Future Climate For Africa

Pilot Phase: Zambia | Technical Report

Zambian workshop participants participate in an activity that elicits insights on the value of balancing knowledge and decisions for climate risk management (Lusaka, May 2014)

Red Cross Red Crescent Climate Centre

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Executive Summary

Future Climate for Africa (FCFA) is a new five-year international research programme jointly funded by the UK's Department for International Development (DFID) and the Natural Environment Research Council (NERC). The aim of the FCFA programme is to support research to better understand and improve confidence in predictions of climate variability and change across sub-Saharan Africa on timescales to inform adaptation. The programme will have a major focus on climate science and modelling, underpinned by the principles of informing real decisions, with emphasis on enhancing the usefulness of climate science and projections, and on adoption of a multidisciplinary approach.

The FCFA Zambia pilot study comprised multi-sector, multi-stakeholder workshops, as well as primary and secondary research of climate science and its applications. This endeavor, led by the Red Cross Red Crescent Climate Centre in collaboration with the Met Office Hadley Centre (MOHC) and the Zambia Red Cross Society (ZRCS), yielded the following recommendations for the consideration of policymakers:

1. **Invest in climate science that directly enables decisions that are robust to a changing climate.** Recognizing the inherent uncertainty that shapes our understanding of future conditions, determine what climate information will allow decision-makers to choose between investment options, and invest in climate research to deliver such information.

2. **Integrate climate information into incentives for long-term engagement.** Historical data, forecasts, projections and other climate information should be considered within a full range of system complexities such as delays, feedbacks, trade offs and thresholds, in order to help climate service providers support stakeholders to find solutions over the long term.

3. **Promote interactive approaches to learning and dialogue for climate-smart decisions.** Design and deploy creative, intensely interactive processes that can break down communication barriers and build trust between producers and users of science, enabling more productive dialogue and decision-making. Complex decision-making requires serious exploration and collaboration across disciplines and with international partners.

4. **Link climate information thresholds to decisions for climate-smart resource allocation.** Develop forecast-based mechanisms, including financial instruments, to support climate-smart, timely and reliable risk management informed by science at various timescales.

5. **Foster open data and hybrid systems to accelerate adaptation under uncertainty**. Unlock existing data making it legally and technically accessible, while nurturing involvement of weather and climate service expertise in order to help align information to action. Hybrid systems that combine the strengths of humans and computers, such as crowdsourcing platforms for massively distributed tasks, are emerging as new ways to collect, analyse and disseminate climate-related data. Civic engagement in participatory sensing, citizen science and other digitally enabled approaches can speed up adaptation; and thus how knowledge informs action about opportunities and risks.

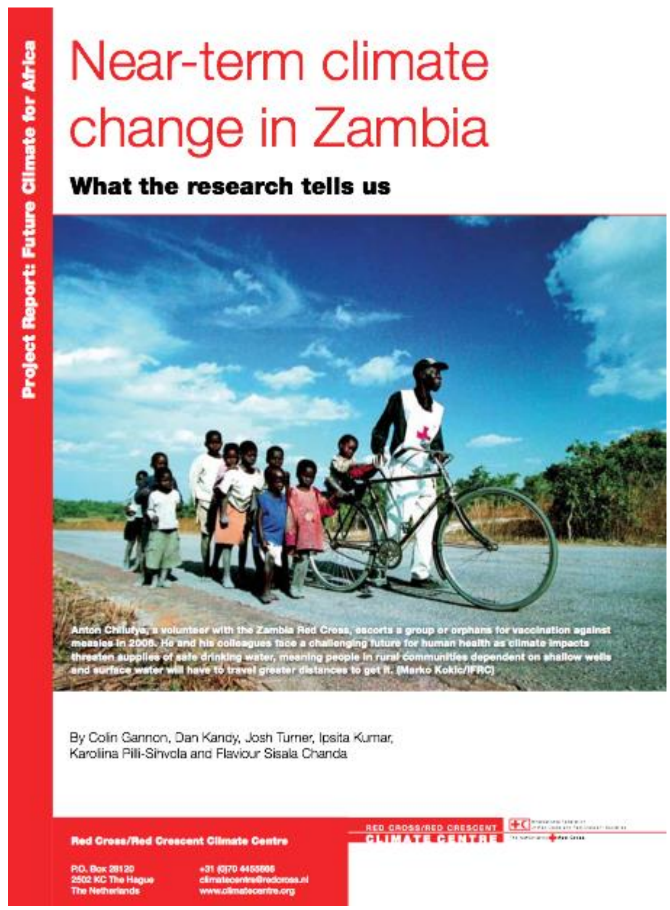
6. **Create information pathways between vulnerable communities, decision-makers and researchers**. Engage local, traditional knowledge along with climate science to facilitate interaction among those groups, building trust and increasing engagement of local experts.

1. Background

1.1. Introduction to the Future Climate for Africa Programme

The UK Department for International Development (DFID) and the Natural Environment Research Council (NERC) are developing a new research program to advance the scientific understanding of sub-Saharan African climate on decadal timescales and, working with African stakeholders, to bring this science into use to inform long-term climate-resilient development strategies. The new program, entitled “Future Climate for Africa” (FCFA) will aim to produce, enhance the availability and accessibility, and demonstrate the use of robust and ‘decision relevant’ climate information products to inform climate-resilient investment, policy and strategies across sub-Saharan Africa.

In this context, DFID commissioned the Climate and Development Knowledge Network (CDKN) to manage a series of consultations and pilot case studies to help DFID assess the potential of such a program to better inform climate adaptation decisions across the continent and define core design principles. This technical report provides a synthesis of the key themes and priority areas for the Future Climate for Africa’s scoping phase based on findings from the Zambia pilot case study. The report format is guided by research questions provided to the FCFA pilot study research teams by CDKN. Additional details on many of these findings are presented in the Climate Centre’s FCFA project report, *Near-term climate Change in Zambia: What the research tells us,* submitted to CDKN as part of the Zambia pilot case study, in September 2014.


Project Report: Future Climate for Africa

Near-term climate change in Zambia

What the research tells us

Anton Chilufya, a volunteer with the Zambia Red Cross, escorts a group or orphans for vaccination against measles in 2006. He and his colleagues face a challenging future for human health as climate impacts threaten supplies of safe drinking water, meaning people in rural communities dependent on shallow wells and surface water will have to travel greater distances to get it. (Marko Kokic/IFRC)

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1.2. Introduction to Zambia pilot case study

The Red Cross Red Crescent Climate Centre (RCCC), in collaboration with the Met Office Hadley Centre (MOHC) and the Zambia Red Cross Society (ZRCS) led the Future Climate for Africa pilot study in Zambia, which sought to examine how to make climate science actionable, so decision-makers could make informed adaptation and development investments robust to a range of possible outcomes in the near- to medium-term future (5-40 years).

The objective of the FCFA Zambia pilot study was to improve the collaboration and dialogue between decision-makers and scientists, and to create a forum in which decision-makers articulated the decisions they confronted and defined the type of information that for them would be most relevant and actionable through facilitated interactive group work. To achieve this, the partners conducted the following activities between February and October 2014:

1. **Convened a multi-disciplinary, multi-stakeholder workshop** focused on real long-term development challenges to enhance understanding on the type of climate science needed to help inform development planning (May 2014);
2. **Reviewed, analyzed, stress-tested and generated relevant scientific information** in support of the country workshop and case study research outputs, to either develop the required information or identify where further research was needed (March – Aug);
3. **Convened a results workshop and high level breakfast meeting** to share outputs and discuss follow up to improving the "fit" of climate information for decision-makers (September);
4. **Produced two reports (this technical report, briefing paper) and a blog,** synthesizing lessons learned from the country workshops and recommendations for the FCFA research call (October 2014).

This FCFA Zambia pilot addressed multiple climate-related aspects of Zambia's development and humanitarian work. The pilot evolved from an initial exploration of a wide range of sectors in the first workshop (agriculture and environment, health, transport and infrastructure were identified as sectors particularly vulnerable to climate shocks and trends), to a final workshop focusing on water-related challenges in Lusaka, in order to deepen the questions and to link to the proposal development process for a second phase of the FCFA programme (FCFA II). The issues identified in the September 2014 results workshop included 1) flooding due to storm water; 2) groundwater contamination and depletion; 3) water infrastructure management; 4) management of groundwater recharge areas.

