REPORT

Capacity Needs Assessment of ICPAC

WISER
Weather and Climate Information Services for Africa

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Contents

Report Summary 01

List of Abbreviations 04

SECTION 1

1. **Introduction** 09
1.1 Overall purpose of the assignment 09
1.2 Information gathering methods 09
1.3 Report structure and Linkages 10

SECTION 2

2. ICPAC 's readiness to be designated a WMO RCC 12
2.1 Mandatory functions for WMO designation as RCC 12
2.2 Highly recommended functions for WMO designation as RCC 14
2.3 ICPAC Status of Delivering RCC Services in the Demonstration Phase 17

SECTION 3

3. **Gaps in ICPAC 's Readiness for WMO Designation** 21

3.1 Mandatory functions for WMO designation as RCC 21
3.1.1 Operational Activities for LRF 22
3.1.2 Operational Activities for Climate Monitoring
3.1.3 Operational Data Services to Support Operational LRF & Climate Monitoring 22
3.1.4 Training in the Use of Operational RCC Products and Services 22

3.2 Highly Recommended Functions for WMO Designation as RCC 22
3.2.1 Climate Prediction and Climate Projection 22
3.2.2 Non-operational Data Services 26
3.2.2.1 Data Rescue 26
3.2.2.2 Access to High Performance Computing & Broadband Internet 29
3.2.3 Training and Capacity building 30
3.2.3.1 ICPAC Training and Capacity Building 29
3.2.3.2 Co-designed ICPAC-University Curriculum 30
3.2.4 Research and Development 31
3.2.5 Coordination (and Financing) Functions 33

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SECTION 4

4. Filling Gaps in the Capacity of ICPAC to Provide Technical Support and Services Intervention..... 35

4.1 Mandatory Functions for ICPAC Designation as a WMO RCC..... 35
4.2 Highly Recommended Functions for ICPAC Designation as a WMO RCC and ICPAC's 2016-2020 Strategy..... 37
4.2.1 ICPAC Internal Programs 39
4.2.1.1 Data Rescue 39
4.2.1.2 Modelling: Assist RCC Users in the Access and Use of WCRP CMIP Climate Model Simulations 42
4.2.1.3 GHACOF Products 44
4.2.2 ICPAC's Partnership with the University and Research Organizations Community 48
4.2.2.1 Co-designed Co-produced Climate Change and applications Curriculum with the University Community 49
4.2.2.2 Co-designed Co-produced Climate Data Technology Curriculum with the University Community 49
4.2.2.3 Co designed Co-produced Research with the University and Research Organizations Community 49
4.2.2.4 Coordination Mechanism for ICPAC and the Research Community 53
4.2.3 ICPAC's Interface with the User Community 56
4.2.4 ICPAC's Partnership with the Information and Computer Technology (ICT) Community 57
4.2.5 ICPAC's Partnership with the Funding Agencies Community 59

SECTION 5

5 Conclusions and Recommendations 60
5.1 Conclusions 60
5.2 Recommendations 61
5.2.1 Short-term Actions 61
5.2.2 Medium-Term to Long-Term Actions 63

SECTION 6

References and Bibliography 71

SECTION 7

Consultees 77

SECTION 8

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ICPAC IGAD Climate Prediction & Applications Centre

WMO World Meteorological Organization

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Annexes…… 84

Annex-1: Plan of a Potential Climate Change Post Graduate Training Program in Climate Information Applications: Proposed for Further Co-Development by ICPAC in Partnership with NMHSs and the University Community ……. 84

Annex-2: Workshop to Develop the Strategy for users to access and apply WCRP CMIP climate model simulations to **B**uild **R**esilience of **I**GAD's **C**ommunities to **C**limate **C**hange (BRICCC) ……. 89

Annex-3: A Concept Note for a Pilot Project on Increasing Resilience of Coastal Communities to Climate Change: A Demonstration Pilot Project for a Co-Designed ICPAC-NMHSs-Research Community-Stakeholders Community, Collaboration Model……. 93

List of Figures

Figure 1: The East African Climate Change Paradox (personal communication, Dave Rowell, UKMO) 24

Figure 2: 257 Rainfall and 18 temperature stations and selected on the LVB side of

Tanzania (ICPAC, 2016d). 28

Figure 3: Newly purchased computers installed and networked at TMA (ICPAC, 2016 29

Figure 4: (a) Status of scientific research capacity in Africa, (b) Status of legislation to support climate services capacity in the World (IPCCAR5)….. 32

Figure 5: Schematic for proposed ICPAC internal programs and partners 39

Figure 6: Shows increased variance between the gridded datasets with more recent time periods presumably due to stations that no longer report. The biggest change is to Uganda, Tanzania and Kenya where previously the disagreement. 41

Figure 7: Stages in the development of the regional climate model that has formulation of the regional processes including full thermodynamics of large lakes which is critical for climate services in Fisheries. There is no regional climate model that has this capability. 52

Figure 8: Hydroclimate project for Lake Victoria (HYVIC) Regional Hydroclimate Project (RHP). 54

Figure 9: Schematic for HyVic regional activities and partners (HyVic, 2016). 55

List of Tables

Table-1: PART A of mandatory functions for WMO designation as RCC or RCC-Network 13

Table-2: PART B of mandatory functions for WMO designation as an RCC or RCC-Network 14

Table-3: ICPAC Status of Delivering RCC Services in the Demonstration Phase 17

WISER
Weather and Climate Information Services for Africa

Report summary

The objectives of this assessment are: (i) To review and consolidate the various assessments performed at ICPAC; (ii) identify ICPAC's key products, services and the needs of their key users; prepare, plan and undertake a complementary Capacity Needs Assessment (CNA); (iii) analyse the findings of the capacity needs assessment and provide a report outlining key gaps that exist to help ICPAC improve its development, production, delivery and uptake of key products and services, (iv) formulate recommendations on how to adequately address the key gaps identified.

The work was carried out between 31 May, 2016 and 01 September 2016.
The assessment comprised a combination of information gathering methods. The expert liaised closely with ICPAC, Relevant technical departments of WMO, in particular the Climate and Water Department (CLW); the AMCOMET Secretariat; WMO Office for Africa and Least Developed Countries (AFLDC); UK Met Office, acting as Fund Manager for the regional component of WISER, and with the managers of existing projects being undertaken under WISER, particularly including the Strengthening Climate Information Partnerships – East Africa (SCIPEA) and Enhancing National Climate Services (ENACTS) projects.

The assessment relied heavily on emails and phone calls to collect relevant information. Site-visits and face-to-face interviews were conducted at ICPAC; Rwanda, Kenya and Uganda NMHSs; and relevant organizations within these countries. Most in-depth consultations or sampling were conducted in Uganda as a reference. Consultation and lessons from Rwanda, Kenya and Uganda were used in conjunction with information collected by reviewing many documents to assess the needs in the region. The documents reviewed and the names of the stakeholders engaged with are provided in sections 6 and 7, respectively. The report presents the following general highlights arising from the assessment of ICPAC's capacity needs to provide entry points for technical support and services intervention. Further details are provided in the main body of the report.

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1. The assessment notes that the greatest urgency in ICPAC's technical capacity needs is to satisfy the requirements and become a WMO RCC. Consultation with ICPAC and the WMO Climate and Water Department (CLW) has confirmed that the remaining needs are relatively straight forward to address as the main requirements have already been addressed in previous cycles of evaluation for RCC status. Key pending requirements to address: ICPAC should improve the organization of its products on the web and make sure that all links at ICPAC's website are populated with content; and ICPAC should continue to engage the NMHSs to use its climate database and archiving service support.

2. The assessment has identified the following entry points for ICPAC to strengthen its capacity in meeting WMO RCC 'mandatory', addressing WMO 'highly recommended' requirements, and implementation of ICPAC's 2016-2020 Strategy, (i) build on and expand the scope of ICPAC's internal programs, and (ii) developing strong partnerships with, the university community and research organizations, the users community, the information and computer technology (ICT) community, and the funding agencies/donors agencies community.

3. In the near-term (approximately, present to one year), the assessment has identified important technical capacity benefits to fill critical gaps in ICPAC's delivery of climate services by strengthening the activities initiated by the WISER SCIPEA and ENACTS pilot projects, expand the scope of these projects to serve all user sectors and ICPAC member countries, and build the technical capacity of ICPAC to own and lead the continuation of the activities beyond the pilot projects phase supported by the WISER program and partners organizations.

4. In the medium term (approximately one to six years from the present; and also in consideration of ICPAC's Implementation Plan 2016-2020, investment is required to build ICPAC's technical capacity in the delivery of climate services to support adaptation to climate change. Addressing this need requires a multi-pronged approach at comparable level of investment and effort as the SCIPEA and ENACTS WISER pilot projects. A preparatory and planning workshop to guide and bring together the broad spectrum of stake holders is considered to be an important pre-requisite for implementing a successful agenda. To address these challenges, ICPAC should capitalize on its best recognized legacy which is the GHACOF process, by expanding its scope to include a component on seasonal to sub-seasonal climate prediction (already started through SCIPEA), expansion of GHACOF products to serve a broader spectrum of user sectors (already started

by ENACTS), and introducing a new component focusing on climate change projections and the corresponding climate services.

5. Specific recommendations are presented in the report on a suite of outstanding gaps to build ICPAC's technical capacity for the next ten years. The recommendations include a suggested conceptual strategy to secure adequate and stable funding for the expanded scope of ICPAC's portfolio.

6. This report was prepared with full awareness of the ongoing preparation of the National Strategic Plans (NSPs) by the NMHSs and that they are at different stages of development. These NSPs will guide the NMHSs in determining where they are, where they want to be and how they intend to get there. Therefore, there is need to harmonize this report's recommendations with the final NSPs to ensure seamless expectations and approaches since ICPAC's primary obligation is to serve the NMHSs succeed in the delivery of climate services.

List of abbreviations

ACMAD: African Centre of Meteorological Applications for Development

AFCLIX: Africa Climate Exchange

AGRHYMET: Agriculture, Hydrology, and Meteorology Center

AMCOME: African Ministerial Conference on Meteorology

AMO: Atlantic Multi-Decadal Oscillation

ASAL: Arid and Semi-Arid Lands

BRICCC: **B**uilding **R**esilience of **I**GAD's **C**ommunities to **C**limate **C**hange

CBS: Commission for Basic Systems

CCBS: Commission for Climatology for Basic Systems

CCD: Comparative Climatic Data

CCI: Climate Change Initiative

CCDA: Climate Change and Development in Africa

CCL: Commission for Climatology

CCP: Climate Change Paradox

CLW: Climate and Water Department

CAN: Capacity Needs Assessment

CMIP: Coupled Model Inter-comparison Project

COF: Climate Outlook Forum

CO: Conference of Parties

CLW: Climate and Water Department

CR4D: Climate Research for(4) Development

DALYs: Disability Adjusted Life Years

DMHS: Director of Meteorological and Hydrological Services

DARE: Climate Change and Development-Adapting by Reducing Vulnerability

DFID: Department for International Development

EAC: East Africa Community

EACCP: East-African Climate Change Paradox

EACCP*:* East African Climate Change Policy

ECCAS: Economic Community of Central African States

ECOWAS: Economic Community of West African States

ENACTS: Enhancing National Climate Services

ESA: Eastern and Southern Africa

FCFA: Future Climate for Africa

GCM: General Circulation Model

GCOS: Global Climate Observing System

GFCS: Global Framework for Climate Services

GHA: Greater Horn of Africa

GPC: Global Producing Centre

HPC: High Performance Computing

HyVIC: Hydro-climate Research Project for Lake Victoria

ICPAC: IGAD Climate Prediction and Applications Centre

ICT: Information Communications Technology

IDPs: Internally Displaced Person

IGAD: Inter-Governmental Authority on Development

INDCs: Intentionally nationally determined contributions.

IPCC: Intergovernmental Panel on Climate Change

IPF:IGAD Partners Forum

IRCCS:IGAD Regional Climate Change Strategy

IRI: International Institute for Climate Change and Society

ITCZ: Inter-Tropical Convergence Zone

LC: Lead Centers

LDCs: Least Developed Countries

LR: Long Range Forecasting

LVB: Lake Victoria Basin

MME: Multi Model Ensemble

MCCA: Master of Climate Change Adaption

MOUs: Memorandums of Understanding

NGOs: Non-Governmental Organizations

NGIs: National Grid Initiatives

NSP: National Strategic Plan

EG: European GRID Infrastructure

NMHS: National Meteorological and Hydrological Services

PDO: Pacific Decadal Oscillation

QALYs: Quality Adjusted Life Years

QA: Quality Assurance

QC: Quality Control

PREPARED: Planning for Resilience in East Africa through Policy Adaptation, Research and Economic Development

RCC: Regional Climate Centre

RCOF: Regional Climate Outlook Forum

REaSM: Regional Earth System Model

ROC: Hit Rate Skill Score

ROCCCC: HyVic **R**esilience **o**f **C**oastal **C**ommunities to **C**limate **C**hange

SAM: Southern Annular Mode

SCIPEA: Strengthening Climate Information Partnerships for East Africa

SDG: Sustainable Development Goals

SST: Sea Surface Temperature

SVS: Standard Verification Scheme

SST: Sea Surface Temperatures

SWNDP: Severe Weather Now casting Demonstration Project

TMA: Tanzania Meteorological Agency

UKMO: United Kingdom Meteorological Office

UNDP: United Nations Development Programme

UNFCCC: United Nations Framework Convention on Climate Change

UNMA: Uganda National Meteorological Authority

UON: University of Nairobi

USAID: United States Agency for International Development

USGS: United States Geological Survey

WCRP: World Climate Research Program

VRCs: Vulnerability reduction credits

WASCAL: West African Science Service Center on Climate Change and Adapted Land Use

WIS: WMO Information System

WMO: World Meteorological Organization

WMO (RAs): WMO Regional Associations

WRF: Weather and Research Forecast model

WTP: Willingness to Pay

WCRP: World Climate Research Program

WWRP: World Weather Research Program

SECTION 1

Introduction

1.1 Overall purpose of the Assignment

- Review and consolidate the various assessments performed at ICPAC (documents to be provided by WMO/AMCOMET Secretariat and ICPAC).
- Identify ICPAC's key products, services and the needs of their key users.
- Following review of existing assessments and user needs , prepare, plan and undertake a complementary Capacity Needs Assessment (CNA) through identification of ICPAC's human, infrastructural, institutional and governance, fiscal and legal, communication and outreach capacity needs (with specific and detailed information) to provide a good understanding of the gaps that exist, with a view to eventually having ICPAC performing all WMO RCC's mandatory functions to qualify for designation as IGAD RCC.
- Analyse the findings of the capacity needs assessment and provide a report outlining key gaps that exist to help ICPAC improve its development, production, delivery and uptake of key products and services.
- Formulate recommendations on how to adequately address the key gaps identified, including a proposed priority of which issues should be addressed first.

1.2 Information Gathering Methods

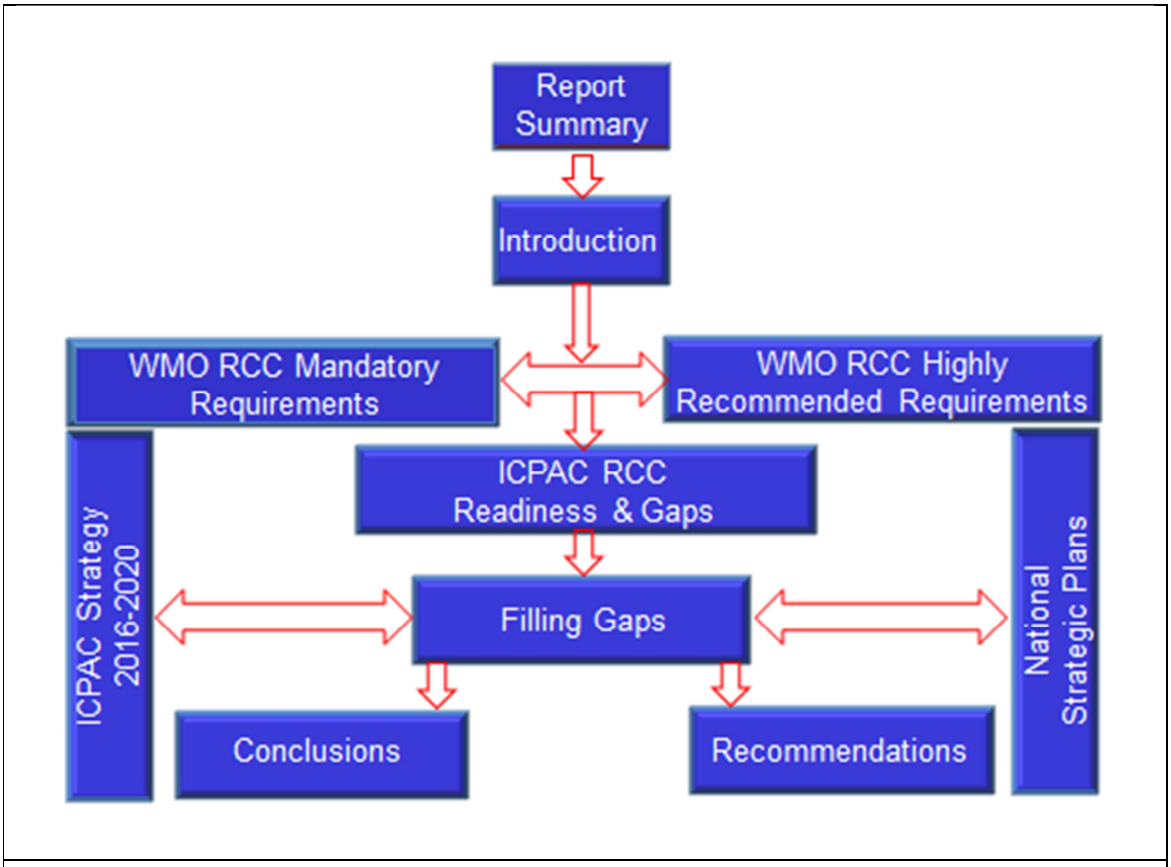
The work was carried out between 31 May, 2016 and 01 September 2016 as follows. The assessment comprised a combination of information gathering methods. The expert liaised closely with ICPAC, Relevant technical departments of WMO, in particular the Climate and Water Department (CLW); the AMCOMET Secretariat; WMO Offices for Africa and Least Developed Countries(AFLDC); UK Met Office, acting as Fund Manager for the regional component of WISER, and with the

managers of existing projects being undertaken under WISER, particularly including the Strengthening Climate Information Partnerships – East Africa (SCIPEA) and Enhancing National Climate Services (ENACTS) projects.

The assessment relied heavily on emails and/or phone calls to collect relevant information. Site-visits and face-to-face interviews were conducted at ICPAC; Rwanda, Kenya and Uganda NMHSs; and relevant organizations within these countries. Most in-depth consultations or sampling were conducted in Uganda as a reference. Consultation and lessons from Rwanda, Kenya and Uganda were used in conjunction with information collected by reviewing many documents to get a sense of the regional needs at national level. The documents reviewed and the names of the stakeholders engaged with are provided in sections 6 and 7, respectively.

1.3 Report Structure and Linkages

Section-1 is the introduction reviewing the conditions of the consultancy, the methods employed to gather information for the assessment and the structure of the report. Section-2 assesses ICPAC's readiness to be designated a WMO RCC and alignment with ICPAC's 2016-2020 Strategy. Section-3 discusses the gaps in ICPAC 's readiness to be designated an RCC in terms of WMO 'mandatory functions' and the 'highly recommended functions'. Section-4 discusses options for filling the gaps. Section-5 gives conclusions and recommendations. For the rest of the sections the content is self-explanatory in the table of contents. A schematic of the important linkages in the report is presented below.



Report Structure and Linkages

SECTION 2

2. ICPAC's Readiness for WMO RCC designation

2.1 Mandatory functions for WMO designation as RCC

The Climate Prediction and Applications Centre (ICPAC) is a specialized institution of IGAD whose objectives are: to improve the technical capacity of producers and users of climatic information in order to enhance the input to and use of climate monitoring and forecasting products; to develop an improved, proactive, timely, broad-based system of information and product dissemination and feedback, at both sub-regional and national scales through national partners; to expand the knowledge base within the sub-region in order to facilitate informed decision making, through a clearer understanding of climatic and climate-related processes, enhanced research and development, and a well-managed reference archive of data and information products (IGAD, 2007).

This is an assessment of ICPAC's capacity to provide entry points for technical support and services intervention for the region. The assessment is based on, (i) ICPAC strategy 2016-2020, and (ii) WMO RCC requirements (Part A and Part B).

ICPAC Strategy 2016-2020

ICPAC strategy 2016-2020 (ICPAC, 2016a) comprises, (i) the ICPAC Strategy 2016-2020, and (ii) the ICPAC Implementation Plan 2016-2020 comprises four programmes:

- Climate Monitoring & Prediction
- Climate Applications
- Data Management, Remote Sensing, and GeospatialTechnology
- Disaster Risk Management

WMO requirements (Part A and Part B) for RCC designation (2008)

Part A (WMO, 2009a) specifies the mandatory set of requirements and Part B (WMO, 2009b), corresponds to the highly recommended category. Table 1 and 2 below give outlines of the two sets of requirements. This assessment identifies gaps in ICPAC's capacity to meet WMO RCC requirements and making recommendations to fill the gaps. It also attempts to analyse the correspondence between ICPAC's strategy 2016-2020 and WMO RCC requirements to identify further gaps in ICPAC's technical capacity.

