Training of Trainers Workshop on Enhancing Forecasting Capacities and Crop Capability Prediction Models and Tools

Yosef Amha | Ernest Afiesimama | Bradwell Garanganga | Gebermedihin Ambaw | Teferi Demissie | Dawit Solomon

Workshop Report

CGIAR | AICCRA Accelerating Impacts of CGIAR Climate Research for Africa

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May 2023

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About AICCRA reports

Titles in this series aim to disseminate interim climate change, agriculture, and food security research and practices and stimulate feedback from the scientific community.

About AICCRA

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The Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) project is supported by a grant from the International Development Association (IDA) of the World Bank. IDA helps the world's poorest countries by providing grants and low to zero-interest loans for projects and programs that boost economic growth, reduce poverty, and improve poor people's lives. IDA is one of the largest sources of assistance for the world's 76 poorest countries, 39 of which are in Africa. Annual IDA commitments have averaged about $21 billion over circa 2017-2020, with approximately 61 percent going to Africa.

This training of trainers' workshop would not have been possible without the assistance of Mozambique's National Institute of Meteorology (INAM) – Dr Aderito Aramuge and Mr. Jonas Zucule.

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ABBREVIATIONS AND ACRONYMS

ACPC	African Climate Policy Centre
AICCRA	Accelerating Impacts of CGIAR Climate Research for Africa
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CCAFS	Climate Change, Agriculture and Food Security Programme of CGIAR
CAMDT	Climate Agriculture Modelling and Decision Tool
CGIAR	Consultative Groups on International Agricultural Research
CIS	Climate Information Services
CSA	Climate Smart Agriculture
DNDAF	Nacional de Desenvolvimento de Agricultura Familiar – MADER
DST	Decision Support Tools
DSS	Decision Support System
DSSAT	Decision Support System for Agrotechnology Transfer
IIAM	Instituto de Investigação Agrária de Moçambique (Agricultural Research Institute)-MADER
INAM	Instituto Nacional de Meteorologia
INIR	Instituto Nacional de Irrigacao (National Irrigation Institute)
MADER	Ministry of Agriculture
NASA	National Aeronautics and Space Administration of USA
NMHSs	National Meteorological and Hydrological Services
SADC	Southern African Development Community
SCF	Seasonal Climate Forecast
SEBs	Socioeconomic Benefits
ToT	Training of Trainers
UEM	Universidade Eduardo Mondlane,
UNECA	United Nations Economic Commission for Africa
WISER	Weather and Climate Information Services
WMO	World Meteorological Organization
WUA	Women's University in Africa, Zimbabwe
WTD	File with daily Weather data aggregated over many years
WTH	File with one Year's daily Weather data

EXECUTIVE SUMMARY

The detrimental impact of hydro-meteorological risks on agriculture frequently leads to food insecurity, particularly in Sub-Saharan Africa (SSA). Hence, the agriculture communities require climate-informed decision support tools that guide adaptation measures against climate change in the agriculture sector. The climate-informed crop capability prediction tool is one of these tools to benefit user community in making tactical and strategic decisions on inputs needed for agriculture and food security sectors as early as the crop-growing season. In this regard, regional partners[1] commissioned a series of studies to develop a crop capacity prediction tool in order to maximize agricultural productivity in the Southern Africa Development Community (SADC) region while limiting the consequences of hydro-meteorological risks on the food system. This tool can assist policymakers and user communities in making decisions on the most up-to-date crop capability based on projected seasonal climate data. However, for this tool to be operationalized and bring maximum impacts, roving training of trainers (ToT) workshops are required for agricultural yield prediction users, seasonal climate forecast (SCF) providers, researchers, and academics. The first of such ToT workshops was held in Harare, Zimbabwe, and the second one in Maputo, Mozambique, from 2–5 May 2023. Around 30 professionals who came from the Universidade Eduardo Mondlane (UEM), the Ministry of Agriculture (MADER), Mozambique National Institute of Meteorology (INAM) and other relevant departments attended this session.

This ToT workshop covered a wide range of topics, including providing a conceptual framework for the Climate Agriculture Modelling and Decision Tool (CAMDT) - Decision Support System for Agrotechnology Transfer (DSSAT) platform; the importance of seasonal climate forecast (SCF); a hands-on exercise in data management (quality control and missing values, as well as a specific template/format); data acquisition; model descriptions (assumptions and uncertainties); and model analysis (simulation and validation).