As the Red Cross Red Crescent Climate Centre has gained experience and esteem for pioneering the use of intensely interactive, innovative tools (e.g. participatory games) to promote learning and dialogue about climate risk management amongst diverse stakeholders, the research methodology for the Zambia pilot was infused with experiential learning exercises and serious games (see Box 2 and 3). These methods were evaluated by workshop participants as highly enjoyable and effective means of eliciting information and stimulating discussion between producers and users of climate information (see Box 1). The interactive exercises enriched information flow by encouraging peer-to-peer learning and by enabling players to collectively 'inhabit' a complex system and share the "Huh?" (confusion) and "AHA!" (revelation) moments. The collective intelligence generated by participants created an environment conducive to deep discussion and truly participatory dialogue. It is worthwhile to note that participants

Box 1. Participant feedback on innovative approaches for dialogue

"I liked the innovation of learning while playing games"
"Games helped me to learn quite a few things."
"[I liked the] Visualization of certain concepts (e.g. voting with your feet exercise)"
- Exerpt from participant evaluation from feedback forms, first workshop (May 2014)

present in the first workshop returned for the second results workshop, in part drawn by the prospect of engaging again in out of the box, dynamic and genuine two-way knowledge exchange.

Box 2. Example of experiential learning: Exploring Tipping Points
Prior to the formal opening of the first workshop, participants explored the challenges of maintaining complex systems in balance by playing the tipping point game. The primary tool for the game is an inherently unstable table made up of two parts: a platform and a stand. On the table top a number of wooden blocks are balanced. Participants play in three or more teams and can decide if they would like to harvest resources (take a wooden block) or foster resources (place a wooden block). If the table tips over all groups have lost as the system has collapsed. While this exercise generated some energy and strategic discussions, participants also reflected on the challenges of maintaining balance in complex systems and how unexpected events and small interventions can have huge impacts on these systems.

Zambian workshop participants literally explore Tipping Points in first FCFA workshop (Lusaka, May 2014)

2. Zambia's Climate Past and Future

Zambian society, with 70 per cent of the workforce dependent upon agriculture (World Bank, 2014) and a large portion of the country in the floodplains of the River Zambezi, is **highly vulnerable to variability in precipitation**, across multiple timescales. Floods are common and affect many sectors; droughts can also be devastating and have prolonged side effects that touch every facet of Zambian life. Both hazards have become more frequent and severe in recent decades (GRZ, 2007).

Historically, Zambia has been prone to extreme rainfall events resulting in widespread flooding. A recent flooding event during the 2006–7 rainy season saw nearly 1.5 million people affected (GRZ, 2007). Typical impacts from a major flooding event include: collapsed houses and buildings, destruction of infrastructure (roads, sanitation facilities), waterlogged agricultural fields, destruction of crops, contaminated water supplies and an increase in human diseases (GRZ, 2007; Leary, Kulkarni and Seipt, 2007).

Projections of future average precipitation are inconclusive in many areas; different models tend to produce notably different results. However, a majority of studies using Global Climate Models (GCMs) predict a drying trend (Hulme et al., 2001) through the next 100 years, with a "very likely" decrease in annual mean precipitation over southern Africa by mid-century (IPCC, 2014; Christensen et al., 2013). The difference between models, however, indicates significant uncertainty in these results (Giannini et al., 2008; Hulme et al., 2001) though there in many areas there is consensus amongst models that heavy rainfall events will increase in frequency (IPCC, 2012; IPCC 2014).

In addition to a general drying trend, global warming is likely to change the onset of the rainy and dry seasons. Tadross et al. (2010) analyzed intra-seasonal rainfall and maize cropping over southeastern Africa from daily observations of 104 stations across the region, and found weak but noticeable trends for later planting and earlier cessation dates in some locations, leading to shorter rainfall seasons. Over southern Zambia this brings the duration of the rainfall season closer to critical thresholds, which forces farmers to plant as early possible; trends at Livingstone station show that although not statistically significant, they lead to a greater risk that critical thresholds of seasonal duration required for maize cultivation are not met.

Patterns and extremes are also likely to change. General rainfall events will tend to become less frequent, while more intense rainfall events, separated by a large number of dry days, will tend to become more frequent (Kay and Washington, 2008; Shongwe et al., 2009). Additionally, the proportion of total rainfall coming from extreme precipitation events is expected to increase (McSweeney, New, and Lizcano, 2010).

3. Climate and decision-making in Zambia

The issues explored in this FCFA pilot will need to be examined by policy makers within a broader framework that considers three questions: (1) how much of the problem is solvable with better science, (2) how much is related to the quality of the decision-making and governance at large (regardless of the science), and (3) how much is about the bridging of science and decision makers. With that in mind, this section examines both the key Zambian stakeholders shaping decisions on climate change, as well as some salient development decisions that involve substantial implications for the medium to long term.

3.1 Key agents of change driving long-term policy formation, plans and investments

The number of institutions directly involved in climate change activities in Zambia is gradually growing. Within the national government, climate change activities have been led by three key entities: Ministry of Finance (MoF); Ministry of Lands, Natural Resources and Environment Protection; and the Disaster Management and Mitigation Unit ((DMMU) under the Office of the Vice President). Most recently, however, a growing number of Line Ministries, donors, civil society organizations and private sector organizations have working to make Zambia's economy more climate resilient. In total, approximately 25 organizations are now directly involved (World Bank Public Information Document). Select government departments (e.g. Meteorological Department, Department of Water Affairs, Department of Agriculture) currently gathering environmental data, sometimes in long time series. This data has a potential to inform decision-making processes - especially those that would benefit by understanding historical trends of identified thresholds.

Under the MoF, the Government of Zambia established a **National Climate Change Secretariat**, tasked with ensuring high-level coordination. The Secretariat comprises staff seconded from various sectoral ministries and leads on coordination of all climate change and disaster risk management activities within Zambia. Zambia is also host to strong civil society networks active in the climate change adaptation discussions, creating many opportunities to establish synergies between government departments and civil society processes. The **Zambia Climate Change Network** (ZCCN) comprises of 7 core organisations, and a network of over 50 organisations and individuals, working in the field of natural resource management and climate change. The ZCCN is represented on the National Climate change Secretariat. Finally, the **Pilot Program for Climate Resilience** (PPCR) is an integral part of Zambia's effort to respond to climate change. The PPCR is a multi-donor Trust Fund, one of the three programs under the Strategic Climate Fund of the Climate Investment Funds (CIFs).

In addition to the entities listed above, there are numerous other stakeholders that, with or without awareness of the climate implication of their actions, are making decisions outside of the aforementioned climate-related processes that shape investments and therefore influencing climate vulnerability and adaptive capacity. This is especially true of the private sector (notably mining and real estate developers), but also applies to a myriad other players that often end up contributing to the social construction of vulnerability in the context of changing socioeconomic landscape of Zambia. The decision making space in Zambia therefore needs to be understood in its complexity, recognizing that action taken today (such as urban planning, mining etc.) even if not explicitly linked to climate change at present, might lead to increased vulnerability to future climate change of sectors and geographical areas.

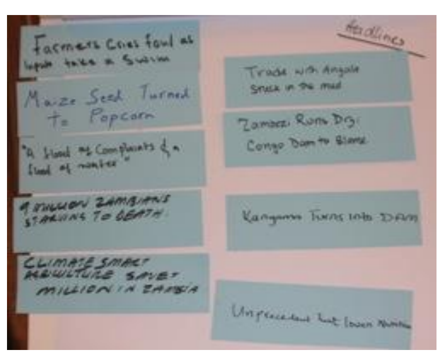
3.2 Development decisions with medium and/or long-lived implications

In the course of the workshop process, participants identified a range of foreseeable climate change impacts in the medium term and concluded that a range of sectors are potentially severely affected by future climate extremes and change. The agricultural sector (which is primarily rain fed), transport and infrastructure, and the health sector in particular were selected in the first workshop based on the expert judgment of participants for further exploration. The participatory design based on Suarez et al (2014) for the May workshops, aimed at helping stakeholders examine the range of investment options for the medium-term, and the value of climate-related information to inform decisions to choose between alternative options. Specifically, it allowed participants to identify actions within key sectors that would be most sensitive to climate shocks or trends; identify which shocks or trends could affect the interventions; consider alternative development interventions to take; and finally identify the level of risk related to acting in vain vs. failing to act if a shock or trend were predicted to materialize. Example 2 describes the design of one of the participatory exercises, called 'Hearing the Headlines'.

