Scientific capacity development in climate change related disciplines:

Analysis of barriers, opportunities and good practice in Africa

Leigh Cobban, Mark New, Michael Baudoin, Anna Steynor, Katinka Waagsaether, Chris Jack, Julius Kamau, Sarah Correy, Robert Ochieng, Heila Lotz-Sisiska, Cherie Forbes, Jean-Pierre Roux, Jon Padgham, Katie Dietrich, Sarah Schweizer, Abby Gwaltney

April 2017

CDKN

FUTURE CLIMATE FOR AFRICA

"You can't say one thing leads to personal development.
You build your knowledge and experiences through life."

- Fellow from the African Climate Change Fellowship Program (ACCFP)

Contents

List of acronyms

ACCCA	Advancing Capacity to Support Climate Change Adaptation
ACCFP	African Climate Change Fellowship Program
ACCRA	Africa Climate Change Reliance Alliance
ACCESS	Applied Centre for Climate and Earth Systems Science
ACDI	African Climate & Development Initiative
AgMIP	Agricultural Model Intercomparison and Improvement Project
AIACC	Assessments of Impact and Adaptations to Climate Change
BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CCD	Climate Change and Development
CCKE	Coordination, Capacity development and Knowledge Exchange of the Future Climate for Africa programme
CDKN	Climate and Development Knowledge Network
CIRCLE	Climate Impact Research Capacity and Leadership Enhancement in Sub-Saharan Africa
CIRDA	Climate Information for Resilient Development in Africa
CMO	Context-Mechanisms-Outcomes
CSAG	Climate Systems Analysis Group
CSIR	Council for Scientific and Industrial Research
CSRP	Climate Science Research Partnership
DFID	Department for International Development
DST	South Africa's Department of Science and Technology
ECR	Early Career Researcher
FCFA	Future Climate for Africa
GCGC	Global Change Grand Challenge

List of acronyms continued

GCM	General Circulation Model
GEF	Global Environment Facility
HCD	Human capacity development
ICT	Information and communications technology
ICTP	International Centre for Theoretical Physics
IPCC	Intergovernmental Panel on Climate Change
M&E	Monitoring and Evaluation
MOHC	Met Office Hadley Centre
NERC	Natural Environment Research Council
NMHA	National Meteorological and Hydrometeorological Agencies
NMHS	National Meteorological and Hydrological Services
NRF	National Research Foundation
ODI	Overseas Development Institute
RC	Research Consortium
RCM	Regional Climate Model
SARUA	Southern African Regional Universities Association
SCD	Scientific Capacity Development
STI	Science, Technology & Innovation
START	Global change SysTem for Analysis, Research and Training
TWAS	The World Academy of Sciences
UCT	University of Cape Town
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WBI	World Bank Institute
WMO	World Meteorological Organisation

Acknowledgements

This study was commissioned by the Climate and Development Knowledge Network under the Future Climate for Africa programme with the dual aim of advancing the understanding of approaches to developing the capacity of African researchers and research institutions in climate change related disciplines, and informing the strategic investment that the Future Climate for Africa programme will be making in this field. This study was undertaken by the African Climate & Development Initiative (ACDI) at the University of Cape Town, with contributions from a number of institutions and individuals:

ACDI (University of Cape Town): Prof Mark New, Dr Marie-Ange Baudoin, Ms Leigh Cobban

CSAG (University of Cape Town): Ms Anna Steynor, Ms Katinka Waagsaether, Dr Chris Jack

INTASAVE Africa: Mr Julius Kamau, Ms Sarah Correy, Mr Robert Ochieng

ELRC (Rhodes University): Prof. Heila Lotz-Sisiska

SouthSouthNorth: Ms Cherie Forbes, Mr Jean-Pierre Roux

START: Dr Jon Padgham, Dr Katie Dietrich, Ms Sarah Schweizer, Ms Abby Gwaltney

The team would also like to acknowledge and thank Dr Eureta Rosenburg (Research Associate at Rhodes University) for her insights and contribution to developing the evaluation framework used in the study, and Prof Guy Midgey and Rick James for their review.

Executive summary

This study investigated the needs and experiences of African researchers working in climate change-related disciplines. It focuses largely on early career researchers based at African institutions (largely universities and national and regional research institutions) who have received support from international donor programmes.

The study used mixed methods and had several components: i) the development of a database of previous climate change related scientific capacity development (SCD) activities and initiatives; ii) a review of academic and grey literature on SCD in Africa and for climate change, as well as the broader domain of sustainability science; iii) a desk based analysis of 12 SCD case studies; iv) an online survey of international climate change scientists and practitioners; and v) in-depth interviews with seven organisers and 28 participants of six different African climate SCD activities. An evaluation framework was applied to the in-depth interviews to identify key contexts, mechanisms and outcomes, of the studies activities. The evaluation framework was used to assess the successes, and barriers to success, of the six SCD activities thereby identifying examples of good practice.

These components revealed interesting findings on the competencies and skills that researchers in climate change-related fields need, and important contextual and mechanistic factors that help or hinder the development of these, advance a person's career or contribute towards more robust delivery of SCD interventions.

The findings supported literature by showing that a combination of specialist or technical skills together with interdisciplinary competencies are needed in an ideal climate scientist, particularly once their career has progressed to a working researcher or practitioner. The combination of competencies is important to advance knowledge in this multi-faceted field; to communicate and work with peers in order to situate one's work into the 'bigger picture'; and to ensure that research findings are relevant, and will be used.

Such competencies can be developed across a range of SCD interventions, though donors and implementers should, as far as possible, ensure that they consider the following supportive factors when designing SCD interventions: i) that there are adequate resources available (financial, human, infrastructural and computing resources), ii) that they have a thorough understanding of the level of technical and analytical skills of recipients prior to designing specific SCD interventions, iii) that there are supportive platforms for communication between implementers and recipients of support, iv) that there are supportive academic-professional interactions with peers and/or superiors (such as mentors, supervisors or other experts), v) that there is an ethic of collaboration, vi) that there are integrative reflexive approaches to enable mutual learning and improvement, and vii) that recipients have autonomy to pursue personal research interests and opportunities, and room to apply skills learnt.

The study supported literature that found that researchers develop their capacity in a very ad hoc manner. However, the findings also suggest that in such a complex, multidisciplinary field there are many areas for specialisation and associated shortages of expertise. In this context, more coherent SCD can be a catalyst for accelerating a person's career and establishing them as an expert. Indeed, from the in-depth interviews, it appeared that all interviewees' careers had progressed; most had moved to or remained within a climate change-related career; and many attributed their career development to the SCD activity being evaluated as part of this study (at least in part).

SCD is not a short term 'once-off' event, but should be conceptualised within a learning pathways framework that allows for access to a diverse range of SCD support mechanisms along a person's full career trajectory. However, if this is left to 'chance' then the SCD process will generally be slower, and lack coherence. If more careful SCD planning and system building takes place, capacity development can be 'fast tracked' for those on climate change research pathways.

A full package of support for SCD that simultaneously builds individual and institutional capacity is an ideal objective. This is especially the case if this full package is situated within a longer term, reflexive, and more systemic framework for SCD. Successful outcomes for both the participant and the delivery institution require buy-in and commitment from both, together with an understanding of each other's needs and existing capacity. Incorporating the factors listed above requires a balance of the resources available in an institution (funding, technical, HR) and in an individual (skills present and skill gaps according to career trajectory).

The study has shown that it is important to understand the full knowledge value chain, and that both ongoing specialisation and more generic competency development are needed across this chain. A robust SCD approach acknowledges this chain and supports SCD across the levels of the individual, institution and the broader enabling system (see the diagram below). This study focused largely at the individual level and to a lesser extent on the institutional level.

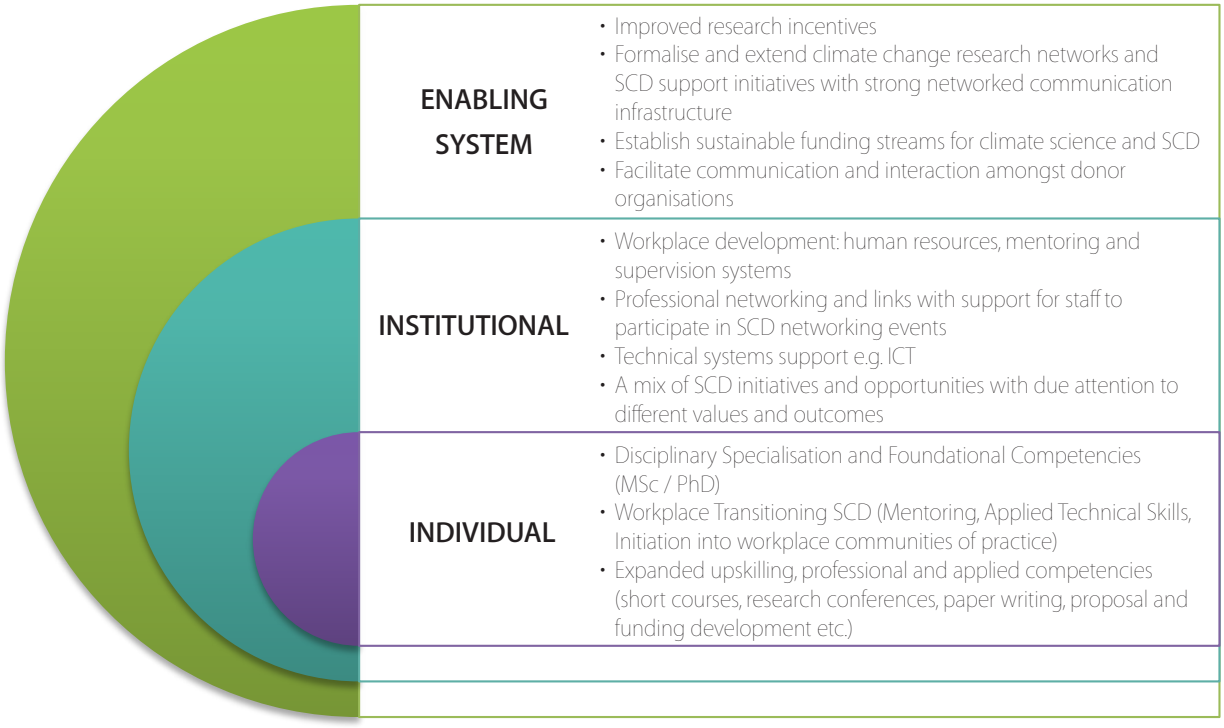

Figure 1: A good approach to capacity development considers multiple factors over the individual, institutional and systemic scales

An analysis of enabling contexts and mechanisms

An indepth analysis of six SCD initiatives in Africa highlighted factors that operate together to help achieve positive learning and career outcomes (or the absence of which may act as a barrier to success).

Table 1: Good practice factors that an ideal SCD initiative or programme should contain.

Factor	Description
Adequate funding	Without suitable personal funding, individual development pathways can be constrained; institutional shortages can constrain the scope or effectiveness of activities
Adequate human resources available	At the institutional level, management or coordination of funds and activities, contracting, procurement, reporting, logistics; expertise present and available (i.e. time). At the individual level, personal time management
Adequate infrastructural, data availability and/or computing capacity	Computational infrastructure and internet available at the institutional or systems (regional) level. At the systems level, data and climate information systems are functional
Adequate technical and analytical skills	At the individual level, an existing 'base' of technical or disciplinary skills, particularly analytical skills, on which the SCD can build
Supportive platforms for communication	Tools and channels that enable relevant information to transfer reflexively between relevant participants and stakeholders
Supportive academic- professional interactions	Peer-to-peer, professional networks or senior supervision or mentoring, to guide, soundboard, challenge or collaborate.
Ethic of collaboration	Commitment and value at the individual and institutional level for collaboration between peers, cross-disciplines, cross-institutions and/or cross-border.
Integrative reflexive approaches	Involving participants and/or stakeholders across the full research or capacity development process
Autonomy to pursue opportunity	At the individual level, room to apply or practice skills, pursue research interests, build confidence and address own skill shortages. At the institutional level, capacity to pursue new areas and create legacy

Such a package should comprise initiatives that consider the good practice 'factors' identified above as far as possible. Significant organisational, coordination and leadership resources are required through an SCD initiative or programme, without which, effectiveness and significant outcomes are likely to be compromised.

Recommendations for research institutions

- Universities could consider this SCD report and the need for integrated competencies in curriculum review and in supporting students and researchers in universities.
- Training organisations and convening organisations such as the African Academy of Sciences and WASSCAL could consider greater coordination across the spectrum of SCD activities that are underway, and build in stronger Monitoring & Evaluation (M&E) processes so that more rigorous learning, reflection and improvement of SCD can take place.

- There appears to be very little cross-institutional networking and knowledge sharing on improving delivery of SCD interventions. A platform for SCD networking with regular meetings to exchange experience and emerging best-practice could significantly enhance the capacity of donors and implementers of SCD interventions, and create a shared understanding of SCD and its importance for building climate resilient societies in Africa.
- To support enabling cross-institutional mentoring and professional exchange programmes, especially also where computing capacity can be shared (e.g. access to supercomputers of University of Cape Town and other well-resourced institutions).
- To support inter-sectoral engagement and possibilities for inter-disciplinary knowledge co-production approaches to emerge.

Recommendations for research funding and policy institutions

- Develop sustainable funding systems and broker national and international partnerships for climate sciences development in Africa.
- Develop incentive systems to incorporate SCD interventions into international climate science research programmes.
- Prioritise climate capacity development at PhD level in bursary programmes, and for academics in regional centres of excellence as they are important for ongoing supervision and development of the academic field.
- Include climate sciences and climate change SCD in national human resources and human capacity development (HCD) planning and policies.
- Understand the need for technical equipment, computing infrastructure and computing competency for climate change research and how these relate to advancing particular research agendas.

1. Introduction

Climate change research in Africa takes place in contexts where climate change poses many challenges and threats to societies, and where scientific research and capacity development systems are generally weak, including and affecting the emergence of new scientific areas such as the climate change sciences. The importance of capacity development for climate change science and research in Africa is increasingly recognised, but there have been few reflections on past capacity development interventions, and their longer-term impacts (Conway, 2011). Such reflections could help to understand what capacity development approaches are most effective in particular contexts.

The purpose of this study is to improve knowledge and understanding of scientific capacity development (SCD) in Africa in the field of climate science, climate impact assessment and climate change adaptation research. In the absence of good macro-economic and quantitative data in this area, this study contributes a qualitative analysis of six SCD programme case studies, 28 African researchers actively working in climate change related disciplines across the continent, and seven administrators who have implemented SCD projects or programmes. The study focused primarily on early career researchers and their interface with the programmes and institutions that fund or host SCD activities with international donor aid support. Though by no means representative, it presents provisional insights towards building a more robust understanding of the problem area, as well as recommendations on the practical implementation of SCD interventions.

The report is divided into three main sections:

- **Section 2** outlines the research methodology and analytic framework used for the analysis
- **Section 3** gives a detailed account of the findings, divided into the findings drawn from the literature review, the online survey and the in-depth key-informant interviews respectively
- **Section 4** offers conclusions and recommendations drawn from the findings in Section 3

The study, from which this report draws, was aimed to inform the Future Climate for Africa programme in the design and delivery of its SCD strategy. This constrained methodological decisions to evaluate past donor-funded SCD programmes of a similar scale; limit the inquiry largely to individual researchers and individual-institution interfaces; and include input from FCFA-affiliated researchers on their needs and priorities.

2. METHODOLOGY

The study ran for several months and used a mix of methods, drawing from multiple sources of information across two phases of work[1]:

Phase 1:

- Captured a database of existing climate change SCD initiatives in Africa. The database included information various activities together with characteristics such as the target participants, implementer, funder, area of operation, and type and duration of activity.
- Conducted an extensive literature review, which was largely informed by grey literature (as very little formal literature exists relating specifically to climate change scientific capacity development in Africa), and broader pedagogical literature. The literature review included 12 desk-based case studies which were developed from content available online (websites, reports to funders), and key-informant feedback. The 12 case studies were compared against criteria informed by the literature review findings.

Phase 2:

- Conducted an online survey sent to 165 advanced-career climate scientists working or with experience in Africa (completed by 43 respondents).
- Conducted in-depth interviews with organisers and participants from selected case studies (Phase 1) using Context-Mechanisms-Outcomes (CMO) evaluation framework and outcomes of case studies to idenfity enabling factors to SCD. These criteria were informed by the literature review and general capacity development objectives.

Methodologies for each of these components are detailed below.

2. 1. Database of activities (Phase 1)

The project team developed a database of climate-relevant SCD programmes, organisations and activities, as experience had shown that many SCD activities in Africa are poorly documented in literature and online, with most documentation being in the form of grey literature.