A: Operational Activities for LRF:
(1) Interpret and assess relevant LRF products from Global Producing Centres (GPCs), distribute relevant information to RCC Users; and provide feedback to GPCs
(2) Generate regional and sub-regional tailored products, relevant to RCC User needs, including seasonal outlooks etc.
(3) Generate consensus* statement on regional or sub-regional forecasts
(4) Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data
(5) Provide on-line access to RCC products/services to RCC Users
(6) Assess use of RCC products and services through feedback from RCC Users
B: Operational Activities for Climate Monitoring
(1) Perform climate diagnostics including analysis of climate variability and extremes, at regional and sub-regional scales
(2) Establish an historical reference climatology for the region and/or sub-regions

(3) Implement a Regional Climate Watch
C: Operational Data Services, to support operational LRF and climate monitoring
(1) Develop quality controlled regional climate datasets, gridded where applicable
(2) Provide climate database and archiving services, at the request of NMHSs
D: Training in the use of operational RCC products and services
(1) Provide information on methodologies and product specifications for mandatory RCC products, and provide guidance on their use
(2) Coordinate training for RCC Users in interpretation and use of mandatory RCC products

Table-1: PART A of mandatory functions for WMO designation as RCC or RCC-Network (WMO, 2009a).

2.2 Highly recommended functions for WMO designation as RCC

Climate Prediction and Climate Projection (Beyond 2 years' time frame)
Assist RCC Users in the access and use of WCRP-CMIP climate model simulations
Perform downscaling of climate change scenarios
Provide information to RCC Users for use in development of climate adaptation strategies
Generate, along with warnings of caution on accuracy, seasonal forecasts for specific parameters where relevant, such as: onset, intensity and cessation of rainy season; tropical cyclone frequency and intensity

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

Develop systems to facilitate harmonisation and assistance in the use of LRF products and other climate services;
Assist NMHSs in user liaison, including the organisation of climate and of multidisciplinary workshops and other forums on user needs;
Assist NMHSs in the development of a media and public awareness strategy on climate service
Training and Capacity building
Assist NMHSs in the training of users on the application and on implications of LRF products on users;
Assist in the introduction of appropriate decision models for end-users, especially as related to probability forecasts;
Promote technical capacity building on NMHS level (e.g. acquisition of hardware, software, etc.), as required for implementation of climate services.
Assist in professional capacity building (training) of climate experts for generating user-targeted products
Research and Development
Develop a climate Research and Development agenda and coordinate it with other relevant RCCs;
Promote studies of regional climate variability and change, predictability and impact in the Region;
Develop consensus practices to handle divergent climate information for the Region
Develop and validate regional models, methods of downscaling and interpretation of global output products;
Promote the use of proxy climate data in long-term analyses of climate variability and change;

Promote application research, and assist in the specification and development of sector specific products;
Promote studies of the economic value of climate information

Table-2: PART B of highly recommended functions for WMO designation as RCC or RCC-Network (WMO, 2009b).

2.3 ICPAC Status of Delivering RCC Services in the Demonstration Phase

Table-3, below is a summary of the current status of ICPAC in delivering RCC services. The status of the implementation of the mandatory functions is given in terms of implemented, partially implemented and not implemented functions. Most of the mandatory functions have already been implemented however a few gaps remain and they will be assessed in the next section.

FUNCTION	CRITERIA	STATUS OF IMPLEMENTATIOM	REMARKS/OBSERVATIONS
Operational Activities for Long-Range Forecast (LRF):			
Interpret and assess relevant LRF products from Global Producing Centres (GPCs), distribute relevant information to RCC Users; and provide feedback to GPCs	**Product:** assessment of the reliability and outcomes of GPCs or Lead Centres on LRF Multi-Model Ensemble (LC-LRFMME) products including the reasoning (making use of Lead Centres Standard Verification Scheme for LRF (LC-SVSLRF), for the region of interest, in the form of texts, tables, figures, etc. **Element:** 2-m mean temperature, total precipitation **Update frequency:** monthly or at least quarterly	Partially implemented	• There are some research papers done within ICPAC on GPCs statistical and dynamical models performance over the region including maps and graphs of model performances • However there are no monthly bulletins analysing and interpreting GPC products although the GPC products are incorporated into the consensus regional climate outlooks

Generate regional and sub-regional tailored products, relevant to RCC User needs, including seasonal outlooks etc.	**Product:** probabilities for tercile (or appropriate quantile) categories for the region or sub-region **Element:** 2-m mean temperature, total precipitation **Output type:** rendered images (maps, charts), text, tables, digital data **Forecast period:** one month up to 6 months **Update frequency:** 10 days to one month	Implemented	• Seasonal outlooks indicating probabilities with forecast consistency information is posted on the web as part of the consensus statement. • Sector specific reports indicating applications of consensus climate outlook by various sectors are also posted on the web.
Generate consensus* statement on regional or sub-regional forecasts	**Product:** consensus statement on regional or sub-regional forecast. **Element:** 2-m mean temperature, total precipitation **Output type:** report **Forecast period:** a climatologically significant period (from one month to one year) **Update frequency:** at least once per year (to be defined by the region)	Partially Implemented	• Consensus statements posted for rainfall regularly but the consensus statement on temperature not provided regularly
Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data	**Products:** verification datasets (e.g. SVS LRF scores, Brier Skill Score; ROC; Hit Rate Skill Score) **Element:** 2-m mean temperature, total precipitation	Partially implemented	• The verification of the latest three seasonal outlooks has been posted on the web • Monthly outlook verification is not provided
Provide on-line access to RCC products/services to RCC Users	**Product:** an on-line data/information portal	Implemented	• RCC website in place
Assess use of RCC products and services	**Product:** analysis of feedback (which is made available using a template)	Implemented	• Results for user survey is posted

through feedback from RCC Users	**Update frequency:** annually, as part of a regular reporting of RCCs to WMO RAs		• User feedback during regional climate outlook fora is posted
Operational Activities for Climate Monitoring			
Perform climate diagnostics including analysis of climate variability and extremes, at regional and sub-regional scales	**Products:** climate diagnostics bulletin including tables, maps and related products **Element:** Mean, Max and Min temperatures, Total precipitation; other elements (esp. GCOS essential climate variables) to be determined by the region, **Update frequency:** monthly	Implemented[1]	• Monthly bulletins posted on the web
Establish an historical reference climatology for the region and/or sub-regions	**Product:** database of climatological means for various reference periods (e.g. 1931-60; 1951-80; 1961-90; 1971-2000; etc.) **Spatial resolution:** by station Temporal resolution: monthly at a minimum **Elements:** Mean, Max and Min temperatures, Total precipitation; other elements (esp. GCOS essential climate variables) to be determined by the region, **Update frequency:** at least 30 years, preferably 10 years	Implemented	• Reference climatology for 1960-1990 and 1981-2010 is posted on the web
Implement a Regional Climate Watch	**Products:** climate advisories and information for RCC Users **Update:** whenever required, based on the forecast of significant regional climate anomalies.	Implemented	• The most recent climate watch is posted on the web site
Operational Data Services, to support operational LRF and climate monitoring			

Table-3: ICPAC Status of Delivering RCC Services in the Demonstration Phase

Develop quality controlled regional climate datasets, gridded where applicable	**Products:** regional, quality controlled climate datasets, gridded where applicable, following CCl guidance on QA/QC procedures **Elements:** Mean, Max and Min Temperature, and Precipitation, at a minimum **Temporal resolution:** daily **Update:** monthly	Implemented	• Monthly and ten day gridded rainfall data is available • Metadata on gridded rainfall is provided
Provide climate database and archiving services, at the request of NMHSs	**Products:** national databases with metadata, accessible to the NMHS in question (backup service, development site, etc.). **Elements:** as determined by the NMHS **Update:** at the request of the NMHS	Not implemented	• ICPAC is ready but no Member State has requested for archiving services
Training in the use of operational RCC products and services			
Provide information on methodologies and product specifications for mandatory RCC products, and provide guidance on their use	**Products:** Manuals, guidance documents and information notes. **Update frequency:** when methods/ products are revised or introduced or discontinued	Partly implemented	• some manuals are posted on the web site but others are in the process of development
Coordinate training for RCC Users in interpretation and use of m mandatory RCC products	**Products:** survey and analysis of regional training needs, and proposals for training activities.	Implemented	• Some training workshop reports are posted on the web site

SECTION 3

3. Gaps in ICPAC 's Readiness as a WMO RCC

3.1 Mandatory functions for WMO designation as RCC

General observations: The recommendation for WMO RCC designation is made by the WMO Commission for Basic Systems (CBS). All the mandatory requirements must be satisfied for an organization to become an RCC. Following consultations with ICPAC and the WMO Climate and Water Department (CLW), ICPAC is close to satisfying all the requirements. As a general observation, however, there is need for ICPAC to improve the organization of its products on the web and making sure that all links at ICPAC's website are populated with content. Specific gaps based on Table-1 are outlined below.

3.1.1 Operational Activities for LRF

Function (***Partially implemented***): Interpret and assess relevant LRF products from Global Producing Centres (GPCs), distribute relevant information to RCC Users; and provide feedback to GPCs (see table-1).

Gap: There are no monthly bulletins analysing and interpreting GPC products although the GPC products are incorporated into the consensus regional climate outlooks

Function (***Partially implemented***): Generate consensus statement on regional or sub-regional forecasts (see table-1)

Gap: Consensus statements posted for rainfall regularly but the consensus statement on temperature is not provided regularly

Function (***Partially implemented***): Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data (see table-1)

Gap: The verification of the latest three seasonal outlooks has been posted on the web; Monthly outlook verification is not provided (see table-1)

3.1.2 Operational Activities for Climate Monitoring

Functions: Fully implemented
Gaps: None

3.1.3 Operational Data Services, to support operational LRF and climate monitoring

Function (not implemented**):** Provide climate database and archiving services, at the request of NMHSs

Gap: One of the key functions for ICPAC to meet its obligations when it becomes a full-fledged RCC is to provide climate database and archiving service support at the request of NMHSs. ICPAC is ready to deliver this service. ICPAC should continue to engage the NMHSs to indicate their plans and potential barriers to take advantage of this important form of ICPAC support.

3.1.4 Training in the use of operational RCC products and services

Function (partially implemented**):** Provide information on methodologies and product specifications for mandatory RCC products, and provide guidance on their use.

Gap: Some manuals are posted on the web site but others are in the process of development.

3.2 Highly Recommended Functions

3.2.1 Climate Prediction and Climate Projection (Beyond 2 years' time frame)

The East African rain seasons are primarily determined by the passage of the inter-tropical convergence zone (ITCZ) of the northeast (NE) and southeast (SE) monsoons and it follows the inter-hemispheric migration of the overhead position of the Sun (Leroux, 2001). The Long Rains (March to May) account for the largest proportion of the annual rainfall. The Short Rains (October to December), although not as wet, are also essential for crop development and other major regional social-economic sectors. Areas over the northern and southern extremes of the region experience unimodal rainfall climate regimes. This simple background climatology is significantly modified by sub-regional factors including the complex orography, vegetation-land-ocean contrasts, and large inland lakes.

On climate change time scales, the most outstanding factor to contend with is the persistent multi-decadal decline in the Long Rains since the 1980's (Lyon & Dewitt, 2012), and the projected increase in rainfall by the IPCC models (IPCC, 2013). Both global warming forcing due to anthropogenic factors (Williams and Funk, 2011) and natural sources of variability (Lyon, 2014; Yang et al., 2014; Semazzi et al, 2015) have been proposed to explain the multi-decadal drop in the Long Rains. The user community wish to know, (i) whether indeed a reversal in the availability of rainfall will occur during the next few decades, (ii) the timing of when it will materialize, and (iii) whether these two factors can be determined at acceptable level of confidence for the management of the leading regional climate-sensitive social-economic sectors. This decrease and the anticipated increase have come to be known as the climate change paradox (EACCP; Fig.1). There are also major shifts associated with the other seasons of the year although they are even less understood than the EACCP.

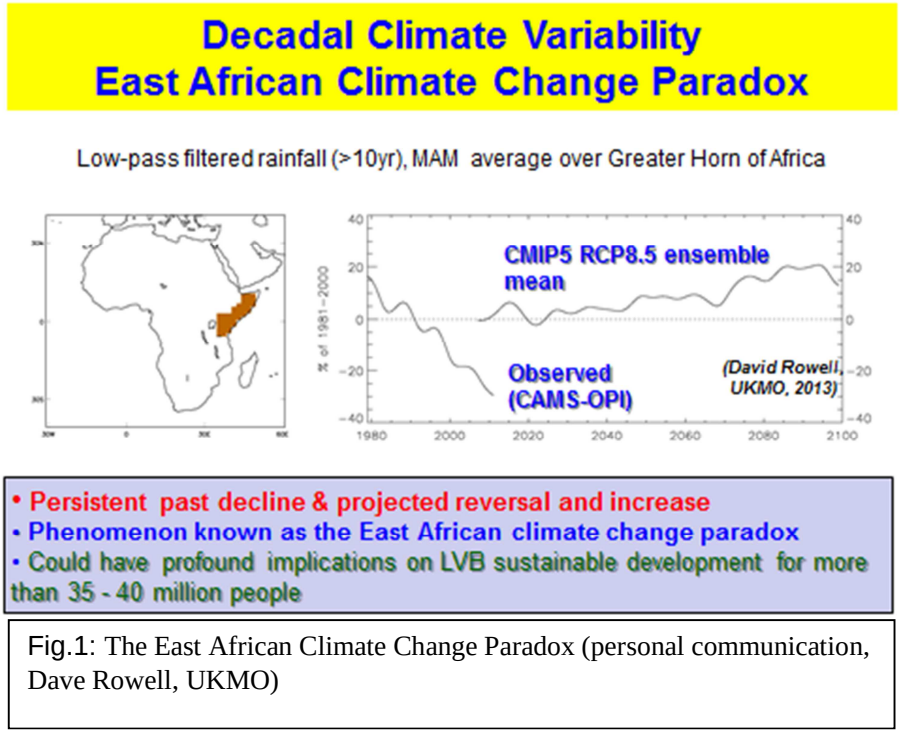


Fig.1: The East African Climate Change Paradox (personal communication, Dave Rowell, UKMO)

The entry point for ICPAC to address the climate change problem is the IGAD Regional Climate Change Strategy (IRCCS, 2016). It amplifies the aspirations of IGAD member states not only to tackle climate-induced droughts and disasters, but also to enhance sustainable development by facilitating/promoting the implementation of key priority sectors and intervention strategies. Moreover, IRCCS is designed to serve as a framework for the implementation of the Sustainable Development Goals (SDGs). The time span for the implementation of IRCCS is recommended to be between 2016 and 2030 to allow the region to synchronize relevant provisions/contents of the various instruments (INDCs, SDGs, the Paris Agreement, etc.) within a reasonable time period. The key priority sectors of IRCCS revolve around:

- Agriculture, livestock and fisheries;
- Renewable energy and energy efficiency;
- Development of climate-resilient Industries and trade;

- Water resources for irrigation, livestock production, domestic consumption and commercial purposes;
- Transport and climate change;
- Climate change, forest resources, wetlands and biodiversity;
- Marine resources, coastal areas and climate change; and
- Arid and Semi-Arid Lands (ASALs)

In addition to the above, a number of cross-cutting priorities are identified:

- Conflicts and climate change;
- Migration, IDPs and climate change;
- Population dynamics and climate change;
- Gender, youth and climate change;
- Health, nutrition, food security, and climate change;
- Climate change, marginal and vulnerable groups/communities;
- Generation of and access to quality data;
- Promotion of research, education, awareness and advocacy;
- Coordinating the setting up of Early Warning Systems as well as drought and disaster resilience;
- Coordination, harmonization and adaptation of regional and international climate change instruments;
- Capacity building for climate change adaptation, mitigation and resilience.

Gaps: Development of ICPAC's technical capacity is needed to, (1) monitor and predict the state of the East African Climate Change Paradox and other major shifts in the regional climate and (2) their implications on the IRCCS'priorities, i.e. assist RCC Users in the access and use of WCRP CMIP climate model simulations; Perform downscaling of climate change scenarios; Provide information to RCC Users for use in the development of climate adaptation strategies; Generate, along with warnings of caution on accuracy, seasonal forecasts for specific parameters where relevant, such as: onset, intensity and cessation of rainy season; tropical cyclone frequency and intensity; Perform verification on consensus statements for forecasts; Perform assessment of other GPC products such as SSTs, winds, etc.

3.2.2 Non-operational data services

As climate science advances and the breadth of ICPAC's products widens, non-operational data services and management must also keep pace supporting these developments. Consultations during the assessments have revealed the following key gaps and opportunities for ICPAC to enhance its activities, data rescue, expertise in quality control, and capacity for archiving and transmitting and sharing it with its member countries.

3.2.2.1 Data Rescue

The implementation plan for the GFCS (GFCS, 2016) includes Data Rescue as one of its priority areas by working through WMO and RCCs, such as ICPAC, which work closely with NMHSs. A substantial amount of the climate archives that go back to the nineteenth century is on paper and has been stored under poor conditions in the NMHSs. They need to be recovered, imaged and digitized before they deteriorate beyond use.

The USAID project Planning for Resilience in East Africa through Policy Adaptation, Research, and Economic Development (PREPARED) has been working closely with the East Africa Community (EAC) Partner States, IGAD Climate Prediction and Applications Centre (ICPAC), and the World Meteorological Organization (WMO) on strengthening climate information generation in the region using especially GeoClim software. GeoClim is a geospatial visualization software tool facilitating climatological analysis of historical rainfall and temperature data. It was developed by USGS FEWS NET in support of the USAID PREPARED for Global Climate Change activities at the University of St Barbra. GeoClim has inbuilt functions to generate the much desired spatial datasets through interpolating technics, blending stations and satellite data.

Directors of Meteorological and Hydrological Services (DMHS) from each EAC Partner State requested the PREPARED Project's assistance in rescuing and digitizing historical meteorological data that will eventually be integrated into the GeoCLIM datasets. This initiative fits in the objective of Global Framework for Climate Services (GFCS) for strengthening climate information generation where Data Rescue (DARE) is number 3 on WMO priority list.

The introduction of additional historical data will provide more robust historical climate record. The objective of the PREPARED Project DARE initiative is to support each EAC Partner State in establishing sustainable operational systems for gathering data; rescuing, preserving, and improving data quality; digitizing, archiving, and analysing records; and disseminating the information to the public. It was envisaged that data Rescue activities would start in Burundi in June 2015 but this was not possible due to unavoidable circumstances. Consequently directors of meteorological services met in Arusha in April 2015 and endorsed to pilot DARE activities in Tanzania as an alternative. ICPAC in collaboration and support of the PREPARED Project are implementing the Piloting of Data Rescue activities at Tanzania Meteorological Agency (TMA) and at the same time planned to build capacity for the Data Managers (DMs) in the EAC region in basics of Climate Data Management. It is anticipated that capturing and recording historical data in Tanzania will demonstrate best practices for DARE that can be replicated in the other NMHSs within the EAC.

Implementation: The following institutions are involved in the data rescue campaign and their roles: ICPAC: Playing the implementation role given its institutional mandate of providing technical support; WMO: through its sub-regional office (RAI) is doing the oversight role to ensure that parity of the Institutions involved exists and also DARE standards and quality are adhered to; PREPARED: facilitates the DARE pilot activities with financial support to increase on usable records; TMA: Routine supervision of the DARE-Pilot activities such as imaging, indexing, quality control and climate database management.

Station inventory: This exercise started with liaison with DFID who were doing data Rescue in Tanzania to establish synergy and avoid duplication of work. DFID interest was on the coast and central Tanzania. This was followed by stations inventory and gaps analysis together with an agreement on the selection of 257 stations to be rescued from the Lake Victoria Basin (LVB) on the Tanzanian side as can be seen in Fig: 1 below. Working with the TMA staff, records for gaps of missing data were identified in this exercise and records to be digitized were made readily accessible.

