FUTURE CLIMATE FOR AFRICA

Programme Rationale, Structure and Scientific Focus

To advance scientific understanding and prediction of African climate variability and change and, through interdisciplinary research, develop the knowledge, data and tools to better intergrate this science into medium-term investments, policies and plans.

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This document provides the rationale and scientific focus of the Future Climate for Africa (FCFA) programme, including information on the structure of the programme and how it will be delivered. For further information on any parts of this document please contact the FCFA Secretariat.

TABLE OF CONTENTS

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1. The FCFA Programme

1.1 Executive summary

Future Climate for Africa (FCFA) is an international research programme jointly funded by the UK's Department for International Development (DFID) and the Natural Environment Research Council (NERC). The programme will fund world-leading interdisciplinary research to enhance scientific understanding on climate variability and change across sub-Saharan Africa. It focusses on advancing scientific knowledge, understanding and prediction of African climate variability and change, together with interdisciplinary research and user engagement to support better integration of science into medium-term decision making (multi-annual to multi-decadal or approximately 5 to 40 years), such as infrastructure investments, urban development plans, land-use planning and national-scale policy initiatives (e.g. Poverty Reduction Strategies or social protection systems).

The need for FCFA is timely; high-quality, robust climate information is crucial for effective climate adaptation, yet this information is not yet available across many parts of sub-Saharan Africa. FCFA will increase the quality and availability of such information and build greater expertise in how to apply this in core development areas. As such, FCFA will contribute towards increasing the resilience of African people to climate variability and change, safeguarding economic development and increasing the effectiveness and value for money of investments.

The partnership between DFID and NERC reflects the triple focus of the programme on scientific excellence, achieving impact, strengthening scientific capacity and international collaboration. FCFA will provide investment of £20M into African climate science, with contributions of £16M and £4M from DFID and NERC respectively. The scale of funding is justified through the scale of the potential economic and social benefits, combined with it being appropriate to deliver significant scientific progress across distinct climatic regions of sub-Saharan Africa, in addition to a suite of products, pilot applications and capacity building activities.

The programme will be delivered through collaborative, interdisciplinary partnerships of the world's best researchers, selected through a rigorous competitive call process. A range of projects will fall under the FCFA programme including large, regionally-focussed research programme consortia, a global model development consortium, smaller targeted supporting projects and cross programme research, knowledge exchange and capacity building activities through the Coordination, Capacity Development and Knowledge Exchange (CCKE) Unit.

The programme's success will be measured by the way that its research contributes knowledge and evidence to enhance the resilience of African people to climate variability and change and through this help to improve the lives of poor people in sub-Saharan Africa.

2 Programme Details

2.1 Context of the FCFA programme – what is the need FCFA is trying to address?

Improvements in climate risk management across Africa will bring immediate, cost-effective benefits in terms of protecting lives and livelihoods and safeguarding development gains (World Bank, 2010[1]). Many African societies are highly vulnerable to weather and climate variability and are likely to be amongst the most severely affected by future changes in climate. Climate plays a big role in the lives of many people in Africa. The majority of livelihoods of African people depend on rain-fed agriculture and in some areas, water resources are increasingly stressed. Sub-Saharan Africa is the only region where vulnerability to weather extremes is rising; since 1980, more than 420,000 people have died and economic damages total at least $9 billion USD[2]. These disasters erode gains in poverty alleviation and can set back economic development by several years.

Climate change is expected to create a more challenging environment for development in the region. For example, the intensity of climate hazards, such as droughts, storms and flooding, is expected to rise over the coming decades (IPCC 2013[3]). There is early evidence that climate change may already have contributed to the occurrence of the Horn of Africa drought in 2011 (Lott et al. 2013[4]). By the 2020s, countries of sub-Saharan Africa are expected to dominate the global rankings of most vulnerable countries both in terms of poverty and climate hazards, with countries such as Ethiopia, Tanzania, Madagascar, Burundi, the Democratic Republic of Congo and Swaziland topping the rankings for both economic exposure and lives at risk (Shepherd et al. 2013)[5]. The recent IPCC AR5 stated that an increased occurrence of precipitation extremes in Africa is 'very likely'. A recent World Bank study estimated that by the 2050s, changing climate conditions could lead to approximately a 10% reduction in total crop productivity across sub-Saharan Africa and up to a 50% reduction in water availability across most of southern and West Africa (World Bank, 2013[6]). Without adaptation, this will have severe impacts in many parts of Africa. At higher levels of warming (4°C), the IPCC have concluded that the risk to food security in Africa could be very severe (IPCC, 2013).

Without climate risk management and adaptation, the progress made against the Millennium Development Goals will increasingly come under threat in Africa (OECD 2009[7]). The May 2013 report of the High Level Panel on the Post-2015 Development Agenda stressed that, *"without tackling climate change, we will not succeed in eradicating extreme poverty"*. The Nairobi Declaration of the African Ministerial Conference on the Environment placed adaptation as one of their priority areas.

[1] World Development Report 2010: Climate Change and Development
[2] Data from EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université catholique de Louvain Brussels – Belgium. Estimates are conservative.
[3] Working Group I of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
[4] Lott et al. (2013) "Can the 2011 East African drought be attributed to human-induced climate change?" Geophysical Research Letters, v.40, pp. 1177
[5] Shepherd et al. 2013 "The geography of poverty, disasters and climate extremes in 2030", an ODI (Overseas Development Institute) Report
[6] "Turn Down the Heat II – Global Hotspots and Regional Case Studies". Schellnhuber et al.
[7] OECD (2009) "Integrating Climate Change Adaptation into Development Cooperation"

The most urgent need is undoubtedly to reduce the risks from climate today; this will bring immediate benefits. But there is also an urgent need to account for future climate risks in long-lived projects, planning and policymaking. Sub-Saharan Africa is a rapidly developing region, where the population is expected to almost double by 2050 and GDP could increase more than 10-fold. This growing wealth will help to increase resilience to climate. However, decisions over how and where societies build, changing livelihoods and patterns of economic growth can have long-lived negative impacts on vulnerability. A failure to properly account for long-term climate in decisions now could lock-in greater risks and costs down the line, for example:

- ***Urban planning:*** the urban population is rising at a rate of more than 4% per year, with most of this in coastal cities. By the 2070s some cities could see a ten-fold increase in people at risk[8]. Without effective planning, every year millions more people will be exposed to sea level rise.
- ***Infrastructure:*** around $70 billion per year is invested in African infrastructure, such as schools, hospitals, roads, water supply systems and energy infrastructure. If long-term climate is not accounted for in these decisions from the start, it could mean costly retrofits, premature retirement or greater risks to people later.
- ***Policymaking:*** long-lived 'climate-sensitive' policies, such as social protection systems and major insurance initiatives are difficult to adjust and so need to be designed to cope with extremes, such as drought and flooding over decades or more.