To compile this database, all collaborators (ACDI, START, CSAG, INTASAVE, and ELRC) contributed their network of contacts of climate-relevant SCD programmes, organisations and activities across Africa. Suitable contacts from each organisation were approached for information on SCD activities amongst their own networks, thereby using a snowball technique and word-of-mouth sampling approach to collate a database of climate-relevant SCD activities and suppliers across Africa. Online searches were also used to add to the database. These SCD initiatives, programmes and activities were primarily those focused on developing capacity at the individual level, though it included regional projects and communities of practice which could constitute institutional capacity development.

The database was then used to inform the selection of the case studies which formed part of the literature review.

2.2. Literature review (Phase 1)

There are limited formal or academic evaluations of climate-related SCD activities and initiatives available. The literature review thus drew largely on educational or pedagogical literature, and grey literature; the latter consisting largely of reports from large climate change initiatives in Africa.

1 A third Phase was included to give programme-specific recommendations for the FCFA programme. This entailed an interactive workshop session with FCFA research consortia to understand their capacity development plans and preferences and inform a detailed operational SCD strategy for the FCFA programme. Findings and recommendations from this phase is not included in this research report.

In terms of educational or pedagogical literature, there is a small but growing wealth of literature relating to environmental education, education for sustainable development, and climate change education. These sources usually relate to higher education and post-graduate teaching and learning (e.g. Blum et al 2013; Bangay & Blum 2010; Fahey, 2012; Anderson, 2012; Lemons, 2011). Much can be learned from these associated sub-fields of education, however SCD is a broader and often less formalised process (than formal education) and there are specific challenges related to SCD for climate change related fields (Kagawa & Selby, 2010).

The literature review also included in-depth reviews of 12 SCD intervention case studies. These case studies comprised a range of SCD activities of different types and duration. Online searches and reports (when available) were used to gather information on the case studies. The information collected included a range of characteristics that emerged during the literature review as being potentially important factors that could influence the SCD activity's outcome. In many cases, contributions to each case study (either written correspondence or short informal interviews) were made from key informants, such as past participants or organisers of the activity.

2.3. Online survey (Phase 2)

The literature review highlighted career trajectories, learning pathways and competencies as important concepts to consider in the research methodology. A short online survey was therefore circulated to analyse these concepts from the perspectives of climate change researchers and practitioners working in Africa.

A short (±10 minute) survey was sent via email to 165 experienced climate change researchers and practitioners in Africa, and was live for one week. The list included IPCC AR5 authors and researchers affiliated to the FCFA programme. 43 completed the survey.

The survey was designed to validate some of the findings and frameworks from the literature review in Phase 1 of the study. The survey also informed the development of a strategy for Phase 2 of the study, during which in-depth interviews were undertaken with participants (i.e. individuals who participated in an SCD activity or programme) and organisers (i.e. delivery or implementing institutions) of different SCD activities (see the section that follows).

The survey asked questions about respondents' career specialisms, the competencies that were needed across their career, and the specific activities that they had taken part in to develop these competencies.

2.4. In-depth interviews (Phase 2)

There is very little formal or accessible literature critically evaluating existing climate change SCD initiatives, particularly those in Africa. To better understand the outcomes of different climate change SCD approaches, semi-structured in-depth interviews were used to gain a deeper understanding of some of the case studies from the literature review. The study undertook a detailed evaluation and analysis of these interviews with SCD project organisers and participants, using a Context-Mechanisms-Outcomes (CMO) evaluation framework.

Sampling

Seven of the twelve case studies from the literature review were selected for the in-depth interviews. The CSRP-1 Fellowship programme, which had not been a case study during the literature review, was also selected. However, two of the selected cases did not commit to the interviews, resulting in a final selection of six cases (including the CSRP-1 Fellowship Programme). From each of these, at least one person who has or had a key role in implementing or managing the activities (the 'organiser') and between four to six people who had participated in the activity in the past (the 'participant') were selected. In addition, one interview (a pilot) from the ICPT PhD programme was included in the analysis. In total 35 interviews were undertaken (see Table 2 for a breakdown of this total).

Table 2: Breakdown of interview numbers across the SCD cases

SCD activity / programme	Number of participant interviews	Number of organiser interviews	Total number of interviews
ACCESS GCS Programme	5	1	6
ACCFP	6	1	7
AIACC	3	1	4
CSAG Winter School	4	1	5
AgMIP Workshop (Ghana, 2012)	4	2	6
CSRP-1 Fellowships	5	1	6
ICTP PhD program	1 (pilot)	0	1
Total	28	7	35

Interview structure

Organisers and participants were asked different interview questions. A key difference between the two was that participants were first asked to reflect back across their full career to date, and to think about the key (formal or informal) activities that had been important to their career trajectory or learning pathway.

Both were asked about key drivers and characteristics of the specific SCD activity concerned, from their perspective as either an organiser or a participant. For the organiser, this included the background and preparation to the activity (such as the financial and human resource inputs needed and the motivation), the structure of the activity and any M&E processes involved. Many SCD organiser institutions did not have a detailed follow-up or M&E mechanism to track the outcomes of the activity. Participant interviews had a larger emphasis on the personal outcomes that the SCD activity contributed to.

Context-Mechanisms-Outcomes (CMO) Evaluation framework

The Context-Mechanisms-Outcomes (CMO) framework takes a critical realist perspective adapted from Pawson & Tilley's methodology for program evaluation (1997). The realist perspective recognises that SCD, as with many initiatives, are influenced by complex contextual factors and driving mechanisms. Contextual factors (e.g. inputs and resources, institutional factors, history and existing experience, system-wide PESTEL[2] factors) and mechanisms (e.g. design and structure of SCD, methods of interacting and training) combine to influence outcomes (or the degree of influence and longer-term impact). Importantly, this framework recognises that activities such as SCD initiatives occur within an open systems framework, which is characteristic of social systems, and positivist causality should therefore not be expected.

A CMO framework is similar to a standard logframe evaluation framework, but it allows for more contextual variables other than just inputs to be included in the analysis. This is an important addition to the logframe as a central question for the study is "What SCD options work best in specific African contexts?" The CMO framework recognises

2 Political, Economic, Social, Technological, Environmental, Legislative

the diversity of African contexts and the potential influence that contextual factors can have in combination with different activities, mechanisms, processes and styles, at the outcome and impact levels. Furthermore, mechanisms provide a stronger conceptual framing than activities, in terms of how they aim to achieve the desired change.

The framework makes the assumption that the contexts (including inputs, motivation and enabling environment) of the SCD case studies partly determine the mechanisms (i.e. approaches, design, delivery mode and processes) of the SCD activity. Differences in mechanisms (i.e. different approaches, designs, delivery modes and processes) can lead to different outcomes, for both the institution and the individual. The outcomes for the individual are also partly determined by his/her own contextual and social background. The context influences the way in which mechanisms produce outcomes, but the mechanisms are key influences of causality: a mechanism is what shapes an activity into what it is. This is described by Danermark (2002: 5): "If we are to attain knowledge about underlying causal mechanisms we must focus on these mechanisms, not only on the empirically observable events".

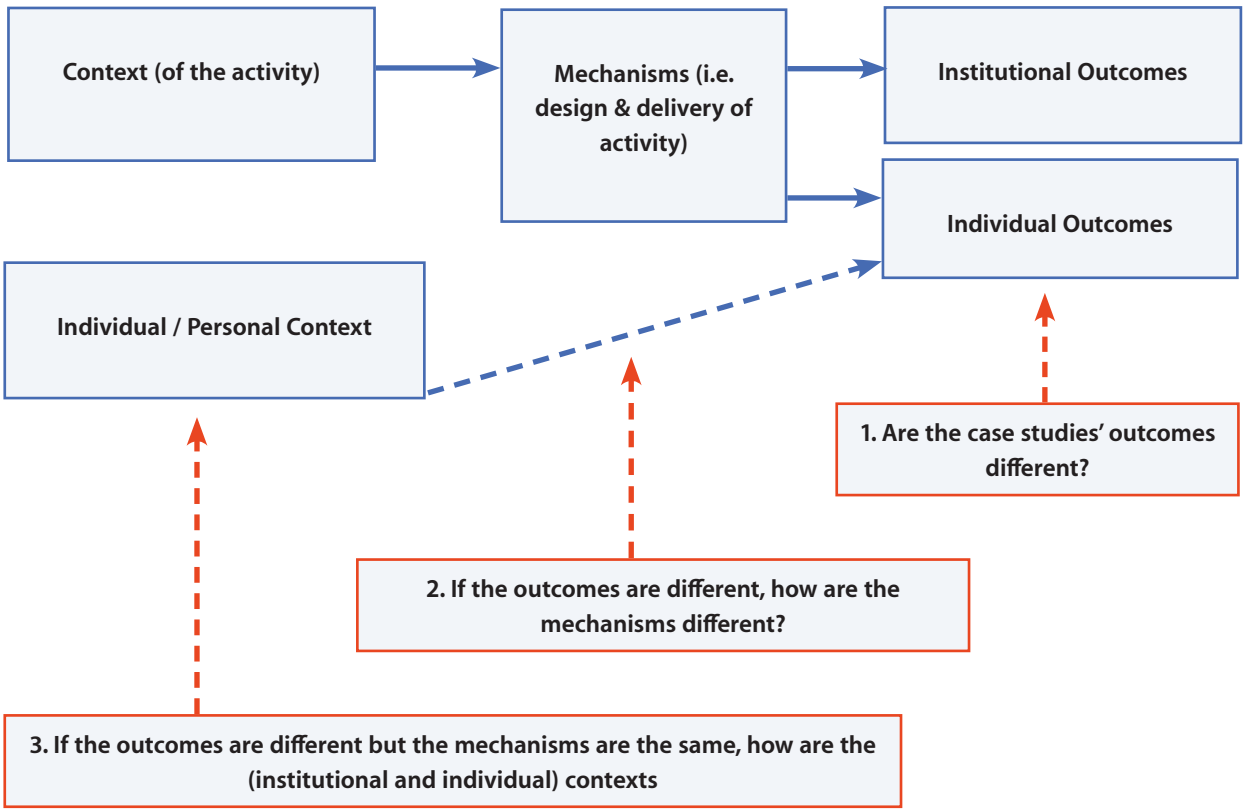

Figure 2 Applying the CMO Evaluation Framework

The indicators for the outcomes in the CMO evaluation framework (see Appendix 1 for evaluation framework template) were derived from the FCFA SCD Objectives formed from input from the FCFA researchers and administrators. The indicators for contexts and mechanisms were derived from a review of the literature which highlighted key educational theories, and properties and drivers influencing SCD initiatives at the individual and institutional level. The indicators for mechanisms were also informed by results from the online survey (see above).

It is worth noting that in addition to the individual and institutional levels, capacity development also occurs through and is influenced by the broader systems or enabling environment level. The broader or enabling level has not been

included in the CMO evaluation framework, but was still considered when drawing conclusions.

A final consideration is the career stage of the participant interviewees. Some interviewees were in advanced career stages, having participated in a SCD many years before. In these cases, interviewees had the benefit of hindsight for interpreting the impact of the activity on their career, though perhaps also with a reduced ability to remember specific details from the activity. Others were in their early career stage, and had only recently participated in SCD initiatives. This range, coupled with the small sample size, made it difficult to evaluate longer-term impacts and benefits from the initiatives (Smidt et al, 2009).

Analysing the in-depth interviews

The interviews were transcribed and were analysed in two supplementary ways. Firstly, detailed CMO reports for each case captured drivers and characteristics relating to context, mechanisms and outcomes at both the individual and institutional levels. The template for this report can be found in Appendix 1. The detailed CMO reports for each case have been simplified in the Appendix 2.

These reports were coupled with textual analysis of each individual interview. The textual analysis identified repetitive or common thematic areas and related these back to contexts, mechanisms and outcomes according to the CMO framework. Illustrative quotes were selected to demonstrate these common thematic areas.

2.5. Limitations of the study

The study was limited by a number of constraints. Firstly, this study aimed to inform the FCFA programme in the design and delivery of its SCD strategy. This influenced the study methodology at various points:

- The choice of past SCD programmes for evaluation to roughly fit the scale and objectives of FCFA and ensure transferable lessons
- The decision to focus the inquiry largely at the individual scale and individual-institution interface, and to a lesser extent the systemic scale,
- Including input from FCFA affiliated researchers on their needs and priorities
- Address the primary objective of the FCFA SCD strategy, namely, the improved ability of emerging African scientists and institutions to deliver high quality research and maximise research uptake to advance the frontiers of effective regional responses to climate variability and change.

The study increasingly focused on SCD for early career researchers, as this was seen as an area where greater impact is possible. The institutional level increasingly emerged later as an important area of enquiry for capacity development in Africa, but was not examined as a core focus on the study. Furthermore, as the study was designed to inform the FCFA programme's SCD activities, more informal mechanisms for developing capacity (such as experiential learning or informal supra-institutional support networks), although considered, were not focused on in detail.

Methodologically, the study was primarily qualitative, relying on recall and self-assessment from those interviewed or surveyed. There were also some limitations from online searches, as there is likely a limited availability of online content for very short term and informal SCD activities, which have likely not been captured (and thus not considered).

It is also worth mentioning that the study did not evaluate SCD activities against all of their own objectives. For example, the ACCESS Global Change Scholars programme had a strong objective to national transformation in South African academia with climate change as one of several global change thematic areas; whereas the ACCFP had the specific objective to develop capacity for climate science research into use in Africa.

These limitations are considered again in the final chapter of this report. The findings from the above mentioned components are detailed in the four chapters that follow.

3. FINDINGS

3.1. Guiding concepts and principles: findings from the literature review

The literature review emphasised several key long-running themes and educational theories which are important for climate change research and capacity development. These are summarised here.

Competencies and skills in an interdisciplinary field:
Climate change is a multi-faceted area of research, encompassing physical or Earth system science (of which meteorology is only a part) as well as fields necessary to understand vulnerability, impacts, mitigation and adaptation (drawing from the biophysical, as well as social, economic, engineering and other sciences). Climate change has the potential to cause catastrophic impacts, often in geographical areas and communities that have contributed little to the problem. Consequently, these impacts require urgent, accurate and diplomatic responses.

This multi-faceted area of study requires specialised skills and interdisciplinary competencies. Climate change research also requires the ability to work closely with peers from different disciplines and to situate research within the broader climate change context including inter alia the latest science, policy and governance. Wiek et al (2011) reviewed the competencies necessary for sustainability research and their associated concepts and methodologies (see Box 1 for detailed explanations). Their review offers a good model that can be applied to climate change science and research.

Box 1: Competencies and associated concepts and methodologies for sustainability research and problem solving, identified by Wiek et al (2011):

Systems-thinking competency includes an understanding of representative concepts such as variables/ indicators, subsystems, feedback loops, tipping points, multiple scales, people and social systems (including values, perceptions, power). Examples of methodologies employing these concepts include qualitative and quantitative modelling, institutional analysis, systems multi-methodologies and participatory systems approaches (Porter and Córdoba 2009; Crofton 2000; Sterling 1996).

Anticipatory competency includes the representative concepts of time (temporal phases, terms, states, and continuity), uncertainty, inertia, non-interventions, plausibility, risk and precaution. Examples of methodologies include scenarios, forecasting from statistical and simulation models, backcasting, participatory anticipatory methods (Major et al. 2001; Withycombe and Wiek 2010; de Haan, 2006; Grunwald 2007).

Normative competency includes the representative concepts of goals, targets, justice, fairness, harm, trade-offs and ethics. Examples of methodologies include risk analysis, and envisioning methods. (Gibson 2006; Sterling 1996; Grunwald 2004).

Strategic competency includes an understanding of representative concepts of intentionality, transformation, strategies, adaptation and mitigation, obstacles, alliances, and social learning. Examples of methodologies include planning methodologies, decision support, transition management tools, and support for behavioural change. (Bammer 2005; de Haan, 2006; Grunwald 2004).

Box 1 continued

Interpersonal competency includes an understanding of representative concepts such as types of collaboration, team strengths and weaknesses, leadership, limits of cooperation, solidarity and ethnocentrism. Methodologies include mediation, constructive conflict methods, teamwork. (Crofton 2000; Kearins and Springett 2003; de Haan, 2006).

These interdisciplinary competencies also relate to the frequently proposed need to co-produce climate change research, so as to make it relevant to policy and practice, and to enhance research into use and impact. Knowledge co-production can be achieved by iteratively involving multiple relevant stakeholders, including policy- and decision-makers, boundary organisations, private sector institutions, and vulnerable communities. This multi-actor engagement process in knowledge co-production is necessary to identify situated pathways that can drive positive, transformative change. A thorough understanding of stakeholder needs supports the researcher to: i) ensure the relevancy of research questions; ii) situate research geographically; and iii) promote research uptake and in turn support change in attitudes, actions and/or social practices.