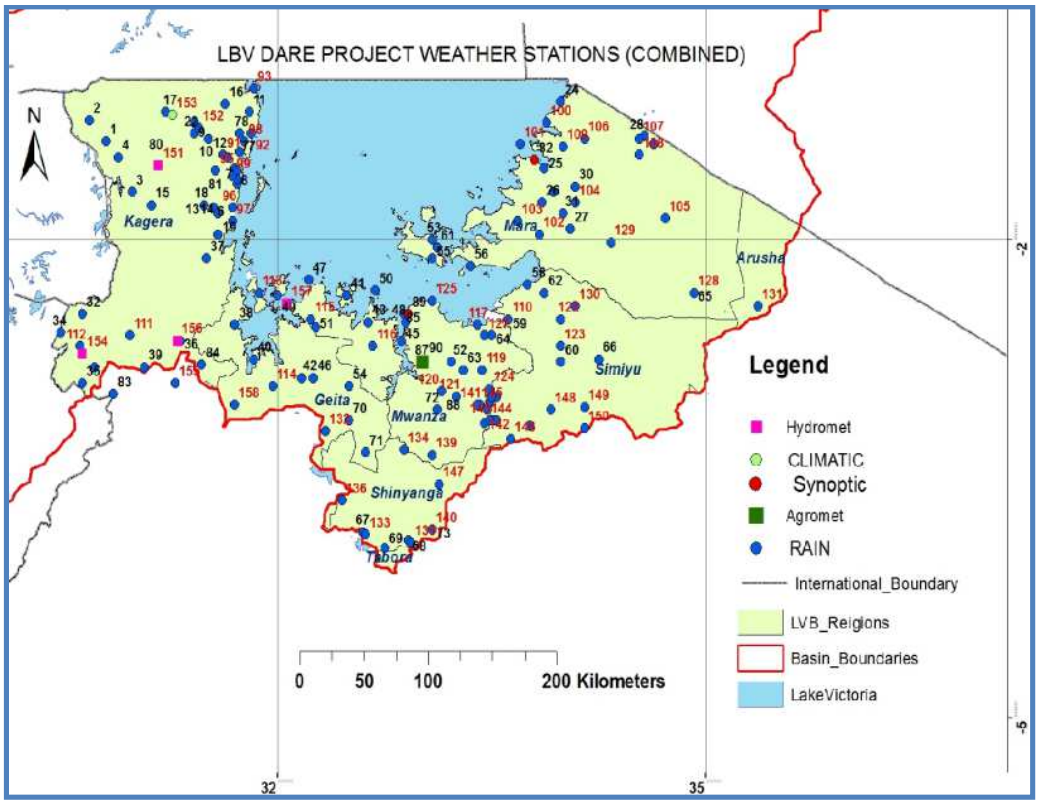


Fig.2: 257 Rainfall and 18 temperature stations and selected on the LVB side of Tanzania (ICPAC, 2016d)

Procurement of DARE tools: The notion that procurement was to be done locally within Tanzania (in consultation with the staff) rather than having to source the DARE equipment from out of the country was highly commended by the TMA top management. ICPAC provided 1 Server with Server OS, 9KVA UPS and 2 Workstation for data rescue at TMA as one of the recipients in the region. TMA had agreed to be the proverbial guinea pig of DARE in the EAC region. Everything emanating from the TMA DARE pilot would be an experience for the betterment of practices in the other NMHSs of the region.

Dare Tools acquired: The items bought were sourced locally except the ones which came from ICPAC and these included among other: (1) 10 Desktop computers ; (2)

3 A3 scanners; (3) Networking cards and cabling wires, (4) 4 UPS of 5KV; (5) 10 Desks; (6) 2Digital Cameras; (7) MS office 2010; professional; (9) Network gadgets and cabling wires; (10) Consumables; (dust coats, gloves, masks, CDs Flush disks, stationery, etc.). The Computers were installed and networked at the TMA Lab as it can be seen in the picture below.

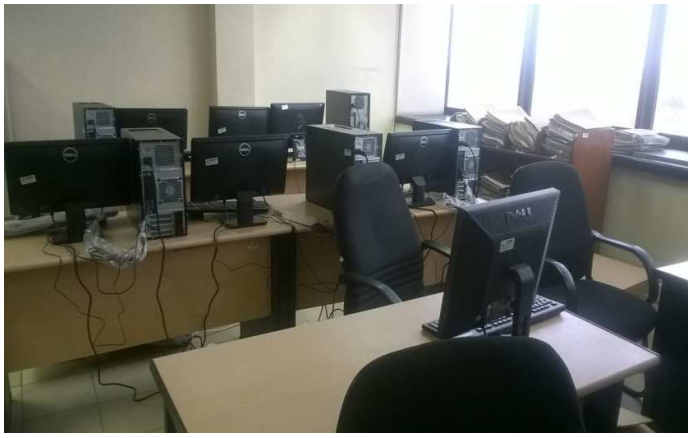


Fig.3: Newly purchased computers installed and networked at TMA (ICPAC, 2016d)

Gaps: Upscale the Dare pilot to the rest of the ICPAC member countries. For sustainability there is no regular financial support to continue the rescue of the data and this needs to be identified.

3.2.2.2 Access to High Performance Computing & Broadband Internet

Lack of access to high performance computing and broadband internet is a major limitation for ICPAC and its partners to the transmission of data and to conduct computer intensive climate prediction/projection calculations.

Gaps: Access to gigabyte internet capacity and HPC computing capacity. This is required to undertake S2S, climate projections and data transmission.

3.2.3 Training and Capacity building

The need for expertise in climate prediction/projection, data services and interface with the user community indicates the importance of targeted ICPAC non-university training and co-produced curriculum involving ICPAC and universities to achieve critical human 'capital'.

3.2.3.1 ICPAC-Training and Capacity Building

Every GHACOF is preceded by a capacity building workshop to enhance capacity of the national climate scientists as well as developing national and regional forecasts for rainfall and temperature which are presented for the consensus GHACOF seasonal climate outlook. Previous sessions focused on statistical downscaling. Typically, several users' specific workshops are also organized alongside GHACOF in collaboration with various partner organizations. These include: agriculture and food security, water resources, disaster risk management, health coastal zones and media. In GHACOF44, for the first time, ICPAC also introduced training to member state NMHSs on dynamical seasonal prediction and super-ensemble forecasting (ICPAC, 2016e).

Gap: Pre-GHACOF training does not include routine capacity development sessions in S2S and climate change. A major gap that should be filled is luck of balanced interdisciplinary training in how the climate functions, how it will evolve over the next few decades, and how the reliability of that information may be assessed and results applied to build resilience to climate change. Therefore, there is urgency to train a new generation of professions who understand how actionable climate science information may be derived and applied to empower stakeholders in making optimal risk management decisions.

3.2.3.2 Co-designed ICPAC-University Curriculum

Climate variability and climate change is an issue that all organizations, both public and private, will have to address in their planning and operations. In recent years there has been increased demand and enrolment in university curriculum that bridges the gap between climate information providers and users, both in East Africa and other parts of the World. The Institute for Climate Change & Adaptation,

University of Nairobi, Kenya has a Masters of Climate Change Adaptation MCCA; UoN (2016)). The MCCA programme of the University of Nairobi seeks to improve the science and practice of climate change and adaptation. It explores the fundamental changes caused by anthropogenic and natural activities that influence the alteration of the living earth's environment. In another program within East Africa, Makerere University, in Uganda, is developing a Master's degree in Climate Sciences. There are similar efforts in West Africa under the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) programme (www.wascal.org).

In the US North Carolina State University offers an innovative Professional Science Master's degree in Climate Change & Society (https://ccs.sciences.ncsu.edu), the first program of its kind at a public university in the South Eastern United States. The program bridges the gap between producers of climate science knowledge and its users. The Climate Change & Society degree is an accelerated program and takes full-time students one year to complete. It combines innovative climate change science and broad knowledge of climate-sensitive sectors to develop creative decisions for mitigating and adapting to climate change.

Gap: For ICPAC member countries to meet the WMO requirements ('mandatory' and 'highly recommended'), and to implement COP21 commitments (see section 3.2.4) they require most of the government institutions, administrative jurisdictions and sectors to incorporate climate change considerations in their plans and budgets(see for example UNDP (2015)).Therefore, there is urgent need to train hundreds of professionals in climate sensitive sectors in each country to acquire end-to-end interdisciplinary understanding of the problem and practical experience to provide climate services. The number of universities that have the desired curriculum is very limited as noted above. The costs and effort needed to establish traditional face-to-face-based instructional programs can be prohibitive. There is need to establish capacity for *online* University-ICPAC co-designed programs which are accessible by students from all ICPAC member countries and mid-career professionals who cannot take time off from work to enrol in the regular degree programs.

3.2.4 Research and Development

The historic Paris 2015 Climate Summit (COP21, 2015) resulted in an agreement to hold, “the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels” (Future Earth, http://futureearth.org). Billions of US dollars have been pledged by the nations of the World to support the actions agreed on at the COP21 Summit. The Green Climate Fund (GCF, 2016) has raised USD 10.3 Billion equivalent in pledges. However, lack of capacity and expertise in developing countries may severely limit the ability to achieve the desired goals. According to IPCC-AR5 Africa ranks at the bottom in the world in climate research productivity measured in terms of research journal publications (IPCC-AR5; see Fig.4a). Consequently, Africa also ranks at the bottom in the development of appropriate legislation and regulatory processes to support climate change policy (IPCC-AR5; see Fig.4b).

ICPAC requires intake of the most current and comprehensive climate science to meet its objectives. Presently, the process for critical scientific advances from the research community to impact ICPAC’s climate services is ad-hoc and important scientific results may not be optimally exploited. Furthermore, the process for adopting new research is highly dependent on the sources of funding resulting in lack of continuity.

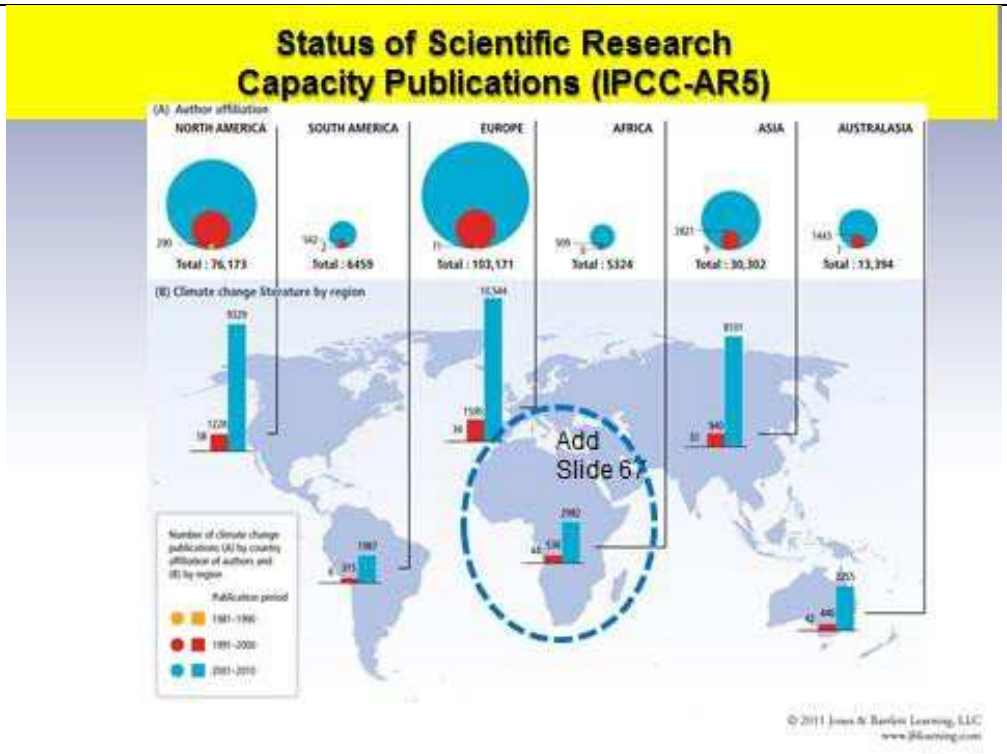


Fig.4: (a) Status of scientific research capacity in Africa (IPCCAR5)**.**

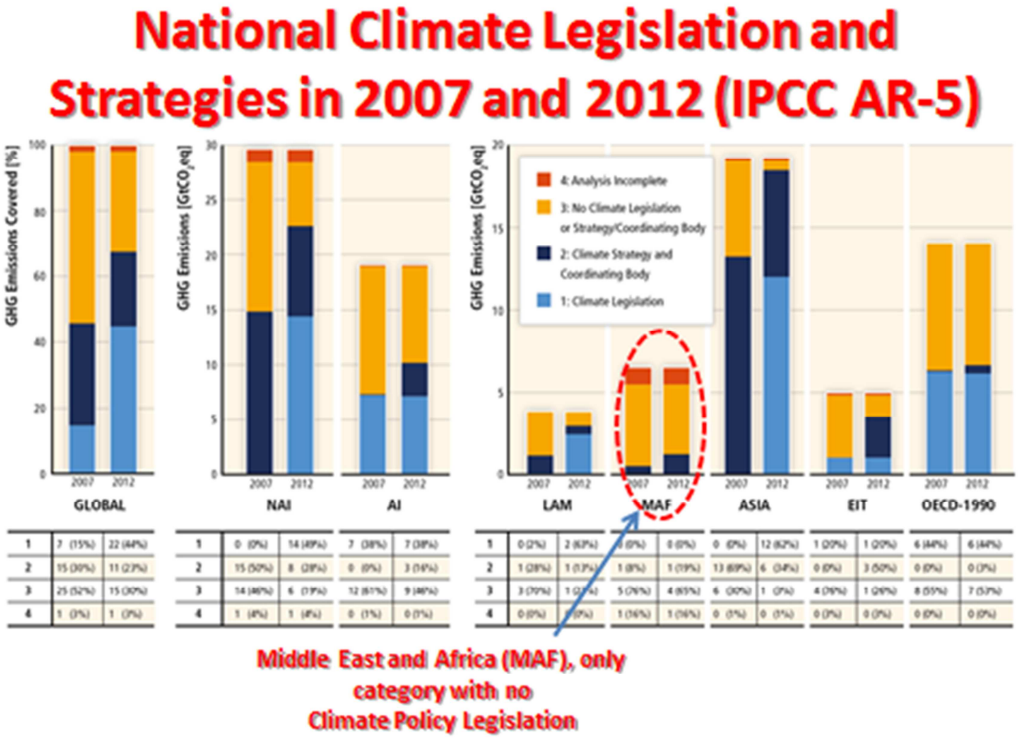


Fig.4: (b) Status of legislation to support climate services capacity in the world (IPCCAR5)**.**

Gaps: (i) streamlining scientific research intake to ensure efficient exploitation of the most current research developments, and (ii) ensuring that ICPAC plays a key role in the prioritization of the work undertaken by the research community in the region and abroad.

3.2.5 Coordination (Financing) Function

Coordination: ICPAC's coordination and management has been key to its vibrant functions and involves the IGAD Member States, the IGAD Secretariat, IGAD specialised institutions and programmes and the Development Partners. Although

the GHACOF events and process has served the region very well, feedback from consultees indicates that, in addition to the present GHACOF 'workshop model', there is need to upgrade the process to a more diffuse platform that increases responsiveness to different sectors and users. It is expected that with the expansion of ICPAC's activities and products to include services in climate change adaptation and mitigation, it will become very challenging to apply the GHACOF 'workshop model' considering the large volume of stakeholders involved. For example a likely community to benefit from ICPAC's climate change portfolio is the annual Climate Change and Development in Africa (CCDA) conference program supported by ClimDev-Africa which is attended by more than 300 participants and who are likely to be interested in attending GHACOF workshop event (see CCDA-V, 2015). The CCDA annual conference has enabled transformative change through the provision of a forum process where hundreds of stakeholders including legislators, mandated government institutions, NGOs, civil society, private sector, international aid agencies and many other organizations can undertake research and present their results at the CCDA conferences (http://www.climdev-africa.org/ccda5/conferencedocuments). Therefore there is need to explore alternative GHACOF models for coordinating user response considering the anticipated rapid growth in demand.

Financing: ICPAC's funding consists of the following sources: Assessed contributions from Member States (main source of the operational funding is from assessed contributions from Member States); Voluntary and/or special contributions; Donations, grants, gifts, and bequests; Funds from Development Partners; Remunerations for services rendered; and other sources as may be approved by IGAD. It is also exploring potential financial support from Public-Private Partnerships and provision of expert consultancy services to organizations and the 'Green Economy' development under various International Agreements. These and other resource mobilizations campaigns are directed through the IGAD Partners Forum (IPF).

Gaps: (i) Coordination of response to future user needs that include services in climate change adaptation/mitigation require significantly increased funding; to ensure sustainable funding to accommodate the higher cost of increased number of the WMO 'mandatory' and 'highly recommended' RCC services and products, (ii) coordination of climate research community require a streamlined approach to avoid

the current ad-hoc process of ICPAC research intake.

SECTION 4

4 Filling Gaps in the Capacity of ICPAC to Provide Technical Support and Services Intervention

This section systematically identifies ways to fill the gaps in ICPAC's technical capacity synthesized in section 3.

4.1 Mandatory Functions for ICPAC Designation as a WMO RCC (Short-Term)

As noted earlier, based on this assessment ICPAC meets nearly all the mandatory WMO requirements to become an RCC. To assess ICPAC's compliance each of the remaining gaps, identified in section 3 (consolidated in the box below), has been examined in context of recent developments.

1. **Gap**: There are no monthly bulletins analysing and interpreting GPC products although the GPC products are incorporated into the consensus regional climate outlooks
2. **Gap**: Consensus statements posted for rainfall regularly but the consensus statement on temperature not provided regularly
3. **Gap**: The verification of the latest three seasonal outlooks has been posted on the web; Monthly outlook verification is not provided.
4. **Gap**: One of the key functions for ICPAC to meet its obligations when it becomes a full-fledged RCC is to provide climate database and archiving service support at the request of NMHSs. ICPAC is ready to deliver this service. ICPAC should continue to encourage NMHSs to indicate their plans and potential barriers to take advantage of this important form of ICPAC support.
5. **Gap**: Some manuals are posted on the web site but others are in the process of development.

6. Gap: Need for ICPAC to improve the organization of its products on the web and making sure that all links at ICPAC's website are populated with content.

Recent major boost in ICPAC's compliance with the WMO RCC requirements is a result of the launching of its dynamical LRF system and the contribution of the WISER SCIPEA pilot project. Both of these initiatives are briefly described below in context of ICPAC's readiness to meet the WMO RCC requirements.

ICPAC Dynamical LRF: To complement its statistical-based seasonal climate predictions, ICPAC has introduced a dynamical Long-Range-Forecasting component based on Global Producing Centers (GPC) model output (ICPAC, 2016e). For the first time ICPAC launched dynamical prediction system at GHACOF-44. ICPAC's LRF system now comprises three state-of-the-art approaches: a) Dynamical downscaling of coupled global model forecasts for precipitation and temperature (min, max, mean) for OND 2016 simulated from late July initial conditions (up to 5 months lead forecasts at 30 km horizontal resolution), b) multi-model super ensemble seasonal probabilistic forecasts for GHA based on more than 70 GCM ensemble members obtained from Global Producing Centers (GPCs) of Long Range Forecasts (http://www.wmo.int/pages/prog/wcp/wcasp/gpc/gpc.php), and c) the traditional statistical forecasts. In addition, ICPAC is developing user-centred actionable WRF-based objective forecasts of onset, cessation, dry spells, and wet spells for OND 2016. Therefore, ICPAC's capacity exceeds the mandatory requirements in climate prediction. ICPAC is committed to continue providing and posting 10-day WRF forecasts and statistical monthly and seasonal predictions operationally. Monthly and seasonal forecasts are made available on the web and to the public using the new dynamical and super-ensemble forecasting approaches after the COF. ICPAC also provides training to member state NMHSs in various areas including on dynamical seasonal prediction and super-ensemble forecasting beginning 15 August 2016 prior to COF.ICPAC also provides data archiving and when appropriate posting of analysis data on the web (ENACTS-ICPAC, 2016). These new developments address all the concerns raised regarding *'Operational Activities for LRF i*n the previous evaluation of ICPAC to become an RCC. The RCC architecture for Africa recognizes ACMAD as continental RCC that should feed the regional RCCs (ICPAC, ECOWAS, ECCAS, etc.). Since ACMAD has already proven its expertise in this area ICPAC should collaborate with ACMAD in implementing this function to avoid potential duplication of new efforts.

SCIPEA LRF Pilot Project: During the same time frame as the development and launching of ICPAC's Dynamical LRF products, the WISER Program started the SCIPEA project (SCIPEA, 2016) in EAST Africa.For many years, the focus (including other regional COFs around the world) has been on seasonal prediction. However, it is now clear that the application community need intermediate predictions products within the seasons in addition to the traditional seasonal predictions (ICPAC, 2016f). The UKMO (Lead, Richard Graham) has made important advances in this area and helping to operationalize the S2S forecasts as part of the GHACOF process. The SCIPEA project aims to strengthen climate partnerships on three levels:

1. Enhancing links and data exchanges between global, regional and national climate organisations – strengthening resources and tools for seasonal forecasts;
2. Climate information providers and users – to co-develop prototype tailored services;
3. NMHSs and Universities/Training Centres – strengthening resources for capacity training and climate service development as well as capacity retention.

There was a special session at GHACOF43 (OCPAC, 2016f) dedicated to the launch of SCIPEA. It is therefore apparent that there are overlapping interests between ICPAC's seasonal dynamical prediction and SCIPEA's activity 1. Based on this assessment the outcomes would greatly benefit from, (i) close partnership between the two initiatives in the use of ensemble predictions from the GPCs including the UKMO, and (ii) institutionalizing SCIPEA's components 2 and 3. In the pilot project mode some aspects of these activities occur outside the existing ICPAC institutional framework. Periodic joint assessment by ICPAC and SCIPEA could help to identify products and lessons in high state of readiness to become part of ICPAC's regular production line.

Based on the recent advances through ICPAC LRF system and the SCIPEA project in practice has addressed gap#1 through gap#3 of the remaining concerns (see box above). However, ICPAC needs to focus its energy in addressing gap#4 through gap#6 as soon as possible to meet the next deadline when its application to become an RCC will be reviewed by WMO.