It is also crucial to ensure that development interventions are resilient to current and future climate. The World Bank (2006)[9] concluded that 20 - 40% of Official Development Assistance (ODA) is at risk from climate and only a small portion takes this risk into account in project planning.

2.2 What issues surround future climate information for Africa?

High-quality climate information is a crucial foundation for effective climate risk management and adaptation; yet this is not available or not accessible across many parts of Africa. Climate data, information and services are a vital input for many social and financial decisions for African populations. This programme is particularly concerned with decisions that have medium-term (5 to 40 year) implications; this predominantly means decisions involving long-lived infrastructure, large-scale planning and decisions with long lead-times or high inertia (see Figure 1). For example, this may include:

- ***Agriculture:*** over the medium-term (5 to 40 years), climate information can guide large-scale agricultural strategies, including large-scale irrigation strategies, capacity development, land-use planning, sectoral development plans and technological development that have both productivity within the projected climate envelopes and resistance to potential increases in extreme events.

[8] Hanson et al. 2011 "A global ranking of port cities with high exposure to climate extremes" Climatic Change, v.104, pp. 89, data for Rangoon and Abidjan.
[9] World Bank (2006) "An Investment Framework for Clean Energy and Development" A progress report.

- ***Water resources:*** projected climate information can inform planning decisions, for example for integrated water management strategies, dams and hydropower facilities.
- ***Resilience:*** disaster resilience requires adequate information about climate risks.
- Infrastructure and building: for longer-lived projects, such as roads, dams and urban planning, engineers require accurate climate information to design safe and effective systems.
- ***National planning:*** many large-scale decisions, such as social protection systems or poverty reduction strategies, can take time to implement or adjust so there are benefits to accounting for climate change in advance.
- ***National or sectoral adaptation plans:*** climate information is a crucial input into the design of effective adaptation strategies.

Investment in climate research to support such decisions will also have co-benefits for shorter-term decision making including, for example, disaster resilience, humanitarian response and health.

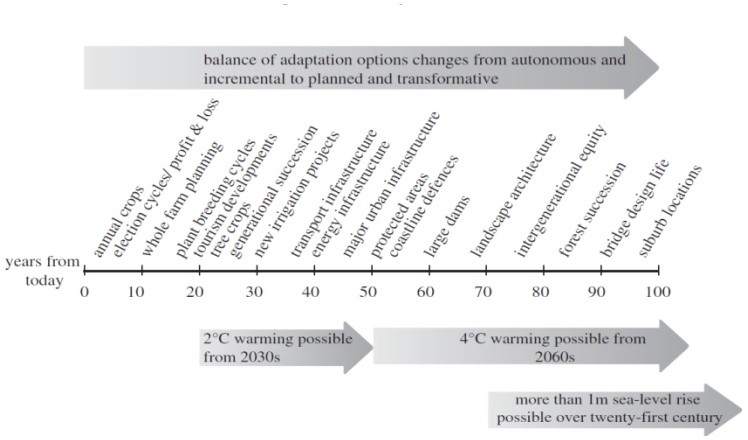

Figure 1: The timescale of different types of intervention compared with the timescales of climate change. Source: Stafford-Smith et al. (2011)

The High Level Taskforce to the Global Framework for Climate Services (GFCS) concluded that investment in improved climate information provides an important, cost effective opportunity to enhance well-being through more effective disaster risk management, climate change adaptation and development (WMO, 2011[10]). For example, improved modelling of El Nino (such as the prediction of this major natural cycle, which particularly affects tropical areas, such as East and West Africa) could lead to a global benefit to agriculture (alone) of $400 million to $1.4 billion every year. Other estimates suggest up to $100 million per year in benefits to hydropower in Ethiopia alone, and $11.6 million per year to regional water markets in northern Taiwan (World Bank. 2008).

Many parts of Africa have very weak climate information and services so forego potential economic benefits associated with improved climate information. This stems mainly from (ACPC, 2011):

[10] "Climate Knowledge for Action: Global Framework for Climate Services – empowering the most vulnerable", Report of the High Level Task for the Global Framework for Climate Services. WMO report No. 1065

- ***Lack of high-quality historical climate monitoring:*** Africa is the continent with the lowest density of climate observations, with many data series disrupted through natural disasters or conflict. Even where records exist these may be inaccessible (e.g. access is often restricted and available data is frequently in a raw format which requires training to utilise).
- ***Relatively low capacity of scientific and meteorological institutions in Africa for climate research and to deliver climate services:*** low capacity is driven by severe limitations in resources, available staff and computational capacity[11] in many low and lower middle-income African countries, in addition to a chronic lack of investment in postgraduate education and research infrastructure. Currently, Europe and the US conduct most climate research on Africa; arguably this means it is less relevant to local user needs.
- ***The global and regional climate models used for research and climate prediction were built by developed countries:*** until recently there has been much lower investment in assessing climate model performance over Africa than for other regions, or on improving the reliability of models for African users. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) concluded that current models have only a modest ability to capture those phenomena that are most important in driving African climates. It also concluded that the African continent is one of the only regions globally where models have not improved markedly since AR4.
- ***Knowledge of African climate variability is relatively poor with major gaps:*** Africa's climate is very diverse and highly variable, driven by processes that are interrelated in many complex ways that are not fully understood (ACPC, 2011). The level of scientific understanding varies significantly from region to region. Whilst it is improving, it remains poor when compared to other continents. There is a particular gap in science to inform medium-term (5 – 40 year) decisions, such as infrastructure, urban development planning, land-use planning and national-scale policy initiatives.

This lack of knowledge and capacity limits our ability to analyse variability, detect trends, and predict climate with a degree of certainty. Uncertainties in long-term climate projections are high relative to other continents (IPCC, 2013). In particular, there is considerable uncertainty and a lack of model agreement in projections for rainfall, leading to low confidence in this area. There are also areas where modelled trends disagree with observations, such as the 'East African Paradox', where observations suggest declining rainfall in the long rains season across Kenya, Somalia and Sudan, yet models project increasing rainfall. As yet, scientists do not know which information is correct. This creates problems for adaptation planners – *do we invest in drought or flood protection?* (World Bank, 2010). Of particular relevance to FCFA, for many regions the 5 to 40 year climate change signal is weaker than current interannual variability.