Drivers and research gaps:

There is a diversity of factors across the African continent that can shape the research capacity development needs of individuals, institutions or regions. These include i) historical impacts such as the education and trade policies of different colonial powers, or the legacy of structural adjustment programmes; ii) differing states of infrastructure and access to ICT; iii) differing economic priorities and socio-political conditions; and iv) differing climate zones and drivers, to name a few key areas. Broadly speaking, there are some common trends influencing the context of climate science capacity development in Africa, such as a reliance on international donor funding for research, which affects research priorities, and often have little continuation from one project to the next. A comprehensive mapping study for the Southern African Regional Universities Association (SARUA) is a useful reference for identifying context-specific climate change capacity needs in southern Africa. The SARUA Mapping Study (SARUA 2014) identifies country-specific contexts, climate knowledge and research gaps, and individual and institutional capacity gaps in southern Africa.

Conway (2011) provides another useful reference for identifying climate change research and capacity gaps in Africa. These gaps include: i) generally low scientific understanding of the drivers of Africa's high climate variability, coupled with generally low research capacity; ii) a need for greater interaction with users of seasonal forecasts; iii) high levels of uncertainty for future rainfall in regions where remote influences are poorly resolved in global models; iv) low (but increasing) coupling of impacts research with adaptation, referring to climate-society relationships and engaging with decision makers; v) low data availability and high background variability hampering efforts to show evidence for anthropogenic ocean warming affecting regional rainfall.

Scales and knowledge value chains:

There are a number of scales and processes which SCD in Africa occurs through. Capacity development is generally considered to be driven at three levels: the individual, institutional and broader system (ODI, 2006; DfID, 2010). Each of these levels has its own properties and considerations, forming a typology of often inter-related activities that develop capacity. For instance, capacity development targeted at the level of the individual usually takes the form of discrete activities of a short duration (anything from a day to a few years). Individual-level capacity accumulates over time, with reflexive application and ongoing exposure over a lifetime or career trajectory. Building system capacity is a long-term endeavour requiring buy-in from multiple institutions, but it is also dependent on high quality individual capacity development. Table 3 summarises examples of types of activities associated with the three levels, associated durations and key factors that influence the outcomes.

Table 3: Scientific capacity development (SCD) Typology oriented around three-levels

	Duration and examples of types of activities that develop capacity at this level	Key factors that can influence outcomes at this level
INDIVIDUAL	• Very short term (days - weeks): Workshops, seminars, conferences, summer/ winter schools and short courses, online courses. • Short term (3 months - 1 year): Exchanges, secondments, coursework - Masters level, honours (where available), short fellowships. • Medium term (1 – 3 years): Research Masters-level, PhD programmes, post-Doctoral positions, fellowships. • Long term (3+ years): Multi-year research programmes / partnerships containing range of SCD opportunities, full time employment, and tenured positions.	• The extent to which the activity has an explicit or implicit skills development component. • The degree of focus on knowledge generation vs. knowledge-into-use. • The degree of disciplinary vs. interdisciplinary competency focus.
INSTITUTIONAL	• Medium term (1 – 3 years): Fellowship programmes, community of practice, cross-institutional working groups (fora, seminars), partnerships between established and emerging centres of excellence, mentorships. • Long term (3+ years): Research unit / centre / school, centres of excellence, master's programmes, PhD training schools, research networks.	• The degree to which multiple institutions across the science-policy-practice knowledge chain are involved. • The extent to which research questions were formed (or influenced) by external or foreign parties. • The degree to which activities relate to and build on from previous or new activities. • The degree to which activities build the legacy and autonomy of the institution.
ENABLING SYSTEM	• Long term (3+ years): Partnerships between regional/ international funding agents, national funding aims and scope, cross-sectoral networks and consortia, long-term donor priorities, national education policies, research programmes and research infrastructure development.	• The extent to which there is collaboration and coordination of efforts amongst funders. • The degree of reliance on international partnerships and funding. • The extent to which incentive structures support or impose on research agendas.

Developing capacity for climate change sciences is more challenging as it needs to take into account the 'knowledge value chain', to ensure research is used effectively. Taking the knowledge value chain into consideration means being aware of how new knowledge is created, how it is transferred and translated, and how it is used and applied by different groups of people, with different purposes. It is important to be aware of the full knowledge value chain or continuum and the point along this chain that SCD is targeting, as each point requires specific skills or competencies.

Furthermore, climate change is a 'new and emergent' global field – related knowledge and related expertise requirements therefore develop and change rapidly. This is challenging in an African context, which is generally characterised by: i) weak institutional capacity for climate change science, ii) insufficient 'critical mass' but rather 'pockets' of expertise, and iii) relatively few dedicated, formal learning programmes for climate change. Learning pathways are often ad hoc in this context across a career trajectory. Short-term SCD initiatives emerge to fill knowledge or capacity gaps, but further attention is needed to promote longer-term institutionalisation of capacity development in line with emerging climate change knowledge. SCD will require support and enabling conditions at both the institutional and broader system levels to have substantive impact over a longer period of time.

Database and case studies:

As part of the literature review, a database of SCD initiatives and activities occurring in and relevant to climate change in Africa was compiled. Compiling the database indicated that i) there is very little formal M&E on SCD initiatives available; ii) there were few activities longer than a month, less than a year (very few online courses, few exchanges or secondments); iii) about half of SCD activities identified had an implementing organisation outside of Africa (mainly from Europe, Britain and America); iv) that the majority of SCD activities have occurred via fellowships, short courses and training workshops.

Furthermore, as part of the literature review, twelve SCD initiatives were reviewed in detail as case studies (Table 4).

Table 4: Overview of the twelve case studies reviewed as part of the literature review

	SCD Type, Context / Value chain	Organiser	Duration	County/ region
FORMAL DEVELOPMENT	**Undergraduate**, multi-university	ACCESS Habitable Planet	Very-short term	South Africa
	Comprehensive **graduate programme**, multi-university	WASCAL	Medium term	Multiple African Headquartered in Ghana
	European-based, course-work **Masters programme**	University of Sussex	Short term	UK
	European-based and focused **Doctoral training** in a research network	LINC	Long term	Europe
	Fellowship programme and exchanges, multi-national	ACCFP	Medium/ long term	Multiple African. Headquartered in Dar es Salaam
USER OR ON-THE-JOB SUPPORT	**In-project skill-building** of researchers within a donor-funded programme	AIACC	Medium term	Global
	On-the-job training for climate service practitioner	ACMAD	Short term	Niamey, Niger
	Winter school for mid-career practitioners	CSAG	Very short-term	South Africa
	User/decision-maker workshops	CIRDA	Very short term	Multiple African
	Multi-national **Community of Practice**	AgMIP	Medium/ long-term	Global
	In-project training by external expert institution	ICPAC	Very short term	Multiple African
	Online **E-learning** courses	WBI e-institute	Very short to short term	Online

The case studies captured the SCD's various properties in terms of course content or focus, structure, level of multi-stakeholder engagement, input mechanisms, successes and barriers to success.

None of these case studies provided a fully comprehensive example of SCD that should be replicated as best practice, however each had merits and lessons, and many were examples of excellent SCD initiatives. The case studies that were reviewed helped to inform the study's sampling choices for in-depth interviews in Phase 2[3].

3.2. Developing competencies across a career in climate change: findings from the online survey

As the previous chapter discussed, the competencies of a climate scientist and the manner in which these are developed across a person's career emerged as important areas of enquiry from the literature review. In order to better understand the competencies that climate scientists in Africa need across their career, and the activities that develop these competencies, an online survey was circulated among senior climate change scientists and practitioners in Africa. Survey respondents had different areas of specialism within the broad field of climate change, which they defined by selecting from a list broken down between climate modellers and forecasters, and experts in adaptation, mitigation, advocacy or policy. Where feasible (due to the small sample size) and appropriate, the 43 responses are split between those who described themselves as adaptation experts (25 respondents) and those that described themselves as modellers (28 respondents), to try to distinguish different patterns of expertise, competencies and related SCD activities between different specialisms. As respondents were able to select multiple categories, there was a degree of overlap.

The majority of respondents, irrespective of career specialism, were from university settings (63%), and described themselves as researchers or generators of knowledge. Most respondents, irrespective of specialism, had obtained a PhD (86%). This points to climate change SCD being oriented to a 'high skills level'.

The survey asked respondents to indicate how useful each of the following interdisciplinary competencies is to their work: Systems-thinking, Anticipatory, Normative, Strategic, and Interpersonal (taken from Wiek et al, 2011; see Box 2 above). The questions included a short explanatory description of each competency. Respondents could rate these as 'Not useful at all', 'Rarely useful', 'Occasionally useful', 'Frequently useful', or 'Always useful'. Their responses were weighted accordingly (0 – 4, with 'Always useful' weighted as 4). The questions also asked what specific activities had been most successful in developing these competencies.

With regards to interdisciplinary competencies, interpersonal competencies were weighted the highest within both the adaptation and modelling groups. Generally, interdisciplinary competencies were weighted as more useful to adaptation experts than to modellers/forecasters, with the exception of anticipatory competencies (Table 5).

Table 5: Usefulness of different interdisciplinary competencies, shown as averages based on rating scale (0 = Not useful at all; 4 = Always useful)

	Systems-thinking	Anticipatory	Normative	Strategic	Interpersonal
Adaptation	3.2	2.3	2.3	2.3	3.5
Modellers	2.5	2.8	1.3	1.3	3.1

3 The full literature review (including the case study reviews) is available as a separate report on request.

SCD activities that were considered most important for developing interdisciplinary skills were: self-tuition, experiential, on-the-job and learnings, as well as PhD, workshop and academic conferences (Figure 3). The value of self-tuition and experiential or on-the-job training were reiterated in the comments section of the survey, supporting these findings.

This may be because the competencies are also closely related to application or a form of applied competency. Notable is the way in which PhD training and academic conferences (i.e. the academic sphere) are suggested to assist with anticipatory and systems-thinking competency, which are essential and specialised competencies for climate sciences. A greater balance of competencies is shown to have been developed via on-the-job, experiential and self-tuition forms of learning in the workplace. Interesting too is the high level of normative competency developed at Masters level, perhaps leading to a choice to specialise in climate science at PhD level, which is a normatively driven science. The Wiek et al. competency framework (2011), on which this question was based, is set up as an integrative, process-oriented framework. This shows up within the field of practice, where a more balanced set of competencies are required for sustainability science (including climate sciences) (Wiek et al, 2011).

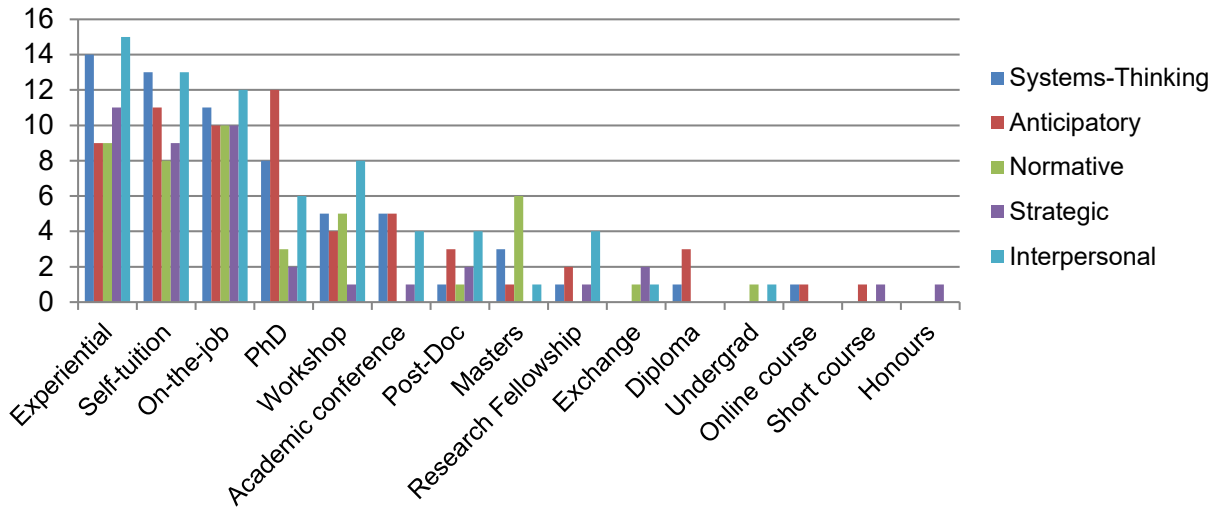

Figure 3 Scientific Capacity Development (SCD) activities that develop interdisciplinary competencies.

Respondents were asked to list specialised or technical skills that have been useful in their careers. These skills included inter alia: i) the ability to use particular software or programs, programming, data processing, statistical analysis; ii) particular methodologies; iii) knowledge of specific theoretical concepts, or processes; and iv) knowledge of geographical areas.

Similar to the patterns seen with interdisciplinary competencies, SCD activities that were important for developing specific, specialised skills were: i) self-tuition; ii) on-the-job or experiential learnings; and iii) PhD and Masters programs (Figure 4). These results reflect the arena of SCD specialisation that characterises the climate sciences. They also reflect areas where specialised competency development is heightened.

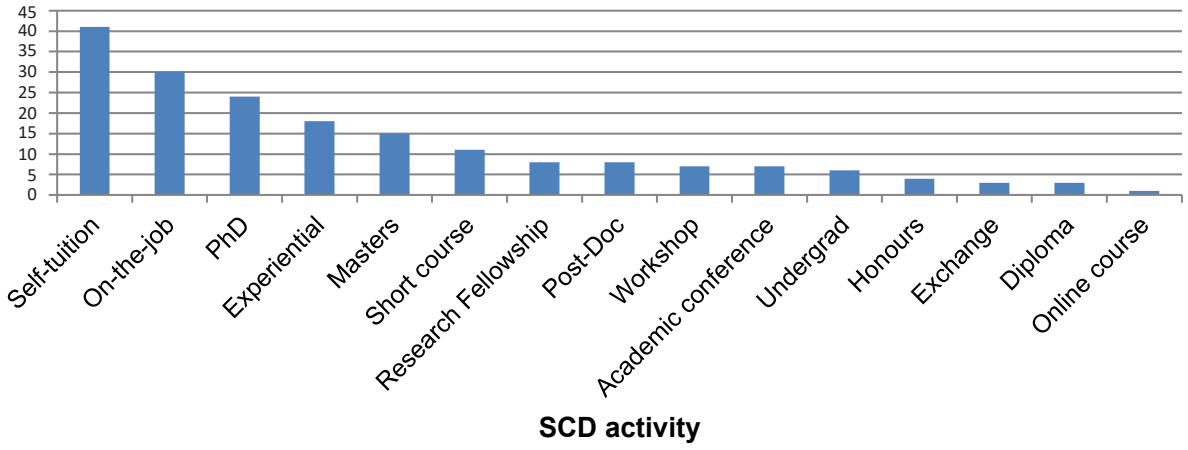

Figure 4 Scientific Capacity Development (SCD) activities that developed specialised skills.

The finding that self-tuition, on-the-job and experiential learnings are important SCD processes raises the question of whether flexibility and autonomy (to identify skill-gaps and self-teach at critical times when the skill is needed) are important aspects for SCD. Alternatively, this finding could indicate that there are insufficient formal, structured SCD activities (such as short courses, exchanges) that would have been more effective or preferred (over self-tuition, experiential learning) had they been available.

Of interest is that few participants are developing their competencies via on-line and distance courses. The database indicates that this may be because there are few online courses which may be linked to the relatively limited availability or access to computers and internet on the continent, compared with other regions. Alternatively, the low reported value of online courses towards developing competency may be as the survey targeted senior researchers, and the availability of online courses might have been even more limited in previous decades, in the early stages of their careers.