4.2 Highly recommended functions for ICPAC Designation as RCC and ICPAC's 2016-2020 Strategy (one year from present to 2020)

After ICPAC is designated a WMO RCC it should devote full attention to address the 'highly recommended' functions in order to become a high performing RCC in providing climate services. Fig.5 shows, in a nutshell, a framework that has emerged to strengthen compliance with the 'mandatory functions' and to fill the gaps regarding the 'highly recommended' functions. It comprises the following primary components with ICPAC internal programs as the centre of mass:

(i) **ICPAC's partnership with the university and research organizations community**: To ensure ICPAC's efficient and effective access to the most credible training and research to contribute to the prioritization of the climate research undertaken by the regional and international researchers,

(ii) **ICPAC internal programs**: ICPAC's capacity to generate and provide co-designed and co-produced information with its climate change research and user community partners**,**

(iii) **ICPAC's partnership with the user Community**: To establish appropriate links with NMHSs and their stakeholders,

(iv) **ICPAC's partnership with the information and computer technology (ICT) community,**

(v) **ICPAC's partnership with funding agencies.**

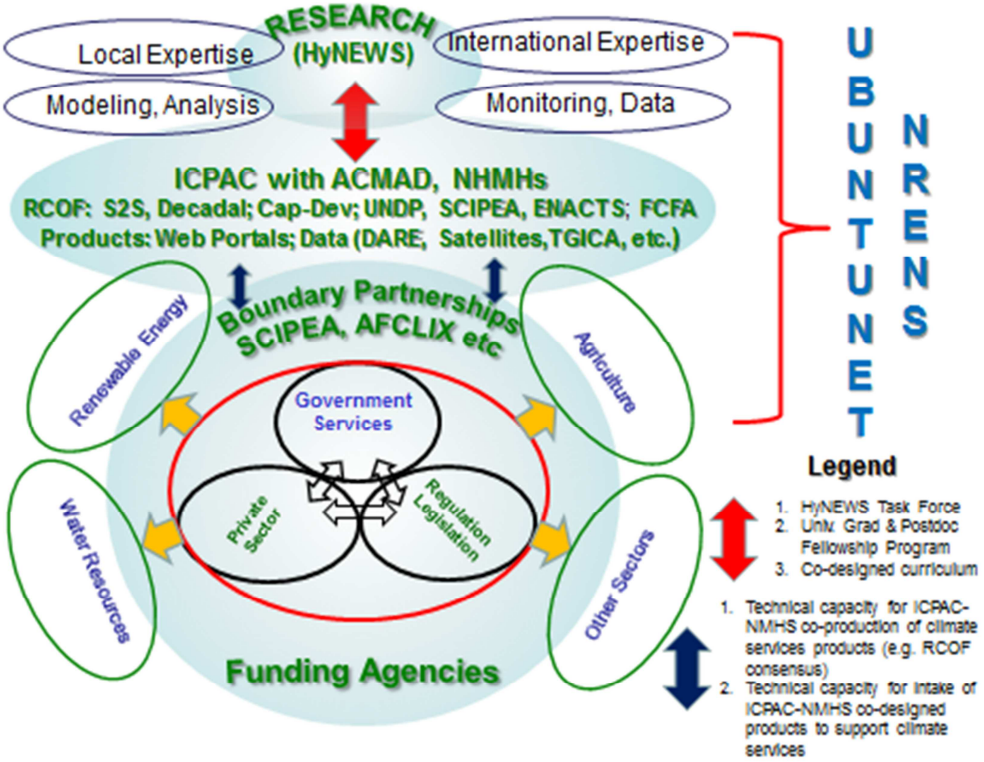


Fig.5: Schematic of a framework for ICPAC's Internal Programs and Partnerships

4.2.1 **ICPAC internal programs**

4.2.1.1 Data Rescue

The assessment has identified the opportunity to upscale the DARE activities to the rest of the ICPAC member countries building on the experience from the DARE pilot project focussing on Tanzania. The introduction of additional historical data will provide more robust historical climate record. There is no identified funding for financing this important program and support to extend the rescue to other ICPAC countries needs to be identified. It is prudent to engage the organizations that were involved in the Tanzanian pilot in the expanded scope of the work. ICPAC has gained significant expertise from that experience and should already be in position to lead

the campaign. Other key partners should include the USAID (PREPARED), the East Africa Community (EAC) Partner States, Tanzania Meteorological Agency (TMA) and WMO. GeoClim software was successfully employed in processing the data in the pilot and should be one of the key tools to be used for the expanded scope to the regional domain. As a developer of GeoClim, USGS FEWS NET should also be a member of the partnership to provide technical support.

The goal should be to establish sustainable operational systems for gathering data; rescuing, preserving, and improving data quality; digitizing, archiving, and analysing records; and disseminating the information to the public. A stations inventory and gaps analysis will be required to select the stations to be rescued. In case of Tanzania campaign 257 stations were identified for rescuing. Working with the TMA staff, records for gaps of missing data were identified and records that were digitized were made readily accessible. A quick and rough estimate based on geographical area indicates that there will be about 8 to 10 times more stations involved for the rest of the ICPAC member countries. This implies that major procurement and installation of equipment will be required in addition to the significantly increased manpower and expertise needed to conduct the campaign. In identifying the stations to focus on for rescuing the missing data it is important to exploit the research which has been conducted on the impacts of missing data for the characterization of observed interannual and decadal climate anomalies. For example Angus (2016) shows, in Fig.6, increased variance between the gridded datasets with more recent time periods presumably due to stations that no longer report. The biggest change is for Uganda, Tanzania and Kenya where previously the disagreement between the datasets was small in these countries; it is now on a similar scale to the Congo rain forest and the coast of Somalia.

More targeted studies at 'missing data' involve creation of surrogate synthetic data for the actual missing data and conducting sensitivity analysis on different scenarios of missing data patterns thereby providing guidance for identifying the most critical data gaps where emphasis should be placed to rescue missing data. In depth consultation is required to carry out this analysis to ensure that the benefits of the rescue mission are maximized. Considering the potential increase in the scope of the effort compared to the pilot which involved only one country (Tanzania), it may be prudent to use such analysis in staging the rescue work starting with the most crucial

gaps and later gradually move on to rescue data for stations that are less critical in filling the gaps.

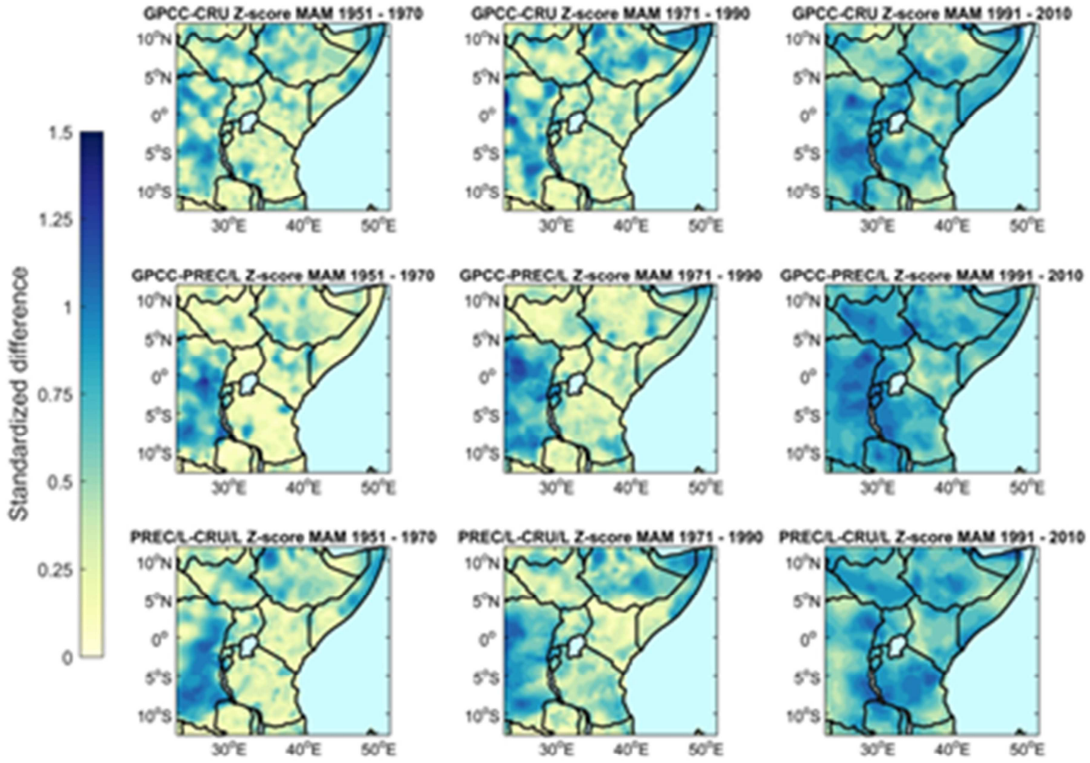


Fig.6: Shows increased variance between the gridded datasets with more recent time periods presumably due to stations that no longer report (Michael Angus, NCSU; personal communication).

If the size of the region for the next phase of the work is comparable to Tanzania then the scope of the equipment required is, 1 Server with Server OS, 9KVA UPS and 2 Workstation for data rescue at the NMHS; 10 Desktop computers; (2) 3 A3 scanners; (3) Networking cards and cabling wires, (4) 4 UPS of 5KV; (5) 10 Desks; (6) 2 Digital Cameras; (7) MS office 2010; professional; (9) Network gadgets and cabling wires; (10) Consumables; (dust coats, gloves, masks, CDs Flush disks,

stationery, etc.). These needs can be prorated based on the area of the data voids in the region.

4.2.1.2 Modelling: Assist RCC Users in the access and use of WCRP CMIP climate model simulations

ICPAC should build on its experience in LRF (see 3.1.1 and 4.1) and the SCIPEA project of assisting users in the access and use of Global Producing Centers model outputs to access and use WCRP CMIP climate model simulations climate change time scales. More specifically, the initial effort could focus on the development of ICPAC's technical capacity to use WCRP CMIP data in the following activities:

(1) Understand the East African Climate Change Paradox (see section 3.2.1). The problem is of profound importance because of the following high level science questions, (i) whether indeed the reversal will occur for the East African Climate Paradox, (ii) the timing of when it will materialize and, (iii) whether these two factors can be determinable at acceptable levels of confidence to inform the management of the leading regional social-economic sectors - including agriculture, fisheries, water resources, tourism, energy, urban development, transportation, bio-diversity conservation, construction and disaster risk management.

(2) Assess the implications of (1, above) on the IRCCS' priorities (IRCCS, 2016), to inform lead application sectors, namely:

- Agriculture, livestock and fisheries;
- Renewable energy and energy efficiency;
- Development of climate-resilient Industries and trade;
- Water resources for irrigation, livestock production, domestic consumption and commercial purposes;
- Transport and climate change;
- Climate change, forest resources, wetlands and biodiversity;
- Marine resources, coastal areas and climate change; and
- Arid and Semi-Arid Lands (ASALs)

In addition to the above, a number of cross-cutting priorities are identified:

- Conflicts and climate change;
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- Population dynamics and climate change;
- Gender, youth and climate change;
- Health, nutrition, food security, and climate change;
- Climate change, marginal and vulnerable groups/communities;
- Generation of and access to quality data;
- Promotion of research, education, awareness and advocacy;
- Coordinating the setting up of Early Warning Systems as well as drought and disaster resilience;
- Coordination, harmonization and adaptation of regional and international climate change instruments;
- Capacity building for climate change adaptation, mitigation and resilience.

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

As noted earlier in this report (section 3.2.1) the controversy regarding the source of the multi-decadal decline in the regional rainfall (Long Rains) has not been resolved thus making the prospects for accurate decadal projections still illusive. ICPAC's use of multi-model ensembles will improve the capacity for more accurate assessment of the SST sources of the multi-decadal decline of the regional Long-Rains. The products from analysis of the WCRP CMIP data should be used to generate tailored products for a new GHACOF session focusing on climate change time scales in addition to the traditional seasonal outlook and the newly introduced GHACOF-Climate Change session focusing on the S2S time scale. It is suggested, based on the discussions with the consultees on climate change, that each GHACOF-Climate Change session includes a component focusing on providing a synthesis to give an update on the state of the regional decadal trends, the latest regional projections, and the consensus regarding the SST sources of decadal variability.

This assessment recommends a workshop (or potentially a series of smaller complimentary workshops) to plan for scoping user needs & development of coordination strategies to support climate change services. Annex-2 outlines the proposed concept of the proposed workshop for further co-development by ICPAC in partnership with NMHSs and the university community.

The proposed suite of activities should address three closely interrelated goals for Greater Horn of Africa region, (i) to conduct stakeholders' scoping for climate change user needs, (ii) develop a framework for governance and coordination needed for climate change services, and (iii) co-design pilot project proposals which will be submitted for funding to the WISER research call program in 2016/2017. The pilots should focus on the high priority sectors identified by IRCCS (see IRCCS, 2016) which include agriculture, crop and horticulture sector, fisheries sector, forestry sector, livestock sector, food preservation sector, water resources, renewable energy, tourism and recreation, roads and infrastructure, environmental protection, conflicts and human migration, etc.). Further details of a preliminary draft proposal for the workshop and budget considerations are provided in annex-2.

The consultant is aware of a related assessment focusing on building the concept and plan for the Uganda National Early Warning System (NEWS; Uganda (2015)). The proposed East African workshop will extend the scope to the entire ICPAC region and also provide an opportunity to address climate change challenges which are truly of a regional nature (see example in annex-3) and require cooperation among several countries.

4.2.1.3 GHACOF Products: RCOF-Expanded pool of tailored products

Presently, GHACOF's products focus on rainfall, particularly for agriculture. The IRCCS has identified several sectors and high level priorities of ICPAC's services for planning on climate change time scales. These include, Agriculture, livestock and fisheries; Renewable energy and energy efficiency; Development of climate-resilient Industries and trade; Water resources for irrigation, livestock production, domestic consumption and commercial purposes; Transport and climate change; Climate change, forest resources, wetlands and biodiversity; Marine resources, coastal areas and climate change; and Arid and Semi-Arid Lands (ASALs). There is need for dedicated efforts to expand the pool of sectors served by ICPAC to the one identified by IRCCS and provide tailored productions to the stakeholders.

In the context of this challenge consultations were held with the coordinator of the IGAD-UNDP project. The objective of the UNDP project is to strengthen drought resilience and conflict prevention in the region and a key component is to generate user tailored products and development of mechanisms for effective delivery of climate information and intake by the user community. UNDP's vision and long-term strategy in the area of climate change is to enable developing countries to secure and expand development gains in the face of climate change. Its vision for addressing the climate change challenges include: (i) the introduction of dynamic, long-term planning mechanisms to manage the inherent uncertainties of climate change; (ii) the development of institutions to manage climate change risks and opportunities in an integrated manner at national and regional levels; (iii) the development and implementation of climate-resilient policies and measures in priority sectors; (iv) the preparation of climate resilient investment plans together with expansion of innovative financial instruments to meet national adaptation costs; and (v) the development of knowledge platforms to generate knowledge and share experience, and feed into the regular evaluation and adjustment of policies, strategies and processes.

In the specific context of 'tailored products' annex-3gives an example of a possible co-designed, co-produced 'tailored products' with ICPAC in the water sector. It is important to produce easily understood products derived from the seasonal forecasts. A series of steps each building on the previous results needs to be undertaken. These are;

1. Assess the level of predictability of seasonal water resources forecast based on seasonal climate forecast issued by ICPAC.-scientific evidence
2. Translate the forecast in to a set of generic measures which can be picked and acted upon depending on the economic activity, location, season…
3. Decide how to package & disseminate the forecasts so that information is available, well understood and trusted by decision makers.

The IGAD-UNDP project has made major contribution in supporting this need for a number of user-sectors. However, it is a project with limited life and according to current plans it ends sometime in 2017.

There is a unique opportunity for partnership between the ENACTS-WISER pilot project for East Africa, the IGAD-UNDP project and Universities and harness the combined technical capacity to ensure optimal outcomes. ENACTS (2016;

Enhancing National Climate Services) is led by the International Research Institute for Climate and Society (IRI) of Columbia University. Its main objectives are:

Objective 1

Improve the availability of quality assured climate information products on the past, present and future climate at the national and local levels through the development of historical and monitoring climate information at the national level by blending all relevant national observations with global products.

Objective 2

Enhance access to climate information products and services relevant to the needs of the public, national and local practitioners in climate sensitive sectors, policy makers, private sector and researchers through web interface that uses IRI Data Library technology and linked to National Meteorological Agency's Website.

Objective 3

Unleash pent up demand for locally relevant, high quality, climate information through effective stakeholder engagement in health, agriculture, water, disasters, national planning, etc.

Dinku et al (2016) indicate major progress made in a number of African countries by this project. ENACTS is a unique, multi-faceted initiative designed to bring climate knowledge into national decision-making by improving availability, access to, and use of climate information. Availability of climate data is improved by combining quality-controlled data from national observation networks with satellite estimates for rainfall, elevation maps, and reanalysis products for temperature. Access to information products is enhanced by making derived information products available online. The use of climate information is facilitated by engaging and collaborating with potential users. ENACTS-WISER has been implemented in Ethiopia, Rwanda, Kenya, Tanzania, Uganda, and there are plans to add Burundi. ENACTS has also been implemented at a regional level in West Africa in collaboration with the Agriculture, Hydrology, and Meteorology (AGRHYMET) Center in Niamey, Niger. Therefore, at one end ENACTS-WISER focuses on integrating in-situ satellite and remote sensed datasets to overcome major gaps in the traditional in-situ data for use in climate services. At the other end the IGAD-UNDP project focusses on the development of high level 'tailored products' for the user community. It is therefore a unique

opportunity to merge the benefits from the two pilot projects. The example of the IGAD-UNDP pilot project would make a good demonstration case by enriching it with ENACTS-WISER data, tools and IRI technical capacity.

Regarding further improvement in the area of 'tailored products, it is useful to consider development of capacity for quantifying the economic value of climate information. The initial work in this area dates back to the 1960s when the field of decision analysis was first conceived (Raffia and Schlaifer, 1961; Howard, 1966). Decision analysis merges statistical decision theory with systems analysis to form a methodology for analysing large, complex, and uncertain decisions. The process involves structuring a decision problem to clarify its alternatives, information, and values. A mathematical model is built to quantify the value of each alternative according to the information and value objectives of the decision maker (Semazzi and Mera, 2006). Important uncertainties in the information are represented stochastically, and a final probability distribution over the potential outcomes for each alternative is determined.

The recommendation for this component is to merge the benefits from the ENACTS-WISER (integrated traditional-satellite data) and IGAD-UNDP ('tailored user products) projects; institutionalize the activities of the IGAD-UNDP and ENACTS-WISER projects to become a permanent and sustainable program of ICPAC; and in addition develop capacity for tools that can be used by NMHS and their partners to quantify added economic value of climate information to assist policy makers in decision-making.

The decision support system should include measures of the quality of forecast information, the communication of the information from forecasters to decision-makers (e.g., members of the health community) and also capture the relevant aspects the decision-maker cares about using a range of outcome measures. These alternative end-user outcome measures may be explored based on both theoretical considerations and availability or collection of reliable applied measures. These measures may include disability adjusted life years (DALYs), quality adjusted life years (QALYs), and willingness to pay (WTP) (Hazen 2004; Hazen 2007).

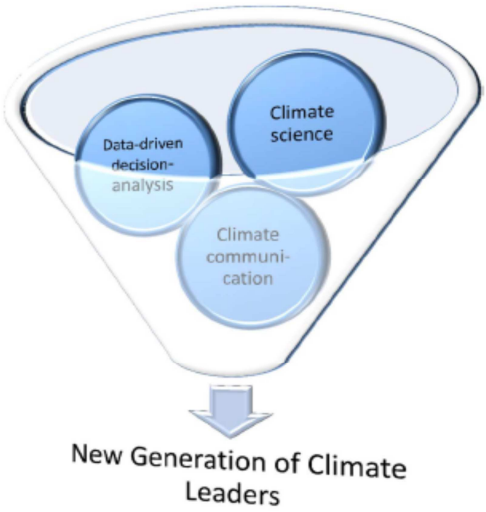
Ongoing and future pilot projects should increase focus on cost-benefit analysis and the tailoring of RCOF products for end-users. This is valuable not only in assessing the value of the prediction systems being employed by RCOF but also in informing the end-users about the benefits of climate prediction in economic terms that they

can easily interpret. RCOFs should continue to emphasize through demonstrated evidences to the user community regarding the superiority of probabilistic prediction compared to deterministic forecasting. Although the concepts involved are subtle it is imperative that they are adequately communicated to the user community to ensure appropriate use of the information. In some instance, research will be required to adjust or redesign better user decisions systems in ways that consider probabilistic inputs.

4.2.2 ICPAC's partnership with the university and research organizations community

4.2.2.1 Co-designed co-produced climate change and applications curriculum with the university community

Gap: For ICPAC member countries to meet the WMO requirements ('mandatory' and 'highly recommended'), and to implement COP21 commitments (COP21, 2016) they require most of the government institutions, administrative jurisdictions and sectors to incorporate climate change considerations in their plans and budgets (see UNDP, 2016). Therefore, there is urgent need to train hundreds of professionals in climate sensitive sectors in each country to acquire end-to-end interdisciplinary understanding of the problem and practical experience to provide climate services. The number of universities that have the desired curriculum is very limited as noted above. The costs and effort needed to establish traditional face-to-face-based instructional programs is very significant. There is need to establish capacity for *online* University-ICPAC co-designed programs which are accessible by students from all ICPAC member countries and mid-career professionals who cannot take-off from work to enrol in the regular degree programs. Annex-1 gives prototype of a post-graduate diploma or certificate which the Uganda National Meteorology Authority (UNMA) and Meteo Rwanda are considering with their partners. ICPAC is uniquely positioned to lead this



process with NMHSs and their partner universities starting with a generic template (prototype) presented in this report and developing a region-wide curriculum to meet the needs of hundreds of governments departments which require expertise in climate information applications.