FCFA will contribute to improving knowledge and prediction of African climate, but uncertainties will inevitably still remain. For this reason, the FCFA programme also places a strong emphasis on research to explore how we can better use current climate information in decision making. This is partly a scientific question of evaluating information but it also requires inputs from other

[11] Few universities are involved in climate research. Job opportunities for professionals are limited and as a result few universities offer post-graduate training. Good scientists are often lost to the US and Europe. For many NMHAs (national meteorological and hydrological agencies) recruiting and maintaining staff is a major issue as the pool of qualified scientists is small and salaries are not attractive (ACPC, 2011). Many have no research departments or partnerships with research institutions.

disciplines such as economics, decision theory and engineering, as well as engagement with stakeholders.

The lack of knowledge, skills and capacity to apply climate information and services in the user community is another important barrier to seizing potential economic benefits in sub-Saharan Africa. Improving climate information will only be successful if capacity and incentives are built in the user community. The Africa Climate Policy Centre (ACPC, 2011) identified several issues here:

- ***Insufficient understanding of user needs:*** acknowledging the work of the Regional Climate Outlook Forums, there is still insufficient understanding of user needs from climate scientists, which means that climate information is often not appropriately tailored to application. This is particularly an issue for longer-term decision making as most previous research focussed on the near-term.
- ***Difficulties in using climate information:*** information often comes from different sources, in different formats, with little guidance or tools on how to utilise it appropriately.
- ***Lack of accessible climate information:*** decision makers often do not know where and how to obtain information and are not accustomed to accessing it.
- ***Technical capacity:*** there is generally a low understanding of climate information, including a poor understanding of scientific uncertainties, and lack of capacity to translate climate into impacts.
- ***Lack of 'proof of concept' case studies in Africa:*** to date there have been very few case studies in sub-Saharan Africa which would demonstrate where long-term climate projections are successfully used in decision-making with improved outcomes.
- ***Low trust in climate prediction:*** there are examples of where disaster response has been delayed due to a lack of trust in forecasts and an inability to interpret them. This problem may be even larger for longer-term projections.
- ***Lack of capacity to integrate climate issues into, for example, development planning and routine decision-making:*** difficulties here include a lack of appropriate institutional arrangements and decision processes, lack of resources and awareness, lack of coordination and a lack of guidance.
- ***Reluctance to incorporate climate issues into management practices:*** issues here include a lack of incentive, low political awareness of the issues and competing priorities elsewhere.
- ***Resources for research and capacity building:*** the resources available are frequently directed towards immediate challenges (e.g. poverty alleviation, food security and public health) rather than towards addressing challenges on medium-term timescales.

2.3 Needs and Opportunities for African climate research – what will FCFA do?

Two workshops were organised by the Climate and Development Knowledge Network (CDKN) on behalf of DFID and NERC in October 2013 in the UK and Tanzania[12], with results published in a CDKN Working Paper[13]. Consultations with users, scientists and adaptation experts identified issues reflected in the preceding section. These consultations also identified a series of needs and opportunities that the FCFA programme is aiming to address.

- ***Harnessing untapped data sources:*** this provides a significant opportunity to enhance science. This could include new analyses of satellite data (e.g. TAMSAT) and reanalysis datasets (e.g. ECMWF ERA-Interim and CLIVAR C20C) and drawing on data from observational campaigns (e.g. AMMA and Fennec) to improve understanding and modelling. Additionally, there could be possibilities to recover historical datasets of multi-decadal African climate change. The private sector could play an important role, for example through the use of 'pass-through' websites where climate data is transformed into a more accessible format.
- ***Fundamental science:*** this is still needed to better understand the processes driving local to regional-scale climate variability and change in Africa, particularly those related to 'high-impact' weather, such as extremes of rainfall, droughts and flooding. This includes, for example, better understanding the processes that have driven recent changes in East African and Sahelian rainfall. It is also important to increase understanding of potential changes to mean climate, which could push populations to the margins of a sustainable climate envelope. The impact of external perturbations on African climate systems forms another key aspect of gaps in fundamental science over Africa.
- ***Critical evaluation of climate model fidelity:*** we need to better understand the ability of models to simulate variability and trends, and more generally, the causes for divergence between model projections. Many complex land-ocean-atmosphere interactions are poorly captured by climate models. There are also systematic biases in GCMs, such as excessive southern African rainfall and the southwards displacement of the ITCZ (Inter-Tropical Convergence Zone).
- ***Model development with an 'African Lens':*** this would include development on improving the representation of convection in models, as well as better understanding the influence of local (e.g. land-atmosphere) and remote climate processes (so-called 'teleconnections') on long-term projections. To understand localised impacts and extremes on timescales to inform planning decisions, increased resolution modelling is required; research is already being undertaken but there are significant resource and time demands.
- ***To identify robust climate information to inform decisions:*** new methodologies are required to better quantify and understand the range of possible future scenarios (given uncertainty), evaluate where models are 'fit for purpose' and to

[12] The first consultation workshop was held in London in partnership with the UK Collaborative on Development Sciences (UKCDS) and the second, in Arusha, Tanzania in collaboration with the Africa Climate Conference http://africaclimateconference.org/

[13] CDKN Working Paper 'Exploring the role of climate science in supporting long-term adaptation and decision-making in sub-Saharan Africa', available at http://cdkn.org/wp-content/uploads/2014/04/CDKN_FCFA_Working_Paper.pdf

identify robust climate signals. There is also an urgent need to better understand how to incorporate and use climate data in decision-making while adequately recognising different sources of uncertainty.

- ***To develop more holistic assessments of climate impacts:*** there is a need for more integrated impacts assessment modelling (on both temporal and spatial scales of importance), to gain an holistic understanding of risk which is of relevance to decision makers responsible for adaptation planning and to reiterate the benefits of adaptation to climate-related risks to the user community. There needs to be an increased understanding of the economic and social impacts of climate change and acceptance of associated uncertainty resulting in planning framed by socioeconomics.
- ***Practical case studies:*** there is a need for more practical case studies demonstrating where long-term climate trends are important in decision making today, and how to incorporate them. Worked examples will allow decision makers to identify where climate change is important today and to build the case for investment in adapting to climate risks. There is also an urgent need for a toolkit for evaluating the economic benefits of adaptation and incorporating uncertainties into decisions.
- ***New technologies:*** these have the potential to increase the production and use of climate information for adaptation timescales. Decision making tools need to be embedded in the process to ensure information is relevant to user needs.
- ***Communication:*** the current ability to transmit useable climate messages from the research community to the user community is poor, with a particular need to inform decision makers on how to use, and base decisions on, available climate information and the uncertainty surrounding it. The involvement and interaction (from farmer to government) of user communities must be improved, with the decision making process spanning the pan-African, national, village and individual level. Climate change must be understood in terms of the effects it may have on vulnerable populations through health, water resources and food security. For the improved uptake of scientific advice, it is necessary to strengthen the links between science and policy in African countries.
- ***Capacity building:*** there is both a need and opportunity to build capacity for climate modelling in Africa. The generation of African climate information currently relies heavily on international centres that lie outside of Africa. This dependence on overseas researchers could reduce the relevance of the outputs to African users. Internationally-renowned centres do exist in Africa, such the University of Cape Town's Climate Systems Analysis Group (CSAG), and there are opportunities to build prediction capacity in other regions. There is also the need to build capacity in other areas, such as the ability to make decisions under uncertainty and increasing awareness of key research and policy questions to ensure research and climate data is effectively tailored to different users.
- ***Ensuring maximum value is achieved:*** there are opportunities to maximise the value of achieving the objectives of FCFA through a number of actions. First, by leveraging influential ministers (e.g. finance or development ministers), there is the opportunity to achieve greater climate resilient development than if less influential environmental ministers were leading. Second, it is important that

policy-tailored research should accommodate complex government structures at a regional or national level. Finally, it is necessary to communicate clearly to stakeholders; bringing groups of stakeholders together can add significant additional value.