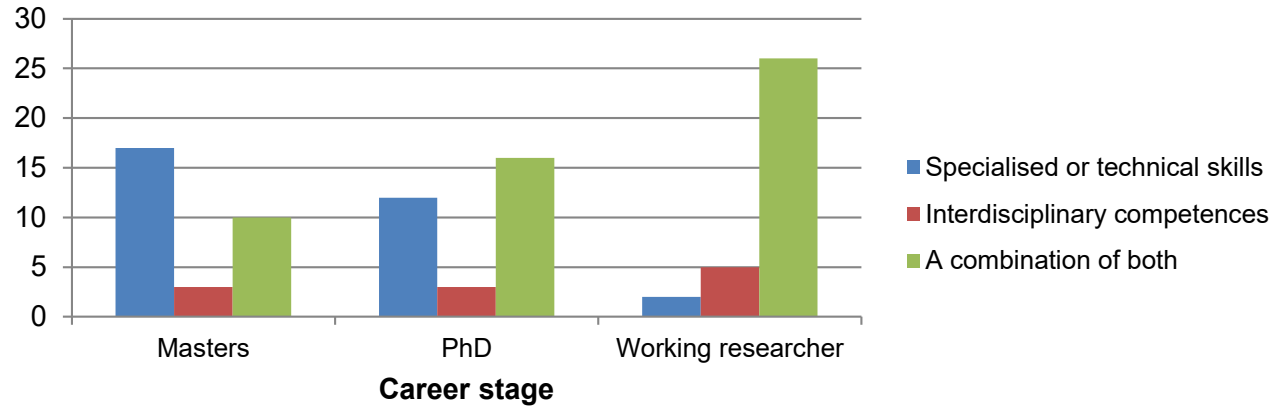

Figure 5 Competencies used at different stages in career development.

Respondents were asked whether interdisciplinary or technical competencies – or a combination of both – were most valuable during a Masters or PhD, and as a working researcher. There was a mix of responses to this question. However, participants clearly felt that having a combination of both sets of competencies (i.e. interdisciplinary together with technical competencies) was most important to them once they became working researchers, compared to during their formal studies (Figure 5). This is perhaps an indication that formal postgraduate training tends to be more focussed within a single-discipline or isolated specialism. However, as one transitions from a specific discipline into a working role, there was as strong shift towards a need to be able to work in an interdisciplinary setting, while still maintaining a degree of specialisation and ability to apply one's technical skills.

The last open-ended questions in the survey asked whether respondents had any comments on skills gaps or important events, circumstances or people that impacted their careers. Common themes in these comments included a desire for career or skill development guidance and being able to anticipate the training that one would need, and the value of collaboration, interactions, guidance and exchanges with peers and superiors. A sample of these comments is given below:

> *"At PhD and Post-doc, there was little support for skills development, and it would have been nice to have a structured career development programme."*
>
> *"[T]here is always a component of self-learning that is essential to advance."*
>
> *"Individuals who challenge rather than simply instruct. Individuals and opportunities that maximise experiential learning."*
>
> *"Much … was self-taught, but I have had good mentors through much of the time."*
>
> *"The international scientific community especially collaborators at different stages in my career development."*
>
> *"Interactions with leading thinkers in my areas of research — opportunities to learn and be mentored by them, to be enthused to be a researcher."*

Significance for the study

The survey thus validated several key findings and conclusions from the literature review, such as:

- Interdisciplinary competencies are valuable to climate change researchers and practitioners.
- Climate scientists require a combination of both specialised competencies as well as interdisciplinary competencies.
- Having the room to apply or practice lessons (i.e. experiential and on-the-job learning, self-tuition) is important and valuable for developing skills and capacity and for application and use of scientific knowledge and skills.
- The value of these applied types of learning (i.e. experiential and on-the-job learning, self-tuition) may be indicative of a lack of formal pathways for SCD, forcing an ability to learn on an ad hoc basis, or as the need arises.
- Adaptation experts generally make more use of interdisciplinary competencies, with the exception of anticipatory competencies (concepts such as temporal phases, uncertainty, risk, plausibility) which are more important for modellers.
- The higher value of interpersonal competencies could be a reflection of the multidisciplinary research environment, and the value of knowledge co-production and stakeholder engagement in climate change research.
- The study also pointed to absences or a lack of efficacy of certain approaches to SCD such as online learning and exchange programmes, possibly because there are few opportunities for these types of activities.

3.3. Factors influencing outcomes: findings from SCD in-depth interviews

Having explored competencies and learning pathways, the study sought to better understand the specific mechanisms, approaches or practices that develop scientific capacity in Africa (or conversely, the factors that could act as barriers to capacity development).

In order to evaluate the success or failings of different SCD practices in Africa, six SCD activities or programmes were analysed in detail through in-depth interviews. These six SCD cases were as follows:

- The ACCESS Global Change Scholars (GCS) Programme: The Applied Centre for Climate and Earth System Science (ACCESS) is a consortium of several agencies, universities and research groups who have aligned to the South Africa Department of Science and Technology's (DST) Global Change Grand Challenge (GCGC). Part of ACCESS's Global Change Scholar's programme is an instrument for funding post-graduate bursaries within set themes.
- The African Climate Change Fellowship Programme (ACCFP) is an integrative fellowship program for African professionals, researchers, teachers and students to engage in climate change adaptation research, active since 2008.
- Assessments of Impacts and Adaptations to Climate Change (AIACC) was a global research initiative to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. AIACC had a parallel SCD process that supported researchers on the projects. AIACC supported 24 regional study teams, including eight throughout Africa. AIACC was implemented from 2004-2007.
- The Climate Systems Analysis Group (CSAG) Winter School at the University of Cape Town (UCT) is an annual 2-week winter school on decision making under uncertainty (in the context of climate change).
- The Agricultural Model Intercomparison and Improvement Project (AgMIP) is a major international effort linking the climate, crop, and economic modelling communities to produce improved crop and economic models. In its first Phase (2010 - 2014), AgMIP hosted a series of workshops for its African teams.
- The Africa Climate Science Research Partnership (CSRP), was a partnership programme funded by the British Department for International Development (DfID) and implemented by the Met Office Hadley Centre. Phase one (CSRP-1) was a 3-year programme focusing on improved African climate modelling and prediction on monthly-to-decadal timescales. Part of CSRP-1 included 11 fellowships to African scholars and practitioners.
- In addition, one interview (a pilot) from the International Centre for Theoretical Physics (ICPT) was included in the analysis. ICPT co-sponsors a PhD programme with the University of Trieste and the Italian National Institute of Oceanography and Experimental Geophysics (OGS) on Earth Science and Fluid Mechanics. This last interview is not included in the graphs below (Figures 6 - 9) as it is not necessarily indicative of the programme as a whole, but was still considered in the analysis when listing total figures.

The interviews demonstrated how small the community of climate change researchers and SCD organising institutions is; some interviewees had benefited from SCD supported from more than one of the above programmes and some institutions were involved in several of the above programmes. The size of this community points to the opportunities for improved supportive interactions and collaboration.

Participants largely came from natural science (geography, hydrology, agriscience and particularly meteorology) backgrounds, and made the shift towards climate change through their own interest and commitment, and through fortuitous opportunities (such as participation in the assessed SCD cases). Positively, all participants reported their careers (or formal post-graduate studies) had progressed since taking part in the different SCD cases, and most had remained with the field of climate change research, policy or practice (26 out of 28). Many participants (22 out of 28), as illustrated by the comment of an ACCFP participant below, attributed progress in their careers specifically to the SCD case concerned:

> *"When the history of my career is written, ACCFP will be seen as a propeller for my career… ACCFP has been a programme that defined my career and has given me an edge."*

Context, Mechanisms, and Outcomes amongst participants:

Given the diversity of aims and objectives of each of the six initiatives, the analysis attempts to draw out generalisable factors relating to contexts and mechanisms that may contribute towards positive outcomes. In the section that follows textual analysis was applied to the participant interviews to identify the most common themes driving individual-level outcomes. In the stacked graphs below, the weight of participants reporting a context or mechanism has been adjusted according to the total number of participants interviewed from that case; i.e. '1' indicates that all participants from the SCD case reported a context or mechanism.

As mentioned, participants interviewed came mostly from natural sciences backgrounds, with a large proportion of these coming from meteorological sciences compared to other the natural sciences (geography, hydrology, marine biology) (Figure 6). At the time of being interviewed, most participants' careers were at mid- or advanced career stage, and the majority were in academic or research positions. ACCESS GCS participants were predominantly still in studies or in early career, whereas all AIACC participants interviewed were in advanced career stages. The different stages of participants' careers is important to keep in mind when considering how these groups valued different mechanisms for capacity development.

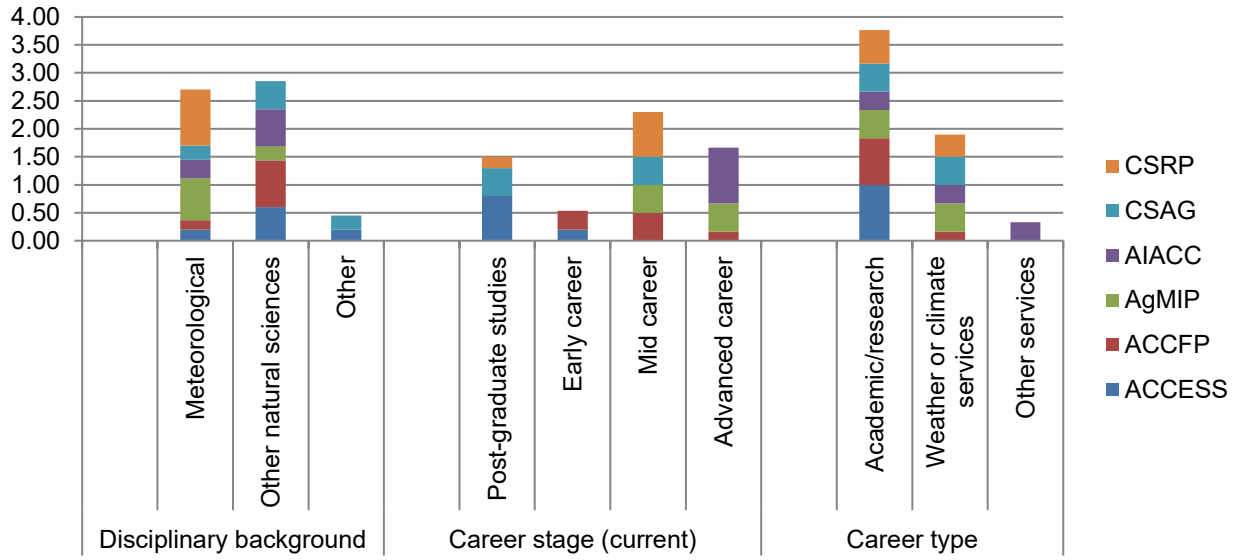

Figure 6 Disciplinary backgrounds and current career stage and type

Textual analysis of the participant interviews revealed several common contextual factors that influenced their participation in the SCD activity concerned. These contained a mix of personal (i.e. individual-level) contexts, institutional-level and broader contexts (Figure 7).

Individual-level contexts included personal time or funding constraints, their access to internet and adequate computers, analytical or technical skills gaps and the inability to speak English well, to a lesser degree. Institutional contexts included the institution's administrative processes (most often fund transfers), and the length of time that the activity ran for. For those working in weather service, the availability of data was a challenging contextual factor to their current work.

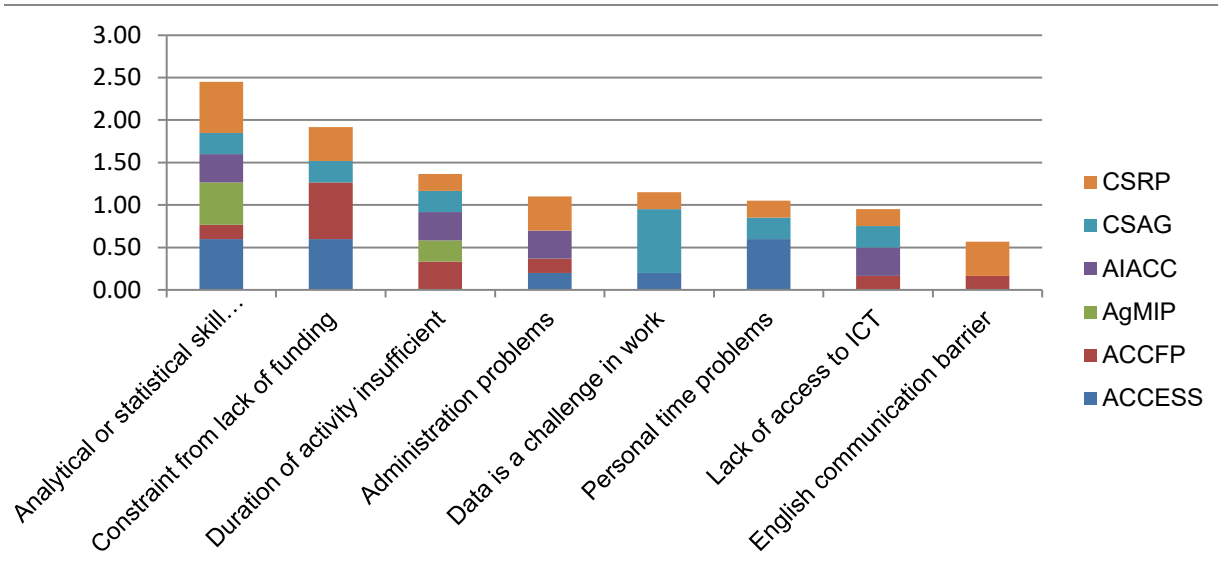

Figure 7 Common contextual factors affecting the reasons participants undertook a particular SCD, and affecting the quality and learning outcomes of the SCD

Textual analysis of the participant interviews also demonstrated a number of mechanisms that participants valued (Figure 8). Value was ascribed to these different mechanisms either by noting the positive role that the mechanism played or through the participant's opinion that had there been such a component, the outcomes of the SCD activity would have been better.

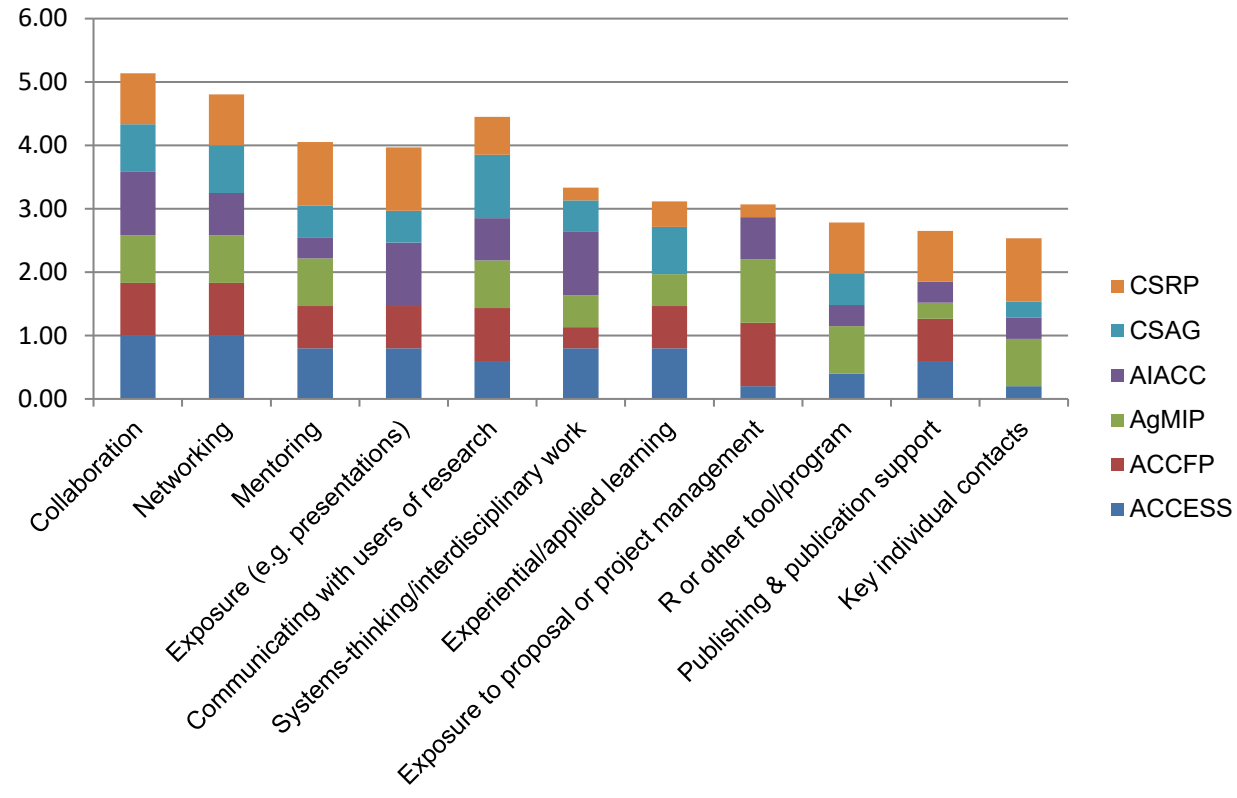

Figure 8 Most common mechanisms valued by participants affecting the quality and learning outcomes of the SCD

The most common mechanisms that participants valued included i) mentoring, ii) networking (with both peers and key contacts), iii) presenting, publishing and communicating their work, iv) technical, analytical tools, v) collaborating, vi) having a broad systems or interdisciplinary perspective, vii) proposal-writing or project management, viii) having the room to apply their skills.

