Despite DMH Myanmar (with support from WMO's RSMC in New Delhi) providing an early warning, the government admitted its response to the disaster was 'limited', with flood warnings not reaching everyone and confusion over evacuations (BBC, 2015).

the information producers and end-users of climate and weather information can help in this regard as well as guidelines for communicating uncertainties such as those provided by the WMO (2008).

Users are unable to interpret the risk information correctly or take appropriate action in response

5.4 Interpretation

Weather and climate information products are not well understood. Traditional climate information products are not sufficiently user-friendly and the same information is often given to all users without advice on thresholds for action. Users are unable to interpret the risk information correctly or take appropriate action in response (IFRC, 2009). This is regarded as a gap in early warning and forecast systems (Ahmed, 2009). Regular two-way communication between providers of information and decision-makers (at all levels) is needed to enable the co-production of information relevant to decisions that need to be taken. Useful forecasts are those that meet recipients' needs in terms of attributes such as timing, climate parameters, spatial and temporal resolution and accuracy.

In November 2003, typhoon Haiyan in the Philippines demonstrated some of the problems people face in interpreting warnings and forecasts, as well as in their understanding of the thresholds. This was an exceptionally powerful tropical cyclone, for which the national meteorological department issued warnings to the public, with a sufficient lead-time. In spite of this, major damage and casualties were reported in Eastern Visayas. One of the key reasons for local communities ignoring the warnings related to their interpretation of the language used. The term 'storm surge' used in early warning and forecast systems was found to be particularly problematic: many people did not expect that the wind generated by a typhoon would lead to such a high surge from the sea (Ahmed et al., 2015). People's knowledge of the phenomenon was low; they perceived the event differently and ultimately, they could not interpret the warnings using local knowledge frameworks and lived experiences of tropical cyclones and associated risks (British Red Cross, 2013).

Close attention needs to be paid to the issues identified above. More 'policy-first' and 'problem-centred' research programmes are needed, as opposed to ones that prioritise the generation of new science and consider its application a secondary concern. These ideas are being embraced by funding agencies, including the Department for International Development (DFID) and Natural Environment Research Council (NERC) in their jointly funded Science for Humanitarian Emergencies & Resilience (SHEAR) programme. This and other programmes aimed at enhancing the production, quality and use of climate and weather information (see Annex 2 below), are increasingly doing so as part of a broader programme of work to build resilience capacities. By working with both producers and users of climate and risk information, policy makers and practitioners; these programmes have gone some way to overcoming the barriers identified above.

ANNEX 1. DIFFERENT SOURCES OF CLIMATE AND WEATHER INFORMATION AVAILABLE IN BRACED COUNTRIES IN ASIA AND AFRICA

The following table shows some sources on the BRACED Asia and Africa countries where stakeholders can access climate information and related products.

	Asia	Africa
National		
Short-range	• Nepal DHM; Myanmar DMH: hourly/daily weather forecasts, hazard-specific severe weather bulletins • Nepal DHM: Flood Forecast Project (River Watch); Myanmar DMH: hydrological monitoring of selected rivers	• NHMSs: daily/five-day/weekly/10-day/monthly weather forecasts
Mid-range	• Nepal DHM; Myanmar DMH: weekly/monthly weather reports, agro-meteorological bulletins, seasonal climate outlooks, ENSO updates	• NHMSs: seasonal weather forecast, El Niño updates
Long-range	• Nepal Climate Data Portal: downscaled climate scenarios, past climate data • Myanmar Climate Data Portal: climate scenarios, past climate data	