- ***Demand-led science and co-production:*** In order to design the format and channels to be accurately targeted, it is necessary to identify the in-country demand for information. Moreover, to effectively lobby stakeholders research should be, where relevant, demand-led. For example, policy makers and technical officials can be involved in the research itself (such as through identifying the scope of research and suggesting possible delivery methods). This characterises the co-production approach to research; the involvement of end users will allow the better integration of science into decision making.

A number of these needs and opportunities for sub-Saharan African climate research are reiterated through regional groupings. The CDKN Working Paper[14] highlighted the views of the East African Community (EAC) Meteorological Department, who identify improved data rescue, capacity building and regional prediction and modelling of climate as their priorities. Equally, there is a clear push by a number of African countries to generate long term strategies for green growth, with examples including Rwanda's Green Growth, Ethiopia's Climate Resilient Green Growth Plan and Kenya's Vision 2030. This reinforces the need for improved climate information on medium-term timescales of 5 to 40 years to support climate resilient development. The most recent IPCC report, the AR5, released in 2013, emphasises the interlinked nature of adaptation and development pathways, and states that given the multiple climate uncertainties in the African context, successful adaptation will depend on building resilience. Furthermore, effective adaptation responses to climate information need differentiated and targeted actions from the local to national level based on the socioeconomic climate (IPCC AR5, 2013). This underpins the FCFA vision to maximise the impact of the programme through an emphasis on advancing knowledge and understanding of African climate with a view to better integrating science into medium-term investments, policies and plans.

2.4 What is the positioning of FCFA in the research sphere?

The major gaps in current knowledge, and the high vulnerability of populations across sub-Saharan Africa to climate, means that there are significant opportunities to deliver real development impact and high value for money through investment in climate science and model development for Africa.

FCFA is strategically positioned to fill critical gaps in current activities and to bring existing science into use through seizing opportunities to build upon existing climate knowledge and data. In addition to delivering high-quality science, development impact will be achieved through:

- ***Emphasis on informing real decision making today:*** the High Level Taskforce to the GFCS concluded that while our understanding of climate is advancing, this is not being effectively translated into services that can inform decision making. It concluded that services are not well focussed on user needs. This suggests an important role for social and behavioural sciences, in understanding the barriers

[14] CDKN Working Paper 'Exploring the role of climate science in supporting long-term adaptation and decision-making in sub-Saharan Africa', available at http://cdkn.org/wp-content/uploads/2014/04/CDKN_FCFA_Working_Paper.pdf

and how climate information and tools can be better designed and communicated to enhance uptake. FCFA will support the co-production of knowledge, tailoring evidence to the needs of users and supports its use in decision making.

- ***Focus on decisions/issues, not sectors:*** much previous research that aims to translate science into relevant information for decision making has focussed on researching the impacts of climate on one or more sectors, such as food, water, health or infrastructure. FCFA is targeted at informing decisions and this requires a more holistic approach. For example, informing an integrated water management strategy will require consideration of not just the impacts of climate on water availability, but also the inter-linkages with food, health, environment, growth paths and development strategies. To make this tractable, FCFA will be highly targeted, with around two or three pilot 'decision' case studies per (regional) consortia. These will focus on specific decisions/issues of relevance to local stakeholder (e.g. a sectoral development plan, a particular large-scale infrastructure investment, an urban development strategy or an integrated water management plan).
- ***Investing in research to better exploit existing knowledge:*** there is vast knowledge and data on African climate variability and change that is not fully utilised. FCFA will bring together interdisciplinary teams to leverage this existing knowledge, extracting useful information and bringing this into use in informing real decisions. For example, major science programmes such as AMMA (African Monsoon Multidisciplinary Analysis) generated vast amounts of data and knowledge that can be brought into use in improving climate predictions. Similarly, the CORDEX-Africa project generated a huge database of state-of-the-art climate model simulations for Africa, which can be leveraged to provide useful information for decision makers.
- ***Focus on science to better inform longer-lived decisions:*** this timescale (5 to 40 years) is neglected in the current portfolio of work and is an area where improvements in science are vital to underpin the resilience of many long-term policies, plans and investments (ACPC, 2011). Such investments include infrastructure investments, national-level planning, poverty reduction strategies and urban development. These types of decisions require both better understanding of current climate variability and trends and more reliable medium-term (5 to 40 year) projections of climate. This area has been neglected in the past and brings different scientific challenges and user needs. However, the improvements in scientific knowledge will have significant co-benefits for climate projections on shorter timescales.
- ***Identifying where it is important to account for climate change:*** FCFA will deliver case studies that demonstrate where climate change is an important factor to account for in decisions today, and will develop and test tools to support these decisions, for example under uncertainty about long-term climate.
- ***Building African scientific capacity:*** one way that this can be addressed is through research partnerships and targeted training (e.g. secondments, workshops, scientific exchanges, summer school). Building capacity can lead to sustained improvements in climate information. This will include better training

scientists to interpret and apply climate model projections within real decisions (as recommended by ACPC, 2011). The CCKE is leading the development of a strategy for such activities.

- ***Building knowledge and skills of users to increase user ability to apply climate information to real decisions:*** ACPC (2011) recommends that the key to improving the use of climate information is to build the capacity of users to understand, demand and use climate information. Knowledge and skills will be strengthened through the participation of users in the pilot case studies, but also through separate CCKE Unit activities.

2.5 Objectives of Future Climate for Africa

The aim of FCFA is to support research to advance scientific understanding and prediction of African climate variability and change and, through interdisciplinary research, develop the knowledge, data and tools to better integrate this science into medium-term investments, policies and plans. The programme has a major focus on climate science and modelling, underpinned by the principles of working with African stakeholders to inform real decisions today with the emphasis on enhancing the usefulness of climate science and projections, and adopting an interdisciplinary approach.