As mentioned above, the participant interviews showed that most people (26 out of 28) had remained and progressed within a climate change-related career path. A high number of these (21) attributed their career development to the SCD activity concerned, either in part or claiming a significant impact.

There were a few other frequent outcomes against which the contextual factors and mechanisms of an activity were compared against. These included i) the publications produced with a link to the participant's participation in the SCD activity, ii) their involvement in the scientific community through collaboration in new research, iii) their improved skills, both interdisciplinary or technical.

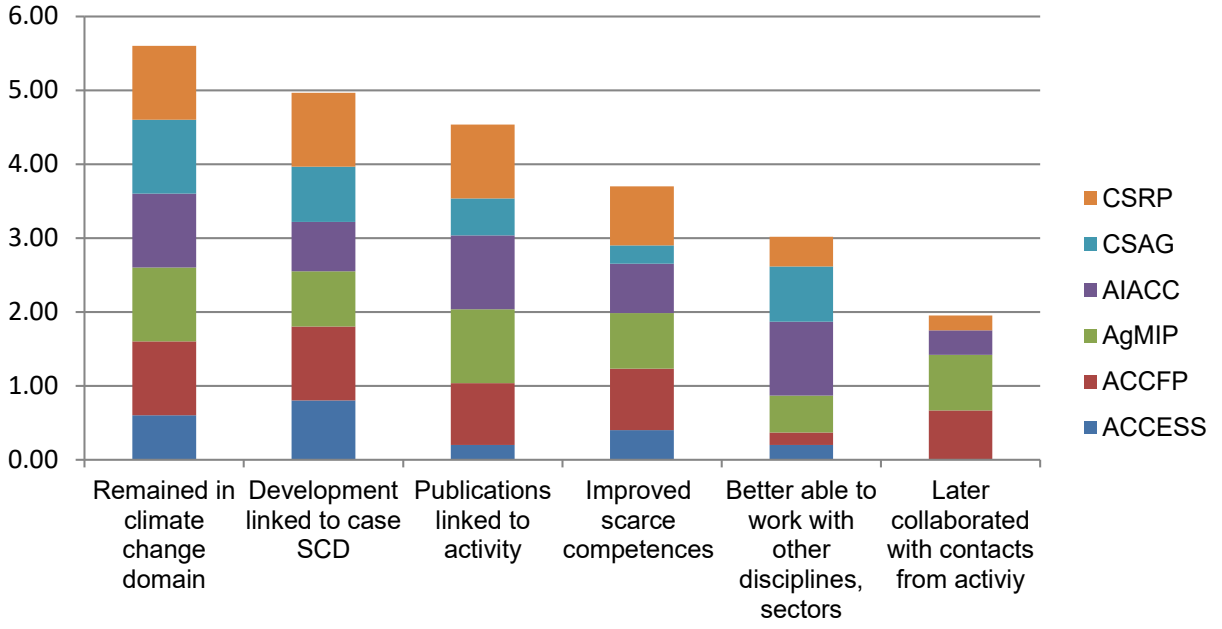

Figure 9 Outcomes at the individual level from different SCD activities

The textual analyses of the participant interviews were used to supplement CMO evaluation reports made for each SCD case. These CMO reports are summarised in the next section, before the key findings from the interviews are looked at in detail.

Context-Mechanisms-Outcomes Evaluations of SCD cases

The context, mechanisms and outcomes (CMO) for each SCD case activity is summarised in Appendix 2; these are in turn derived from more detailed CMO-based summary reports from each set of interviews. The CMO reports were informed by the participant interviews, organiser interviews and online content and reports.

These CMO reports, combined with the analyses from the individual participant interviews above, can be distilled into some key lessons on the contexts and mechanisms that contribute towards experiences, events and outcomes.

The lessons are shown in bold for emphasis in the table below (Table 6), so that we can start to see common or related trends. These common or related trends are then listed as enabling factors in the adjacent column, noting that there is some degree of overlap in many cases (for example, tailoring courseware can relate to an integrative, reflective approach, but it can also be a way to allow participants the autonomy to pursue their own interests).

Table 6 CMO lessons from the six SCD cases and associated common enabling factors

SCD Case	CMO lessons	Enabling factors
ACCESS GCS	Demonstrates the need for sufficient funding and coordination to drive an initiative, in this case the available funding covered bursaries and a few support activities Student experience can be restricted by time and travel costs Demonstrates the need for institutional collaboration, not competitiveness From the participant's perspective, demonstrates the need for mentoring and platforms for dissemination and engagement	Adequate funding Adequate human resources Collaboration Supportive academic- professional interactions Supportive platforms for communication
ACCFP	Demonstrates the mutual benefits of on-going communication and follow up engagement, for the institution and individual (ongoing connections established; improved delivery of service) Benefits of wide south-south institutional partnerships, possibly influencing strong positive outcome of confidence amongst ECRs and institutional gains Strong vision and objectives from dialogue and planning between START and IDRC; continual strong leadership Well-resourced for coordination of additional program of activities and ongoing engagement	Adequate funding Adequate human resources Collaboration Supportive platforms for communication Autonomy to practice or pursue opportunity
AIACC	Demonstrates the value of good leadership and supportive structures; the importance of communication, sense of common goal, networking (and other support activities) Demonstrates the value of flexibility: in setting own research questions and in research design (flexibility to adjust with new information or feedback) Inclusion of multiple SCD elements; strong communication focus (e.g. collaboration, writing workshops, 'working series' publication mechanisms for high publication outputs.	Adequate human resources Collaboration Supportive platforms for communication Autonomy to practice or pursue opportunity Supportive academic- professional interactions

AgMIP workshop	Demonstrates how sequencing of very short-term activities (such as workshops) is important, with improvements made over time; the importance of co-producing workshop content/run-up & run-down engagement Technical skills learnt at the workshop (R, MatLab) were reported favourably by participants who found these useful; more substantial career impact and change was driven through involvement in AgMIP program as a whole. Demonstrates the value/benefits/ importance of networking with peers and key contacts/experts	Collaboration Integrative reflexive approaches Adequate technical skills Supportive academic- professional interactions
CSAG Winter School	Demonstrates the benefit of engaging with practical / on-the-ground issues and organisations; of understanding climate information users' needs Demonstrates the benefits of co-design / tailoring content High demand for climate change capacity development amongst early and mid-career scientists and practitioners	Adequate human resources Integrative reflexive approaches Autonomy to practice or pursue opportunity
CSRP Fellowships	Demonstrates the importance and substantial benefits of close mentoring across full research process, combined with other opportunities (exchanges, conferences); publication output reduced without extended support Demonstrates value of flexibility (responding to fellows' technical/analytical skill needs) Demonstrates the challenges of high transaction costs and unexpected administrative/coordination burdens. Linked to this, the challenges of incentivising user / external institutions	Supportive academic- professional interactions Autonomy to pursue opportunity Integrative reflexive approaches Adequate technical skills

Through using the CMO evaluation framework, it appeared that there was often a blurring of the lines between 'context' and 'mechanisms'. It may be better to think of a series of initiation, design and process 'factors' that can drive or enable positive outcomes. By grouping the contexts and mechanisms in bold in the table above (Table 6), a number of key factors emerged, some of which may be pre-existing (such as the amount of resources available to an initiative), and others may be more process-based (though often constrained or defined by pre-existing factors).

It is perhaps better to consider these key factors as interacting on a context-mechanism continuum, as demonstrated in the table below (Table 7) where one factor is often dependent on or facilitated by another (e.g. the availability of human resources may be dependent on the availability of funding; collaboration may be facilitated by effective, supportive platforms for communication).

Table 7 Contextual and mechanism-related factors with descriptions

Contextual to mechanism	Factor	Description
Context ↕ Mechanism	Adequate funding	Without suitable personal funding, individual development pathways can be constrained; institutional shortages can constrain the scope or effectiveness of activities
	Adequate human resources available	At the institutional level, management or coordination of funds and activities, contracting, procurement, reporting, logistics; expertise present and available (i.e. time). At the individual level, personal time management
	Adequate infrastructural, data availability and/or computational capacity	Computing resources or internet available at the institutional or systems (regional) level. At the systems level, data and climate information systems are functional
	Adequate technical and analytical skills	At the individual level, an existing 'base' of technical or disciplinary skills, particularly analytical skills, on which the SCD can build
	Supportive platforms for communication	Tools and channels that enable relevant information to transfer reflexively between relevant participants and stakeholders
	Supportive academic-professional interactions	Peer-to-peer, professional networks or senior supervision or mentoring, to guide, soundboard, challenge or collaborate.
	Ethic of collaboration	Commitment and value at the individual and institutional level for collaboration between peers, cross-disciplines, cross-institutions and/or cross-border.
	Integrative reflexive approaches	Involving participants and/or stakeholders across the full research or capacity development process
	Autonomy to practice or pursue opportunity	At the individual level, room to apply or practice skills, build confidence and address own skill shortages. At the institutional level, capacity to pursue new areas and create legacy

Each of these factors is explored and substantiated in more detail in the section that follows.

The main differences in outcomes were often closely aligned to the theory of change (or original objectives and target participants) of the SCD organisers. As one might assume, it was often the case that an SCD initiative's gains and success were tied to larger budgets and longer-term projects, but this was not always the case and some shorter-term, resource-constrained initiatives proved very successful in achieving their aims.

Across the different cases, it appears that the strong gains are especially possible by long-standing programs (e.g. CSAG Winter School and ACCFP, which have been running for seven and eight years respectively) that are able to learn from past experiences and continually refine their content to better suit the needs of their participants, who in turn also benefit from the renown or legacy of the institution. To counter a lack of experience (in delivering a particular SCD activity) it is clear that newly established programmes and once-off events would benefit from more intensive planning, consultation with participants, flexibility and a review of the experiences and lessons of similar past initiatives. This supports the importance of adopting a reflexive approach to any SCD initiative, a factor that also emerged as important in the literature review.

It is clear that careful planning and alignment is necessary with regards to the individual's and institution's needs and objectives, to maximise potential outcomes at both levels.

Contextual and Mechanism-related Enabling Factors

Adequacy of Resource Allocation and Management

At the individual level, personal educational development is strongly linked to socio-economic factors. This was demonstrated in the interviews where 12 of the 28 participants mentioned how they would have been constrained from continuing their formal development or studies if funding had not been available. The restrictions funders imposed on the use of funds could also be frustrating for participants; for example, CSRP fellowship funds could not be used to pay tuition fees.

Box 2: Challenges on resource (time, funding, human resources) allocation or management

"The coordination of the whole thing is a big overhead… we probably underestimated the amount of administration overhead that comes with it. The amount of resources needed to keep track and keep the admin up to date, checking upon the general welfare of the fellows, the contact between fellow and mentor is going well and arranging the payments. It's all time consuming." [CSRP fellowship organiser]

"More money: funding for operations so we can have proper staff as well as funding for bursaries." [ACCESS GCS organiser]

"The ACCESS secretariat is too small for the amount of work they need to do." [ACCESS GCS participant]

"Time is a constraint, because I am a PhD student." [CSAG Winter School participant]

"I needed a strong support from my supervisor, but they were also involved in other activities and projects." [ACCFP participant]

"It could have been a further six months to allow people who would like to engage in the programme". [ACCFP participant]

"The design itself was perfect but probably time was not enough for people who were being introduced to new tools for the first time." [AgMIP participant]

At the institutional level, aside from funding shortfalls placing limitations on the full scope of potential activities that an initiative can undertake (e.g. ACCESS GCS and CSRP Fellowships), a few programmes faced unexpected financial or logistical challenges. For example, coordinators from CSRP and ACCESS GCS respectively commented on having insufficient funds for the proper coordination of their program of activities. AgMIP organisers and ACCFP and ACCESS GCS participants experienced challenges or delays with the disbursement of funds, which could delay research or create unnecessary stress leading up to an event. This suggests that a balance needs to be struck between resourcing the number of participants in an activity and the activity itself; it appears that often, in satisfying funders about the number of programme graduates, the quality of the program may then suffer.

As with needing funding and human resources to manage or coordinate a programme of activities, individuals participating in SCD also need to commit time to the capacity development process itself. Individuals, especially students, often felt that they did not have enough time to take part in extra or additional SCD opportunities (e.g. three of the five ACCESS CSG participants). Similarly, some fellows from both CSRP and ACCFP were unable to meet the demands of their supervisors from their home and host institutions.

The suitability of the length of time of the SCD activity or programme also frequently came up in discussions with both participants and organisers. For example, some participants felt the CSAG Winter School (two weeks) could have been longer to include more actual computational programming (though this was not the objective or focus of the course). Both fellowships (ACCFP and CSRP) were generally seen as too short (six months and a year respectively). AIACC was a longer term program, but some participants still felt there was not enough time, given the number of people involved and the difficulties coordinating them.

Adequacy of Technical and Analytical Skills, Data Availability and Computing Capacity

In general, many participants noted their own gaps in technical skills causing a challenge or a barrier to their career progression at some point, particularly around statistical and analytical skills and tools (40% of participants). This was reiterated by organisers, such as for the CSRP fellowship programme, AgMIP and the ACCESS GCS programme, who all commented on the challenge posed by low standards of maths or statistics amongst participants. ACCESS GCS responds to this challenge through optional stats workshops, whereas CSRP included programming training as part of the fellows' one-month visit.

Not all of the cases included the development of specific technical skills. However, it is still worth noting how some tools, techniques and software packages came up independently or were emphasised as important by a number of interviewees across different cases. Although not an explicit or specific objective of the five-day workshop, the AgMIP workshop in Ghana trained participants in the use of the free statistical package R. Most of the participants interviewed from the workshop mentioned how useful R was to them. GrADs (Grid Analysis and Display System), another free analysis software, was mentioned by ACCESS GCS participants and the CSRP organiser, who was surprised at the level of competency for this software when there was not much familiarity with other common programming languages.

Linked to the challenges of technical and analytical skill shortages, the shortage of infrastructure or physical technical capacity for complex climate analysis was also cited. These technical shortages included limited computation power, internet and analytical tools or software.

These factors contribute to and are further constrained by shortfalls in data, technical capacity and climate information systems at a national or enabling systems-level. Across the different SCD cases, five interviewees, all working within national weather or meteorological services, described these as major challenges to their work.

Run-up activities, or staggered SCD activities (such as a series of workshops), appear to be important mechanisms for ensuring that skills are built up in an accumulative way. The lessons from the interviews indicate the need for careful evaluation of pre-existing skills of participants, and design of preparatory training so that participants can gain maximum benefit following the SCD activity.

Box 3: The benefits of specific technical skills and skill gaps, and infrastructural limitations

"From that workshop, I got very skilled in data analysis — screening the particulars of the data, and generating these scenarios… Before, I was using MATLAB and Excel to do analysis, but they showed us how to use R — which is free online — so I was free to use R for very large data sets." [AgMIP participant]

"I struggled a lot with some of the concepts in R and I know that ACCESS is now organising an R or stats short courses or workshop, and if that workshop was available… then I would've benefited a lot from that." [ACCESS GCS participant]

"Scientists working in the developed world would be expected to code quite complex things to do analytical tasks. We were aware that we would not come across that level of expertise in the fellows, but we really didn't have prior knowledge to what the level of technical expertise from the fellows would be. My impression was that it is quite low and it would be useful to get a general picture (in advance) of where that level lies." [CSRP fellowship organiser]

"It is much harder to find numerically competent students to recruit into numerically demanding positions… stats and maths are poor and that is why we are doing the statistics short course, there is enormous demand for it." [ACCESS GCS organiser]

"It took me a long time to get my PhD — when I went back to my country, I couldn't do any modelling or simulation. My department there doesn't have super computers…So I couldn't continue my work." [ICTP participant]

"If everyone had come with their data in the same format… if we had had a better ability to pre-screen out the annoying technical stuff so that we could really focus on the big picture… that would have been better." [AgMIP organiser]

"Mathematical analysis I had to learn on my own, and that was challenging. There was no computer when I was in school too, so that I had to learn on my own". [AIACC participant]

"In this kind of research and studying, we need good internet. Here it is a challenge to have a good quality internet to do studies." [CSAG Winter School participant]

"There was a challenge in getting station meteorological data. We need to validate our products from the climate data. ... If you don't have that station data, you can't know if your output from the climate model or your projection is good — that it is real." [AgMIP participant]

"[In my current work position] as senior researcher at the CSIR: since we've been using models that were developed outside of Africa, now we want to empower ourselves and develop our own model with help from international experts." [ACCESS GCS participant]

"The big challenge here is correcting climate data. In Mozambique we had war from 1970 until 1992, so many meteorological stations were closed because of war. In this period we don't have exact data, observed data, the ground data or climate parameters, so when we are trying to do some studying or some research, it is getting a little bit difficult because we don't have good data for this period." [CSAG participant]

"Most importantly, we need more climate data, improve skills around collecting and accessing data. Lots of data are scattered, these need to be merged." [CSRP fellow]

Supportive Platforms for Internal and External Communication

Communication platforms have both technological and human components – without people's coordination and involvement, the technological platform is generally not used. One of AIACC's and ACCFP's key driving mechanisms for success was their strong communication systems between participants and organisers. This helped form linkages between researchers, and fostered a sense of community and a shared objective.