Box 3. Characterizing climate–related threats to development through gameplay

Building on earlier participatory exercises, participants engaged in the exercise, 'Hearing the Headlines' to deepen the exploration of relevant climate information needed, focusing on possible risk thresholds.

The exercise was structured in two steps: first participants were asked to reflect on what possible newspaper headlines could be in the future if they implemented certain development interventions today; second, participants were asked what type of information would enable them to assess the climate risks for that intervention, adjust their decision-making to select a decision that is the most robust to possible climate futures. See photo of headlines the participants came up with below.



Understanding development decisions, by sector

Compromised human **health** is one of the leading concerns associated with floods in Zambia. Beyond malnutrition, associated diseases include malaria, cholera, dysentery, and bilharzias (schistosamiasis) (GRZ, 2007). The outbreak in water-borne diseases (cholera and dysentery) is a result of Zambians' dependence on surface water for drinking; these sources may become contaminated after a flood. This is a particular concern in areas where pit latrines are commonplace. An example of a recent disaster is the April 2010 floods, which hit Lusaka, resulting in 3,381 cases of cholera and 87 deaths (IFRC, 2010).

Vector-borne diseases, particularly malaria, are also associated with these events, as stagnated water serves as a breeding ground for disease-carrying mosquitos (GRZ, 2007). Malaria kills more people than any other disease in Zambia (UNICEF, 2014) and is associated with variations in precipitation. More frequent extreme precipitation events may also result in a rise in water-borne diseases. Flash flooding events could result in more frequent contamination of the water supply, and communities already stressed with limited water supply may see a rise in the number of cholera cases.

A distinct warming trend has been observed in Southern Africa through the 20th century. Surface temperatures have increased by half a degree Celsius or more over most of Africa (Hulme et al., 2001; New et al., 2006; IPCC, 2007, 2014) with the 1995 to 2010 period seeing significantly higher surface temperature anomalies compared to the prior 15 years (Collins, 2005; IPCC, 2014). Although not as economically or socially devastating as the expected changes in precipitation variability, the expected temperature rise has several key consequences in the health sector in Zambia. Most notably, overall warmer temperatures can foster elevated disease transmission rates among livestock and aquaculture, exacerbating the stress caused by reduced pasture health and water quality respectively. Expected warmer temperatures during the cold season could result in a higher number of malaria cases, although this could be offset by elevated rates of evapotranspiration and the subsequent reduction in stagnant water.

Participatory Workshop Results:

The workshop explored development interventions and how they would be affected by a changing climate in the medium term. The discussion also focused on the cost of implementing an adapted intervention and the associated costs, including the cost incurred if no action was taken, or if action was taken but the "planned for events" did not occur. In this context the health sector identified increasing occurence of extreme weather events impacting on nutrition and health services alike. Some specific responses and thresholds were then explored.

Name of development Intervention	**Shock or trend that could affect this intervention**	**Alternative Plan(s)**	**Fail to act *** (Risk Level)	**Act in vain*** (Risk Level)
Health				
Nutrition	Extreme seasonal rainfall and increasing trend in high temperatures	Switch from traditional seed varieties to climate change tolerant crop	Medium	Very Low
Health services	Increasing occurrence of extreme weather events	Mobile clinics	Medium	Low

The Zambian **agricultural sector** can be expected to suffer greatly from the decline in total precipitation and the shortening of the growing season; as a result, production is likely to decrease. When precipitation does come, the quantity and run-off may be so great that it will benefit the crops only minimally, potentially even doing more harm than good, inundating fields and destroying crops. While floods often result in immediate disaster situations, many longer-term societal threats exist during times of drought, particularly in the agriculture, energy and human health. A 2004–05 drought, during which about two thirds of the country received little or no rainfall during the growing season, resulted in 1.2 million people being affected (GRZ, 2007).

Participatory Workshop Results:

The workshop participants explored a variety of interventions in the agricultural sector that would be affected by medium term climate. Cross-sectoral linkages become clear when exploring aspects of market access by road, access to infrastructure and technology.

Name of development Intervention	**Shock or trend that could affect this intervention**	**Alternative Plan(s)**	**Fail to act *** **(Risk Level)**	**Act in vain*** **(Risk Level)**
Agriculture and environment				
Better feeder roads	Increased intensity and frequency of rain and hail	Reconstruct road taking into account other negative impacts (superstructure)	Medium	0
Construct crop storage facilities	Rainfall and temperature patterns	Change construction code (i.e. build it higher) Build a temporary mobile storage	Medium	Very Low
Land ownership	Prolonged drought-increased max temperatures - variable rainfall patterns	Concrete beacons Metal beacons GIS positioning Zoning codes No titles granted close to flood areas	Medium	Very Low
Access to inputs and technology	Shift in seasonal rainfall patterns, more erratic rainfall	Develop new varieties Increase stocks of different seed varieties	High	Low

The **energy** sector in Zambia is almost entirely dependent upon rainfall. The country generates over 90 per cent of its power from hydroelectricity, making energy security highly dependent upon precipitation patterns. Reduced power generation in recent years has had a negative impact on the economic productivity as this leads to increased power shortages, forcing industries to reduce their levels of production (GRZ, 2011; Beilfuss, 2012; World Bank, 2010). A 2010 World Bank assessment of hydropower in Southern Africa, including Zambia, simulated a reduction in annual average energy production. Reservoir levels behind the hydroelectric generation dams are expected to decrease on an annual basis as a result of more frequent and prolonged drought conditions. This combined with increased surface water evaporation, especially from upstream reservoirs and floodplains, could result in reduced energy generation capacity throughout Zambia (Beilfuss, 2012).

Participatory Workshop Results:

Long-term investments were identified as very affected by medium climate. Especially anticipated increased temperatures and reduced or more erratic rainfall might affect transportation on the trans-boundary canal.
Another identified strategy for addressing future climate was the planned transition to renewable energy and to stimulate investment in the renewable energy sector.

Name of development Intervention	**Shock or trend that could affect this intervention**	**Alternative Plan(s)**	**Fail to act *** **(Risk Level)**	**Act in vain*** **(Risk Level)**
Transport and infrastructure				
Canal trans-boundary water links	River drying up	Road Rail for transport	-	-
Incentive renewable energy investment	Shift in the anticipated patterns used for planning	Import energy Gas	Medium	Very Low

This process surfaced a few interesting insights: firstly it became apparent that information about future climate is mostly ignored in current planning of sectoral development interventions. The discussion of alternative development interventions and discussing the risk of inaction (or acting in vain) was followed by an exploration of possible thresholds crucial for understanding future risk to planned investments. These important points of conversation and analysis link the decision making space to climate science, but would require much more time and support in order to accomplish meaningful results.

Water related sectors as described above have been identified as a major cross cutting challenge in rural and urban Zambia, notably Lusaka, sensitive to medium term climate change. Considering the already observed increase in average and maximum temperatures and increased pressure on urban water resources due to urban growth, the currently experienced water crisis will be aggravated in the future. While many of the underlying causes are related to policy, planning and implementation - these will be aggravated by increased strong rainfall events and increased temperatures forecast for the medium term future. Also, the lack of good information on rainfall over the recent past makes it difficult to adequately plan improvements in infrastructure and climate resilience policies in general and hinders the development of detailed future climate scenarios critical for adaptation planning.
Similarly, access to safe drinking water is likely to diminish, putting stress on both cities and rural areas. Cities which currently rely on boreholes and shallow wells risk depleting their sources, while rural communities dependent upon shallow wells and surface water will have to travel greater distances to collect drinking water, increasing incidences of water-borne diseases (cholera and dysentery) and human-wildlife conflicts.