Research for FCFA is structured around three pillars, which will be complemented by activities focussed on building user-demand, knowledge and skills, and strengthening scientific capacity in Africa.

i. ***World-leading scientific research to advance understanding and prediction of African climate variability and change over medium-term timescales (roughly 5 to 40 years);*** advancing knowledge of African climate variability and change in areas critical to inform longer-lived decisions; develop and evaluate models with an 'African lens'; assess uncertainties and extract useful information.

ii. ***Interdisciplinary research to support better integration of science into medium-term decision making, such as infrastructure investments, urban development and national policy and planning***. This pillar will invest in research to better exploit knowledge and bring this into use, including through the development of new tools and methods. This pillar will place at least equal emphasis on better utilising existing knowledge – there is a vast knowledge and data on African variability and change that is not fully utilised. Consortia will draw on interdisciplinary teams to explore ways to better leverage this existing knowledge, extracting useful information and bringing this into use in informing real decisions.

iii. ***Targeted pilot studies to demonstrate how science can be better used in real decisions.*** Working with users, conduct pilot studies to better understand user needs and to test and demonstrate the application of information and tools in a real decision making context, informing and drawing on research from pillars 1 and 2.

Details of the scientific scope of each pillar of research of FCFA can be found in Annex 1. An example of the interaction of these pillars is shown in Figure 2.

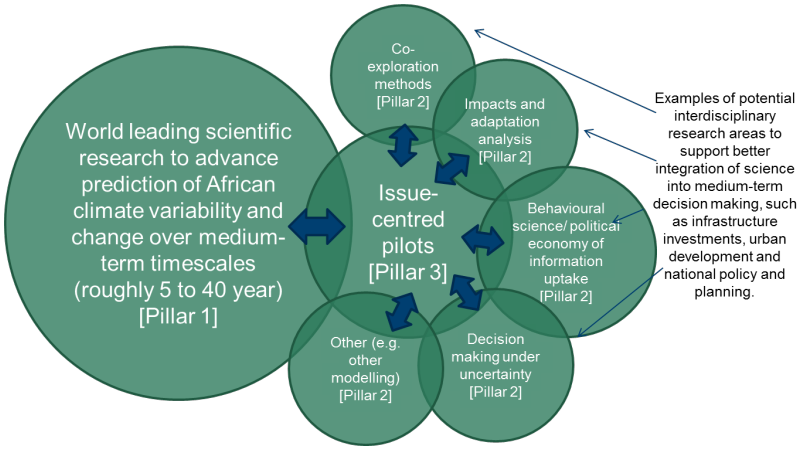

Figure 2: Illustration of how the three research pillars work together, with pillars 1 and 2 producing world-leading research outputs that each contribute to the delivery of an applied 'issue-centred' pilot study.

2.6 Impacts, Outcomes and Outputs expected from the FCFA programme

Future Climate for Africa will have a much stronger focus on delivering development impact than many previous climate science research programmes, with maximising such impact a clear goal of the work of both NERC and DFID. It is a requirement for all FCFA projects to have a clear and well-defined pathways to impact plan, with the co-production of knowledge, tools and products with users and stakeholders, including DFID, an important aspect of this. This plan details beneficiaries of the proposed research (beyond academia) and how outputs will be secured that are both relevant and useful to decision makers in Africa.

The preliminary impact pathway (or 'Theory of Change') of the programme is shown in Figure 3. In this framework, specific outputs from the programme lead to specific outcomes in the near-term and medium-term, which in turn contribute to a set of desired impacts. These steps are described in more detail below. During the inception phase, researchers will work together with the funders, the CCKE Unit and other partners to devise a more detailed impact pathway for the programme.

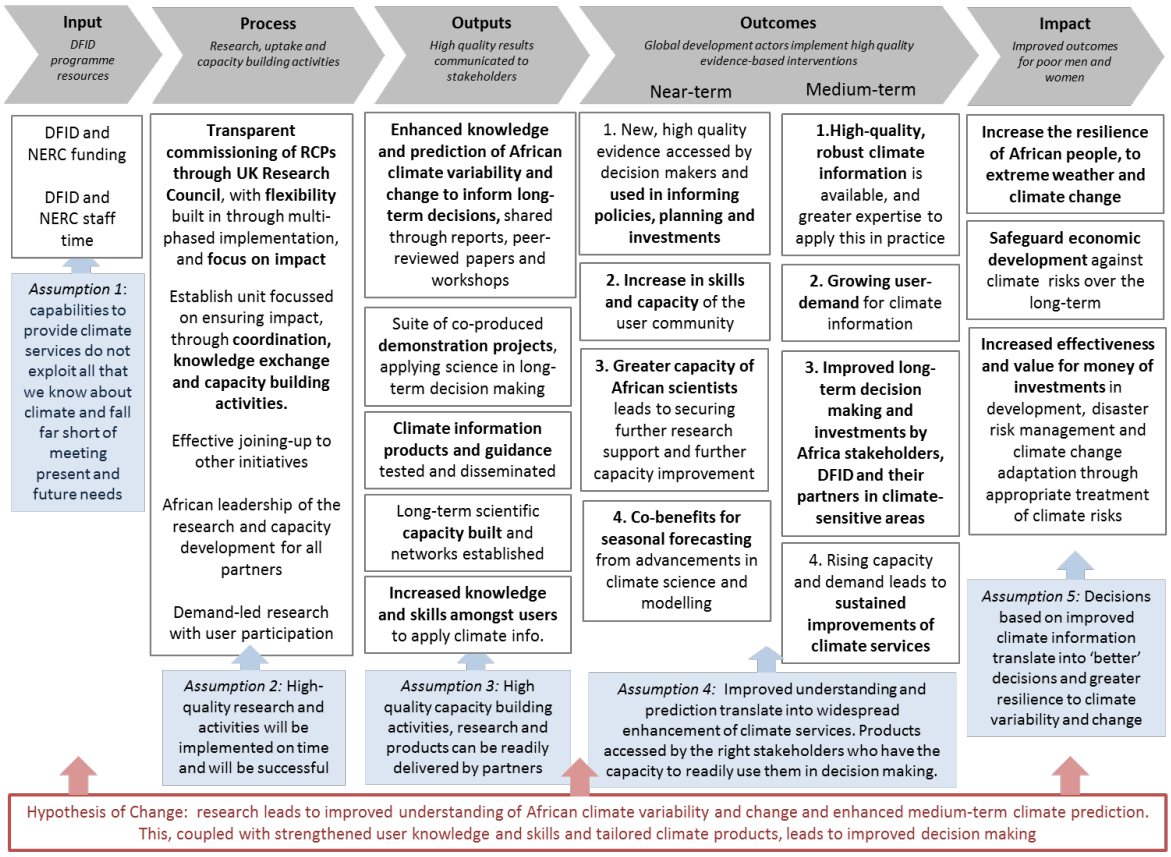

Figure 3: Preliminary impact pathway of FCFA

Impacts

The Future Climate for Africa programme aims to deliver the following impacts through strengthening the availability and use of climate information across sub-Saharan Africa:

- ***To increase the resilience of African people and economies*** to climate variability and change.
- ***To safeguard investments and development gains*** against climate risks over the medium-term.
- ***To increase effectiveness and value for money of investments*** in development, disaster risk management and climate change adaptation.