Similarly, the AgMIP programme had to navigate the problem of having several disparate research teams with the broader programme management happening in a different continent and time zone. AgMIP responded to this challenge by setting up AgMIP Resource People (ARPs) who were individuals from developed country institutions who were embedded in the different research teams; ARPs were not in a leadership role but were instrumental in maintaining strong communication between AgMIP and the different research teams.

Even a simple mailing list, such as the ACCESS GCS, was appreciated by all five of the interviewed participants as a way of keeping informed about events and opportunities (the mailing list includes job advertisements).

Box 4: The benefits of supportive platforms for communication

"I worked before I started with my PhD — I never got to publish anything. But I started to learn how to publish and I managed to publish three papers. They really focus on publications… they push you and guide you." [ICTP PhD Programme participant]

"I was able to publish, but in Africa we don't have many opportunities to work on publishing skills. It would be nice to have seen this incorporated into the programme - maybe be mentored on this and actually work on a publishable paper together." [CSRP Fellow]

"Further exposure I experienced from this programme is going to the AMMA and CCDA [Climate Change and Development in Africa] conference. I was able to present my project. These conferences helped me develop my presentation skills in a way that people could understand." [CSRP Fellow]

"[A] challenge is in communicating or coming up with climate information that is useful for various users… Perhaps it speaks to us going more into the field of communication and really teasing out ways of disseminating the message of climate change results more effectively." [ACCFP participant]

"… I still need to improve in communication — I need to develop my skills in communicating to high-level politicians." [AgMIP participant]

Conference or workshop presentations and publications are platforms for academic and professional communication. The desire to publish, the need for support for publications, and praise for where publication support was available, were mentioned by a number of interviewees across the SCD initiatives. A few participants interviewed mentioned these as helping their English communication or writing skills. The AgMIP workshop in Ghana included, as part of its design and objectives, that each team would produce a chapter in an AgMIP publication. This was a draw card for participating and was positively recounted by participants. Part of the AIACC program included writing workshops, to which the high publication outputs of the program are partly attributed to. Similarly, the ACCFP had a strong focus on communication (to different stakeholders, and writing skills) which comes across in ACCFP's participant interviews as a positive mechanism for increasing publication output (five out of six publishing and attributing publications to their involvement in ACCFP).

Platforms (and pathways) for communicating with non-scientific communities are also important. Developing the capacity to communicate complex climate science and research was a strong focus across the AIACC program, ACCFP, the CSAG Winter School, and these cases appear to have largely been successful in this regard, with positive feedback from participants relating to this outcome (and high publication outputs for AIACC and ACCFP). The other cases were oriented almost solely, and often rigidly, to orientation and skill transfer (AgMIP workshop), or knowledge generation (CSRP Fellowships, ACCESS GCS) which drew some criticism from participants who valued being able to communicate their findings to relevant climate-information users. From the organisers' perspective, however, integrating or involving external parties or users could be challenging. For instance, the CSRP Application Fellowship initially required the endorsement of a user institution, but the organisers relaxed the requirements when it became apparent that it would be difficult to do that on the user's purely voluntary basis (there were no funds available for supporting the user institution's involvement).

Supportive Academic - Professional Interaction

Mentoring and supervision was particularly useful for early career researchers who needed support for technical skills, research design, 'big picture' thinking and exposure to international quality science. Mentoring was interpreted and illustrated in many forms across the different cases: from a facilitator in a once-off workshop to ongoing, dedicated senior mentor or supervisor support.

One-on-one time with mentors or supervisors, to advise on the refinement of research questions, proposals, analysing results, training on analytical tools, writing, publications and communication more generally were all commented on as important and beneficial experiences for participants. Twenty of the twenty-eight participants saw mentoring (in various forms) as an effective way to develop their capacity.

While mentoring was generally discussed positively, a few participants (25%) lamented shortfalls around its implementation or identified ways or mechanisms that could strengthen the mentoring aspect of the activity. These shortfalls primarily centred around mentors or supervisors not having enough time, mentoring processes needing more structure or formality, and the practical difficulties (and resources needed) to monitor mentoring processes.

Similar but distinct from the benefits of mentors and supervisor relationships, many interviewees emphasised the benefits of exposure to the broader scientific community through conferences and workshops, establishing useful contacts, networks of peers and/or building working relationships with other research institutions or individuals. Participants frequently mentioned the benefits of newly established relationships formed with key individuals, with these relationships developing into on-going partnerships often instrumental in the further development of the participant's skills or career. Workshops and conferences, as well as being opportunities for new meetings and relationships, were also activities that allow the participant to get exposure to the broader scientific community, and for the broader community to be exposed to their research. Many participants found it beneficial and helpful to present their research, both for critical feedback and for recognition.

The benefits of supportive face-to-face interactions were explicitly mentioned by both organisers and participants. The importance of supportive face-to-face interactions came up a number of times with regards to developing technical and analytical skills (e.g. learning a new program or tool), demonstrating the need for supervised experiential learning.

Across the variety of different mentoring styles – facilitation, peer-learning and senior mentor – the International Centre for Theoretical Physics' (ICTP) PhD programme had an innovative approach that seemed to work very well and addressed the mentoring strong-points and challenges from the other cases. The mentoring component from the ICTP programme was split between a senior mentor (generally with less time to spare for detailed support) providing a systems-perspective or 'big picture' thinking to the research question, together with a couple of senior-peer mentors (who generally have more flexible time) providing specific technical (or statistical/analytical) skill support. The effectiveness of such a structure is supported by an AIACC researcher whose mentor was 'hands-off' and did not receive much support, but whose interactions with peer advisors (other AIACC researchers) were helpful and made up for that loss of support. The ICTP PhD mentoring approach reflects (or would alleviate) the common problem of senior mentors or supervisors having insufficient time, as described by an ACCESS GCS participant:

> *"I think ACCESS could organise training workshops to give students a start so that they do not stay stuck for long periods of time waiting for supervisors to have to teach them to use common software like Linux, Fortran, MATLAB and GrADS. That can then free up the supervisor's time to focus on more specialised skills or interpretation of results."*

Commitment to a Collaborative Ethic

Of the participants interviewed, twenty-four of the twenty-eight explicitly mentioned the benefits of collaborating with their peer researchers, or with other disciplines, institutions, sectors or regions.

Box 6: The benefits of collaboration with peers and across disciplines, sectors and regions

"What has helped is collaboration… bringing on board scientists from various disciplines. When I start drafting a paper I get people to come in to comment and give input on the paper, because that will make my paper stronger… The exposure and collaboration opportunities are what stood out for me." [ACCFP participant]

"Students in the programme should collaborate and it is what I would like to see happen in the programme. This could've happened within themes but there was no collaboration in research or papers written together." [ACCESS GCS participant]

"This is a field that does not live on its own only; it is even more effective when applied hand in hand with other fields, such as your agriculture, hydrology, information systems/technology or IT." [CSAG Winter School participant]

"In the south we sometimes don't have enough knowledge or capacity. So the main rule is to bring in people from all over, to have a north-south link." [ICTP PhD programme participant]

"There was a missing link between the home and host institution. The moment you left the home institution, there was no continuation or connection." [ACCFP participant]

Box 7: The benefits of supportive face-to-face interactions and experiential learning, particularly for technical skill development

"What was most useful was that it was a hands-on experience. It takes a lot longer when someone only explains to you, for you to get it and understand. It's one thing for someone to describe to you how to go about a process, but it's another thing for someone to take you through the process, asking questions and going through the process of trial and error." [CSRP fellowship participant]

"Face-to-face interactions go a lot farther than a series of webinars or phonecalls or online interactions. For modelling there are a lot of little tests that could be run in 5 minutes…you can imagine that asking someone to help you run a 5 minute test and writing back in an email when you have a 10-hour time difference, to write ten tests might take you 10 days but when you're sitting with somebody can take you 15 minutes." [AgMIP workshop organiser]

The benefits of north-south and south-south collaboration with other institutions were seen in the CSRP and ACCFP fellowship programmes, where participants strongly expressed the gains made by linking up with other institutions.

For some institutions, creating partnerships and collaborating relationships can be a challenge, particularly partnerships between African institutions. For instance, the ACCESS GCS would benefit from partnerships with African institutions, but is constrained by funding and is unable to maintain such partnerships. Furthermore, the ACCESS GCS programme works towards a national mandate through several partner universities, each with their own mandates, which can lead to tensions and even to competition in large bids, as opposed to collaborating on a collective bid under a national mandate.

Integrative Reflexive Approach

Linked to several of the above factors (notably collaboration, supportive platforms for communication, supportive interactions), integrative, reflexive approaches were shown to be useful mechanisms in two distinct but related ways. Firstly, integrative, reflexive approaches can be applied in the relations and interactions between SCD activity organisers and participants; secondly, researchers' can take an integrative reflexive approach to working with impacted communities or the users of their research.

Organisers or implementing agencies of SCD initiatives can very likely improve the applicability of the initiative's content or design by engaging with participants to understand their needs. An integrative approach to capacity building activities can be seen in undertaking needs assessment or surveying to understand participants' needs and tailor (or co-develop) the SCD activity's' structure or content accordingly. For example, CSAG requires applicants to the winter school to submit a covering motivational letter which includes what the participant wishes to gain from the course. In more practical activities, run-up engagement could include simple pointers to align data and models, and iron out technical set-backs.

ACCFP benefits from having a leader who was part of designing the programme and who has been part of the coordinating entity since inception – this continuity and familiarity with successive participants and partner institutions has been an advantage. An integrative approach is captured in a comment from the lead of the AIACC program:

"The overall message is viewing capacity building as not a simple training workshop but a comprehensive package of support systems in place, making use of participants themselves as contributors."

Actively involving participants – such that they become contributors – could be achieved, for example, by having

a peer-to-peer mentoring or support network (particularly for technical skills training), or through having past participants act as mentors for new participants (which has been the case for the ACCFP).

Post-activity engagement with participants could be very helpful to ensure that the capacity developed through the activity is not lost and to promote the best use of the skills gained. However, it appears that post-activity engagement is quite rare. Such engagement could include attempts to understand the on-going skill or support needs, or to recommend options for further study.

Post-event engagement (or reflexivity) is an on-going mechanism between START and the ACCFP participants, where START maintains good communication with Fellows after the program; the interviews suggest this could be a good mechanism for improving the structure, design and support for the program. Post-event reflexivity can also serve as an opportunity for monitoring and evaluation, particularly for longer-term impacts, which was generally found to be ad hoc, informal or unsubstantial across the different cases. Although some of initiatives were continually improving their delivery or design of activities based on feedback from participants, these processes were often informal (such as a session on 'Reflections' on the last day of short-term activities) and not based on a critical alignment between the organisation's Theory of Change and the desired longer-term outcomes from the initiative.

Box 8: Illustrative quotes showing the benefits of integrative, reflexive approaches to activity design

"Maybe three or six months after, to contact the students to see if they are using their knowledge or they need maybe some support." [CSAG Winter School participant]

"START has kept in touch with fellows and is integrating us into the system. If there are other conferences and opportunities, they let us know. They have done a good job at keeping fellows connected." [ACCFP participant]

"You need to know first what skills participants want to improve. What we used to see is that a programme is already designed and participants don't use skills afterwards." [CSRP Fellow]

"That workshop is very useful because… every two years they have something new. There is a lot of improvement. They want to test these new things in the workshop. It's a win-win workshop." [ICTP PhD participant]

Box 9: Illustrative quotes on perceived benefits and challenges of reflexive engagement with research users

"I have only presented my work to a scientific community; I haven't gone to community levels at all. If it was an opportunity in the ACCESS programme I think I would've definitely done so, especially on the community level, to make our science more practical." [ACCESS GCS participant]

"The experience was very good - not just reading about the people who require our services or our products, but actually sitting with them, interacting with them, trying to understand how much they understand of our products and the angle through which us as scientists tackle the problem..." [CSAG Winter School participant]

"The big challenge for me in my career is that policy makers need to accept the tools that I developed, related to climate… They don't have confidence to mainstream the climate or weather information." [AgMIP participant]

"In Nigeria, maybe 15 or 20% of research work has a follow up for the benefit of the community or nation. On bookshelves you have volume of work completed, but with no recommendations." [AIACC participant]

Similarly, researchers can also apply an integrative, reflexive approach to their research by working with communities, decision makers or other users of their research. Seventeen of the 28 participants interviewed recognised the importance of communicating their research to other non-scientific communities, decision-makers, or other users of climate information and research. Notably though, of these, six reported that communication with climate information users or decision makers, and even with one's peers, was difficult.

The challenges and difficulties of communicating one's research accurately and meaningfully to those who need it – of their research actually being used – appears to relate in part because their research is not trusted, because it is uncertain or because it may contain errors.

Autonomy to Practice or Pursue Opportunities

Part of an integrative, reflexive approach to capacity development is incorporating flexibility into the design, allowing room to practice and autonomy to pursue new opportunities, interests and needs.

The value of experiential learning was described by just over half the participants, who spoke about practicing, working independently or 'on your own', or having 'hands-on' experience. As mentioned above, face-to-face tuition was a beneficial mechanism for developing technical capacity (computational or analytical skills).

At the individual level, climate change researchers and practitioners come from a variety of backgrounds: across this study, most participants came from ecological (including forestry, botany, marine biology), geography (hydrology, oceanography) or meteorological backgrounds, but also from law, economics and other disciplines. These different backgrounds mean that individuals had (and were missing) a variety of different skills; restricting them to a fixed set of workshops or conferences can be frustrating and ineffective. For example, some CSRP fellows felt frustrated with being restricted to CSRP events, and would have preferred attending conferences of their choosing; ACCESS GCS graduates commented on their wish to attend conferences or workshops (or short courses) that addressed their specific skill needs.

Containing a range of opportunities or multiple (optional) elements within a programme could be a mechanism for covering a broad and diverging range of skill and knowledge needs, but participants must have the resources in place (time, funding) and the freedom or flexibility to take part.

Box 10: Illustrative quotes on pursuing opportunity

"If we left it alone [and not pursued a transformation objective] we would've only had three partner institutions participating in ACCESS: likes of highly experienced proposal writers who have been writing for decades, competing with new or junior researchers or researchers with inferiority complexes… who don't feel they can compete… and therefore don't submit proposals. They feel intimidated." [ACCESS GCS organiser]

"Give students opportunities to spend extended periods of time with international partners to expose them to the international community, and give them confidence in their work." [ACCESS GCS participant]

"It was a small amount of money, but it placed me in a good position. I was the first academic to create this awareness in my university. That… has made people call me a climate change expert. When I came to ATPS I could attract a big grant for the university." [ACCFP participant]

"I was proud because my supervisor could see… that the programme was helpful. It didn't only give me scientific capacity, but opened a door for the organisation." [ACCFP participant]

"Believing in my capacity and also venturing into a new area that most people were not looking at or analysing or factoring in." [ACCFP participant]

"We can't always rely on international agencies to help us. They will have to eventually leave sometime. They need to give the projects to the local communities to pursue." [AIACC participant]

Institutions must also be able to pursue opportunities, to build their legacy and capacity. Although principally developed in or held by an individual, proposal writing skills and grant management skills (such as project management or report writing), together with the confidence in one's work (to take part in competitive bids or to pursue innovative research) are important aspects for developing or maintaining institutional capacity, centres of excellence or new 'nodes' of excellence. For example, in the ACCESS GCS programme, the design or structure of the program needed to ensure that it aligned with one of the programs key objectives, that of transformation. In contrast, success in even a small grant or proposal can have positive knock-on effects, for both the individual and the institution.

In this respect, the ACCFP stands out as building confidence amongst its participants in pursuing new areas of research and collaborating in research programs, which creates opportunities for the institution. Ultimately, such confidence in one's research ability combined with the skills to take forward a proposal is necessary to build institutional capacity, and develop more systemic, longer-term capacity and the autonomy to pursue opportunities and new research questions.