	Asia	Africa
Regional		
Short-range	• RSMC, New Delhi • Neighbouring countries: Bangladesh Meteorological Department, Thai Meteorological Department	• ACMAD: severe weather forecasts, 10-day rainfall forecasts and monitoring, flood risk forecast, weekly rainfall forecast, Southern Africa extreme weather forecasts, 10-day/monthly climate monitoring and forecast, monthly climate and health forecast • ICPAC: Regular regional climate advisories, including 10-day and monthly climate bulletins as well as timely early warning information on evolving climate extremes and associated impacts • Africa Hazards Outlook: 10-day rainfall and drought estimate • African Water Cycle Monitor • FEWSNET Map Viewer • Drought Status Monitor
Mid-range	• India Meteorological Department/RSMC: Pune ENSO Bulletin • APEC Climate Center: Multi-Model Ensemble with six-month outlook • India Meteorological Department, Pune: seasonal forecast • South-West Asia Drought Monitor	• ACMAD: West Africa monsoon forecast, sub-regional (western and central sub-regions) probabilistic seasonal rainfall forecast • AGRHYMET Regional Centre: monthly bulletin on agricultural situation, hydrology and plant health • ICPAC: regional climate advisories, including seasonal climate bulletins • African Drought Observatory: precipitation, soil moisture, temperature, drought vulnerability, risk and hazard, climate, river basins • GIDMaPS
Long-range	• SAARC Meteorological Research Center; Southeast Asia START Regional Center; ICIMOD; ADPC; BIMSTEC; CSIRO; and others	• ICAPC: downscaled regional climate change scenarios based on CORDEX data on request
International/global		
Short-range	**Precipitation/rainfall/floods:** TRMM; NASA; GFMS, University of Maryland; UN-SPIDER; Disaster AWARE; Global Flood Alert Network; Global Flood Detection System; GLOFAS; PERSIANN-CONNECT; G-WADI; EOSDIS **Tropical cyclones:** WMO; RSMC (New Delhi, Tokyo); JTWC; University College London; Disaster AWARE **Thermal anomalies:** EOSDIS	
Mid-range	**Seasonal forecasts:** IRI; ECMWF; Climate Center; APEC Climate Center; Climate Prediction Center (CPC), National Oceanic and Atmospheric Administration (NOAA); CPC; China Meteorological Administration/Beijing Climate Center; CPTEC/INPE, Brazil; Met Office, UK; Bureau of Meteorology (BOM), Australia; Meteorological Service of Canada (MSC); Hydrometeorological Centre of Russia; South African Weather Services; Korea Meteorological Administration (KMA); Japan Meteorological Agency/Tokyo Climate Centre; Météo-France; WMO LC-LRFMME, jointly coordinated by KMA and CPC/NOAA; WMO LC-SVSLRF, jointly coordinated by BOM and MSC **Drought:** Global Drought Information System; Disaster AWARE; Global Drought Portal Data; RSMC satellite-based drought monitoring and warning system; Institute of Industrial Science, University of Tokyo, Japan	
Long-range	**Scenarios:** IPCC Data Distribution Center, International Conference on CORDEX, UK Met (for PRECIS Model and training), CSIRO, etc.	

ANNEX 2. EXAMPLES OF SOME INITIATIVES OF MAINSTREAMING WEATHER AND CLIMATE INFORMATION IN VARIOUS COUNTRIES

- Pilot Program for Climate Resilience (PPCR)
- Strengthening Climate Resilience (SCR)
- Global Alliance for Action for Drought Resilience and Growth
- Drought Resilience and Sustainable Livelihoods Program (DRSLP)
- IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI)
- Climate Field Schools (CFS)
- Future Climate for Africa (FCFA)
- Adaptation Learning Programme, CARE International
- Food and Agriculture Organization (FAO) Resilience Initiative, Sahel
- Heat Action Plan, Ahmedabad, India
- District Disaster Management Plan (DDMP), Gorakhpur district, India
- Caribbean Climate Online Risk and Adaptation Tool (CCORAL)
- Kenya's National Climate Change Action Plan
- Humanitarian Futures Programme at King's College London, Kenya and Senegal
- Climate and Development Knowledge (CDKN) El Salvador Programme
- Guidelines for Climate Compatible Construction and Disaster Risk Reduction in Rural Punjab in Pakistan
- CDKN work in Colombia

REFERENCES

Ahmed, A.K. (2009) 'Report on Communication Mapping and Planning at Community Levels'. Bangkok: ADPC. www.preventionweb.net/files/22230_22230dminseriesreport2clifmareportj.pdf.