These impacts will contribute to improving the lives of poor people in sub-Saharan Africa.

Outcomes

The desired impacts are delivered through achieving main outcomes of the FCFA programme, on both near-term and medium-term timescales:

Near-term:

- ***New, high quality*** evidence accessed by decision makers and used in informing policies, planning and investments.
- ***Increase in skills and capacity*** of the user community.
- ***Greater capacity of African scientists*** leads to securing further research support and further capacity improvement.
- ***Co-benefits for seasonal forecasting*** from advancements in climate science and modelling.

Medium-term

- ***Increased availability and use of high-quality, robust climate information across Africa,*** and greater expertise on how to apply this in practice.
- ***Growing user-demand*** for climate information.
- ***Improved medium-term decision making and investments*** by Africa stakeholders and their partners in climate-sensitive areas.
- ***Sustained improvements in climate services*** (e.g. climate scenarios or expertise) across Africa, resulting from rising scientific capacity for climate research in Africa and increasing user demand for services.

Outputs

The FCFA Programme is aiming to achieve the following outputs:

- ***Scientific advancement of the understanding and prediction of African climate variability and change and new interdisciplinary knowledge, methods and tools***, disseminated through reports, working papers, workshops and articles in peer-reviewed journals.
- ***A suite of practical 'proof of concept' case studies*** demonstrating the application and value of scientific knowledge, methods and tools for medium-term decision making, communicated through academic papers, briefing papers and guidance materials. For example, case studies of the application of climate information to the design of a hydropower facility and evaluating methods and tools.
- ***Tailored climate information and service products and tools*** communicated openly through appropriate platforms, including robust climate scenarios, decision making tools and guidance materials.
- ***New evaluation and guidance on co-production processes*** to increase the knowledge and skills of users, deliver user-relevant research and increase research uptake.
- ***Contribution to cross-programme activities and outputs***, such as capacity development activities (e.g. training workshops, summer school, mentoring, secondments and an international network of climate scientists), international knowledge sharing activities (e.g. workshops and the FCFA conference) and products (e.g. publications, data products and training materials).

2.7 Who will benefit from the FCFA programme?

At the outset of the programme, the expected primary beneficiaries of the knowledge, training and capacity developed through FCFA will be:

- ***Decision makers involved in long-term planning and investments across sub-Saharan Africa,*** particularly African government (national, regional and local), infrastructure and service providers (particularly water, transport and energy), civil society organisations, development organisations, NGOs, and the private sector. Training and capacity building activities designed into the programme will directly work with a significant number of decision makers, but many tens of thousands will benefit from the knowledge and tools disseminated through open platforms.
- ***Climate scientists in Africa will benefit*** from increased research funding and targeted capacity building; in particular, early career scientists will benefit from specialist training, including workshops, secondments and summer schools.
- ***African societies and economies will ultimately benefit***. The outputs will be available to all, but we expect the main benefits to come through improved investments in infrastructure and planning, and more resilient patterns of growth.

While the programme focusses on science to inform medium-term planning and investments, this science will have significant co-benefits for weather and seasonal forecasting across Africa, with additional beneficiaries including farmers, emergency services and humanitarian responders.

2.8 Alignment with DFID and NERC strategic priorities

The High Level Panel report on the Post-2015 Development Agenda emphasised the important role of science in supporting the achievement of the Post-2015 Agenda. Climate information is a vital underpinning component of well-designed policies, technologies and measures for climate risk management. As such, FCFA supports several of DFID's objectives:

- ***Maintain momentum:*** on actions to achieve the Millennium Development Goals (MDGs) under DFID Priority 2.2. Investment in improved climate information will provide significant benefits in many DFID priority areas, including food security, water and sanitation, disaster resilience and health (WMO, 2011).
- ***Combatting climate change:*** this is DFID Priority 6, with the report of the High Level Panel on the Post-2015 Development Agenda reiterating that 'without tackling climate change, we will not succeed in eradicating extreme poverty'. Enhanced climate information is a crucial input to DFID's commitment to making development programmes more 'climate-smart', supporting developing countries' climate adaptation and low carbon growth and making DFID more responsive to climate change and resource scarcity.

FCFA delivers on the vision of the NERC strategy to place environmental science at the heart of responsible management of our planet, by aiming to strengthen the availability and use of climate information by decision makers involved in long-term planning and investments across

sub-Saharan Africa. This will allow them to make climate-resilient decisions that will have positive economic and social impacts. The programme will address NERC's strategic research priorities:

- Decisions around investments in agriculture, food-security, water resources and energy infrastructure will help to secure *benefits from natural resources* in a changing climate for African people.
- Better prediction and early warning of climate hazards across critical climate-sensitive sectors (including health, transport and disaster management) will *increase resilience to environmental hazards.*
- The programme will take a whole-system approach to understanding interaction between natural climate variability and man-made change from global to local scales. African stakeholders will use this knowledge to *manage environmental change* through responsible climate adaptation strategies.

Annex 1: Examples of scientific scope for each pillar of FCFA

Pillar 1: World leading scientific research to advance understanding and prediction of African climate variability and change over medium-term timescales (5 to 40 years): Advancing knowledge of African climate variability and change in areas critical to inform longer-lived decisions; develop and evaluate models with an 'African lens'; assess uncertainties and extract useful information.

There are opportunities to enhance scientific knowledge through increasing understanding of the drivers of natural variability and their interaction with anthropogenic change. The programme has identified a development need to work at multi-decadal timescales (5 to 40 years) in order to provide decision makers with information to enable climate-resilient adaptation planning. These are timescales that present a scientific challenge of understanding the drivers of natural decadal variability and their interactions with man-made changes. This especially includes those related to 'high-impact weather' such as extremes of rainfall; droughts and flooding. The following areas are illustrative of the breadth of the research scope that could come under the first pillar of FCFA (with GCM development within the scope of the Global Project), and are not intended as an exhaustive list.