4.2.2.2 Co-designed co-produced climate data technology curriculum with the university community

Climate change has pushed or resulted into new knowledge like detection and attribution and the related uncertainties, requiring research and serious insight of the subject matter. Climate change research requires well managed quality controlled datasets. Despite the fact that various course units like Hydrometeorology, Agro-meteorology, Satellite meteorology, etc., have been introduced in the learning of meteorology, no course unit for climate data management has been introduced. It is important to note that with the advent of climate change several issues surrounding climate data have emerged and they need to be scrutinized such that they get a correct response. There is urgent need of personnel who have serious insight into the subject matter to be nurtured and become available to address the issues. While it is true that WMO has been providing guidelines on Climate Data Management, they are not read by many people. Issues of data exchange, climate data policy and WMO resolutions on data sharing are not familiar to many meteorologists and yet they have to take decisions on them. This problem is operationally affecting the LDCs NMHSs who look upon the fresh graduates to address some of these issues (ICPAC, 2016g).

4.2.2.3 Co designed co-produced research with the university and research organizations community

Climate Change Synthesis: There is strong disagreement about the sources of climate variability of the ongoing multi-decadal East African drought, and whether and when it will reverse into wet conditions indicated by the IPCC projections for the region. In the very least HYVIC can contribute in creating an environment for the scientists to reach consensus and direct future research to reliable projections under an expanded GHACOF agenda that includes climate change. Moreover, it is not yet clear whether all the primary sources of multi-decadal variability for the Long Rains have been identified. Equally important, climate models have not been evaluated to determine how well they are capable of making reliable projections of the relative contributions of the dominant natural sources of decadal variability for the Long Rains

in the next few decades which is crucial for climate services. Recognizing, (i) that recent studies suggest that both anthropogenic and natural sources of decadal variability could be significantly contributing to the decline of the Long Rains in recent decades, (ii) the established link between the Long Rains and SAM, and (iii) the attribution of AMO, ATV, PDO and ENSOD to the decadal variability of SAM, the latter are all viable candidates for determining the variability of the Long Rains on decadal time scales and hence its recent decline.

The suggested GHACOF-Climate Change session during GHACOF should have a component (Synthesis) to review and present a consensus view by the science community. The leading members of the international science team should comprise the lead scientists and advocates of the different sources of variability with their counterparts in East Africa. This informative and capacity building event would in due course be manned entirely by East Africans. The statement from 'Synthesis' event should be uploaded on ICPAC website for access by ICPAC stakeholders. The statement could include the actual consensus and guidance regarding the implications for the different climate application sectors.

Perform downscaling of climate change scenarios: As noted in 3.2.4 according to IPCC-AR5 Africa is at the bottom in the world in climate research productivity measured in terms of research journal publications (Fig.1; IPCC-AR5). Consequently, Africa also ranks at the bottom in the development of appropriate legislation and regulatory processes to support climate change policy (Fig.2; IPCC-AR5). In context of the downscaling IPCC climate change scenarios ICPAC is already running the WRF downscaling model for 10-day operational forecasts but not climate scenarios. The WMO 'highly recommended functions' include the need for RCC capacity to "perform downscaling of climate change scenarios'. However, many studies (Anyah et. al, 2006 and others) show that for climate change projections it is not scientifically credible to simply use the dynamical downscaling models acquired from other places and apply it for the Greater Horn of Africa (GHA). Very significant amount of work is required to customize and incorporate the important regional processes in the regional climate model and accommodate the needs of the full spectrum of user sectors. For example, East Africa is one of the regions with the largest (number and size) of fresh water lakes in the world. Because most regions in the world where the primary computer codes have been developed do not have such an imposing presence of lakes the models do not have realistic formulation of this particular geophysical factor. Leading application sectors such as the fisheries industry require

comprehensive inclusion of lakes in the models otherwise the traditional models acquired from outside simply cannot provide vital information for this particular sector. So this is a challenge because ICPAC's stakeholders demand the information but the right tools are not available or easily accessible or acquirable. At the same time it is impractical for ICPAC to invest in leading such effort given its limited resources. The best option is therefore for ICPAC to partner with international organizations, through the LVB-HyNEWS and others, with the international community and incrementally develop its internal technical capacity in this area. In the past a dedicated pool of climate modelling experts in the region have contributed and participated in joint work with their international colleagues to develop important components that are essential for developing the local capacity. These collaborations can be harnessed to initiate work in this area that could eventually mature to achieve the necessary capacity. A step-wise approach is strongly recommended to develop this regional modelling capacity at ICPAC starting with the simplest configuration of the model and gradually incorporating additional components of the regional climate system (Fig.7).

A state-of-the-art high resolution Regional Earth System Model (REaSM) that incorporates main mechanisms to address user sector needs identified by IRCCS should be developed to provide climate information for ICPAC member countries' policymakers for the exploitation of climate-sensitive natural resources. The REaSM will be critical for downloading CMIP Global Model simulations and form the core for the Flagship CORDEX regional model for East Africa. WCRP has recommended the development of the next generation of CORDEX models for downscaling IPCC CMIP projections for different parts of the World. Unlike CMIP models which are developed at major climate centers in the World, the Flagship CORDEX regional model have to be developed by the region (see Flagship-CORDEX (2016)). ICPAC is best suited to lead this initiative considering the high level of regional cooperation that is required and the need to ensure that the formulation of the model is consistent with the regional factors that modulate regional climate and provides the unique information required by the leading user sectors. Development of human and infrastructure capacity will be needed to support this need. During the consultations, some concerns were expressed that this task might not be among the highest priority at this time. However, there is overwhelming expression of urgency by the majority of the consultees to start investing in the development of a regional model starting with

a relatively simple coupled REaSM and gradually adding further components with time.

Based on the consultations this report outlines below a configuration that would address the regional needs. REaSM would comprise the following interactive model components: a social-economic module to model the effects of different land cover change scenarios corresponding to projected the future urbanization over the LVB; a state of the art regional climate module which is the center piece for the REaSM; a coastal ocean/lake module for calculating the currents and thermodynamics of Indian Ocean (coastal basin) and Lake Victoria which modulate the aquatic ecosystem including fish population dynamics; hydrological modules for assessing groundwater availability, lake levels for planning the hydroelectric power industry and flooding potential for the lakeside road infrastructure (see annex-3); and a crop module to provide information for the food security sector. A limited observational campaign will be required to monitor the lake's surface temperature conditions required to calibrate the REaSM system. As shown in Fig.6 the development will entail several incremental steps over a period of approximately 4 years. ICPAC and NMHSs could partner with several international organizations (North Carolina State University, University of Connecticut, Stonybrook University, UKMO and others who collaborate through HyNEWS) to assist in the development of the system.

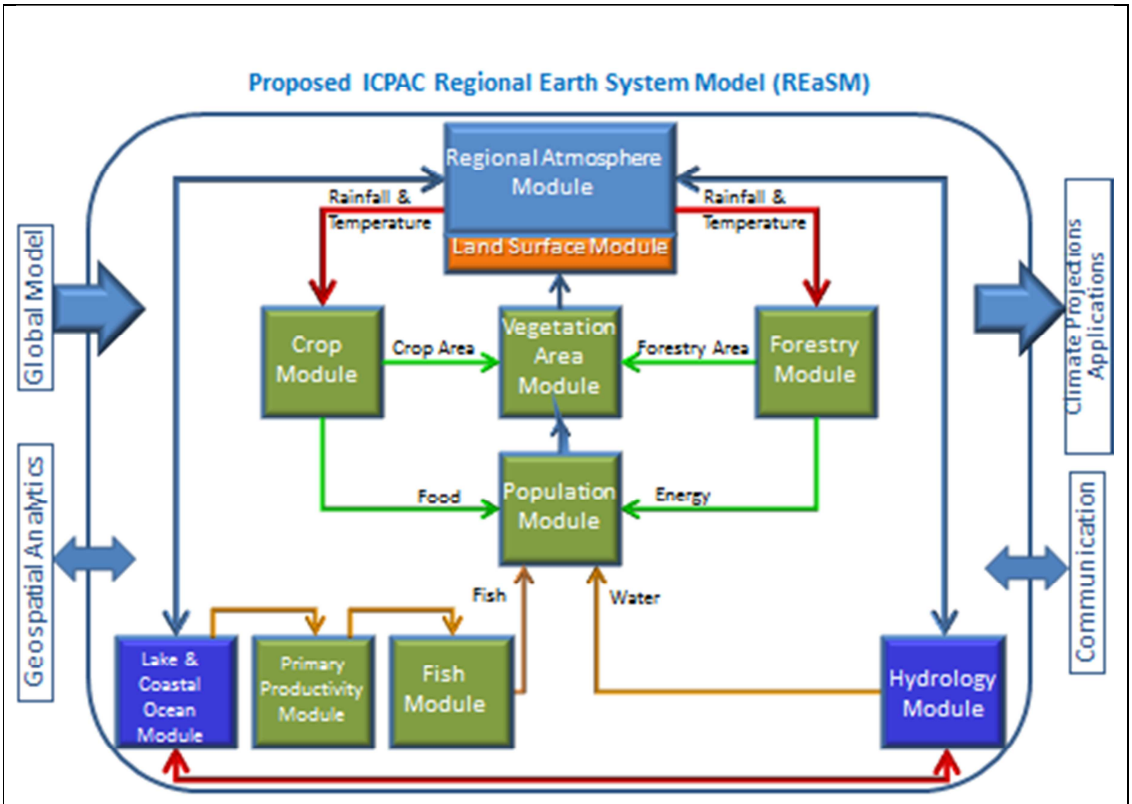


Fig.7: Development of the regional climate model that has formulation of the regional processes including full thermodynamics of coastal ocean and large lakes which is critical for climate services, including the fisheries sector. Presently there is no regional climate model that has this capability. A step-wise approach is strongly recommended to develop this regional modelling capacity at ICPAC starting with the simplest existing configuration of the model (coupled regional model with coastal ocean or lakes), and gradually incorporating additional components of the regional climate system.

4.2.2.4 Coordination mechanism for ICPAC and the Research community

Presently, there is no formal mechanism for vetting the climate science that is consumed by ICPAC in its development of its climate services products. Consequently, there is a risk that some of the tools and methods used by ICPAC could have limited credibility, controversial or altogether outdated and need to be

replaced. A coordination mechanism is needed between ICPAC and the research communities to ensure timely and effective vetting of the prevailing state of knowledge of climate science. Moreover, such a mechanism must have both regional and international credibility and buy-in.

In recent years the East African Community in collaboration with the World Climate Research Program (WCRP; http://public.wmo.int/en) and the World Weather Research Program (WWRP; http://public.wmo.int/en) have formed the LVB-HyNEWS consortium which would meet this requirement. In order to promote regional trans-boundary logistical and funding coordination the National Meteorological and Hydrological Services (NMHSs) of Burundi, Rwanda, Kenya, Tanzania and Uganda formed the LVB-HyNEWS consortium during the meeting of Heads of Meteorological Services, 5th - 7th May, 2014, Arusha, Tanzania. The LVB-HyNEWS consortium comprises the following international projects: (i) HyVic which is envisaged to serve as the international supreme authority on the science of the climate of Lake Victoria Basin (HyVic, 2016), and (ii) the Severe Weather Now casting Demonstration Project (SWNDP) under the auspices of World Weather Research Program (WWRP), and (iii) the EAC-Navigation Early Warning System (EAC-NEWS) for Lake Victoria project. LVP-HyNEWS has an executive committee to provide high level oversight and guidance. It comprises the 5 NMHS directors, EAC and AMCOMET secretariat representations. LVP-HyNEWS also has day-to-day coordinating team comprising mainly of projects PIs and NMHS technical contacts appointed by the MET services directors.

The GEWEX HYVIC RHP project arose from grass-root support. It was inspired by the East African Community (EAC, 2011) feasibility study that made the recommendation for the creation of HyVIC. The feasibility study was funded by EAC. Authors: Fredrick Semazzi (lead), Sandra Yuter, James Kiwanuka-Tondo, Lian Xie, Casey Burleyson, Bin Liu, Kara Smith, Pascal Waniha (NC State University); Lynn Rose (Atmospheric Technology Services Company, Norman, OK); Ruben Barakiza (Institut Geographique du Burundi), Peter Ambenje (Kenya, Meteorology Department), Anthony Twahirwa (Rwanda Meteorological Service), Hamza Kabelwa (Tanzania Meteorological Agency), Ronald Wesonga (Uganda Meteorological Department), Laban Ogallo and Joseph Mutemi (University of Nairobi and ICPAC, Kenya) and Francis Kirudde (Uganda, UMEME).

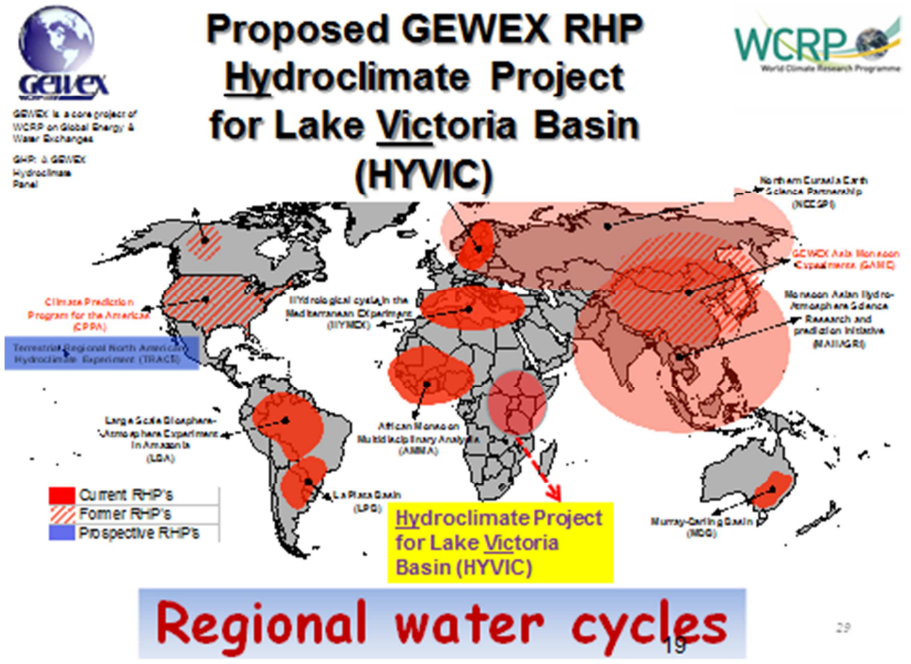


Fig.8: Hydroclimate project for Lake **Vic**toria (HYVIC) Regional Hydroclimate Project (RHP; HyVic, 2016).

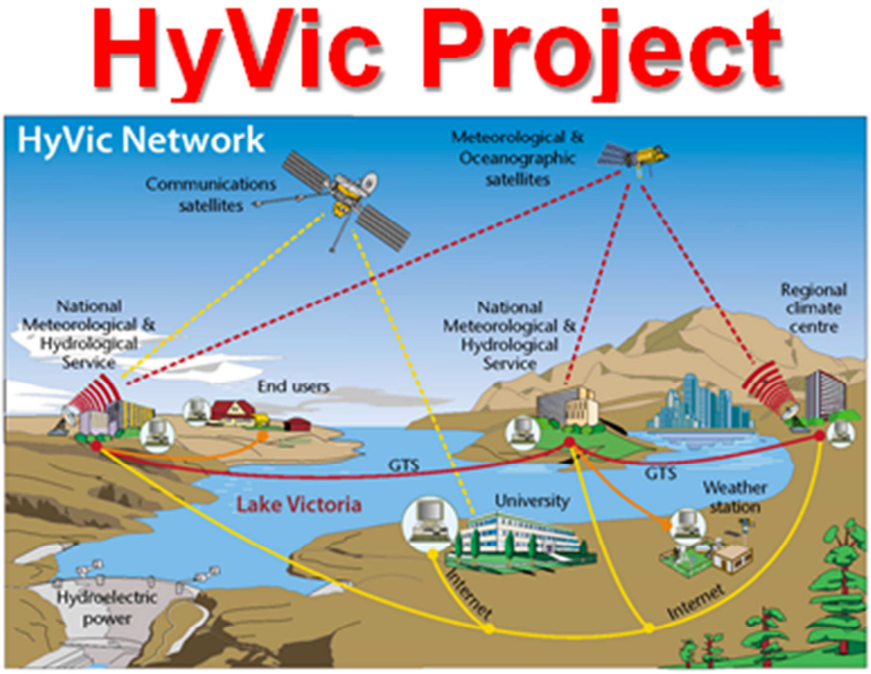


Fig.9: Schematic for HyVic regional activities and partners (HyVic, 2016)

To create the link between ICPAC and LVB-HyNEWS it is suggested that ICPAC has permanent representation on the LVB-HyNEWS board of directors and task team and also the HyVic Executive Committee (EC) to ensure that ICPAC can make strong contribution to the vetting and prioritization of the climate research undertaken by the regional and international researchers to serve its needs and priorities. In its present form LVB-HyNEWS serves 5 countries (Burundi, Rwanda, Kenya, Tanzania and Uganda). In order to serve the full membership of ICPAC it is suggested that LVB-HyNEWS's expand its domain to include all member countries of ICPAC thus include, South Sudan, Sudan, Eretria, Ethiopia and Djibouti. A viable approach to address this need is for the LVB-HyNEWS 5 member countries of the EAC to make this request to ICPAC steering committee which already includes them as members.

For the ICPAC-HyNEWS partnership to work there should be strong engagement with universities and research organizations. So LVB-HyNEWS consortium provides

the coordination and oversight while universities and ICPAC co-design and co-produce the course curriculum and conduct the actual research which is fully responsive to the needs of ICPAC and its stakeholders.

4.2.3 **ICPAC's interface with the user Community**

ICPAC has made significant progress in the development of web products to establish appropriate links with NMHSs and their stakeholders within ICPAC member countries. There are currently seven computer Apps:

(i) Agriculture App Gallery (Rangelands and Livestock (no content); Crops (maps provide information on crops in relation to the climatic and weather updates))
(ii) Climate App (Application has three categories of data; Climate monitoring, Climate Forecast and Climate Change).
(iii) Disaster Risks App (Drought Hazard and Risks; Integrated Regional Early Warning System; Flood Hazard and Risks).
(iv) Environment App (Protected areas; Land degradation; Forest monitoring)
(v) Integrated Regional Early Warning System App
(vi) Socioeconomic and Demographic Data App
(vii) Water App (Floods; Water point mapping; Water resources)

The consultations with NMHSs personnel indicated much interest to see this ICPAC service advance to the next level by providing more interactive functionality. The primary objective is to produce an interactive climate web portal environment for the region to support optimal early warning information and exploitation of natural resources.

Further development of ICPAC's Atlas web-apps should be closely coupled with user needs scoping. There are major gaps in the appreciation of user needs from the apps to support decision making. To fill this gap there should be a dedicated user needs scooping planning workshop and implementation of strategic pilot projects to identify pragmatic information they wish to see on the portals and the desired functionality. Further considerations for the workshop and pilots could include the following specific objectives:

(ii) Carry out a comprehensive assessment of different formats used throughout the world and choose or develop the one most appropriate for the EAC regional needs.

(iii) Develop high-powered computer interface software, including internet and web technology, on an electronic platform to provide information to stakeholders in an efficient and user-friendly manner. The Atlas should have a structure that is easily updatable as new and more refined basic data becomes available.

(iv) Produce a hard copy version of the Atlas that can be distributed to providers of climate outreach services in agriculture, health, tourism, and other socioeconomic sectors which may not have access to adequate computing and internet capabilities.

As noted above, the existing Apps on ICPAC's website is the natural starting point for further development. Annex-3 gives an example which has been designed by members of the GEWEX HyVic Regional Hydroclimate Project (RHP) community as a potential opportunity for partnership with ICPAC and HyNEWS to co-design, co-produce and seek funding for enhancing the producer-user interface and the coordination between the research community (HyNEWS), the operational community (UNMA & ICPAC) and end-user community (Ministry of Transport, Uganda).

4.2.4 ICPAC's partnership with the information and computer technology (ICT) community

Gaps: Access to gigabyte capacity for internet capacity and HPC computing capacity. This is required to undertake S2S, climate projections and data transmission.

During the assessment consultation was made with the research internet provider community to explore the prospects for ICPAC access UBUNTUNET Alliance for Research and Education Network broadband Internet and HPC. The potential partnerships are briefly described below at the 3 levels.

International Level: ICPAC primary partner at the international level would be the CHAIN-RED consortium (http://www.chain-project.eu). It supports intercontinental internet collaboration and resources sharing with the following objectives.