Creating institutional legacy is beneficial for the institution and the individual. For example, CSAG found that delivering the Winter School raised its institutional profile, which has been useful when pursuing new funding or project opportunities. In the fellowship cases (ACCFP and CSRP) participating home and host institutions benefited from the connections and association, in the same way that there can be benefits to an individual through their association with a centre of excellence. Such benefits to individuals were particularly clear in ACCFP, where participants benefitted from their association with the esteemed program. The impression was that fellows found their careers were advanced through taking part in the fellowship specifically, and through the networks and opportunities that it presented, more so than through the particular skills that the fellowship developed.

4. CONCLUSIONS AND RECOMMENDATIONS

This report shows that analysis on SCD programmes can help to understand i) the different characteristics and drivers of particular SCD approaches; ii) an emergent picture of how donor aid funded SCD programmes are delivered in Africa; and iii) what general factors should be considered when conceptualising SCD programmes. The report also shows that there is already a burgeoning range of programmes that are oriented towards SCD for climate change sciences.

In short, the study found that formal development programmes such as Masters and PhDs are vital for building in-depth disciplinary capacity, but that a range of additional mechanisms are necessary for developing technical skills and interdiscplinary competencies. These include mentoring programmes, publishing and conference programmes, training, fellowships and exchange programmes (amongst others) which extend experiential learning. The study found that mentoring, while widely reported to be of high value to participants, were often poorly developed and supported as an SCD mechanism. The study also shows that SCD is not a short term 'once off' activity, but should be conceptualised within a learning pathways framework that allows for access to a diverse range of SCD experiences along a person's full career trajectory. However, if this is left to 'chance' then the capacity development process takes longer, and lacks coherence. If more careful SCD planning and system building takes place, capacity development can be 'fast tracked' for those on climate change research pathways.

This chapter briefly summarises the study, providing key SCD insights associated with the different research processes, insights into best practice and different levels of SCD. Recommendations are made for four groups of actors who are likely to be involved in SCD provisioning and support: i) delivery organisations), ii) networked support institutions and conveners (whom delivery organisations may engage with); iii) research funding and policy institutions (e.g. national research foundations, departments of science and technology) who support SCD activities and their expansion.

4.1 Findings that can inform best practice and emergence of a robust SCD system

The findings from this study indicate a number of particular approaches or factors that are important for building capacity in an individual and in institutions. To ensure that positive outcomes are achieved where there are contextual barriers, these points could be valuable guidelines to achieve best practice:

- Successful outcomes for both the individual and institution requires buy-in and commitment from both, together with an understanding of each other's needs and existing capacity.
- Institutional resources should not be underestimated (funding, technical, human resources, ICT infrastructural), especially with regard to logistics and the less structured aspects of SCD (such as on-going mentoring).
- For individuals, it is important to understand the extent of their technical skills and skill gaps and co-developing the SCD mechanism around noted needs.
- A full package of support that simultaneously builds individual and institutional capacity is an ideal objective, especially also if this is conceptualised within a longer term, reflexive, and more systematic framework for SCD.
- Such a package should comprise activities that incorporate consideration of the contextual and mechanism related factors identified in Section 3 as far as possible, namely supportive platforms for communication, supportive academic-professional interactions, ethic of collaboration, integrative reflexive approaches, and autonomy to pursue opportunity.
- Significant organisational, coordination and leadership resources are required through an SCD activity or programme, without which, effectiveness and significant outcomes are likely to be compromised.
- Where possible, SCD programmes should seek to link up to, and learn from other SCD programmes within a system oriented, networked framework, given that this is an emerging field of practice, critical to the success of expanding climate sciences capacity in Africa.

Together, the findings presented in the study highlight several components of a robust SCD system which are relevant

at individual, institutional and/or system-wide levels.

Individual level SCD: The study outlined the individual competencies of climate change scientists and the processes for their development in African contexts, which are generally characterised by weak institutional support and a lack of formal capacity development pathways. As indicated in the literature review, this approach can lead to unnecessarily long and complex learning pathways for individuals. Significantly, findings in this study show that there is a high retention level in careers in climate change and that significant gains and positive impacts are made from each of the different types of SCD activity. This needs to be built on within a more systemic approach to SCD design and implementation. The study also pointed to the value of experiential learning / self-tuition (learning on the job) for applied and interdisciplinary competency development, but also showed that this appears to be enhanced with high level mentoring and workplace transitioning / upskilling support.

Ideally, an individual climate scientist must have a base of strong disciplinary, functional technical and analytical skills, together with interdisciplinary competencies. In particular systems-thinking and interpersonal competencies are shown to be very valuable, but capacity development in these areas is not often formally available. Interpersonal competencies include communication skills (non-scientific communications and academic publications and presentations) and an ethic of collaboration. As an individual's career advances, s/he moves towards research independence, where proposal and project management in turn can contribute towards the development of institutional capacity.

The study has shown that the SCD process for the individual actually involves an emergence of what can be seen as a 'knowledge value chain', building on i) foundational studies at Masters level (where ethical engagement with societal issues appears to motivate specialisation into climate sciences); ii) at PhD level (where essential deep level specialism capability is developed); iii) transitioning into the workplace (where important induction and professional support, especially for more applied forms of research and interdisciplinary engagement is needed); and into iv) an ongoing journey of expanded upskilling, and expansion of professional and applied competency is needed (where participation in conferences, scientific publishing and knowledge co-production becomes more important) and v) provision of scientific leadership (e.g. where research fundraising, supervisory support and provision of mentoring, network leadership etc.) becomes important.

The study has shown that it is important to understand full knowledge value chain, and that there is both ongoing specialisation and more generic competency development that is needed across the value chain. This mix of deepening specialisation and expansion of generic scientific competencies and leadership appears to be important to respect and maintain in climate change-related SCD planning and support. An SCD programme focussing on the individual level of climate science capacity development should ideally give attention to:

- **Disciplinary specialisation and foundational competency** via Masters / PhD as this is an area of 'high skill'.
- **Workplace transitions capacity development** in the form of mentoring, supervision, adequate support for applied technical skills development, and initiation into workplace communities of practice and networks.
- **Expanded upskilling of professional and applied competencies** via short courses, research conferences, paper writing support, participation in interdisciplinary teams and research programs, support for proposal and fundraising development.
- **Overall scope of capacity development** across the full range of competencies including ongoing deepening of disciplinary and specialist knowledge within a systems approach, development of technical and practical competency, and development of interdisciplinary competencies including interpersonal competency (ethics of collaboration), anticipatory and normative competencies. As found in this study, giving ongoing attention to the development of this full scope of competencies appears to be important especially in the applied workplace context, but, as recommended by SARUA (2014), these could also be integrated more fully into initial foundational education and training programmes.
- **Awareness of specific needs of specialism routes, sectors in climate science**, such as climate modelling and services, climate change adaptation or mitigation experts, and boundary agents operating in academic or public service (i.e. routes for specialisation in the climate sciences). Different specialisms have nuanced roles in the

knowledge value chain (from knowledge generation, translation or use), and accordingly nuanced needs. Although needing the full range of competencies (above), routes of specialism heighten certain competency needs. For instance, the survey findings showed adaptation experts had a higher need for systems-thinking and interpersonal competencies than modellers, while the latter had a higher use for anticipatory, normative and strategic competencies than adaptation experts. Different sectors also place greater emphasis on specialised technical skills, such as writing for scientific journals (academic).

Institutional level SCD: An institution's profile and legacy are raised through participating in esteemed initiatives and programs, requiring an ethic of collaboration and the ability to pursue such opportunities, as well as sufficient resources (infrastructural/technical, funding and human resources). The study has shown how African contexts are often defined by a lack of centres of excellence for climate change research, and where individual capacity is developed these individuals appear to have good career prospects to fill these gaps. An individual's capacity can provide a mechanism for increasing institutional capacity if their capacity continues to develop, transforming them from a single 'node' of excellence, and creating legacy and esteem for their institution. This is facilitated if adequate workplace learning and transitioning support is provided, and where communities of practice can emerge in workplaces.

An SCD programme focussing on institutional development initiatives to complement individual climate science capacity development should give attention to:

- **Workplace human resources, mentoring and supervision systems development,** including developing workplace mentoring systems and communities of practice, and human resources planning that allows for access to upskilling opportunities for existing employees within a coherent learning pathways framework
- **Professional networking and links:** Developing and maintaining climate change SCD network links, ongoing scanning of SCD capacity building opportunities for employees, with support for staff to participate in conferences, short courses and other professional networking events
- **Technical systems support:** Giving attention to technical, practical aspects of functioning such as adequate funding, computational and internet capacity access
- **A mix of SCD initiatives and opportunities, noting differences:** Providing opportunities for a range of SCD initiatives and opportunities, with due attention to the value of different types of SCD activity in institutional SCD planning. For instance, workshops or summer/winter schools with face-to-face training and application for technical or practical skills; fellowships of sufficient length and with sufficient resources, support and collaboration; co-authorship, writing workshops and support for publications; facilitated engagement with research users; continual or ongoing communication for stimulating collaboration, reflexive evaluation, and further career development (e.g. jobs or further training opportunities).

Enabling system-level SCD development: To complete the individual-institutional SCD picture, a better understanding of the full scientific capacity development system in Africa and associated processes, challenges and enabling mechanisms requires a focus on the interface between the institutional level and the enabling system level. This could, for example, look at mechanisms or approaches that: shift the ownership of research questions away from external funding agencies, and build research programmes that are defined and managed from within Africa; that develop centres of excellence or that promote institutional trust and collaboration. Some system-level enabling support mechanisms for individual and institutional SCD could include:

- **Improved research incentives** for individual and group-based researchers and research institutions (including professional and financial incentives), especially with regard to retention of talent. This should also include ways of incentivising research users (e.g. governments, businesses, etc.) to support SCD for climate change.
- **Formalise and extend climate change research networks and SCD support initiatives and opportunities** with strong networked communication infrastructure to make opportunities more widely available (e.g. via a climate change SCD association, regular pan-African climate change conferences, support for pan-African climate journals).
- **Establish sustainable funding streams for climate change science and SCD interventions** at national, regional and international levels, which enable longer term engagement by the beneficiaries of SCD in climate change

research (e.g. the Global Change National Research Plan in South Africa).

- **Facilitate communication and interaction amongst donor organisations** to avoid duplication and enhance coordination of external and internal funding of SCD and associated research programmes.

4.2. Next steps and areas of enquiry

As indicated in the introduction of this report, the primary focus of this study was SCD of individual researchers in climate change related disciplines, and to a lesser extent the necessary supporting institutional capacity. Even within this primary objective, through the progression of the study, the focus narrowed further to understanding SCD amongst early career researchers, with institutional capacity development as a lessor focus area.

Furthermore, in the absense of good macro-economic and quantitative data in this area, this study contributes a qualitative analysis of case studies, providing provisional insights towards a more robust understanding of the problem area, as well as fit for purpose recommendations on the practical implementation of SCD interventions.

The study was also able to point to some of the elements of the enabling system-level that supports early career researcher SCD, but this is an area that requires in-depth research in its own right. The enabling system-level is intimately related to policy and research incentive systems, which fell outside of the boundaries of this study, yet have a significant longer term impact on SCD, as was also pointed to in the SARUA Mapping study (2014). Institutional capacity development for SCD also requires further research, especially from a workplace mentoring and human resource planning and development perspective, and from a wider university supply system perspective (current insights into this from a systems perspective are currently limited to the SARUA study 2014, which covers southern African countries only).

A next or later stage interest or study would need to address in more detail the secondary capacity development objective, namely that of climate information users, decision makers and other stakeholders, including on-the-ground communities. This should align with the enabling factors for SCD and the competencies for early career researchers for reflexive integration of science and practice, which has been demonstrated as important across the study – i.e. the two objectives are not separate objectives and are linked, as working and communicating with (and indeed, developing the capacity of) these groups have been inherent in the study's understanding of a 'good climate scientist' in Africa.

REFERENCES

Conway, D. (2011). *Adapting climate research for development in Africa.* Wiley Interdisciplinary Reviews: Climate Change, 2(3), 428-450.

Danermark, B. (2002). *Explaining society: Critical realism in the social sciences.* Psychology Press.

Machamer, P., Darden, L., & Craver, C. F. (2000). *Thinking about mechanisms.* Philosophy of science, 1-25.

Pawson, R., Tilley, N. (1997). *An introduction to scientific realist evaluation*. Sage.

SARUA (Southern African Regional Universities Association). (2014). *Climate Change Counts Mapping Study.* Regional Knowledge Co-Production Framework. www.sarua.org.

Schmidt, H. G., Van Der Molen, H. T., Te Winkel, W. W., & Wijnen, W. H. (2009). *Constructivist, problem-based learning does work: A meta-analysis of curricular comparisons involving a single medical school.* Educational psychologist, 44(4), 227-249.

Wiek, A., Withycombe, L., Redman, C., (2011) *Key competencies in sustainability: a reference framework for academic program development. Sustainability Science.* Volume 6, Issue 2, pp 203-218.

APPENDIX 1: CMO EVALUATION REPORT TEMPLATE

CMO Evaluation framework, indicators and sources of information

	CONTEXT	Source	MECHANISMS	Source	OUTCOMES	Source
INSTITUTIONAL	Motivation: Original purpose of the initiative, continued motivation	Organiser interview	Design of the activity/program of activities (incl. methodologies used, practical application, mentoring)	Case study & Organiser interview	Benefits (and risks/harm) to the institution's capacity	Organiser interview
	Inputs: financial, human, technological and infrastructural resources	Organiser interview	Recruitment process , requirements & restrictions	Organiser interview & Case study	New partnerships between established (or international) and emerging African centres of excellence/scientists	Organiser interview; Participant interview
	Target participants & motivation; statistics of actual participants	Organiser interview & Evaluation reports	Support or pressures/constraints on structure of institutional partnerships / collaboration, research networks	Organiser interview	Extent of advanced frontiers of regional knowledge /responses to climate variability and change	Organiser interview
	Where the training took place and over what duration	Case study	Course content: new vs expanded capacity, extent of transdisciplinarity, K* focus, ethics, competency or skill development focus	Case study & Organiser interview	Pathways to impact: Extent of engagement with policy-makers, decision-makers, or users of climate information	Organiser interview
	Funder/s	Organiser interview & Case study	Content design; was it co-produced, demand-led, pre-designed?	Organiser interview		
	Other systems factors (political, environmental, legal)	Organiser interview	Processes for ensuring continuity and sustainability	Organiser interview;		
			Evaluation processes, & motivation for evaluation	Organiser interview		
INDIVIDUAL	Prior disciplinary background	Participant interview	Interaction and engagement	Participant interview	Science into action: Practical examples of acquired competencies assisting researcher/ user interface	Participant interview
	Career-stage (current & at time of participation), country origin, gender, sector origin (e.g. govt.)	Participant interview	Motivation for continual learning and interest in SCD	Participant interview	Research generation: # of knowledge products published/ proposal developed	Participant interview
	Other personal factors (political, cultural, financial, legal (e.g. study visa))	Participant interview	Values and interest / commitment to climate change issues and concerns	Participant interview	Career advancement: % / # of recipients that progress, or # practical examples where new skills used in subsequent job / research activities; nature or career (e.g. academic, met service); Resulting qualifications	Participant interview
					Improved scarce technical competencies, interdisciplinary competencies, communication skills with users of climate information	Participant interview
					Scientific community: # of abstract submissions, conference presentations, # of new research collaborations formed, networks or CoPs	Participant interview

APPENDIX 2: DEMOGRAPHICS OF PARTICIANT INTERVIEWEES

SCD case study initiative	Gender	Nationality
ACCFP	1. Female	Zimbabwe
	2. Female	DRC
	3. Male	Nigeria
	4. Male	Nigeria
	5. Female	Zimbabwe
	6. Male	South Africa
AIACC	1. Female	Sudan
	2. Male	Nigeria
	3. Male	Malawi
CSAG Winter School	1. Male	South Africa
	2. Male	Mozambique
	3. Male	Nigeria
	4. Male	Nigeria
ACCESS GCS	1. Male	South Africa
	2. Male	South Africa
	3. Female	South Africa
	4. Female	South Africa
	5. Male	Nigeria
AgMIP Workshop (Ghana, 2012)	1. Male	South Africa
	2. Male	Malawi
	3. Male	Ethiopia
	4. Male	Tanzania
CSRP-1 Fellowships	1. Male	Kenya
	2. Male	Mozambique
	3. Male	Uganda
	4. Female	Kenya
	5. Male	Cameroon
ICTP PhD program	1. Male	Sudan