Box 4. Participatory Mapping of current water challenges in Lusaka
A wide range of stakeholders was asked to identify current challenges relating to water affecting various sectors currently in Lusaka. The key challenges were identified and inter-disciplinary groups discussed the experienced problems, their causes and the spatial areas of impact in Lusaka.
In a next step all groups mapped the areas where particular challenges incurred, for example areas of high ground water contamination, areas of frequent and severe flooding after storm events, reserves for ground water recharge recently proclaimed as industrial areas.

The groups presented their findings (see section 4.2) and in the following discussion reflected on the value of cross linkages between sectors and the need to address medium to long term developmental challenges while considering additional stressors being placed by future climate extremes.

Photo 1: The map identifying water challenges for Lusaka as compiled in the participatory process

4.The Role of Climate Science in National Decision-making Processes

The FCFA research reveals the importance of investing in climate science that directly enables decisions that are robust to a changing climate. Recognizing the inherent uncertainty that shapes our understanding of future conditions, it is essential to determine what climate information will allow decision-makers to choose between investment options, and to invest in climate research that will deliver such information.

4.1 Climate science outputs available to decision makers: an overview

At the national level, the project team confirmed, based on findings from the literature review and stakeholder workshops, that **robust information on expected changes in seasonal, monthly and daily temperature is currently available** to decision-makers influencing policy. The frequency of heavy rainfall events is expected to increase along with indications that dry-spells will also get longer (consistent with the finding that for annual rainfall little overall change or possibly a slight decrease is expected).

Another issue that was raised in the workshops and revealed in the literature review was the lack of locally generated climate change projections despite coordinated efforts to develop **downscaling in Southern Africa, which are still in their early stages and present a number of challenges.** A lack of long-term, extensive, and complete observed data in the region limits the ability of statistical downscaling to be used and so most efforts are focused on the use of dynamical downscaling models. The most significant recent effort in this context is the World Climate Research Programme (WCRP) Coordinated Regional Climate Downscaling Experiment (CORDEX), which has coordinated some dynamical downscaling simulations and analyses from which data are beginning to become available. However, there is still the need to broaden this activity, to undertake comprehensive evaluations of these data and to understand their applicability.

Workshops discussions also focused on **the capacity within Zambia to generate or interpret relevant climate information**. There is relevant data and some expertise within the Zambian Met Service and university to assess the reliability of these findings. However, the understanding how to combine the observations and knowledge of the climate of the country with the simulations of current and future climate to generate information useful for decision-making was largely absent due to the limited number of people with relevant skills having no experience or opportunity to be involved in this sort of work.

Participants highlighted a number of reasons why there isn't much uptake of existing climate information, notably (a) insufficient quality of data, methods and communication to justify integration of science-based projections into decision making, and (b) insufficient capacity among potential users to access, understand, trust, process and act upon available information. Additional remarks included:

- Indications of increases in number of dry spells but large differences in historical simulations which inturn indicated the need for further research on their reliability (e.g. comparisons with observations).
- Results on changes in rainy season were difficult to calculate as definition of rainy season onset was unclear
- Clear indications of projected increases in heavy rainfall existed, but these came from modelling studies whose resolution is low compared to district or city scales. This implies that higher resolution modelling may be required to confirm if these findings can be applied at the geographic scales that matter for decision making
- Further research is required on the credibility of the models used to generate the information, e.g. validation with observations, and its reliability, e.g. to demonstrate confidence in the processes responsible for the projected changes.

No evidence was found of climate science being used directly to inform decisions relevant to longer-term planning or long-lived infrastructure. It was clear that experience of floods and droughts within the country coupled with messages received about projected future increases in these sorts of events (and the general trends in temperature both experienced and expected to continue) have sensitized government departments and sector specialists to the need to include future climate trends in developing strategies and plans. However there is little evidence of these being implemented, which is the point at which more detailed climate information is required. For example, the information available on extreme precipitation points to increases in frequency of heavy rainfall events but that these can only be considered to be applicable at scales of the order of 100km. Thus at the district or city scale, no relevant climate change information is available and the detailed implementation of measures would need to be accompanied by scientific research including the application of high resolution modeling. At the stage of decision-implementation is there both the clarity of the requirements for and the stimulus to undertake the required research. **Not much information was found about whether decisions on long lived timescales informed the generation of climate-related research agendas**, potentially revealing that one had little influence on the other; a second phase of FCFA could improve on this disconnect.

As of now there is **little evidence of established mechanisms to integrate insights and feedback from the most vulnerable communities into scientific research and climate services aimed at the medium- to long-term future** – and, by extension, to atmospheric sciences and impact assessments in general. The flow of information continues to be vastly dominated by unidirectional approaches, from producers of allegedly actionable information to potential users who rarely know whether the information can justify changes in planned action (or inaction). At different time scales, notable exceptions include some past work of the Southern Africa Regional Climate Outlook Forums (which sometimes included representatives from agricultural extension services, the Red Cross and other organizations working directly with subsistence farmers). New approaches conducive to improved communication, better access to data, and systems thinking is discussed in Section 5.

Special importance deserves the exploration of new, meaningful information pathways between vulnerable communities, decision-makers and scientists. In order to plan effectively for the medium to long term it is crucial to consider all types of knowledge available, including harmonization of science-based approaches with existing, traditional methods for anticipating future conditions at the local level. It is thus of high importance that planning processes consider information, mental models and priorities on all levels and can effectively integrate these. Participatory processes and interactive methodology can support such communication processes.

4.2 A focus on the water sector

In order to gain a more in depth understanding of the interactions of scientific climate information and decision-making, the interactive workshop in September 2014 examined the challenges for the water sector in Lusaka as an urgent cross-sectoral challenge in Zambia. While a range of other sectors, such as agriculture, health and infrastructure were also identified as being especially affected by medium term climate change in the first workshop, the urban water sector was chosen as a focus sector to support more in depth exploration of current and future opportunities and challenges and how climate science could possibly support more effective decision making.

Some of the current water related problems in Lusaka were identified in the workshop as follows:

- Lack of expertise to manage planning processes, planning and implementation of water infrastructure, catchment management, hydrological modeling, forecasting of frequency of extreme events, etc.
- Limited data and monitoring of water quality and water abstraction rates while facing increasing demand for safe drinking water.
- The vigorous growth of the Lusaka urban area and the geology in parts of the city does not allow for effective conventional water and sewerage infrastructure. Open sewerage and inadequate water provisioning in parts of Lusaka are problems that are likely to be further aggravated by medium term climate change.

While the above problems are already urgent, they are sensitive to medium-term climate change, especially increases in average and extreme minimum and maximum temperatures and increases in extreme rainfall events, which will have to be considered as an additional stressor in the sector.

As one workshop participant stated, “We are facing an ongoing water crisis in Lusaka: drinking water is often contaminated and in some areas water is only provided for a few hours every day, because the current water demands cannot be met." The water situation in Lusaka is concerning, with water rationing being implemented in certain areas, ground and surface water pollution exacerbated by flooding, unsuitable development and watershed management due to a lack of climate information required for proper planning, the uncontrolled sinking of private boreholes and short supply of safe drinking water. It has become clear in the course of the workshops that an integrated approach for improved decision making, including drawing on local climate expertise and data augmented by international expertise, is crucial to address the roots of the current situation and to improve the complex problem of water management in Lusaka in the mid to long-term. A coordinated approach of decision-making and effective implementation could then integrate medium term climate information to be considered to consider future climate risks in current planning processes.