(i) Extend and consolidate international cooperation of Europe with other regions of the world in the domain of e-Infrastructures for Research and Education.
(ii) Promote, coordinate and support the effort of a critical mass of non-European e-Infrastructures for R&E to collaborate with Europe addressing interoperability and interoperation of Grids and other DCIs.
(iii) Study the opportunities of data sharing across different e-Infrastructures and continents widening the scope of the existing CHAIN Knowledge Base to Data Infrastructures and Cloud implementations.
(iv) Promote trust building towards open Scientific Data infrastructures across the world regions, including organizational, operational and technical aspects.
(v) Demonstrate the relevance of intercontinental cooperation in several scientific data fields addressing existing and emerging VRCs and propose pragmatic approaches that could impact the everyday work of the single researcher, even if not structured in a VRC.
(vi) Provide guidance and recommendations for roadmaps for long-term global collaboration in e-Infrastructures and harmonization of existing polices

***Regional Level*:** The UBUNTUNET Alliance for Research and Education Network (http://www.ubuntunet.net) has a key role of enabler for the participation of several African countries in the CHAIN consortium, organizing training and dissemination events and contributing to the deployment of pilot grid infrastructures in the countries participating in the consortium. UbuntuNet Alliance for Research and Education Networking is a regional Research and Education Network of Eastern and Southern Africa whose mission is to secure affordable high speed regional and international connectivity as well as efficient ICT access and usage for African NRENs. The Alliance has a close relationship with the Association of African Universities. Membership to UbuntuNet Alliance is open to all bona fide African NRENs serving research and education institutions. UbuntuNet Alliance UbuntuNet also promotes Virtual Research Centers (VRC) by researchers focusing on specific research projects in a cluster of countries with National Grid Initiatives (NGIs). The Africa Connect project of the UbuntuNet Alliance specifically aims to establish a high-capacity Internet network for research and education in Southern and Eastern Africa to provide the region with a gateway to global research collaboration.

The grid computing resources provided by the European GRID Infrastructure (EGI) federation are used by scientists and researchers across Europe and beyond. Case studies already exist (http://www.egi.eu/case-studies) in the following areas

Astronomy & Astrophysics, Earth sciences, Physics & climate change, Life sciences, Chemistry, Mathematics & Engineering. The goal for ICPAC and its member countries' NMHSs is to access the UBUNTUNET Research and Education broadband Internet and HPC network.

The procedure for ICPAC and NMHSs to secure membership (Consultee: Dr. Isaac Kasana, Director, RENU; https://www.uixp.co.ug/node/40): The application is fairly straight forward. ICPAC has to submit a request to the Government of Kenya (relevant ministry) for approval for the status as a "Research Organization" and then submit the application to UbuntuNet. Once the "Research Organization" status is secured the application to UbuntuNet is virtually automatically approved by the KENYA NREN and takes only about a couple of weeks for the entire process. It is recommended that all ICPAC NMHSs engaged in research apply for membership to benefit from ICPACs enhanced access to the broadband Internet and HPC network.

4.2.5 **ICPAC's partnership with the funding agencies community**

Coordination to secure funding to sustain the higher cost of increased number of WMO 'mandatory' and 'highly recommended' products to become an RCC is essential. Furthermore, sustained funding is required to support new services in S2S and climate change. Becoming an RCC will make ICPAC more visible to donors in the immediate future. In the long-term funding will have to be institutionalized through IGAD budgets and resource mobilization through the IGAD Partners Forum (IPF).

It is recommended to launch a dedicated initiative to systematically examine variations of a framework proposed in Semazzi (2011) and others to develop pragmatic strategies for promoting sustainable funding. It is based on the recognition that a major obstacle to the provision of climate services by organizations is the existence of a self-sustaining cycle, which is continuously eroding and undermining progress. This cycle begins with poor support and funding for research and climate services, leading to the inability of climate service providers to meet stakeholder needs and, thus, further eroding support and perpetuating the cycle. The proposed alternative approach that would break this cycle and create a new class of stakeholders for climate services in developing countries, who will use and advocate for funding and other forms of support for services and relevant research their outcomes. This framework comprises 3 components, namely, implementation sites for incubation projects, a joint task team for guiding the relevant cross-cut research,

and a coordination agenda all seamlessly working together for the provision of climate services

SECTION 5

5. Conclusions and Recommendations

5.1 Conclusions

The report presents the following general conclusions arising from the assessment of ICPAC's capacity needs to provide entry points for technical support and services intervention. Further details are provided in the main body of the report.

1. The assessment has revealed that the greatest urgency in ICPAC's technical capacity needs is to satisfy the WMO mandatory requirements and become an RCC. Consultation with ICPAC and the WMO Climate and Water Department (CLW) has confirmed that the remaining needs are relatively straight forward to address as the main requirements have already been addressed in previous cycles of evaluation for RCC status. Specific pending issues are identified but a general overarching need is for ICPAC to improve the organization of its products on the web and making sure that all links at ICPAC's website are populated with content and to motivate NMHSs to use its climate database and archiving service support.

2. The assessment has identified the following entry points for ICPAC to strengthen its capacity in meeting WMO RCC 'mandatory', addressing WMO 'highly recommended' requirements, and implementation of ICPAC's 2016-2020 Strategy, (i) build on and expand the scope of ICPAC's internal programs, (ii) ICPAC should collaborate with, and build on, ACMAD experiences, and (iii) developing strong partnerships with, the university community and research organizations, the users community, the information and computer technology (ICT) community, and the funding agencies/donors agencies community.

3. In the near-term (present to one year), the assessment has identified important technical capacity benefits to fill critical gaps in its delivery of climate services by strengthening the activities initiated by the WISER SCIPEA and ENACTS pilot projects, expand the scope of these projects to serve all user sectors and ICPAC

member countries, and build the technical capacity of ICPAC to own and build toward sustainability and continuation of the activities beyond the pilot projects phase supported by the WISER program and partners organizations.

4. In the medium term (approximately one to three years from the present), investment is required to build ICPAC's technical capacity in the delivery of climate services to support adaptation to climate change. Addressing this need requires a multi-pronged approach at comparable level of investment and effort as the SCIPEA and ENACTS WISER pilot projects. A preparatory and planning workshop to guide and bring together the broad spectrum of stake holders is considered to be an important pre-requisite for implementing a successful agenda. To address these challenges, ICPAC should capitalize on its best recognized legacy which is the GHACOF process, by expanding its scope to include a component on seasonal to sub-seasonal climate prediction (already started through SCIPEA), expansion of GHACOF products to serve a broader spectrum of user sectors (already started by ENACTS), and introducing a new component focusing on climate change projections and the corresponding climate services.

5. A variety of specific recommendations are presented in the report on a suite of outstanding gaps to build ICPAC's technical capacity for the next ten years. The recommendations include a suggested conceptual strategy to secure adequate and stable funding for the expanded scope of ICPAC's portfolio.

6. The report was prepared with full awareness of the ongoing preparation of the National Strategic Plans (NSPs) by the NMHSs and that they are at different stages of development. These NSPs will guide the NMHSs in determining where they are, where they want to be and how they intend to get there. Therefore, there is need to harmonize this report's recommendations with the final NSPs to ensure seamless expectations and approaches since ICPAC's primary obligation is to serve the NMHSs succeed in the delivery of climate services.

5.2 Recommendations

5.2.1 Recommendations for Short-Term Actions

<u>Recommendation-1</u> (Consolidate the partnership of ICPAC with SCIPEA and ENACTS, in addressing the requirements for 'mandatory functions for WMO

RCC designation): The gaps in addressing the requirements for 'mandatory functions for WMO RCC designation are all in the process of being addressed by ICPAC or already addressed. They are relatively straight forward to address. The WMO Commission for Climatology for Basic Systems (CCBS) which approves new RCC designations meets next time in November/2016 and the deadline for submitting all application documents is in September/2016.

Based on this assessment the following is recommended, (i) strengthen the partnership between the ICPAC dynamic models-based LRF with SCIPEA in the use of ensemble predictions from the GPCs including the UKMO to generate S2S predictions, and (ii) institutionalize all SCIPEA's components which include strengthening of climate partnerships on three levels:

1. Enhancing links and data exchanges between global, regional and national climate organisations – strengthening resources and tools for seasonal forecasts;
2. Climate information providers and users – to co-develop prototype tailored services;
3. NMHSs and Universities/Training Centres – strengthening resources for capacity training and climate service development as well as capacity retention.

There is considerable common interest between SCIPEA, ENACTS, and ICPAC dynamical LRF because they all promote the engagement of the stakeholders community. ICPAC (as lead), ENACTS and SCIPEA should maximize coordination to ensure seamless unified climate services products.

Product: Integrated/unified climate services products.
Entry points: ICPAC dynamical LRF, ENACTS, and SCIPEA.
Lead organization: ICPAC
Lead coordinator: ICPAC
Partners: SCIPEA, ENACTS; ICPAC stakeholders.

<u>Recommendation-2</u> (Integration of ICPAC Web-Apps, in addressing the requirements for 'mandatory functions for WMO RCC designation): There is strong and broad support to create a one-stop advanced ICPAC platform for an interactive atlas for researchers and decision makers. This recommendation applies

to both the WMO “Mandatory Functions” and “Highly Recommended Functions”. In case of the WMO “Mandatory Functions” the recommendation is to improve the present ICPAC’s Geospatial Apps for better accessibility and readability, and to populate the existing links with limited information, with more complete content.

Proposed product: Integrated ICPAC Atlas
Proposed entry points: ICPAC Web-Apps
Proposed lead organization: ICPAC
Proposed lead coordinator: ICPAC
Proposed partners: NMHSs; ICPAC user community partners.

5.2.2 Recommendations for actions approximately one to six years from the present (Highly Recommended Functions and Alignment with ICPAC’s 2016-2020 Strategic Plan)

<u>Recommendation-1</u> (Continuation of ENACTS and IGAD-UNDP Project Activities)

(i) ENACTS is an end-to-end initiative developing NMHSs capacity to link data to impacts and to decision making. It is not only about creating the data but also makes the data useful and used which involves many issues that may also require additional funding and co-ordination. In order to capitalize on its comparative advantage relative to other products and services ENACTS should be implemented in the remaining countries and lead application sectors, and in particular those identified by IRCCS (i.e., agriculture, livestock and fisheries; renewable energy and energy efficiency; development of climate-resilient Industries and trade; water resources for irrigation, livestock production, domestic consumption and commercial purposes; transport and climate change; climate change, forest resources, wetlands and biodiversity; marine resources, coastal areas and climate change; and Arid and Semi-Arid Lands (ASALs).

(ii) To ensure sustainability of the activities started by ENACTS, the responsibility shifts to ICPAC. Therefore, ICPAC will be required to take on ENACTS’ development of user-relevant products/metrics derived from basic climate information and the training of NMHSs. The IGAD-UNDP project has made important progress in building ICPAC’s in-house capacity in the development of

user-tailored products (building user interface) and therefore can take over this responsibility after ENACTS. However, the IGAD-UNDP project will end soon. Therefore, it is recommended that support is identified to continue IGAD-UNDP activities to sustain the work started by ENACTS. ICPAC technical support should mainly focus on assisting low technical capacity NMHSs. NMHSs with relatively higher capacity have in some cases already made much progress in addressing this need without ICPAC's support.

Product: Implement ENACT in the remaining countries and also lead application sectors; continue IGAD-UNDP activities to sustain the work started by ENACTS in user interface development.
Entry points: RCOF, ENACTS, IGAD-UNDP
Lead organization: ICPAC
Lead coordinator: ICPAC
Partners: WISER, ENACTS, IGAD-UNDP, lead regional research and application organizations; regional universities; ACMAD, HyVic research community; CR4D research community, ICPAC stakeholder partner organizations.
Estimated cost: $500,000/year

Recommendation-2 (Develop Capacity for ICPAC RCC users' to access and use WCRP CMIP climate model simulations): ICPAC should build on its experience in the provision of climate services based on LRF for seasonal prediction, and extend it to include climate services based on CMIP climate change simulations for multi-decadal projections. A new initiative is needed of comparable or greater scope than the WISER SCIPEA project, but focussing on climate change projections instead of seasonal to sub-seasonal forecasts (LRF). This need is of profound importance for the social-economic development of the IGAD member countries considering the regional vulnerability to the East African Climate Change Paradox (see 3.2.1), and other regional decadal shifts in climate. This assessment indicates the need to form a platform to **B**uild **R**esilience of **I**GAD's **C**ommunities to **C**limate **C**hange (BRICCC). This platform involves partnership with the user and research communities to streamline and maximize intake of the most current and vetted climate science research. BRICCC has 6 inter-related components.

1. Introduce a Pre-GHACOF training session (expansion of the current seasonal forecasting-based Pre-GHACOF workshop to include climate change projections),

2. Introduce a GHACOF climate change session (by expanding the current GHACOF workshop program; initially to be based on CMIP global simulations but later on the proposed ICPAC's Flagship CORDEX REaSM downscaling of CMIP models,

3. Develop and apply ICPAC Flagship CORDEX Regional Earth System Model (REaSM) for East Africa for downscaling CMIP global model simulations for climate change projections,

4. Develop ICPAC platform for end-to-end projects to demonstrate present and future ICPAC's capacity to support NMHSs and users. This is needed to road-test ICPAC's new climate change services in support for the ICPAC 2016-2020 Strategic Plan, IGAD Regional Climate Change Strategy (IRCCS), National Strategic Plans (NSPs), COP21, and also providing a concrete mechanism for monitoring of the compliance of ICPAC with WMO RCC 'mandatory' and 'highly recommended' requirements. A concept note for a demonstration pilot project is presented in annex-3 for a co-designed ICPAC-NMHSs-Research-Decision community collaboration Model.

5. A graduate students' fellowship program to support development of tools and knowledge in collaboration with partner universities.

6. Organize a plan workshop to scope and update ICPAC's climate change services users' needs in accessing and using WCRP CMIP climate model simulations and guide the development, coordination and financing for BRICCC (see outline of proposal in Annex-2).

Product: The six components of BRICCC (see above).
Proposed entry points: GHACOF
Lead organization: ICPAC
Lead coordinator: HyVic
Partners: WISER, DFID/NERC FCFA/HyCristal project; WISER-ENACTS project, WISER-SCIPEA project; DARE project; ACMAD, regional universities; CORDEX Flagship Program; IPCC/TGICA DDC and other IPCC programs; international climate research programs, ICPAC stakeholder partner organizations.
Estimated cost: $2.1 million/4 years

Recommendation-3 (**Non-operational data services; Continue DARE Project Data Rescue):** As climate science advances and the breadth of ICPAC's products expands, non-operational data services and management must also keep pace in supporting these developments. Consultations during the assessment has revealed the following key gaps and opportunities for ICPAC to enhance its activities, (1) data rescue (see 3.2.2.1), (2) expertise in quality control (see training, 3.2.3), and (3) capacity for archiving and transmitting and sharing it with its member countries (see 3.2.2.1). Major progress has been made with the DARE pilot project for Tanzania through the Tanzania Meteorology Agency (TMA). In this recommendation it is proposed that the lessons learned in the DARE pilot are extended to all ICPAC member countries.

Product: *Rescued data in addition to DARE pilot for Tanzania*
Entry points: DARE Tanzania
Lead organization: ICPAC
Lead coordinator: PREPARED-DARE Project
Partners: PREPARED DARE team comprising ICPAC, EAC, WMO, DARE, ENACT, TMA and other NMHS members of ICPAC.
Estimated cost: To be Determined

Recommendation-4 (**Non-operational data services; Improve ICPAC & NMHSs Access to High Performance Computing & Broadband Internet):** Lack of access to broadband internet and high performance computing (HPC) is a major limitation to ICPAC's research, data archiving, data transmission, and computing. The UBUNTUNET Alliance for Research and Education Network has a key role of enabler for the participation of several Eastern Africa countries in the CHAIN consortium, organizing training and dissemination events and contributing to the deployment of pilot grid infrastructures in the countries participating in the consortium; & at the national level: the National Grid Initiative. This assessment brings attention to a unique opportunity that ICPAC, its member NMHSs, partner universities and other partner research organizations which are eligible, to apply for membership and access to research broadband internet and HPC computing networks in the region. The application and qualifying process is straight forward. Some information is provided in the main body of this report and further details may be obtained by contacting the Ubuntunet Alliance.

Product: *Access to broadband internet and HPC*

Proposed entry points: ICPAC and NMHS ICT
Proposed lead organization: ICPAC
Proposed lead coordinator: HyVic
Proposed partners: Ubuntunet and its member organizations; NMHSs, partner universities, other partner research organizations, and CHAIN-RED consortium.
Estimated cost: $10,000/year (subscription for multiple countries).

Recommendation-5 (**ICPAC-Training and Capacity Building; Expand Scope of Pre-GHACOF Training):** Pre-GHACOF training does not include routine capacity development in S2S and climate change projections/adaptation.

Product: Pre-GHACOF training in S2S prediction (in particular, sub-seasonal), and climate change projection
Entry points: GHACOF
Lead organization: ICPAC
Lead coordinator: ICPAC
Partners: NMHSs, UKMO, SCIPEA, ACMAD, North Carolina State University (HyVic/Climate Change), CCDA-VI.
Estimated cost: $40,000/year

Recommendation-6 (**ICPAC-Training and Capacity Building; Co-designed University-ICPAC Curriculum):** For ICPAC member countries to implement the COP21 commitments (see section 3.2.4) they require most of the government institutions, administrative jurisdictions and sectors to incorporate climate change considerations in their plans and budgets. Therefore, there is urgent need to train hundreds of professionals in climate sensitive sectors in each country to gain hands on experience in using climate information to reduce vulnerability to climate variability and change. The number of universities that have the appropriate balanced curriculum is very limited as noted above. The costs and effort needed to establish traditional face-to-face-based instructional programs is prohibitive. It is recommended to establish *online* University-ICPAC co-designed programs which are accessible by students from all ICPAC member countries and mid-career professionals who cannot take-off time from work to enrol in the regular degree programs. These training programs should work closely with the SCIPEA, ENACT, IGAD-UNDP projects and other similar ICPAC's partners, who are closely engaged with the user community, in the development of the instructional content. The

curriculum should also embrace ICPAC's web map room tools and use of products from the downscaling of CMIP and ICPAC's LRF. ICPAC is uniquely positioned to lead this effort starting with a generic template that may be adopted widely in the region and the rest of Africa.

Product: Co-designed Online University-ICPAC curriculum in linking climate science and applications
Entry points: ICPAC partnerships with the regional and international universities
Lead organization: ICPAC
Lead coordinator: HyVic
Partners: WISER; WMO; ACMAD, Meteo Rwanda, UNMA, KMD and other NMHSs; UKMO; SCIPEA; HyVic, HyCristal project; Institute for Climate Change & Adaptation, University of Nairobi, North Carolina State University, Makerere University and other partner universities.

Estimated cost: $200,000/year

Recommendation-7 (**Research Coordination):** The current process for research intake to support improvements in ICPAC's technical capacity has benefited from interactions with a small number of universities and research institutions. There is need for streamlining scientific research intake to ensure efficient exploitation of the most current and credible research developments from the entire region and the rest of the world, and ensuring that ICPAC plays a key role in the prioritization of relevant research undertaken by the regional and international research community. LVB-HyNEWS was created specifically to serve this important partnership. It is recommended that ICPAC secures representation on the LVB-HyNEWS consortium Board of Advisors and Task Team. However, LVB-HyNEWS primarily serves the EAC countries. It is suggested that efforts be made to extend LVB-HyNEWS mandate to cover all ICPAC countries. It is also apparent regarding the climate change services that the WCRP HyVic project is the natural partner to implement several recommendations arising from the assessment. More specifically, in the co-development and implementation of the climate change services and capacity development (recommendations 2 and 6, respectively). To maximize the impacts of the ICPAC-HyVic partnership it is recommended to explore prospects for physical co-location of HyVic secretariat or part of it at ICPAC.

Product: Coordination process to provide ICPAC efficient access to the most credible climate science and tools to support its functions.
Entry points: ICPAC Research Program
Lead organization: ICPAC
Lead coordinator: HyNEWS/HyVic
Partners: ICPAC regional and international research partners, Universities, regional research organizations, UKMO, WCRP, ENACTS, SCIPEA, WCRP/GEWEX, CR4D, ACMAD, WISER-HIGHWAY (project in planning stage).

Estimated cost: $50,000/year (ICPAC-HYNEWS Coordination)

Recommendation-8 (**Financing Coordination):** Coordination to secure funding to accommodate the higher cost of increased number of WMO 'mandatory' and 'highly recommended' products to become an RCC is essential. Furthermore, sustained funding is required to support new services in S2S and climate change. Becoming an RCC will make ICPAC more visible to donors in the immediate future. To ensure sustainability, in the long-term increasingly part of the funding will have to be sourced through IGAD budgets and resource mobilization through the IGAD Partners Forum (IPF).

It is recommended to launch a dedicated initiative to systematically examine variations of existing frameworks to develop pragmatic strategies for promoting sustainable funding. This recommendation is based on the recognition that a major obstacle to the provision of climate services is the existence of a self-sustaining cycle, which is continuously eroding and undermining progress. This cycle begins with poor support and funding for research and climate services, leading to the inability of climate service providers to meet stakeholder needs and, thus, further eroding support and perpetuating the cycle. Therefore, the goal of the proposed dedicated initiative is to break this cycle and create a new class of stakeholders for climate services, who will use and advocate for funding and other forms of support for services and relevant research their outcomes.

Product: Strategy for enhancing ICPAC funding
Entry points: IGAD Partners Forum (IPF).
Lead organization: ICPAC
Lead coordinator: ICPAC
Partners: WISER, EAC, WCRP, WMO, HyNEWS/HyVic, CR4D

Estimated cost: Invitation of funding organizations included in the planning workshop under recommendation-2.

<u>Recommendation-9</u> (Harmonizing this report with National Strategic Plans, NSPs): The report was prepared with full awareness of the ongoing preparation of the National Strategic Plans (NSPs) by the NMHSs and that they are at different stages of development. These NSPs will guide the NMHSs in determining where they are, where they want to be and how they intend to get there. Therefore, there is need to harmonize this report's recommendations with the final NSPs to ensure seamless expectations and approaches since ICPAC's primary obligation is to serve the NMHSs succeed in the delivery of climate services.