Ahmed, A.K. (2013) 'Mainstreaming in Changing Climate and Extremes: Emerging Pathways to Integrate Risk Foresight and Climate Services into Development Processes'. *Asian Disaster Management News* 19.

Ahmed, A.K. (2015) 'Changing Landscape of Early Warning Systems: Reflections on the Asia-Pacific Region's Developments, Challenges and Future Pathways from a Practitioner's Perspective'.*Asian Disaster Management News* 21(2015): 4–7. www.adpc.net/igo/category/ID798/doc/2015-a17Hx3-ADPC-Asian_Disaster_Management_News_Volume_21_(Web).pdf.

Ahmed, A.K., Kodijat, A., Luneta, M. and Krishnamurthy, K. (2015) 'Typhoon Haiyan, an Extraordinary Event? A Commentary on the Complexities of Early Warning, Disaster Risk Management and Societal Responses to the Typhoon'. *Asian Disaster Management News* 21: 20–25. www.adpc.net/igo/category/ID798/doc/2015-a17Hx3-ADPC-Asian_Disaster_Management_News_Volume_21_(Web).pdf.

Bahadur, A.V., Peters, K., Wilkinson, E. et al. (2015). *The 3As: Tracking Resilience Across BRACED*. London.

Barry, R.G. and Chorley, R.J. (2009) *Atmosphere, Weather and Climate*. London: Routledge. Dutton, J.A. (2002) 'Opportunities and Priorities in a New Era for Weather and Climate Services'. *BAMS*, May: 1303–1311.

BBC (2015) 'Myanmar Floods: People 'Should Leave Low-lying Areas'. 6 August. London: BBC.

British Red Cross (2013) 'Typhoon Haiyan'. www.redcross.org.uk/What-we-do/ Teaching-resources/Quick-activities/Typhoon-Haiyan.

Chang, C.-P., Wang, B. and Lau, G.N.-C. (2005) 'The Global Monsoon System: Research and Forecast'. Reports of the International Committee of the Third International Workshop on Monsoons (IWM-III) 1266(1266): 552.

DIE (German Development Institute) (2012) 'Options for Improving the Communication of Seasonal Rainfall Forecasts to Smallholder Farmers – The Case of Kenya'. Briefing Paper 17/2012. Bonn: DIE.

FAO (Food and Agricultural Organziation) (2015) 'Myanmar Floods Deal Major Blow to Country's Agriculture'. 3 September. Rome: FAO.

Foresight (2012) 'Final Project Report: Reducing Risks of Future Disasters: Priorities for Decision Makers'. www.bis.gov.uk/assets/foresight/docs/reducing-risk-management/12-1289-reducing-risks-of-future-disasters-report.pdf.

Githungoa, W.N., Kinuthia, R.G., Kizito, K. and Raod, KPC (n.d.) 'Effects of Seasonal Forecasts on Farm Decision Making for Small Holder Farming systems in Semi Arid Parts of Kenya'. www.dewpoint.org.uk/Asset%20Library/ICID18/8-GITHUNGO_et_al_ICID+18.pdf.

Hansen, J.W., Mason, S.J., Sun, L. and Tall, A. (2011) 'Review of Seasonal Climate Forecasting for Agriculture in Sub-Saharan Africa'. *Experimental Agriculture* 47 (Special Issue 02): 205–240. www.die-gdi.de/uploads/media/BP_17.2012.pdf.

Hellmuth, M.E., Mason, S.J., Vaughan, C. et al. (2011) *A Better Climate for Disaster Risk Management*. *Climate and Society*. New York: IRI.