Table 1. Water-related challenges in Lusaka: a summary of the participatory mapping process

Key challenge	Climate related trends or shocks	Decision making space: key stakeholders	Cross cutting linkages	Climate and other information needed for decision making
Groundwater recharge	Heavy/extreme rainfall leads to flooding of drains/pit latrines and contamination of groundwater Extreme temperatures lead to increased evaporation and decreased ground water recharge	Department of Water Affairs Department of Planning Municipality Civil Society Networks Local community participation Conservation sector	Health impact of unsafe drinking water Insecure infrastructure leads to drinking water and groundwater contamination Effective catchment management to ensure recharge	Expected annual extreme rainfall events • Expected increase in average and extreme temperatures • Hydrological modeling of recharge patterns • Catchment management mapping of anticipated change due to development, change in climatic patterns, etc. • Monitoring water abstraction and ground water recharge
Provision of sufficient and safe drinking water	Higher or extreme temperatures lead to higher urban water consumption Higher temperatures can stimulate disease vectors Heavy/extreme rainfall leads to flooding of drains/pit latrines and contamination of water supplies	Department of Water Affairs Department of Planning Department of Health Municipality Civil Society Networks Local community participation	Increased flooding will prevent supply of clean drinking water in affected areas Health impact of water born diseases Water provision and sewerage infrastructure adequate for current and future volumes Solid waste management affecting drinking water provision	• Expected annual rainfall • Expected extreme rainfall events (frequency and amplitude) • Regulation of sinking private boreholes • Monitoring groundwater abstraction rates • Monitoring water quality
Effective storm water drainage	More extreme rainfall events lead to increased storm water and flooding	Department of Water Affairs Department of Planning Solid Waste management Municipality Civil Society Networks Local community participation	Blocked storm water drainage due to poor solid waste management and associated blockage of storm water drains Geology might make storm water drainage	• Expected extreme rainfall events (frequency and amplitude) • Mapping of existing stormwater drainage and areas of flooding • Modeling flow of stormwater (including increased flow in the future) • Innovative options for stormwater drainage in areas with Limestone bedrock
Management of water infrastructure	Extreme rainfall and flooding damages infrastructure	Department of Water Affairs Department of Planning	Damaged infrastructure of sewerage and drinking water pipes can lead to contaminated drinking water with	• Expected annual extreme rainfall events • Hydrological modeling of recharge patterns and wate availability

		Municipality Civil Society Networks Local community participation	implicated health impacts Broken water pipes lead to interruption of drinking water provision, loss of drinking water Open sewerage systems can lead to health implications - especially during flooding	• Understanding current and future water abstraction rates • Innovative options for sewerage management in areas with Limestone bedrock

It emerged from the discussions in the workshop that climate information should not be seen in isolation from other research relevant to the actual sector or cross cutting theme. Additional, non-climate related research as identified by the stakeholders could support more sustainable decision-making on climate adaptation.

4.3 How can science help address sector-specific development challenges?

This review of the current state of knowledge surrounding near-term climate change in Zambia suffers from multiple limitations. **Perhaps the largest and most obvious limitation in this study stems from the lack of information addressing Zambia**. Much of the literature concerning climate phenomena and climate change deal with Southern Africa as a whole; this limits the applicability of some of the findings to Zambia specifically, as the climates across Southern Africa are not homogeneous. By the same measure, some studies address climate change in general or in the longer term, and had to be interpolated for relevance to the near-term temporal scale.

A lack of local expertise in regional climate processes and model interpretation, as well as **limited access to existing climate information** from external research organizations, generally increases uncertainty among local decision-makers and stakeholders, depressing the initiative to act upon projections. More local participation in the development and analysis of information could positively result in action to adapting to projected climate change. Through this study, decision makers will have a more robust understanding of these topics and be empowered to act with greater climate consciousness.

There is uncertainty in the future of the ENSO phenomena, in terms of both changes in frequency and intensity of La Niña and El Niño events as well as changes in the mean state of the tropical Pacific Ocean. As a result of the large effect ENSO has on Southern Africa, this uncertainty translates to uncertainty for projections of Southern African rainfall. Moreover, the augmenting strength of the ENSO teleconnection in this region provides an additional form of uncertainty for projections of near-term as well as long-term climate change for Zambia. ENSO, however, is a reasonably well-understood phenomenon, especially in relation to the other dynamical factors influencing the climate of Zambia.

For some climate factors that influence the climate of Zambia, there is little, if any, information on how they will change in a warming world. No information was found to address how the Angola Low or Benguela Niños might change due to warming. Consequently, model studies and/or downscaling exercises could be used to fill this gap. In terms of dynamical downscaling, there are current efforts to address this shortcoming, like the CORDEX experiment. Additionally, spatial resolutions have been improved by way of more computing power; but this is, and cannot be, the only solution. Many dynamical downscaling attempts are plagued with parameterization issues (IPCC, 2014). At the time of this study, little useful downscaled information could be gleaned from the literature.

As described above, **downscaling in this region presents many difficulties**. The choice of model can lead to differing sign and magnitude for changes in precipitation. Statistical methods of downscaling, as mentioned before, have suffered from insufficient observational records; as time goes on, especially with improvements in remote sensing, observational data is becoming more robust and hopefully can translate to some useful statistical methods in the future.

Importantly, **data is not always freely accessible.** There are observations from Zambia, but those datasets are limited and not available for use for outside research organizations. Access to this data could prove valuable for many reasons, including improved statistical methods for seasonal forecasting and statistical downscaling of climate models. Finally, there was no information found concerning how low frequency climatological phenomena, decadal or multi-decadal, will change in the near or long term.

Future research of value to Zambia should include more robust understanding and less uncertain projections of ENSO in the future, additional downscaling exercises for more country and regional information, and further efforts to increase spatial and temporal resolution (including rainfall intensity patterns at less-than-24-hour-periods, which can be crucial for a large range of sectors from agriculture to road infrastructure but is largely overlooked by data and research)**.** Ideally, downscaling would be able to individually assess each of the agro-ecological zones, which have distinct climates and will change variably under future scenarios. Perhaps more difficult, but still valuable, will be efforts to understand lesser-known phenomena like low frequency variability, Benguela Niños and the Angola Low. However, additional research with respect to these phenomena could alleviate this gap in knowledge and improve climate change projections for Zambia.

It is important to note at this stage that more climate science on its own will not necessarily lead to better climate risk management; not just because of the irreducible uncertainties in the climate system but also due to the predictable gaps between knowledge and action. Perhaps the lowest hanging fruit is to improve the use of existing information (including building capacity use it), likely leading to better dialogues between users and providers, and increased appreciation of the value of advancing science.

While there is some political commitment and innovation in Zambia to address the current and mid-term challenges posed by climate change, in the course of the workshops and interactions it became clear that addressing the challenges in the water sector faces some serious challenges. They include the lack of integrated approaches to address the complex problems of water challenges, interventions addressing the long-term effects not being effectively implemented.

It was emphasized that increased capacity for cross sectoral planning, community participation, improved environmental and water monitoring and long-term planning considering medium term climate information would be a possible avenue to address some of these barriers.

In order to support decision-making space it is important to **critically explore thresholds in the respective sectors and to relate these clearly to already existing or possibly newly generated climate information** (see Coughlan et al 2014a, and example in Box 1). Such a process would ensure that tailored climate information can be provided to decision makers and thus the chances of effective implementation in the medium term are increased.

Box 5. Climate-related thresholds for Zambia

Workshop participants brainstormed possible steps to take in addressing the climate challenge in Zambia in the mid- long term. They listed what type of climate science information would be useful to access for various sectors. A wide range of issues were discussed and three different classes of information resulted from this exercise, specific climate information, information on climate and related physical factors and climate information provided in the context of specific sectors or activities. The list below guided the scientific research conducted by the MOHC as part of the FCFA pilot and findings of this research were presented at the results workshop and high-level breakfast in September 2014.

Specific climate information (and issue of relevance):
1) Average rainfall during a three-month period in the rainy season;
2) Change in average monthly temperature (crops);
3) Change in average seasonal temperature (mosquitos);
4) Trend in minimum temperatures (bronchitis);
5) Trends in 5/7/10-day cumulative rainfall totals (crops);
6) Trends in number of dry days in February/March (crops);
7) Change in the number of wet days;
8) Start date of rainy season;
9) Extreme winds (wind-farms, crops);
10) Extreme daily or multi-day rainfall (urban drainage/flooding).

Information on climate and related physical factors:
1) How frequently would the expect to observe enough total of rainfall as to cause flooding in Kanyama;
2) How fast will large water bodies evaporate given changes in temperature, rainfall and river-recharge.