APPENDIX 3: SUMMARY CMO EVALUATIONS FOR THE DIFFERENT SCD CASES

Note that each case has a more detailed full report

CMO evaluation for ACCESS GCS

	Context	Mechanisms	Outcomes
Institutional	- Set national mandate and design (science, policy and development) by SA government - Focus on transformation, (75% black South Africans but only got to 67% target participants in 2014/15) - R10 million (post grad bursaries and all expenses) from SA Department of Science and Technology - Objective to create a fraternity among young scientists beyond mainstream institutions - Varying degree of commitment from theme leaders (from partner institutions); competition between ACCESS and partners institutions (each institution has its own mandate) - Funding limitations and limited partnerships (Namibia, Kenya, Ghana) with other African institutions - 10 yr duration, 2009/2010 – 2019/2020	- Supervisors' support is key/influential - Content/design of ACCESS GCS programme was not co-developed with students/participants but Global Change Research Plan co-developed with general research community - Multidisciplinary - Primarily knowledge generation - Recruitment requirements: no. students recruited, race allocation, no. papers and patents produced - Support: ACCESS is comprised of partner institutions - Some guidance for developing skills further, opportunities for further involvement: side activities for GIS, R, stats, etc. - Limited networking and collaboration opportunities, and for students to communicate findings - No formal defined mentorship program - Mailing list with job ads	- 70 research outputs and 28 graduations for 2014 - Connections between historically disadvantaged and well-resourced universities, though relationships sometimes strained and institutional processes can impede collaboration (e.g. co-supervision of student registered at one institution) - International research projects started with Germany and Japan - Research themes strategic for impact; advanced knowledge in the region. Outputs from "Climate Change Impacts and Adaptation" theme are integrated into various other programmes namely SASCAL, CORDEX and the SADC STI framework
Individual	- Of interviewees, environmental & meteorological related backgrounds; mix of Masters, PhD and post-docs. Program also supports Honours - Mostly South African, some African - Numerical/mathematical ability reportedly low across applicants - Sufficient bursary funding - Timing of funding for expenses sometimes unpredictable	- Many passionate about global change; involvement in student organisations and establishment of new NGO - Strong appreciation for ACCESS - Funding and time is a limitation (e.g. to travel to/attend a conference)	Career impact: High academic progression; participants were at early / development stage of career compared to other cases Networks: Key individuals (supervisors) influential in advancing career Skills: Varied; mainly technical and research skills Products: Mostly academic theses; few articles in review or other products Policy impact: Limited; few opportunities available during program

APPENDIX 3 CONTINUED

CMO lessons	- Demonstrates the need for sufficient funding and coordination to drive an initiative, in this case the available funding covered bursaries and a few support activities - Students can be restricted by time and travel costs - Demonstrates the need for institutional collaboration, not competitiveness - From the participant's perspective, demonstrates the need for mentoring and platforms for dissemination and engagement - Relevant impacts (outputs integrated into other climate change programs) made through the climate change research theme - Careers of participants still in early stages / post-graduate studies; difficult to gauge impacts

CMO evaluation for ACCFP

	Context	Mechanisms	Outcomes
Institutional	- $1,291,500 (from IDRC) for Phase II (30 months) - Followed series of dialogue between START and IDRC on how to build CC SCD in Africa - Fellowships between $2500 and $14000 - Focus on new climate change science and adaptation, translating science to action - Making use of ties in scientific community - 'Immense amount of coordination involved'	- Teaching, Policy Doctoral or Post-doctoral fellowships - 6 to 12 month fellowships, with an extensive program of support including mentoring workshops, conferences and south-south exchanges - Home and host institutions - Interdisciplinary - Primarily academic and oriented to knowledge generation, but with strong focus on communication, responsibility and research-into-use - Opportunities for networking with other fellows, strong communication and a sense of community - Competitive recruitment process but fellows design their own projects - Good follow up engagement from START (invitations to participate etc) - Collaboration an institutional incentive for participation	- ACCFP has earned a reputation as a major platform for education, training and capacity building in Africa - Very strong/wide networks established: By the completion of Round 1, partners engaged a network of more than 120 people from African academic, practitioners and policy communities and 58 African institutions. - Climate change was integrated into some participating partner institutions' programs - Improved renown for institution/s involved - Pressure to transfer management to African institution (as US-based)
Individual	- Scientists, policy makers and practitioners - Of interviewees, all were post-graduates (with Masters or PhDs) in generally NRM-related disciplines with some technical expertise established	- Feeling of comradery amongst fellows - Some fellows better at communication than others - Accommodation budget inadequate for some - Mixed experiences of mentoring, of home/host relations - Links with disciplinary backgrounds to CC motivation for continued learning	High confidence amongst participants with institutional benefits; understanding amongst participants of the importance of research-into-use and communicating findings; outputs related to academic career paths; Career impact: High Networks: High conference attendance Skills: Communication; varied tech skills (GIS, remote sensing) depending on subject, institution & need Products: Relatively high Policy impact: Up to participant and impact of publications Community: Strong affinity amongst past fellows

APPENDIX 3 CONTINUED

CMO lessons	- Demonstrates the mutual benefits of on-going communication and follow up engagement, for the institution and individual (ongoing connections established; improved delivery of service) - Benefits of wide south-south institutional partnerships, possibly influencing strong positive outcome of confidence amongst ECRs and institutional gains - Strong vision and objectives from dialogue and planning between START and IDRC; carried through strong, continual leadership - Well-resourced for coordination of additional program of activities and ongoing engagement

CMO evaluation for AIACC

	Context	Mechanisms	Outcomes
Institutional	- Multi-faceted 5 year program (2002 – 2007) - 350 researchers from 150 institutions in Latin America, Africa and Asia working on 24 multi-disciplinary research teams (across 50 developing and 12 developed countries) - Develop science capacity for multi-disciplinary integrative assessments of climate change, and connect science communities - Executed by START and TWAS - Primarily GEF funded ($7.5 mil), also some IDRC, USAID and other funds Broader system:	- Primary mechanisms i) funds for research teams, ii) paid assigned technical advisors / supervisors to provide guidance for each team (IPCC authors), iii) several global workshops to train researchers on specific skills, and iv) small grants for ad hoc regional workshops - Open call for proposals - Contained writing workshops - Researchers encouraged to re-design their work plans following feedback from their advisors , peers or after results (i.e. flexible design) - AIACC created a 'working papers' series of publications - Strong cross-program communication (e.g. advance warning or activities) & networking, sense of common project/goal - Regular meetings within each team or region	- Improved institutional profiles (e.g. CSAG, START) - Continued institutional relations and collaboration on different opportunities (e.g. ACCCA, ACCFP; CCAA) - IDRC-funded CCAA program continued SCD effort from AIACC - Impact through tailored assessments – different teams established stakeholder relations and numerous policy activities - Although deemed a success, additional/further funds were not made available - 24 climate change assessment reports and over 200 publications - 30 AIACC members IPCC Fourth Assessment authors - Two factors impeding follow-on impact of AIACC after the project was completed were i) GEF unwilling to fund another similar initiative (seen as outside their mandate), ii) reluctance of European funders to continue with US-based organisations (i.e. START)
Individual	- Participants are actively involved researchers and research assistants - Competent, capable researchers in the fields, had experience in research projects but not multi-disciplinary settings - Interviewees came from natural sciences backgrounds	- Shift to multidisciplinary research a challenge and shift in research culture - Motivation through early training on interdisciplinary research and 'big picture' research - Utilised network	Strong career advancement, exposure to both research and research-into-use Career impact: High transition to more senior positions, incl. to govt/policy Networks: Communities and collaboration emphasised in AIACC Skills: Research skills (design, indicators) and communication across disciplines Products: Very high 200+ Policy impact: Direct policy/govt linkages; transition to govt/policy
CMO lessons	- Demonstrates the value of good leadership and supportive structures; the importance of communication, sense of common goal, networking (and other support activities) - Demonstrates the value of flexibility: in setting own research questions and in research design (flexibility to adjust with new information or feedback) - Inclusion of multiple SCD elements; strong communication focus (e.g. collaboration, writing workshops, 'working series' publication mechanisms for high publication outputs		

APPENDIX 3 CONTINUED

CMO evaluation for AgMIP Workshop			
	Context	**Mechanisms**	**Outcomes**
Institutional	- 5 day 'kick-off' workshop in Ghana (sept 2012) as part of AgMIP Phase 1, which had teams for southern, eastern and west Africa working on multi-discipline model assessments (climate change, economics, crops) - Estimated cost for workshop alone: $150 000 (includes flights for 70 participants) (DfID funded) - AgMIP as a whole has multiple funders, $11 000 000 to fund eight research teams (four in Africa, four in Asia)	- Focus on practical orientation to AgMIP protocols, approaches, models (climate, crops and economic), teams and roles - Involvement via proposal process, teams must have climate, crop and economic expertise and be in touch with local stakeholders acting on climate timescales (30% success rate in proposals) - Round-robin supervised breakaway groups, alternating by theme and region - Skill development (R and MatLab), limited knowledge generation - No engagement with decision makers during this workshop, subsequent workshops included engagement and build on lessons learnt - (Ongoing after workshop) AgMIP Resource People assigned to teams, email communication and support, online workshops	- On its own, the workshop did not lead to clear institutional outcomes - AgMIP has been involved with over 60 African institutions, notably WASCAL (integrating AgMIP methods into curriculum) - Subsequent changes to later workshops (e.g. external engagement with users, field trips); use of research also emphasised in Phase 2 - All participants active climate information users; many government/public or met agency practitioners who applied new tools or benefited from networks/ contacts
Individual	- 70 participants from African teams, most from academic institutions or government practitioner agencies - Limited technical / computational capacity reported by organiser - Of interviewees, mostly meteorology and hydrology backgrounds, mid- to –advanced career	- Of interviewees, many were not involved in proposal stage for their teams - High initiative and value amongst interviewees to establish working relations with peers from other regions - General will for improved communication skills and for stakeholder engagement	Good career impact from technical skills gained in workshop, and from involvement in AgMIP Career impact: Fairly high, mostly through improved modelling and R, and opportunities to work on new projects Networks: Some good peer networks; key individuals Skills: R, MatLab. R emphasised as very important/useful skill Products: All authored a chapter as part of workshop; one used skills learnt in country's 'Climate Resilient Green Economy National Strategy' Policy impact: Seen as shortfall by participants – no pathways; up to participants initiative
CMO lessons	- Demonstrates how sequencing very short-term activities (such as workshops) is important, with improvements made over time; the importance of co-producing workshop content/run-up & run-down engagement - Technical skills learnt at the workshop (R, MatLab) were reported favourably by participants who found these useful; more substantial career impact and change was driven through involvement in AgMIP program as a whole - Demonstrates the value/benefits/ importance of networking with peers and key contacts/experts		

APPENDIX 3 CONTINUED

CMO evaluation for CSAG Winter School			
	Context	**Mechanisms**	**Outcomes**
Institutional	- Theory of change- target mid-career, mid-level for indirect impact, a lot of early career (PhD students, or recent PhD) attend too for orientation to the subject - Launched in 2009 with funding from UNITAR; initially in first year a 2-month course fully-funded course, subsequently 2-weeks and paid for by participants (with some participants subsidised) - On UCT campus - Local partnerships (e.g. SANBI, CSIR), and international (e.g. SEI and Oxford Group) - High volume of applications (200+ annually, from which around 25 selected	- 'Decision-making under uncertainty' - Two weeks (trialling 1 week in 2015) with multiple speakers, facilitators and experts on different topics; field visits - Content sometimes limited by availability of staff/experts - Multidisciplinary, focus on knowledge transfer and use - Tailored courseware adjusted to each year's groups' needs and sector - Learnings continually applied to a case study that runs and develops across the course - Screen applications to ensure a diversity of participants; application includes a motivation and skills/knowledge needs - Introduction to CSAG's climate information portal (CIP)	- Modest or indirect outcomes (in line with ToC / objectives) - Local partnerships (e.g. SANBI, CSIR), and international (e.g. SEI and Oxford Group) - Raised institutional profile (further project/ funding opportunities) - Institutional difficulties/tensions application process may move to under management by UCT, rather than under CSAG
Individual	- 25 participants in each course - Mid-career, mid-level, mostly practitioner - From interviewees, range of disciplinary backgrounds (incl. meteorological, natural sciences, law)	- Amongst interviewees, general willingness to engage, learn more or improve practice relating to climate change issues	Better engagement with users & understanding of uncertainty in climate change; confidence Career impact: Confidence & inspiration for further development Skills: Better engagement with users Policy impact: Improved ability to convince decision-makers Products: low, dependent on initiative of participants (largely non-academic)
CMO lessons	- Demonstrates the benefit of engaging with practical / on-the-ground issues and organisations; of understanding climate information users' needs - Demonstrates the benefits of co-design / tailoring course content - High demand for climate change capacity development amongst early and mid-career		

APPENDIX 3 CONTINUED

CMO evaluation for CSRP-1 Fellowships			
	Context	**Mechanisms**	**Outcomes**
Institutional	- Aimed at improved understanding of African climate and modelling thereof - 11 one-year (max) fellowships focused around 7 themes as part of the CSRP-1 program (selected from 80 applicants) - Total cost £150K (DfID and Met Office Hadley centre) - Time spent by Met office mentoring: 1.3 person years; Admin and coordination time: 0.9 person years, and approx. 0.1 person years for IT support - Endorsement from home and host institution	- Three fellowship types: Postgraduate research (£9000); postdoctoral research (£13000); application project research (£6500), the latter focused on making use of climate information - 1 month visit to the UK Met office and other UK partners (Universities of Leeds and Reading); met with visiting scientists from Oxford University - Activities undertaken during induction visits included the finalising of project plans, acquisition of model simulation and observational data as well as software for data analysis and visualisation - Climate science program (not multidisciplinary); application fellowships only were designed to advance research into use - Coaching and mentoring on project plan, programming, data analysis according to fellows' needs, and ongoing mentoring through email correspondence - Presentations on plans and progress at internal meeting; option of participation on other CRSP events (e.g. Regional climate outlook forums) - Application procedure was based on ACCFP - Some institutional challenges: some host institutions required higher proportion of funding which could shorten the research time; initially endorsement sought from user institutions, but difficult to get commitment without incentive	- Impact/research-into-use driven through other aspects of CSRP (fellowship largely academic / knowledge generation) - Unexpected large overheads - No key institutional networks, partnerships noted or emphasised, though benefits for home/African institutions assumed, particularly where an institution was home/host and user (e.g. Kenya Met office) - Capacity built/experience in the 11 fellow to go through scientific method from start to finish with a published piece of work to put onto the CSRP website; some fellows had difficulty taking publications further and would have benefitted from additional funding for publications/ Phase 2
Individual	- Fellows were postgraduates, post-docs and practitioners - Must come from African country; the different fellowships had specific requirements for the type of degree that must be held in order to participate as a fellow. - From interviewees, largely meteorological disciplinary backgrounds -Organiser surprised by weak analytical /computational ability	- Amongst interviewees, general willingness to develop technical / analytical climate change skills - Differing degrees of communication/ engagement with mentors, though all commented on benefits - Some interviewees experienced constraints from administrative processes/requirements	Strengthened and consolidated skills and career paths Career impact: Strengthened existing career paths (e.g. good preparation for planned PhD), new opportunities through key contacts (e.g. participation in FCFA and other large research programs) Networks: UK connections favourable; key individuals (mentor) Skills: Presenting/ communication modelling, writing, tools (e.g. R, GrADs) Products: All fellows published in a newsletter; over half of the fellows produced multiple publications
CMO lessons	- Demonstrates the importance and substantial benefits of close mentoring across full research process, combined with other opportunities (exchanges, conferences); publication output could have been higher with extended support - Demonstrates value of flexibility (responding to fellows' technical/analytical skill needs) - Demonstrates the challenges of high transaction costs and unexpected administrative/coordination burdens. Linked to this, the challenges of incentivising collaboration with user / external institutions		

Scientific capacity development in climate change related disciplines: Analysis of barriers, opportunities and good practice in Africa. Climate and Development Knowledge Network.

This document is an output from a project funded by the UK Department for International Development (DFID) and the Natural Environment Research Council (NERC) for the benefit of developing countries and the advance of scientific research.


University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad
ACDI
African
Climate &
Development
Initiative
RHODES UNIVERSITY
Where leaders learn
environmental
LEARNING RESEARCH CENTRE
Climate Systems Analysis Group
SOUTH
SOUTH
NORTH
S T A R T
global change SysTem for Analysis, Research & Training
CARIBSAVE
INTASAVE
Caribbean
Working together in a changing climate