Herzog, T.N., Scheuren, F.J. and Winkler, W.E. (2007) *Data Quality and Record Linkage Techniques*. New York: Springer.

Hijioka, Y., Lin, E., Pereira, J.J. et al. (2014) 'Asia', in Barros, V.R., Field, C.B., Dokken, D.J. et al. (eds) *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. Cambridge and New York: Cambridge University Press.

IFRC (International Federation of the Red Cross and Red Crescent Societies) (2009). *World Disasters Report: Focus on Early Warning*. Geneva: IFRC.

IRI (International Research Institute for Climate and Society) (2015) '2015 El Niño: Notes for the East African Malaria Community'. New York: IRI.

James, R. and Washington, R. (2013) 'Changes in African Temperature and Precipitation Associated with Degrees of Global Warming'. *Climatic Change* 117(4): 859–872.

Janicot, S., Mounier, F., Hall, N.M.J. et al. (2009) 'Dynamics of the West African Monsoon. Part IV: Analysis of 25–90-Day Variability of Convection and the Role of the Indian Monsoon'. *Journal of Climate* 22(6): 1541–1565.

Lafore, J.P., Flamant, C., Guichard, F. et al. (2011) 'Progress in Understanding of Weather Systems in West Africa'. *Atmospheric Science Letters* 12(1): 7–12.

Manatsa, D., Morioka, Y., Behera, S.K. et al. (2014) 'Impact of Mascarene High Variability on the East African "Short Rains"'. *Climate Dynamics* 42(5): 1259–1274.

Mitchell, T., Ibrahim, M., Harris, K. et al. (2010) 'Climate Smart Disaster Risk Management, Strengthening Climate Resilience'. Brighton: IDS.

National Climatic Data Center (2011) 'NOAA's 1981–2010 Climate Normals'. www.ncdc.noaa.gov/oa/climate/normals/newnormals.html.

Niang, I., Ruppel, O.C., Abdrabo, M.A. et al. (2014) 'Africa', in Barros, V.R., Field, C.B, Dokken, D.J. et al. (eds) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the IPCC. Cambridge and New York: Cambridge University Press.

Nicholson, S.E. (2009) 'On the Factors Modulating the Intensity of the Tropical Rainbelt over West Africa'. *International Journal of Climatology* 29(5): 673–689.

OCHA (UN Office for the Coordination of Humanitarian Affairs) (2015) 'Myanmar: Floods and Cyclone Response – Multi-cluster/sector Initial Rapid Assessment (MIRA) Report'. 3 September. Geneva: OCHA.

Okoola, R.E. (1998) Spatial Evolutions of the Active Convective Patterns across the Equatorial Eastern Africa Region during Northern Hemisphere Spring Season Using Outgoing Longwave Radiation Records'. *Meteor. Atmos. Phys*. 66: 51–63.

Opondo M. (2012) 'A Bottom-up Approach to Climate Change Adaptation Policy: A Case Study of a Community Drought Resilience Project in Sakai Sub-Location, Makueni District, Kenya', in A. Musyoki and K. Meleckidzedeck (eds) *Environment and Development: Selected Themes from Eastern and Southern Africa*. Gaborone: Bay Publishing. www.die-gdi.de/uploads/media/BP_17.2012.pdf.

Perera, A. (2015) 'South Asia "Reacts Slow" to Monsoon Forecasts'. *SciDev.Net South Asia*. www.scidev.net/south-asia/agriculture/news/south-asia-reacts-slow-to-monsoon-forecasts.html#.

Red Cross/Red Crescent Climate Centre (n.d.) El Niño/La Niña. Climatecentre.org. Web. [Accessed: 24 November 2015].

Rowell, D.P. (2012) 'Sources of Uncertainty in Future Changes in Local Precipitation'. *Climate Dynamics* 39(7–8): 1929–1950.