General information on climate and climate change for specific development areas:
1) Combining climate change information with AU infrastructure development plans;
2) Wind and solar atlas to provide guidance on investments in renewable energy;
3) Temperature, rainfall and soil moisture information relevant to selection of crops.

4.4 Considering alternative futures: implications of findings for adaptation planning

Given the uncertainties in projected climate trends, adaptation strategies that are robust to a variety of possible futures can reduce the need for certainty in the projections. As climate information becomes more precise and predictability increases, its dissemination to vulnerable populations will become increasingly valuable. Actors within Zambia, having a better understanding of near-term climate change, can then engage in “no-regrets” actions that can help the country to better understand and address climate-related hazards, thus leading to improved humanitarian and development outcomes. Having contingency plans that can be acted upon based on improved climate information will greatly reduce the risks posed to the agriculture, human health, energy, and other sectors.

The current water-related challenges in Lusaka are the responsibilities of several departments and a variety of stakeholders, including the private sector. In the course of the participatory mapping, the strong feedback loops shaping the performance of the different sectors became apparent. In this complex setting, isolated departmental approaches are likely to be ineffective in addressing the larger system of problems, and climate information about likely future conditions is unlikely to bear fruit. It also became clear that the current situation urgently demands effective and integrated action to be taken. The climate change adaptation platform and the engagement with medium-term climate scenarios have a potential to become the platform for a more integrated and more effective way for longer term planning and implementation in the water sector.

In order to address adaptation challenges in Zambia, three key areas of importance have been outlined in the September 2014 workshop: **Capacity development, communication, and improved data access and analysis**. These areas should also be considered in policy development and innovative mechanisms should support cross cutting exploration of the challenges to ensure effective implementation.

Box 6: Climate shocks and trends: considering alternative futures

Participants discussed how understanding the impact of past and current climate events -- which may require improving access to past observations -- is important for planning response to any changes in frequency or intensity of climate related shocks and trends in the future.

Second, with regards to the potential for adaptation interventions to reduce current vulnerability as well as vulnerability over the medium term, it is often relevant to understand what short-range or seasonal forecast information is available as this could be of use in planning to avoid negative outcomes or to exploit potential beneficial outcomes. Finally, in the context of longer-term planning, it is important to be aware that we have already have some robust information such as on further increases in temperature but also have less clarity on, for example, seasonal precipitation and thus may need to consider a range of possible futures. In this case it is important to clearly articulate where key uncertainties are delaying or confusing decisions and where the information needs to be further refined.

Participants summarized the following **possible strategies for adapting to alternative futures** and presented them in three clusters:

Capacity building

- Creating structures for continuing public servants education/ capacity building
- Find structures that facilitate learning exchange at local, provincial and national levels
- Exploring innovative ways of learning (trans-disciplinary and trans-sectoral)

Communication

- Community agronet participatory extension service
- Farmer driven extension service related to on farm production
- Observation of local conditions
- Dissemination by and with farmers
- Analysis and reflections on decisions
- Invest more in analysis and sharing: how to get it understood and spread
- Media capacity building (help journalists learn & do)
- How to use meteorological information and knowledge
- Stories from communities, NGOs etc.
- From information to communication: needs driven and relevant for people's decisions)
- Schools and community clubs
- Inter-organizational discussions
- Exhibition spaces and shared experiences

Data access and analysis

- Forestry/ River flow information from 1920s/ 30s exists in Zambian institutes and some from ZMD

- Data from 1953-63 possibly exists in Zimbabwe from time of the federation - significant work done in this time
- Data collected and sent to Lusaka (analysis, but data is not returned) Meteorological data on Zambezi
- Deforestation and land-use change is affecting river flows, floods, sediments and siltation
- Model Zambezi tributaries (Kafue very important) would provide input for planning energy, agriculture, tourism, fisheries (Kariba) and floods.
- Ministry of science and technology and NISA (research on climate and agriculture). Funding from SASSCAL doing research on some of these issues - so need to be aware of those.
- Impacts on floods, droughts and national park is important
- Agriculture: Ministry of Agriculture/ NISA has good data and recent years have been good so possibly combine these with Meteorological data to study future impacts (including opportunities) but need reliable future data (currently single model studies).
- Health insufficiently detailed climate information to study impacts
- Groundwater "mining" in some regions for irrigation is having impacts on river flow and levels of recharge not understood - so overall impact needs studying.

In the discussion a need for greater collaboration between sectors was expressed. It was also emphasized that while various departments often collect environmental monitoring data, the data is not necessarily available to stakeholders to inform planning processes. While some of the data has potential to support cross-sectoral processes a call for greater collaboration and data sharing was made. These questions as well as the specific thresholds raised by participants will be explored by the UK Met Office and presented in the next workshop. In order to stimulate cross-sectoral / cross -disciplinary networking of participants the following exercise was designed to support this process.

5. Opportunities for better linking climate science to decisions

Patt and Gwata (2002) identify six key constraints limiting the usefulness of forecasts and related climate services among people at risk: *credibility*, *legitimacy*, *scale*, *cognitive capacity*, *procedural and institutional barriers*, and *available choices*. Addressing these and other constraints for more effective and meaningful dialogue challenges us to consider innovative tools and processes for spurring action.

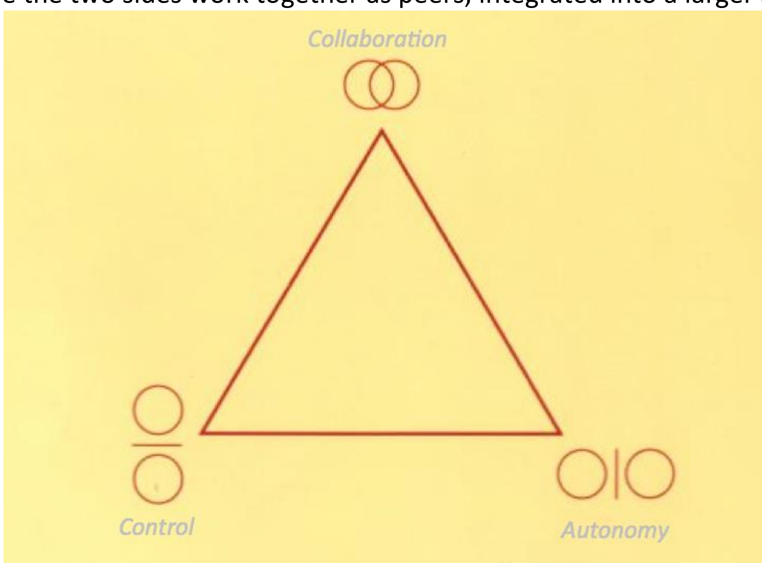
The research activities carried out during the FCFA project revealed four promising options for overcoming barriers to uptake of climate services in development planning in Zambia. They can be clustered into four kinds of approaches that could be well served with further support: (1) system-based approaches; (2) open data approaches; (3) interactive communication approaches; and (4) science-based approaches to link funding with forecast-based action. These approaches are potentially ready to deploy in Zambia in the foreseeable future, and can be nurtured by promising innovations such as participatory games to experience the system complexity of climate risks, hybrid systems that create synergies between humans and computers to improve climate services through massively distributed tasks, and forecast-based financing for climate risk management.

5.1 Support for system-based approaches that recognize and address complexity

Climate services can only be understood as relevant to development planning if decision makers recognize and have incentives to address the complexity of systems relevant to changing climate risk. Trade-offs, feedbacks, non-linearities, delays, probabilities and unanticipated “side effects” are inherent in risk management decisions (Gonçalves 2008), and should be part of targeted learning and dialogue for government officials and subsistence farmers alike.