Product: Seamless linkage between NMHSs & ICPAC technical capacity development strategies
Entry points: NSPs
Lead organization: ICPAC
Lead coordinator: ICPAC
Partners: WMO, ICPAC member NMHSs
Estimated cost: Commission Consultancy to harmonize recommendations of this report and NSPs - $15,000

WISER
Weather and Climate Information Services for Africa

SECTION 6

References and bibliography

AMCOMET, 2016: Website: www.wmo.int/amcomet

Angus., M :2016: Recent Decline in Consistency Among Gridded Precipitation Datasets for the Greater Horn of Africa, 22nd Conference on Applied Climatology, American Meteorological Society General Meeting, 2016; [https://ams.confex.com/ams/96Annual/webprogram/Paper284290.html].

Anyah, R. O., F. H. M. Semazzi and L Xie, 2006. Simulated physical mechanisms associated with multi-scale climate variability over Lake Victoria Basin in East Africa. Mon. Wea. Rev, 134, 3588-3609.

CCDA-V, 2015: Fifth Climate Change and Development Conference (CCDA-V); [http://climate-l.iisd.org/events/fifth-climate-change-and-development-conference-ccda-v/].

COP21, 2015: The 21st session of the Conference of the Parties (COP21) [http://www.cop21.gouv.fr/en/].

Dinku T, Cousin R,Corral J. Ceccato P, Thomson M, Faniriantsoa, R, Kohmyakov I, Vadillo A: 2016. The ENACTS Approach: Transforming climate services in Africa; one country at a time.(world policy papers) http://www.worldbank.org/en/news/speech/2015/06/02/transforming-weather-climate-and-hydrological-services-in-africa

EAC (East African Community), 2011. Enhancing Safety of Navigation and Efficient Exploitation of Natural Resources over Lake Victoria and its Basin by Strengthening Meteorological Services (Authors: Semazzi, F. (Lead), S. Yuter, J. Kiwanuka-Tondo, L. Xie, C. Burleyson, B. Liu, K. Smith, P. Waniha (North Carolina State University); L. Rose (Atmospheric Technology Services Company, Norman, OK); R. Barakiza (Institut Geographique du Burundi), P. Ambenje (Kenya, Meteorology Department), A. Twahirwa (Rwanda Meteorological Service), H. Kabelwa (Tanzania Meteorological Agency), R. Wesonga (Uganda Meteorological Department), L. Ogallo, and J. Mutemi (University of Nairobi and ICPAC, Kenya), and F. Kirudde (Uganda, UMEME) [http://climlab.meas.ncsu.edu/Final_Report_LVBC.pdf].

EAC, 2011: Summit on the Horn of Africa crisis ending drought emergencies: A commitment to sustainable solutions.

EAC, 2016a: EAC Secretariat. 2016 Report of the Planning Meeting for the Weather and Climate Information Services for Africa (WISER) Programme.

EAC, 2016b: Final EAC Five Year Met Strategy, East African Community EAC. 2013.

UNCP, 2012: Uganda National Climate Change Policy, The Republic of Uganda: Ministry of Water and Environment.

ENACTS-Ethiopia, 2016: Maproom, [http://www.ethiometmaprooms.gov.et:8082/maproom/].

ENACTS-ICPAC, 2016: Maproom, [http://digilib.icpac.net/maproom/Climatology/].

ENACTS-Tanzania, 2016: Maproom, {http://maproom.meteo.go.tz/maproom/]
GFCS, 2016: Global Framework for Climate Services: www.wmo.int/gfcs

GCF, 2016: The Green Climate Fund has raised

(http://www.greenclimate.fund/contributions/pledge-tracker#states).
Hazen, Gordon. 2004. Multi-attribute Structure for QALYs. Decision Analysis. 1(4):205-216.

Hazen, Gordon. 2007. Adding Extrinsic Goals to the Quality-Adjusted Life Year Model. Decision Analysis. 4(1):3-16.

Howard, R.A. 1966. “Decision Analysis: Applied Decision Theory.” In Proceedings of the Fourth International Conference on Operational Research: Publications in Operational Research, No. 15

HyVic, 2016: Hydroclimate project for Lake Victoria (HyVic) Regional Hydroclimate Project (RHP); http://www.gewex.org/hyvic.

Flagship-CORDEX, 2016: http://www.cordex.org/index.php?option=com_content&view=article&id=256&Itemid=771

ICPAC, 2016a: ICPAC Implementation Plan 2016-2020 08-apr-2016_zachary//

IGAD Climate Prediction and Application Center (ICPAC)

ICPAC. 2016b: “Proposed Activities”: Support to Enhance the Institutional Capacity of the IGAD Climate Prediction and Applications Centre; to Provide Regional Climate Information Services (available on request).

ICPAC. 2016c: Support To Enhance the Institutional Capacity of the IGAD Climate Prediction and Applications Centre (ICPAC) To Provide Regional Climate Information Services. (available on request)

ICPAC., 2016d: Data Rescue Activities at ICPAC (Author: Fortunata, Lubega)

ICPAC, 2016e. Climate modelling and diagnostics Expert for GFCS programme over eastern Africa. (Author Zewdu, Segele)

ICPAC, 2016f: http://www.icpac.net/

ICPAC, 2016g: Training Program for Climate Data Management in University; A Requirement to Introduce a Training Program on Climate Data Management in Tertiary Institution through WMO.

ICPAC, 2015 (September): Human capacity needs assessment of ICPAC for effective climate services in Greater Horn of Africa (GHA). For WMO/GFCS and Norwegian refugee council (NRC) expert deplymenr/NORCAP. Available on request to ICPAC.

IGAD: 2007 Protocol on the Establishment of the IGAD Climate Prediction and Applications Centre.

IGAD, 2013: The IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI), (Available on Request).

IGAD-EAC, L., 2012: The Summit on the Horn of Africa Crisis; NBI Summit Declaration. Ending Drought Emergencies. A Commitment to Sustainable Solutions, Intergovernmental Authority on Development (available on request).

IGAD-UNDP, 2014: Strengthening the Capacity of IGAD in Building Resilience in the Horn of Africa. (Available on request from ICPAC).

IPCC, 2013 (AR5): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
IRCCS 2016: IGAD Regional Climate Change Strategy (available on request through ICPAC, contact Abebe Tagede).

Karpatne, Anuj., and Vipin Kumar. "Adaptive heterogeneous ensemble learning using the context of test instances." Data Mining (ICDM), 2015 IEEE International Conference on. IEEE, 2015.

Karpatne, Anuj, Varun Mithal, and Vipin Kumar. "Post Classification Label Refinement Using Implicit Ordering Constraint Among Data Instances." Data Mining (ICDM), 2015 IEEE International Conference on. IEEE, 2015.

Khandelwal, Ankush., Anuj Karpatne, Miriam E. Marlier, Jongyoun Kim, Dennis P. Lettenmaier, and Vipin Kumar. "An approach for global monitoring of surface water extent variations using MODIS data", Big Remotely Sensed Data Special Issue of Remote Sensing of Environment, 2016, under review. Currently available as University of Minnesota Technical Report 16-030.

Raiffa, H. and R. Schlaifer. 1961. Applied Statistical Decision Theory. Cambridge, MA: Harvard University Press.
Leroux., M :2001 The Meteorology and Climate of Tropical Africa (ISBN-1-85233-6439)

SCIPEA, 2016: Strengthening Climate Information partnerships-East Africa (SCIPEA) kick off meeting, Naivasha, Kenya, 1-3 June 2016: Summary of activities and outcomes.

UNISDR, 2015: DRR and CC Integration Framework, Disaster Risk and Climate Information Integration for Informed Resilience Planning and Programming (Author, Gilbert Ouma).

UNDP, 2015: Uganda National Development Plan, [http://npa.ug/wp-content/uploads/NDPII-Final.pdf].

UoN, 2016: Master of Climate Change Adaptation (MCCA) graduate program [(http://icca.uonbi.ac.ke/].

Semazzi, F: 2011, Framework for Climate Services in Developing Countries, Climate Research Clim. Res, Vol. 47: 145–150.

Semazzi, F. H. M., and R. J. Mera, 2006: An extended procedure for implementing the relative operating characteristic graphical method. J Appl. Meteor. Climatol, 45, 1215-1223.

Uganda, 2016: Building the concept and plan for the Uganda National Early Warning System (NEWS). In preparation.

WMO. 2009a. Additional 'highly recommended' functions of designated WMO RCCS or WMO RCC-Networks.

WMO. 2009b. Detailed criteria for mandatory functions of WMO RCCS or WMO RCC-Networks.

WMO-GFCS-NORCAP 2015: Human capacity needs assessment of ICPAC for effective climate services in greater horn of Africa (GHA). Commissioned by the World Meteorological Organization (WMO)/the Global Framework for Climate Services (GFCS) and the Norwegian Refugee Council (NRC) expert deployment/NORCAP.

WISER
Weather and Climate Information Services for Africa

SECTION 7

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SECTION 8

Annexes

Annex-1: Plan for a Potential Climate Change Post Graduate Training Program in Climate Information Applications: Proposed for Further Co-Development by ICPAC in Partnership with NMHSs and the University Community

Based on the consultations with ICPAC, the NMHS (specifically with UNMA and Meteo-Rwanda) and the university community, the following plan for a potential climate change post graduate training program in climate information applications has been developed by the consultant during the assessment. This preliminary plan is proposed for further co-development by ICPAC, NMHSs and the university community. The prototype is based on parameters in Uganda and Rwanda for the sake of specificity, but may be applied to the other countries or group of countries served by ICPAC. In broad context this assessment is complementally to the ICPAC (2015) report on human capacity needs assessment of ICPAC for effective climate services in Greater Horn of Africa (GHA). However, here, the emphasis is on empowering capacity development for the users and stakeholders that ICPAC serves.

The prototype is designed for professionals in Uganda or Rwanda working in government, NGOs or private sector firms. Core course content includes methods of risk analysis to evaluate options for dealing with climate change. A capstone/internship project is intended to provide students unique opportunities to work with government agencies and the private sector or work on problems defined by faculty who work very closely with the stakeholder community. The program is designed with scalable features to facilitate its expansion to the other partner states of the East African Community, in particular, and potentially to other countries in the rest of Africa. The program would recruit trainees from climate science backgrounds and climate-sensitive sectors. The program will comprise innovative instructional modules designed to “fast track” graduate students from a broad range of climate-

sensitive sectors to equip them with critical climate knowledge and skills to address the full spectrum of climate change issues that Uganda or Rwanda is facing. Unique training in climate communication will support a new generation of practitioners able to reach multiple publics/stakeholders effectively about the climate issue. Partnerships with multiple cross-disciplinary faculty and agencies will enable broad "hands-on" experiences in a variety of climate sectors and multiple career pathways. Skill development through formative feedback mechanisms will provide students opportunities to reflect on and refine their practices specifically in regard to their research, communication, and written and oral skills. Ethics training, teamwork skills, and cultural practices will also be emphasized during instructional module offerings.

Description

Primary training elements: The Post-Graduate Diploma is a 15 credit hours program consisting of four, three credit courses and a three credit internship. The objective of the program is three-fold:

1. Provide students with training in climate science and climate risk analysis.
2. Provide students with training in climate adaptation policy, tools and resources for communication, policy, planning and implementation.
3. Prepare Post-Graduate Diploma students who wish to transfer to the University of Makerere in Uganda of or the University of Rwanda for Masters or PhD degrees that involves extensive use of climate information (agriculture, water resources, health, energy, tourism, environment protection, etc.).
4. Maximize use of modern instructional online tools. Concern is sometimes raised that online instruction is not as effective as the traditional face-to-face teaching. To the contrary, there is accumulating evidence that if the right tools are employed, online instruction can even be more effective than the traditional approach because of its interactive capabilities and the flexibility for online instruction to capitalize on the vast universe of information on the internet guided by well-designed computer software. Below, is an example of a tool recommended for the proposed online courses which meet these criteria.

The tool is the Instructional Computer Adaptive Testing (ICAT) method developed at NC State University (John Fountain, personal communication) for learning assessment in the climate systems module. ICAT combines instruction and assessment in an approach designed to increase students' mastery of material. ICAT will be used for both tests/quizzes and part of the instruction. It combines five features.

1. ICAT is adaptive: a wrong answer to any question may lead to sub-questions that investigate the knowledge areas needed to answer the question that was missed.
2. ICAT is instructional: wrong answers may lead to instructional material that is designed to provide the material necessary to correctly answer the question.
3. ICAT questions may include both multiple choice and student-generated products such as plots, maps or sketches.
4. Students are informed immediately if each answer is correct or incorrect, and they receive a grade at the conclusion of the test/quiz, providing immediate feedback on the extent of their mastery of the material.
5. Every question in ICAT must be answered correctly eventually: wrong answers may lead to sub-questions, but the exam will return to the missed question after the sub-question was answered correctly.

In addition, ICAT automatically generates an excel gradebook for each test/quiz, with students grades and an analysis of each question. This analysis includes calculation of the percent of times students answered each question correctly the first time they tried it, and a plot of the frequency of each answer for each question. These data allow quickly identifying knowledge areas that students have not mastered, allowing changes in instruction/and or/ questions.

Proper question development in ICAT involves higher level “main” questions, typically developed from the learning objectives for each lesson. Such questions usually involve multiple knowledge areas. Answers are chosen to investigate these individual knowledge areas.

For example if a learning objective is to understand the greenhouse effect, a question such as “which of the following statements best describes the greenhouse effect” would be combined with answers, each of which incorrect answers may leave out one part of the process. A student who answered incorrectly would see an instructional page (with image), or an instructional video, that outlined the entire process (instructional material is not designed just to provide the answer). The student may then get a sub-question on the specific area (for example the wavelength of radiation emitted from heated ground relative to incident radiation). If the sub-question is answered correctly, the student would be returned to the main question.

In theory, when a student completes a test/quiz, the student will have demonstrated understanding of each learning objective. ICAT tests/quizzes may be taken multiple times if the instructor allows and a master-quiz grade (number of times each student took the exam, and their highest grade) will be provided in addition to the regular grades.

Courses for the Post-Graduate Diploma Program
Semester –1 Courses

1. *Fundamentals of Climate Change Science (UR-001; 3 credit):* The course prepares students with core knowledge in climate systems, components and controls. Topics address key questions including: How does the climate system work?, Ocean-atmospheric teleconnections (seasonal), Physical mechanisms, Primary teleconnections, Predictability and interpretation of uncertainty estimates, projection models Statistical & Dynamical; Climate variability, Climate change, What is the role of greenhouse gases in the climate system?; What is the role of the oceans in the climate system?; How do sea/lake levels and the cryosphere respond to climate change?; What can we learn from study of past climate conditions (paleoclimateology)?; How can human activities change climate?; What evidence do we have that humans have changed current climate (temperature, precipitation, and extreme events)?; Tools for projecting future climate and causes of uncertainty in their projections, GCMs, RCMs, review of key findings of the IPCC; How might humans change future climate (temperature, precipitation, and extreme events), Land use change?

At the end of this course, students should be able to speak competently on a professional level both inside and outside of the science community using commonly used terms and acronyms.

2. *Communication Elective (UR-002; 3 credits):* Application of GIS and/or easy to understand visualization techniques for communication of climate information to the public, design, use and interpretation of surveys; application of technologies including smartphones, tablets or related readily available technology; & community meetings.

Semester –2 Courses

1. *Climate Change Informatics (UR-003; 3 credits)*: Faculty and experts from university, government and public sector team taught instructional modules linked & tailored to the educational needs of students. Designed to address knowledge and skills that are accessible and are presently only available as full courses in specific disciplinary-focused graduate programs; the course will also provide opportunities for reflection, application, examination, and formative feedback on the tools, skills, and practices students learn in the formal multidisciplinary modules through active and

collaborative learning in order to support infusion into government development visions and plans for Uganda. Training to communicate with the public through the Uganda National Meteorological Authority (UNMA) to government agencies, local industry, NGOs and the international community is a key element of the course.

2. *Climate Change Risk Analysis (UR-004; 3 credits):* The course provides experience for students in hands-on analysis of climate risks & development of adaptation and mitigation management strategies/policies in climate-sensitive application sectors. The specific content is based on case studies in health, hydrology and energy transportation & other critical sectors for sustainable national development & building resilience to climate change.

Semester-3 Internship (*UR-005;* **3 credits):** Students will participate in a capstone project or internship in collaboration with the UNMA& the internship host institution (government agencies, NGOs, private sector, others). The project is jointly overseen by the course instructor & the primary supervisor at the internship host institution. Students prepare a professional presentation & paper based on the research which they presented at the end of the session. Students get practical experience in how the following concepts may be applied in practice. Compilation of sectoral/stakeholder's needs for the adaptation; Synthesis of vulnerability and adaptation plans and policies; Development of frameworks for the adaptation strategies; Assessment of main vulnerabilities;; Recognition of barriers to implementation; Identification of priority adaptation needs; Development of a list of adaptation actions; A ranking of priority areas; Identification of the most urgent needs; Implementation strategies; & Development of project profiles.

Annex-2: Workshop to Develop the Strategy for users to access and apply WCRP CMIP climate model simulations to **B**uild **R**esilience of **I**GAD's **C**ommunities to **C**limate **C**hange (BRICCC)

Planning Team

1. ICPAC/NMHS representatives
2. HyNEWS/HyVic representatives
3. Users' Organizations Partners
4. World Meteorological Organization
5. East African Community
6. Boundary Organizations
7. Private sector representatives
8. Funding agencies representatives

1.0 Introduction

The proposed workshop and supporting activities will contribute to IGAD Regional Climate Change Strategy (IRCC). The suite of workshop activities will help to develop plans for designing and implementing BRICCC's 5 components (see recommendation-2 in sub-section 5.2.2): (i) pre-GHACOF training session on climate change, (ii) the climate change session during the GHACOFs, (iii) ICPAC Flagship CORDEX Regional Earth System Model (REaSM) initiative for East Africa to downscale CMIP global model simulations, (iv) a graduate fellowship program for human capacity development and development of tools and methods, in collaboration with partner universities, and (v) ICPAC end-to-end climate change pilot projects. The pilots projects will focus on the high priority sectors identified by IRCCS, (Agriculture, Crop and horticulture sector, Fisheries sector, Forestry sector, Livestock sector, Food preservation sector, Water Resources, Renewable Energy, Tourism and Recreation, Roads and Infrastructure, Environmental Protection, Conflicts and Human Migration, etc.).

2. Terms of Reference (TOR) for the proposed workshop and supporting activities

TOR-1: In the pre-workshop phase prepare expert review reports and presentations to initiate discussion in the plenary of the proposed main workshop. The reports will focus on BRICCC's 5 components, outlined in the introduction and sub-section 5.2.2.

TOR-2: Organize a 3-day workshop for developing plans for designing, implementing and coordinating the components of BRICCC's 5 components.

Day-1: Plenary presentations of background papers prepared by experts during the pre-workshop phase (the papers will be circulated ahead of the workshop).

Day-2: To be dominated by parallel breakout sessions. The decision/policy makers breakout session will be conducted through a participatory communication processes to create a framework for the institutionalization of lessons from the pilot projects. This activity will maximize leverage on outcomes from the HyCristal, Future Climate for Africa (FCFA) Regional Consortium Project (see Fig.2 showing potential partners of HyCristal and potential invitees to the proposed workshop), and supporting activities of CCKE and FCFA.

Other participants will include representatives of WISER-ENACTS project, WISER-SCIPEA project; DARE project; ACMAD, regional universities; CORDEX Flagship Initiative; IPCC/TGICA DDC and other IPCC programs; international climate research programs, ICPAC stakeholder partner organizations, etc.

Fig.2: Shows HyCristal (one of the Future Climate for Africa (FCFA) Regional Consortium Projects).

Day-3: Co-designing climate change pilot projects. Participants will include members of parliament responsible for climate-related legislation and policy, mandated government institutions, national development partners and relevant stakeholders to co-design an optimal coordination framework to ensure that the best science informs the regional and national agendas for climate change mitigation/adaptation. The decision makers participants will build on the pre-workshop paper presented in the plenary session on day-1 to ensure manageable dialogue, tangible outcomes and representative participation from the broad spectrum of the decision-makers community (legislators, mandated government institutions, NGOs, civil society, private sector, international aid agencies and other organizations that can benefit from the incorporation of climate information in making decisions for their services).

3. Proposed outputs from the workshop

The proposed outputs are refined plans for designing and implementing BRICCC's 5 components (see recommendation-2 sub-section 5.2.2), based on the integration and consolidation of lessons learnt from the workshop and the pre-workshop documents prepared by the experts.

4. Proposed Budget

TOR-1 budget: Conduct pre-workshop consultations using experts in the 5 BRICCC's components.

Consultancy (4 weeks consultancy work; $12,000 x 5 = **$ 60,000**)

TOR-2 budget: Three-day workshop.