Sharon, E. and Nicholson, S.E. (2009) 'A Revised Picture of the Structure of the "Monsoon" and Land ITCZ over West Africa'. *Climate Dynamics* 32(7): 1155–1171.

Singh, R. (2015) 'Climate Corner: How El Niño Is an Opportunity for Climate and Development Practitioners'. London: BRACED. www.braced.org/news/i/?id=7836cb8d-39cf-49cf-bfbc-65b0bfd732d1.

Suzuki, T. (2011) 'Seasonal Variation of the ITCZ and Its Characteristics over Central Africa'. *Theoretical and Applied Climatology* 103(1): 39–60.

Tierney, J.E., Russell, J.M., Sinninghe Damsté, J.S, et al. (2011) "Late Quaternary Behavior of the East African Monsoon and the Importance of the Congo Air Boundary". *Quaternary Science Reviews* 30(7): 798–807.

Turner, A. (2015) 'The Indian Monsoon in a Changing Climate'. London: Royal Meteorological Society. http://dx.doi.org/doi:10.1038/nclimate1495. www.rmets.org/weather-and-climate/climate/indian-monsoon-changing-climate.

Turner, A.G. and Annamalai, H. (2012) 'Climate Change and the South Asian Monsoon'. *Nature Climate Change* 2: 587–595. doi:10.1038/nclimate1495.

UNISDR (UN Strategy for Disaster Reduction) (2009) 'Global Assessment Report'. Geneva: UNISDR.

Webster, P.J. (2013) 'Effective Forecasting Systems for Reducing the Impacts of Cyclones and Extreme Weather Events', in World Bank *Building Resilience for Sustainable Development of the Sundarbans through Estuary Management, Poverty Reduction, and Biodiversity Conservation: A Non-Lending Technical Assistance*. Washington, DC: World Bank.

Webster, P.J., Magaña, V.O., Palmer, T.N. et al. (1998) 'Monsoons: Processes, Predictability, and the Prospects for Prediction'. *Journal of Geophysical Research* 103(C7): 14451. doi:10.1029/97JC02719.

WFP (World Food Programme) (2014) 'El-Niño and Seasonal Forecasts Seasonal Outlook for 2014'. June. Rome: WFP.

WMO (World Meteorological Organisation) (1992) Manual on the Global Data-Processing and Forecasting System Volume I (Annex IV to the WMO Technical Regulations). WMO – No. 485. Geneva, Switzerland.

WMO (World Meteorological Organization) (2011a) *Guide to Climatological Practices*. Geneva: WMO.

WMO (World Meteorological Organization) (2011b) 'Climate Knowledge for Action: A Global Framework for Climate Services'. ftp://ftp.wmo.int/Documents/SESSIONS/Cg-XVI/English/DOCs/d11-1(1)_1065_HLT_report_en.pdf.

WMO (World Meteorological Organization) (2015) *Background Paper: Synthesis of the Status and Trends with the Development of Early Warning Systems*. Geneva: WMO.

WMO (World Meteorological Organization) (2008) *WMO Guidelines for Communicating Forecast Uncertainty*. Geneva: WMO.

WCRP (World Climate Research Programme) (2011) 'The Global Monsoon Systems Programme Fact Sheet'. Geneva: WCRP. doi:10.1142/8109.

Yi Song, F., Semazzi, H.M., Xie, L. and Ogallo, L.J. (2004) 'A Coupled Regional Climate Model for the Lake Victoria Basin of East Africa'. *International Journal of Climatology* 24(1): 57–75.

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The BRACED Knowledge Manager generates evidence and learning on resilience and adaptation in partnership with the BRACED projects and the wider resilience community. It gathers robust evidence of what works to strengthen resilience to climate extremes and disasters, and initiates and supports processes to ensure that evidence is put into use in policy and programmes. The Knowledge Manager also fosters partnerships to amplify the impact of new evidence and learning, in order to significantly improve levels of resilience in poor and vulnerable countries and communities around the world.

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