An important issue is that short-term development pressures and immediate crises often prevent long term planning. The dominant incentives for individuals and organizations tend to reinforce preferences that favor the ‘now’ over the ‘later’, especially when emergency situations become the norm. A policy choice that produces improvement in the short run can also be one that degrades a system in the long run. Similarly, acting to optimize the subsystem closest to a decision maker often can lead to a sub-optimal outcome for the broader system of national development. According to FCFA workshop participants, this is particularly noticeable in the "territorial attitude" (often linked to budgets) of various entities within and beyond government. Even when stakeholders understand and want to properly address these tradeoffs, the incentives to find long term-integrated solutions are insufficient vis a vis the forces promoting or enforcing myopic and selfish decisions. This lack of system-based approaches plays a role in how climate service providers can relate to development planners. As represented in the figure below (from Keidel 1995), there are three modalities in which information producers could interact:

- Autonomy (where the science providers and the decision makers are completely separate)
- Control (where one of them is subordinated to the authority of the other)
- Collaboration (where the two sides work together as peers, integrated into a larger system)

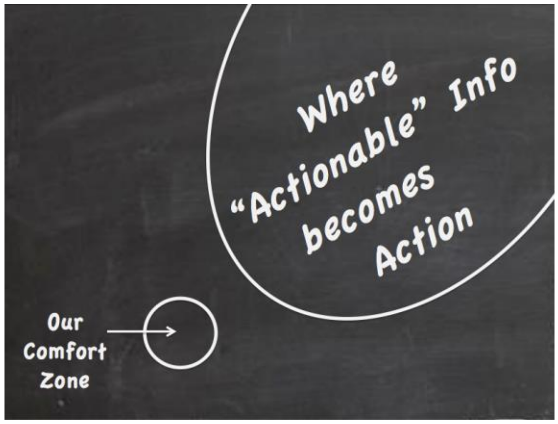


At present, the institutional arrangements place many science providers in almost complete separation from potential users of their services. While of course a substantial level of autonomy is desirable to ensure quality of evidence-based research, organizational structures could Ideally be designed with purposeful specifications of dynamic relationships (including collaboration and, where necessary, control) in order to ensure that services actually offered are aligned with user needs, and that decision makers actually use information when it can substantially improve outcomes.

5.2 Support for interactive communication approaches

The usual sequence of unidirectional presentations from decision-averse scientists to decision-oriented practitioners often leads to a frustrating experience for both sides, in part because of the excessive use of complex graphs and text-packed slides that can cause utter confusion or simple boredom among non-expert audiences. We know that the usual approach will predictably lead to insufficient results. As of now there is very limited capacity in Zambia and across Africa to design and deploy interactive approaches, with event organizers consistently reverting to their comfort zone (i.e. sequence of

Powerpoint presentations followed by insufficient time for Q&A), and hoping that magic will happen so that allegedly actionable information becomes real-world action.



Suarez and Tall (2010) report on a workshop linking African scientists and decision makers that was designed to create an atmosphere of collaboration without hierarchies. It combined *Small dialogue tables* (where practitioners and community members would have time to ask in-depth questions to experts, and jointly explore options for turning plausible predictions into concrete action) with *Participatory games* specifically designed to broker a constructive dialogue, reveal key obstacles to forecast communication and use, and elicit concrete ideas for action.

Of particular importance is the exploration of information pathways between vulnerable communities, decision-makers and scientists. In order to plan effectively for the medium to long term it is crucial to consider all types of knowledge available. It is thus of high importance that planning processes consider information, knowledge and priorities on all levels and can effectively integrate these. Participatory processes and interactive methodology can support such communication processes.

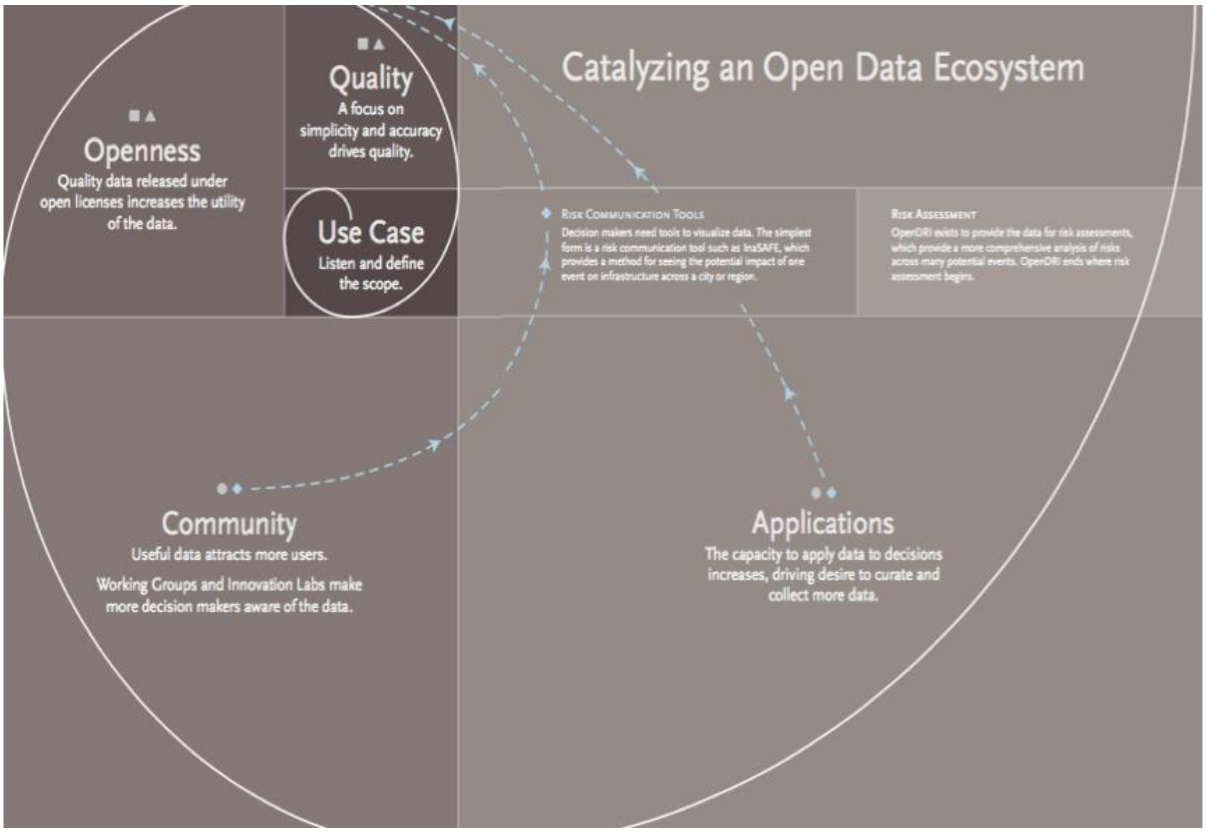
Box 8. Participatory games to experience the system complexity of climate risks

The use of games to experience the future of climate risks in Africa was substantially refined through innovation grants by the Climate and Development Knowledge Network (CDKN). Over the past four years, a combination of design, facilitation and applied research has yielded valuable insights about the opportunities that intensely interactive, game-enabled processes can establish and enrich the bidirectional information flows between scientists and policy makers (see Suarez and Bachofen 2012, Jones et al 2014). The lessons from those and other successful participatory approaches were intentionally embedded in this FCFA project.

Like climate change adaptation, well-designed games involve decisions with consequences. Games enable us to explore in a rational yet sensory and creative way the sometimes surprising or counter-intuitive outcomes of our individual and collective decisions. Games can encourage *peer-to-peer learning among diverse stakeholders* by enabling players to collectively experience and 'inhabit' a complex system and share the "Huh?" (confusion) and "AHA!" (revelation) moments - generating a collective intelligence that can set the stage for deep discussion and truly participatory dialogue.

5.3 Support for open data

In the words of the OpenDRI Field Guide (World Bank 2014): *Decision makers and their datasets tend to be loosely connected (…) existing stocks of data which remain latent, inaccessible even to other ministries and municipalities because they are in forms that prevent them from flowing freely. Some are frozen on paper. Others are blocked by technologies that lock datasets into proprietary ecosystems, stoppered by policies that prevent release beyond small groups, or fragmented into bureaucratic silos that require significant investment to assemble back into a whole picture (…).* The figure below, from the same field guide, depicts a proposed approach to address the lack of 'open data ecosystems'.



One of the valuable outcomes of the stakeholder workshops held under the FCFA project in Zambia was to help participants from different organizations to see that much of the data that they were looking for actually existed somewhere in the system of government, academic or international organizations, and that there might be ways to secure access to that data – be it about hazards, vulnerabilities, or capacities. Nonetheless, without a systemic approach to data management, these obstacles may endure.