- ***Global scale processes:*** such as the interaction of African climate with climate variability originating in all three of the main ocean basins (Indian, Atlantic and Pacific). The influence of the El Niño Southern Oscillation (ENSO) of the Pacific Ocean of African climate is well established, and ENSO simulation has improved in climate models, but the representation of the teleconnections to Africa remain weak. Model representation of the modes of variability in the Indian Ocean (e.g. the IOD) and Atlantic Oceans (e.g. the AMO) are also generally weaker than for the Pacific. Research gaps remain in understanding modes of ocean-atmosphere variability in observations and models and their impact on African climate.
- ***Regional scale processes:*** such as tropical convection and the seasonal alternation of the monsoon. These processes determine the regional and seasonal patterns of temperature and rainfall across Africa. Equally, understanding regional and pan-African responses and feedbacks to global scale processes and their response to climate change is an area for improvement.
- ***Land-atmosphere coupling:*** an increased understanding of land-atmosphere coupling is required to improve the physical basis of climate change scenarios for Africa, given the high sensitivity of African climate to land surface conditions. This includes understanding of the processes and feedbacks related to slowly evolving dynamics of vegetation, aerosols, the water cycle and land use change.
- ***Model evaluation:*** better understanding of the ability of models to simulate variability and trends and understanding of the causes of divergence between model projections across multi-model ensemble and with observations is required.
- ***Model development:*** the focus for model development should be on those processes of highest importance for improving GCMs to support medium-term adaptation decisions and may include a mixture of 'quick wins' and research aiming at longer-term improvements in GCM performance. The focus should be

justified in terms of relevance (to climate science and potential users of climate information) and risk and return and explain the justification for such a focus.

- ***Multi-decadal timescales:*** at this temporal scale, decision makers need to know trends and frequencies for rainfall and temperature at regional and country levels. Global model projections are currently available at relatively coarser resolutions; for example, most general circulation models (GCMs), such as those used in CMIP5, typically operate at horizontal resolutions of between 250 and 600km. While coarse resolution is useful in exploring longer-term feedbacks between the oceans and atmosphere for example, backcasting and projections on a decadal timescale will require downscaling of GCMs. There is scope to aggressively challenge computational limits to capture variability at local scales through the development of model hierarchies. Simulations at finer scales will allow the size and nature of land-ocean-atmosphere feedbacks (e.g. the means, variability and extremes) to be better understood as well as the sensitivity of these to external perturbations.
- ***Projection of rainfall patterns:*** this is of particular interest to decision makers in African countries, largely reliant on the natural resource, tourism and agricultural sectors for GDP and economic growth. It is the distribution and variability of rainfall that is at the core of the uncertainty between observed and modelled variability for East Africa and the Sahel. Convection modelling is one example of an area with the potential to offer improved understanding of weather and climate systems influencing areas of Africa on scales ranging from tens to thousands of kilometres, including storm systems.
- ***Projection of extreme weather:*** this is important to African countries, many of which are susceptible to the devastating impacts of a range of extreme weather events (including floods, drought and cyclones) which may increase in intensity with climate change. Study of decadal dynamics can increase understanding of the clustering of extreme events and natural variability in the African climate system, which can help to inform projections of extreme weather. Focussing efforts on better understanding the range as well as the means in climate projections (i.e. the tails of the distributions) can provide better information about medium-term risks.
- ***Harnessing untapped data sources:*** provides a significant opportunity to enhance science. This could include new analyses of satellite data or data from past observational campaigns to improve understanding and modelling. There is also an untapped resource of historical multi-decadal climate records in Africa.

It is recognised that observations of climate across many parts of Africa is a limiting factor and many international efforts to improve the observations are underway (e.g. ISACIP/AfriClimServ). Recent observational programmes have developed process-level datasets of multiple variables (e.g. AMMA and Fennec). There are also satellite products (e.g. TAMSAT datasets) and higher resolution or longer reanalysis datasets (e.g. ECMWF's ERA reanalyses of multi-decadal series of past observations and the CLIVAR C20C datasets). Both of these provide a large-scale context for process studies. The focus of FCFA is on making best use of existing climate data and major new observational campaigns are out of scope. However, in two cases, new measurements may

contribute to the aims of the programme where the data will be used and fully integrated within projects, and inform the needs for long-term climate monitoring in those areas:

1. In geographical regions where data is extremely sparse and where new short-term observations could provide critical insights into processes suspected to drive variability.
2. Working in partnership with African meteorological agencies, where enhancements to monitoring capability will increase capacity to generate and communicate climate data.

Pillar 2: Interdisciplinary research to support better integration of science into medium-term decision making, such as infrastructure investments, urban development and national policy and planning: This pillar will invest in research to better exploit knowledge and bring this into use, including through the development of new tools and methods. This pillar will place at least equal emphasis on better utilising existing knowledge – there is a vast knowledge and data on African variability and change that is not fully utilised. Consortia will draw on interdisciplinary teams to explore ways to better leverage this existing knowledge, extracting useful information and bringing this into use in informing real decisions.

Interdisciplinary research including, for example, natural science, social science, economics, engineering, decision science and behavioural science, will generate knowledge, methods and tools that support the development and delivery of robust climate information and services to inform medium-term adaptation. This may include, but is not limited to, the following areas:

- ***Interdisciplinary approaches to multi-model evaluation:*** including evaluation from an 'application perspective' to aid the interpretation of existing projections for decision making. This may include, for example, defining criteria to evaluate model-based projections for the purpose of informing specific multi-sector adaptation strategies in the region, and drawing conclusions on potential methods to combine projections to create meaningful multi-model ensembles (including, for example, weighting models and exclusion criteria), leading to guidance on methods to interpret multi-model projections.
- ***Quantification of uncertainty in climate change:*** this is necessary in order to characterise better performance, credibility and confidence for longer-term climate projections, in consultation with end-users. Validating model fidelity with observational data will be a critical element in evaluating model development and performance. Innovative approaches to increase and assess the utility of climate projections for decision makers are sought.
- ***Understanding barriers to uptake:*** this particularly needs to be the case for barriers associated with the communication and application of evidence and how research programmes can contribute to overcoming these. This may include, for example, researching how stakeholders interpret and use climate information and tools for decisions, their perception of risk and uncertainty and how science can be better communicated to facilitate action. This may also include trialling innovative methods such as games and scenario planning.
- ***Co-production of science:*** the development and evaluation of co-production methods of science and tools with users, for example using participatory

decision making approaches, has the potential to contribute to better integration of science into decision making.

- ***Development and evaluation of practical tools:*** drawing on economics and decision science, the development and evaluation of practical tools for dealing with uncertainty in projections is needed. An array of tools are already available, but in many cases they need to be evaluated and refined to operate in an environment of data scarcity and where there are limits on the resources and capacity of users (including computational, technical, time and financial constraints). This may include evaluating the suitability and robustness of more simple heuristic tools to decision making.