1. Main room ($500) for plenary room for day-1: sub-total: **$500**
2. Main room ($500) for plenary room and 2 rooms ($250/each) for breakout sessions for day-2; sub-total: **$750**
3. Main room ($250) for plenary room and 2 rooms ($250/each) for breakout sessions for day-3; sub-total: **$750**
4. Flights/travel for 10 international experts to participate in the workshop ($3,000/person); flights/travel for 35 experts from ICPAC member countries ($500/person); sub-total: **$47,500**.
5. Hotel accommodation for 4 nights for 45 workshop participants ($120/person per night); sub-total: **$21,600**

6. Per Diem for 4 days (two half travel days before and after workshop & 3 days for workshop) for 45 participants @$150/day: sub-total **$27,000**
7. Two coffee breaks and water for 3 days: sub-total **$2,000**

Total for Workshop: **$100,100**

Grand total=$160,100

Annex-3: A Concept Note for a Pilot Project on Increasing Resilience of Coastal Communities to Climate Change: A Demonstration Pilot Project for a Co-Designed ICPAC-NMHSs-Research Community-Stakeholders Community Collaboration Model

Lead Organizations: IGAD Climate Prediction & Applications Centre (ICPAC); Uganda National Meteorological Authority (UNMA) & North Carolina State University (NCSU)

Proposed Partners Organizations: Eastern-Central-and-Southern-Africa (ECSA) Group of Consultants; Uganda National Meteorological Authority (UNMA); Lake Victoria Basin Commission (LVBC, Kenya); IGAD Climate Prediction & Applications Centre (ICPAC, Kenya); Climate Change Unit (Uganda); Climate Change Information Technologies (CCIT, Uganda); Makerere University (Uganda); North Carolina State University (NCSU, Uganda); University of Minnesota (UM, USA).

Preamble: The proposed project will utilize all the components of the collaboration strategy displayed in Fig.5 thus contributing to strengthening of regional institutional framework for climate change services. The key components are:

(i) ICPAC's partnership with the university and research organizations community,

(ii) Engage and partner with ICPAC's internal programs to execute the project and upscale lessons to the region.

(iii) ICPAC's partnership with the user Community: To establish appropriate links with NMHSs and their stakeholders,

(iv) ICPAC's partnership with the information and computer technology (ICT) community,

(v) ICPAC's partnership with funding agencies.

This is a prototype or example of the BRICCC (Building Resilience of IGAD's Communities to Climate Change) demonstration projects platform (see recommendation-2). It focusses on building the Resilience of Coastal Communities to Climate Change (ROCCCC) for the Lake Victoria Basin the attributes.

The projectis a collaborative road-test case study for ICPAC's climate change services in support of the goals for the ICPAC 2016-2020 strategic plan, IGAD Regional Climate Change Strategy (IRCCS), National Strategic Plans (NSPs), COP21, and also providing a mechanism for monitoring of the compliance of ICPAC with WMO RCC 'mandatory' and 'highly recommended' requirements. The BRICCC-ROC demonstration project (or simply, HyVic BRICCC-ROCCC project) would partner with LVB-HYNEWS to collaborate with the research community (HYVIC, DFID/NERC FCFA/HyCristal project, WISER-ENACTS project, WISER-SCIPEA project, DARE project) for intake of the most current and vetted climate science research. A planning workshop, in recommention-2, will guide the development, coordination and financing of the BRICCC-ROC project and others under the demonstration projects BRICCC platform.

Introduction: In recent years, there has been widespread and extensive coastal infrastructure and property damage due to the increase of the Lake Victoria water level (Fig.1). Research indicates that this century the level could rise higher than at any time in contemporary history and significantly higher than the record rise in the early 1960s. The combination of the projected expansion of the coastline and the very rapid urbanization occurring around the lake (Seto et al., 2012, *PNAS*, Fig.2 & 3) could result in a worst case scenario unless appropriate adaptation and mitigation action is taken. The purpose of the proposed project is to co-design and implement practical strategies to use climate information in building resilience of the coastal communities to the anticipated changes in lake levels. The primary deliverables are: stakeholders' and decision makers' interactive online tools for year-to-year predictions and decadal projections of coastal flooding due lake level rise; monitoring of coastal lake level rise and human interactions; and development of complimentary university distance learning curriculum for long-term sustainability of the ROCCC project. The project involves partnership between researchers, the operational community and decision makers. ROCCC is a HyVic project (http://www.gewex.org/hyvic).

Fig.1: Sandbags surrounding property to protect it from the rising level of Lake Victoria. The present level of the lake (about 12 meters) corresponds to the level in 1998 when the lake level was decreasing and the shoreline receding. The exposed land which attracted new settlement at that time is now being reclaimed by the lake which is rising beyond 12 meters.

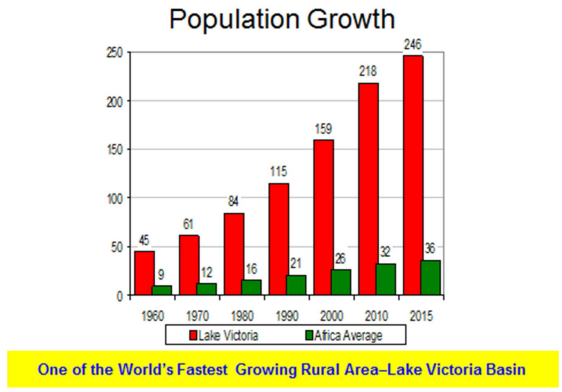

Fig.2: Global compared to Lake Victoria population growth

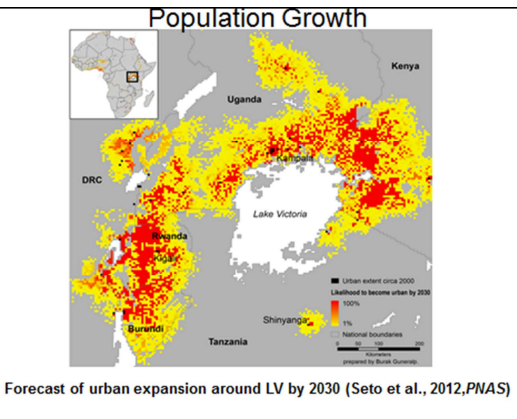

Fig.3: Projected population growth over Lake Victoria basin

Methodology

There are two major categories of vulnerable coastal infrastructure near the shoreline of Lake Victoria. The first one and most vulnerable category corresponds to the settlements that were a direct result of the recession of the coastline as the lake dropped towards its recent lowest level in 2006. In order to provide immediate actionable and practical information to these communities a survey will be conducted to determine the GPS location and year in which the property or structure was constructed relative to the lake minimum level in 2006. For example, the present level of the lake (about 12 meters) corresponds to the level in 1998 when the lake level was decreasing and the shoreline receding. The exposed land which attracted new settlement at that time is now being reclaimed by the lake because it is rising beyond 12 meters. By knowing the location of a specific infrastructure in this category and the year it was constructed we can use the lake level prediction to infer when flooding will set in due to the rise in the lake level. This category of infrastructure includes, makeshift coastline markets, beech property for entertainment, opportunistic wet zone horticulture agriculture and ill-advised residential homes. These kinds of stakeholders will be the most important beneficiaries from the proposed climate services products.

In the second category of coastal infrastructure construction was complete prior or during the early 1960s when the lake level was much higher and they are therefore relatively safe from the present and near future lake levels. However, considering

that the climate projections suggest that in this century the lake level is likely to increase or exceed any level in the past 200 years, it is important to consider adaptation or mitigation strategies to increase resilience of the coastal communities to climate change since the lifetime of most infrastructures is on order of decades.

The primary method for estimating and displaying the lake level comprises three components, namely, (i) interpolation of gridded (observed or model) rainfall data to six locations (Jinja, Entebbe, Kisumu, Musoma, Bukoba, and Mwanza) or direct use of raingauge station data for the six locations, (ii) use of the six-locations rainfall data as input to a water balance model (Tate et al, 2000) to estimate the lake levels, and (iii) a GIS interactive application to display interaction of lake level and social-economic functions. Details for the methodology for computing the lake levels are given in Smith and Semazzi (2012).

The HyVic-ROCCC project will work closely with ICPAC and LVB-HyNEWS to upscale the lessons learned during the project to the rest of Eastern Africa.

Interannual predictions: Fig.4 shows a comparison of the lake level estimated from the WBM and the gridded CRU rainfall data, and the observed levels. Lake Victoria levels are calculated using the water balance model. The Lake Victoria level observations for January 1949 to May 1998 are based on data from a gauge at the main river outlet at Jinja, Uganda and were obtained from an archive at the Ministry of Water Resources in Uganda (Davis, 2007). This data set was extended through the present using TOPEX/POSEIDON and Jason-1 satellite altimetry data (USDA, 2012). The model does well until 2005-6 when it over predicts by as much as 0.73m, which is likely related to the over release from Nalubaale and Kiira dams described by Kull (2006a,b) and discontinuity of reporting from the raingauge stations. Therefore, partnership with the **C**limate **C**hange and **D**evelopment **A**dapting by **Re**ducing Vulnerability (CC DARE) and ENACTS projects is important to rescue any data that may have not been included in the gridded CRU data used in the construction of the graph in Fig.4.

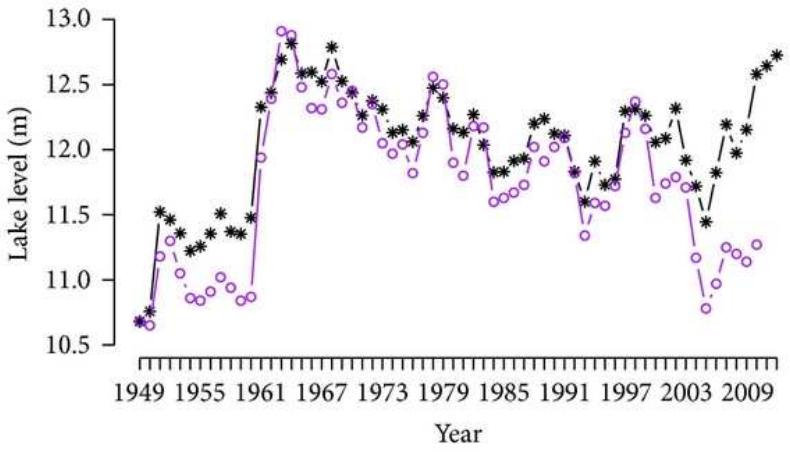

Fig.4: Comparison of Lake Victoria levels modelled using CRU 3.21 (black with asterisks) and observed lake levels (purple with circles). The discrepancy at the beginning of this period may be related to the construction of the Owen Falls dam, 1951-1959. The observed lake level decline in 2006 has been attributed 50% to the drought and 50% to over release according to Kull (2006a, b). However, the lake level obtained from the model may have also be slightly overestimated because of gaps in the 6 raingauge stations at Jinja, Entebbe, Kisumu, Musoma, Bukoba, and Mwanza. These gaps will be addressed through partnership with the DARE data rescue project funded by WISER/DFID.

Building on previous success for end-of-year Lake level nowcasting (Smith and Semazzi, 2014), maximum use can be made of the LRF rainfall at the 6 raingauge stations to predict the rainfall for all or part of the upcoming annual cycle. The lead time during the course of the year will depend on when the predicted part of the annual cycle is made. For instance if the observed rainfall data at the six stations (Jinja, Entebbe, Kisumu, Musoma, Bukoba, and Mwanza) along the perimeter of the lake is used up to the end of September a combination of IPCAC LRF and SCIPEA project predictions will be used for the remaining part of the year (the Short rains). This will give a lead time of up to 3 months since the current WBM algorithm predicts end of year lake levels in increments of one year. These estimates will be highly useful for the stakeholders to purchase temporary materials, e.g. sandbags, for protection against flooding or make other strategies for the impeding lake level conditions. Each property is likely to have a different lake level threshold before flooding occurs. Therefore the product under this task will be projected lake level in

form of an interactive high resolution online App mapping easily accessible by users. HyVic-ROCCC will partner with the DARE and ENACTS projects to update the rainfall datasets used earlier to the near present time.

Summary of Climate Services Product

Information: Annual (or partial annual) prediction of lake levels throughout Eastern Africa (starting with Lake Victoria).
Primary Stakeholders: Lakefront property owners and businesses; emergency responders to flooding; public health services; hydroelectric dam managers.
Partners: PREPARED DARE, ENACTS, HyCristal, UNMA, ICPAC
Stakeholder access to information: (i) Interactive online mapping App (see prototype at, http://go.ncsu.edu/lakevictoria, Username: lakevictoria, Password: Victoria423. The proposed update of the prototype will include a feature to click on a coastline location and find out when (season or year) flooding is predicted to commence; and (ii) GHACOF session dedicated to coastal flooding.
User platforms: Smart mobile phones and computers

Multi-decadal projections: On decadal time scales the methodology is similar to the approach for interannual time scales described above except that theCMIP5 multi-decadal model projections will be used. The comparison in Fig.5 confirms that the ReGCM3 regional climate model realistically reproduced past decadal variability of the lake level. The corresponding projections indicate more than 2 meters of increase in the lake levels that could occur later in this century. During El Nino years the level increases up to one meter, thus including this contribution the level could exceed 15 meters, thus 3 meters above the present level which could have devastating consequences for the coastal communities.

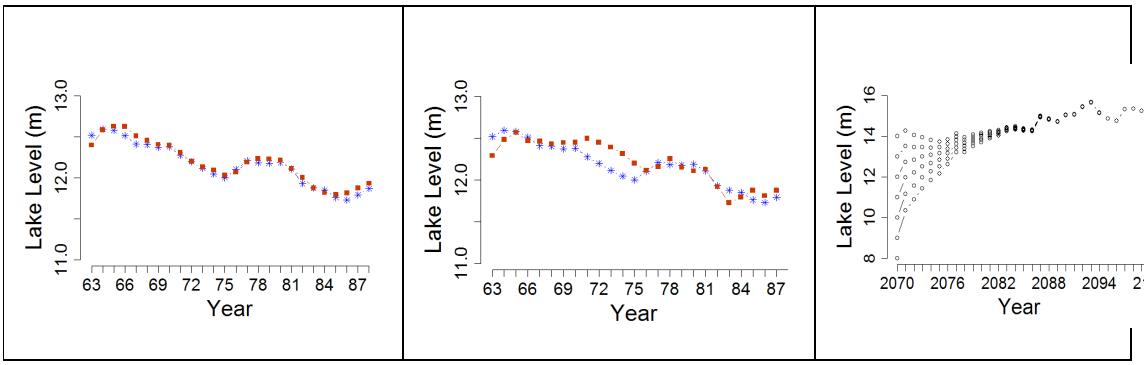

Fig.5: ***Left:*** *Ten year running mean of Lake Victoria observed levels (blue) compared to estimates based on our modified version of Tate et al (2004) water balance model for Lake Victoria with observed rainfall from six rain gauge stations (red);* ***(Center)*** *Ten year running mean of Lake Victoria observed levels (blue) compared to estimates based on our modified version of Tate et al (2004) water balance model for Lake Victoria with rainfall from RegCM3-20km resolution reference run (red);* ***(Right)*** *lake levels projections (2071-2100) based on rainfall input from RegCM3 (20km grid) A2 simulation. Since the initial level of the lake for 2071 is unknown, we assume multiple initial conditions for the hydrological model. All initial states converge to the same projection curve after about 10 years.*

Summary of Climate Services Product: Multi-decadal prediction of lake levels throughout Eastern Africa (starting with Lake Victoria);GPS location of most vulnerable shoreline properties, year of construction and continuous monitoring of initial flooding due to lake level raise including satellite and traditional photograph footage.
Primary Stakeholders: Government planners for adaptation and mitigation strategies, including building permit offices, Uganda National Road Authority (UNRA), Hydroelectric Power managers, marine and land transport sector, Lakefront property owners and businesses; public health services; hydroelectric dam managers.
Primary Partners: WISER, DFID/NERC FCFA/HyCristal project; WISER-ENACTS project, WISER-SCIPEA project; DARE project; ACMAD, regional universities with students' fellowship program to support the activity; CORDEX Flagship Initiative; IPCC/TGICA DDC and other IPCC programs; international climate research programs, ICPAC stakeholder partner organizations.

Stakeholder access to information: (i) Interactive online mapping App (see prototype at, http://go.ncsu.edu/lakevictoria, Username: lakevictoria, Password: Victoria423. The proposed update of the prototype will include a feature to click on a coastline location and find out when (season or year) flooding is predicted to commence; and (ii) GHACOF session dedicated to coastal flooding.
User platforms: Smart mobile phones and computers
Monitoring of lake-level changes and coastal settlement interactions: Fig.6 illustrates the tool that could be adopted in monitoring the lake-level changes and coastal settlement interactions. The product is derived by applying computer science abrupt change methodology (computer artificial learning) and MODIS satellite data (Karpatne and Kumar (2015); Karpatne et al (2015); and Khandelwal et al (2016)) to detect locations where the surface changed from water to land, thus corresponding to

the recession of the lake's coastline. Although, since 2006 the lake level has gradually recovered, the locations identified by this method remain land points. It is therefore evident that the liberated land quickly attracts new settlements. This development is exasperated partly by the very high population growth and demand for land which is projected to grow significantly by 2030, according to projections (Fig.3). Therefore, as the lake levels recovered (Fig.6) these locations never recovered because of protection structures which had been constructed earlier and prevented the lake to reclaim its territory. These artificial constructions to protect coastal infrastructure could increase flooding risks for non-protected neighbouring areas which have to take on the additional water displaced from the protected areas.

It could envisage that in the next few decades, as the water level increases, they will be a new threat where the lake level reaches local record heights and the lake begins to claim new territory for the first time in the last 200 years. The abrupt change metric used in Fig.6 will be very valuable in detecting the onset of such a situation. It is therefore proposed to adopt the abrupt change metric for monitoring the expansion of the lake and apply the information to validate the model projections discussed above for lake level rise.

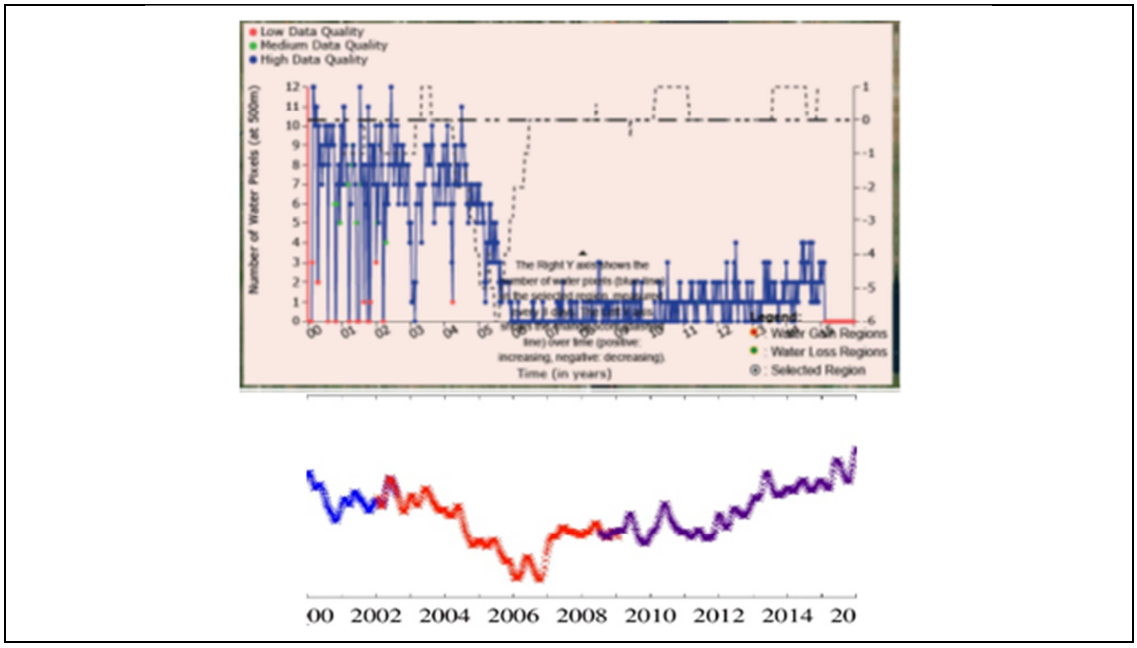

Fig.6: Time series for a location around Lake Victoria showing abrupt change from water to land (abrupt change metric, upper graph). Although the lake level is back to its 2000 level (see lake level in lower graph) when this point was water (upper graph), the lake cannot reclaim the territory it lost in 2006. Since then the coastal area which has been vacated by the lake has been occupied by human settlement and protective barriers/structures have been constructed to keep the water away.

Summary of Climate Service Product

Information: Lake Level and Human Settlement metric mapping throughout Lake Victoria Basin.

Primary Stakeholders: Government planners for adaptation and mitigation strategies, including building permit offices, Uganda National Road Authority (UNRA), Hydroelectric Power managers, Lakefront property owners and businesses; public health services; hydroelectric dam managers; emergency responders.

Primary Partners: WISER, DFID/NERC FCFA/HyCristal project; WISER-ENACTS project, WISER-SCIPEA project; DARE project; ACMAD, regional universities with students' fellowship program to support the activity; CORDEX Flagship Initiative; IPCC/TGICA DDC and other IPCC programs; international climate research programs, ICPAC stakeholder partner organizations.

Stakeholder access to information: (i) Web-viewer for monitoring surface water dynamics (University of Minnesota); Incorporation of Web-viewer I (i) above, into the Interactive online mapping App (see prototype at, http://go.ncsu.edu/lakevictoria, Username: lakevictoria, Password: Victoria423. The proposed integrated App will include a feature to click on a coastline location & find out when (season or year) flooding is predicted to commence; & (ii) GHACOF session dedicated to coastal flooding.

***User platforms*:** Smart mobile phones and computers