Box 9. Hybrid human+computer systems to improve climate services

The rapidly growing reach of technology may help nurture feedback loops that both enrich the science and improve its reach to decision makers, turning unidirectional communication processes into genuine two-way approaches to learning and dialogue. Digital technologies offer remarkable opportunities. The possibly unprecedented capabilities that can arise from innovative human-computer collaborations allow us to ask the question: *How can we leverage the strengths of humans and machines in combined systems that exceed the best each can do alone?* The emerging field of "human computation" (Michelucci 2014) offers tools, processes and insights that can certainly help bridge gaps and explore new possibilities linking science, decisions involving climate risks.

One example emerged in the context of activities held in Zambia alongside the FCFA project: the crowdsourcing game "*UpRiver*", designed through a collaboration between the Climate Centre, the Engagement Game Lab, and the Zambia Red Cross, which combines new techniques like *participatory sensing*, *gamification* and *citizen science*. Upriver is a game played by multiple communities along the Zambezi river. Teams compete to earn points by taking such actions as measuring and reporting river levels (thus supporting calibration of science-based hydrological models with open data) and trying to predict the future river level, competing with the best available scientific flood forecasting model (thus helping participants become familiar with the skill of the scientists model and, when an extreme flood is anticipated, increasing the chance of communities heeding the warnings).

Open Data approaches can help Zambia and other countries improve how information knowledge informs action. The five principles of Open Data are: *Technical openness* (so that any software can open and manipulate data, and save new analyses in open formats), *Legal Openness* (in terms of intellectual property licenses that permit them to be reused, repurposed, and redistributed without cost), *Accessibility, Interoperability,* and *Reusability.* To the extent possible, data needs to be collected, analyzed, and curated not just by scientific organizations but also in collaboration with the people facing the risks and the organizations mandated to manage such risks. Only through this process of having the data be available to all and curated by those who are potentially affected can behavior fully change.

5.4 Support for science-based approaches to link funding with forecast-based action

A changing climate for Zambia means more risk of extreme events, and therefore more need for adequate financial instruments to support timely action. Some mechanisms exist to deal with disasters during and after the extreme events that cause them. Yet a valuable window of time exists after the issuance of science-based early warnings but before a potential disaster materializes – a window that is at present largely ignored, whether in terms of imminent flooding due to observed rainfall upstream, or seasonal forecasts indicating unusual chances of dry conditions. The current funding landscape does not make sufficient use of this window of heightened risk in which a variety of short-term activities become worthwhile to implement and can provide a large return on investment (Coughlan et al 2014b).

Box 10. Forecast-based financing for climate risk management

Post-disaster evaluations call for mechanisms to trigger and incentivize consistent early action based on available early warning information, with responsible persons clearly designated. The mandate to take action based on early warning systems is not well defined. It is often unclear who would be responsible for making this type of decision, and what decision is appropriate based on the early warning. Coughlan et al (2014) propose a forecast-based financing (FbF) mechanism coupled to risk-based operating procedures. Based on the successes and failures of previous efforts to act based on climate-based early warning information, FbF elaborates three components of a system for early warnings to become operational: (i) information about worthwhile actions, (ii) available funding mechanisms, and (iii) designed entities that are responsible for taking the pre-planned actions.

A systematic forecast-based financing system integrates each of these three elements, contingent on the availability of (skillful) forecasts for the region in question. In the case of Zambia, this approach could prove useful for risk management measures at various timescales, ranging from days of lead time before flooding upstream of Victoria Falls as a result of observed or predicted rainfall in the upper Zambezi river basin, to months of lead time for seasonal forecasts for unusually high rainfall suggested by a *La Niña* phenomenon. Opportunities for loss-reducing action range from reducing vulnerability (such as distributing mosquito nets before heavy rainfall), to preparedness for disaster response, such as training volunteer teams on first aid procedures or prepositioning relief items before roads become impassable, to simply supporting communities at risk to take out of harms way their people and assets threatened by potential floods, from cattle to birth certificates.

However, according to a recent review of disaster-related financing by ODI and GFDRR, only about 12 % of funding in the last 20 years was invested in reducing the risk of disaster before it happens; the rest was spent on emergency response, reconstruction and rehabilitation (Kellett and Carvani, 2013). Lack of funding based on early warnings is attributed to protracted debate over the best intervention, inherent discomfort on the part of donors to invest in a situation that will "likely" arrive but is not certain, the high consequences of "acting in vain", and the lack of accountability to act on early warnings.

Our scientific knowledge about likely future conditions for the coming decades indicates higher risk of extremes. Therefore, it is crucial that we promote new ways to improve how forecasts at all timescales are used to improve decisions: not just based on long-term climate projections but also on seasonal rainfall forecasts and even shorter-term floods warnings and other very useful but substantially underutilized tools. In the words of the IPCC Special Report on Extreme Events (IPCC 2013), measures that provide benefits under current climate and a range of future climate change scenarios are available starting points for addressing projected trends in exposure, vulnerability, and climate extremes. They have the potential to offer benefits now and lay the foundation for addressing projected changes.

6. Conclusion and Next Steps

Decision-makers in Zambia find themselves in the particularly tenuous position of having to address critical areas of climate and development policy today that must set the course for achieving developing outcomes in the medium and long term. Yet limited climate information over the medium and long-term makes this challenge complex. The FCFA Zambia pilot has provided answers on how much of the problem is solvable with better science; how much is related to the quality of the decision-making and governance at large (regardless of the science); an how much is about the bridging of science and decision makers. The pilot engaged a wide range of stakeholders through specially-designed interactive methods, achieving an in-depth exploration of the broader socio-political context in which policymaking takes place. It yielded insight on the role of science in policy making, outlined the most important barriers to uptake of climate information in key climate-sensitive sectors, and identified strategic opportunities for improving the uptake of science for medium to long-term policy making.

More specifically, the pilot study found that information about future climate is largely ignored in current planning of sectoral development interventions. No evidence was found of climate science being used directly to inform decisions relevant to longer-term planning or long-lived infrastructure. Not much information was found about whether decisions on long-lived timescales informed the generation of climate-related research agendas, potentially revealing that one had little influence on the other. At the same time, it was clear that while robust information on expected changes in seasonal, monthly and daily temperature is currently available to decision-makers, a lack of local expertise in regional climate processes and model interpretation, as well as limited access to existing climate information from external research organizations, generally increases uncertainty among local decision-makers and stakeholders, depressing the initiative to act upon projections.

In order to support decision-making space it is important to critically explore thresholds in the key climate-sensitive sectors and to relate these clearly to already existing or possibly newly generated climate information. Such a process would ensure that tailored climate information can be provided to decision makers and improve the likelihood of effective implementation in the medium term.

Future research of value to Zambia should include more robust understanding and less uncertain projections of ENSO in the future, additional downscaling exercises for more country and regional information, and further efforts to increase spatial and temporal resolution. At the same time, study findings indicate that more climate science on its own will not necessarily lead to better climate risk management; not just because of the numerous uncertainties in the climate system but also due to the foreseeable gaps between knowledge and action. As a result, improving the use of existing information (including building capacity use it) has strong potential to lead to better dialogues between users and providers, and increased appreciation of the value of advancing science.

Importantly, the creation and expansion of new, meaningful information pathways between vulnerable communities, decision-makers and scientists is essential to be able to make sound decisions for medium to long term development. This implies considering a vast range of available knowledge, and specifically seeking ways to harmonize science-based approaches with existing, traditional methods for anticipating future conditions at the local level.

Based on these findings, for the FCFA programme to achieve its aims of enhancing understanding and improving confidence in predictions of climate variability and change across sub-Saharan Africa, this pilot offers six concrete recommendations: (1) support climate science research that directly enables decisions that are robust to a change climate; (2) integrate climate information into incentives for long-term engagement; (3) promote interactive approaches to learning and dialogue for climate-smart decisions; (4) link climate information thresholds to decisions for climate-smart resource allocation; (5) foster open data and hybrid systems; and (6) create information pathways between vulnerable communities, decision-makers and researchers.

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