Pillar 3: Targeted pilot studies to demonstrate how science can be better used in real decisions. Working with users, conduct pilot studies to better understand user needs and to test and demonstrate the application of information and tools in a real decision making context, informing and drawing on research from pillars 1 and 2.

The third pillar of FCFA is expected to be the most applied pillar and will be centred on at least two major case studies per consortia (in addition to smaller pilots and more illustrative case studies as required). This is where the research in pillars 1 and 2 comes together, with the following points of key importance to the case studies.

- ***Co-production/co-exploration:*** the pilot studies are expected to be developed through a co-production/co-exploration process with users. They should be targeted at informing specific medium-term decision, for example concerning a local adaptation strategy, an urban development plan or a water infrastructure design. The cases selected should be justified in terms of the relevance of medium-term climate to the decision (e.g. infrastructure and planning decisions will usually have a high relevance, whereas for shorter-lived decisions, for example the selection of crop planting times by individual farmers, medium-term climate will have lower relevance to decisions made today). A combination of different types of sector is preferred, but most importantly they should be tractable, have adequate stakeholder engagement and have the potential to achieve development impact.
- ***Multiple objectives:*** the pilot studies have multiple objectives. First, the pilots should inform the research in pillars 1 and 2 through deepening the understanding of user needs (pillars 1 and 2 are expected to be flexible enough to respond as this understanding deepens during the project). Second, they provide a forum to trial the methods, tools and data products being developed in the other pillars. Third, the case studies are expected to be one of the key outreach pathways of the programme and where the programme demonstrates its impact on real decisions. Fourth, the pilots are expected to contribute to the capacity development of both researchers and users through knowledge sharing and through the co-production/co-exploration process.
- **Outcome:** an outcome of the pilot studies will be to demonstrate where medium-term climate trends are important in decision making today, and provide the tools and methods to incorporate them. Together, they will provide a set of worked example to allow the decision makers to identify where climate

change is important in their activities today and to build the case for investment in adapting to climate risks. An output of the pilot studies will be a well-tested toolkit for integrating medium-term climate information into key decisions today.

- **Success:** to be successful the pilot cases may need to incorporate a much broader set of inputs than those directly researched in pillars 1 and 2. For example, information on vulnerability and resilience, locally relevant trends (e.g. water demand or economic growth projections), understanding the institutional context, climate impact modelling and economic assessment of risk and adaptation options. Consortia will be expected to incorporate this expertise or build on other initiatives as relevant to supply this broader context needed for successful pilot studies.

Annex 2: Scope of the Global Climate Model Development for Africa project

The goal of the Global Climate Model Development for Africa (Global Project) call is to deliver a step-change in the performance of General Circulation Models (GCMs) for Africa and to make a long term contribution to model development with an African lens. This should lead to improved projections of future changes in rainfall and extreme weather for Africa, increasing the availability of high quality, robust climate information across the continent.

The IPCC (Intergovernmental Panel on Climate Change) Fifth Assessment Report concluded that current climate models have only a model ability to capture those phenomena that are most important in driving African climate. Equally, it also concluded that Africa is one of the few continents where GCMs have shown little improvement in performance since the Fourth Assessment Report of 2007, which constrains the confidence we can attach to climate projections for Africa. As a result, the Global Project will involve a single project that will enhance the performance of one or more GCMs for sub-Saharan Africa in generating robust and reliable projections of the characteristics of rainfall and extreme events over medium-term timescales. The requirements of the Global Project are as follows:

- The focus of this project is on evaluating and developing the representation of processes affecting pan-African climate on timescales for adaptation (medium-term or 5 to 40 years). This will include improving the understanding and representation of drivers, processes and feedbacks responsible for the greatest uncertainty in model representations of African climate and global processes affecting African climate.
- Potential aspects for development include those acting at a pan-African scale; for example teleconnections to global phenomenon (e.g. ENSO, IOD, AMO, global and tropical SSTs, AEJ), the representation of convection (e.g. the meso- to large-scale organisation of convection and diurnal cycles of convection), aerosol forcings and land-atmosphere coupling.
- The research should focus on those processes of highest importance for improving GCMs to support medium-term adaptation decisions (i.e. focus on areas of highest relevance to the FCFA programme objectives) and may include a mixture of 'quick wins' and research aiming at longer-term improvements in GCM performance. Focus should be justified in terms of relevance (to climate science and potential users of climate information) and risk and return and explain the justification for such a focus.
- Global models inevitably require an element of simplification, and it is therefore important to use knowledge of the underlying processes to test that models are 'getting the right answer for the right reason', rather than simply being tuned to reproduce a small number of target metrics. Innovative methods of integrating process-based observational information into evaluations are welcome.
- It is expected that initial evaluation criteria for model performance will be suggested, which may be refined during the course of the project and will be subject to peer-review.
- It is expected that the Global Project will work closely with the FCFA regional consortia and retain a degree of flexibility to ensure that model development is

responsive to the findings of the regional consortia. Active dialogue and knowledge sharing is also expected to ensure that the work is complementary and mutually supportive. To help facilitate this collaboration, all PIs are expected to contribute to the Programme Management Unit (PMU), which is accountable to the Programme Executive Committee (PEC).

- To avoid overlaps with the regional projects, the Global Project should not involve the evaluation or development of regional climate models (RCMs), aside from where this research is directly for the purpose of improving GCMs.
- It is a requirement that the Global Project will involve partnerships between at least one world-leading GCM development centre (defined as a centre that has contributed a GCM to CMIP5 or will contribute to CMIP6) and at least one academic institution.
- Meaningful international partnerships are welcomed, particularly where they involve partners based in Africa.
- Scientific capacity development is welcomed. This should involve science that contributes to the objectives of the Global Project and should target early career researchers based in Africa. Examples of appropriate capacity development activities include secondments or other professional development opportunities. The regional consortia will include capacity development initiatives and there may be opportunities to integrate activities during the course of the project.
- It is expected that opportunities for drawing on, collaborating with and adding value to other initiatives, with the purpose of improving GCMs for Africa, are identified.

The required outputs of the Global Project are:

- ***Improved GCM projections of extreme weather and rainfall for Africa over timescales to inform adaptation,*** as evidenced by performance against the set of pre-defined evaluation criteria. Evaluation criteria could include, though is not limited to, metrics concerning the representation of current African climate and relevant parameters and processes. This may include criteria specified in conjunction with the user-community.
- ***Scientific advancement of the understanding of African climate variability and change***, disseminated through reports, working papers, workshops and articles in peer-review journals.
- ***Data products (including selected model runs and analytical products)***, made available to the regional consortia and the broader academic community, via an appropriate platform.
- ***Contributions to cross-programme outputs***, including annual reporting, stakeholder events, workshops and publications.