Participants' feedback indicated that the model and its outputs were successfully transferred, resulting in proficiency with the tool for future applications. They also thought the training was extremely relevant and valuable to the user communities. Despite the availability of a user manual, participants preferred a simpler programme-assisted method so that individuals with less computer knowledge could run the model for immediate use and application.

It was emphasized that complete implementation of the SFC-driven crop capability prediction model and its timely deployment will result in large savings considering the vital role agriculture plays in the area. Participants recommended that the model be improved by including local circumstances and cultivars. However, for this capacity-building programme to be successful and have a lasting impact, it needs the full support of pertinent national and regional organizations, projects, and governments in the area. More resources are also required to guarantee that developers continued to engage in model improvement and skill transfer within SADC and beyond.

[1] Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA-ESA), the African Climate Policy Centre (ACPC) of the United Nations Economic Commission for Africa (UNECA), the World Meteorological Organization-Regional Office for Africa (WMO-ROA), Digitron Consulting-Zimbabwe and the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA).

INTRODUCTION

Climate information services (CIS) in agriculture provide critical information to agricultural institutions, input suppliers, local cooperatives, and community-based groups and assisting them in making practical, realistic, and relevant decisions in the face of climate change. Given the reality of extremes in climate variability and climate change, as well as the negative consequences for agriculture, it is critical to deploy crop intelligence tools, such as crop yield prediction models, to strengthen the sector's resilience to the impacts of climate change and variability. Crop growth simulation models have evolved into helpful tools for agricultural research and production syxssstems that benefit end users. User communities can, for example, use a Climate Agriculture Modelling and Decision Tool (CAMDT) linked Decision Support System for Agrotechnology Transfer (DSSAT) to correlate crop biological requirements to physical attributes of land in order to give management greater opportunities for enhanced agricultural planning.

These models require climatic factors such as temperature, solar radiation, and precipitation, which all have an influence on crop growth and yield development. The models also require evolutions of these variables on a daily basis during the season. However, the majority of the publicly available seasonal climate forecasts (SCF) released by Regional Climate Outlook Forums (RCOFs) and other Centres are provided in typically three-monthly means in tercile probabilities (for rainfall and temperature), i.e., below-normal (BN), near-normal (NN), and above-normal (AN). Thus, SCFs alone could fall short of delivering highly relevant information for enhancing farm-level decisions and policy-level actions. As a result, the CAMDT-DSSAT (i.e., SCFs connected with crop simulation models) become crucial CIS-based decision support tools to assist user communities to improve their strategic and tactical decisions so as to maximize benefits and minimize any climate-related risks in the growing season.

It is worth mentioning that DSSAT has been used in over 174 countries for over 30 years by researchers, educators, consultants, extension agents, farmers, private industry, policy and decision makers, and many others. The DSSAT package includes 16 distinct crops, as well as software for evaluating and deploying crop models for various purposes. the DSSAT crop simulation modelling can also help to forecast the impacts of future global climate change, and can, therefore, contribute in the development of national adaptation and mitigation policies. Other policy challenges that might benefit from crop yield prediction modelling studies include yield projections, agribusiness planning, operations management, and the effects of management activities on environmental issues. User groups can also minimize losses due by unforeseen inter-annual climate variability by using CIS such as crop yield prediction modeling (CAMDT-DSSAT combination), and thereby maximize productivity more efficiently under conditions of favourable climatic patterns when these are predicted in advance.

BACKGROUND

Despite significant advances in climate research and technology, smallholder farmers do not use the majority of the available weather and agrometeorological information, resulting in low agricultural productivity. To address this, the UNECA, in collaboration with its regional partners, commissioned a study to develop a set of simple and rigorous scientific tools that can be used to make evidence-based decision in agriculture planning and policy. The Wather and climate Information SERvice (WISER)-funded study took place in three southern African countries namely Malawi, Mozambique, and Zimbabwe. The study produced a tool for measuring crop capability in different agro-ecological zones, with the aim of improving agricultural production and food security. A group of relevant experts from the three countries' National Meteorology and Hydrology Services (NMHSs), Ministries responsible for Agriculture and their affiliated research institutes, and relevant departments from Academia endorsed the tool at a Validation Workshop held in Lilongwe, Malawi.

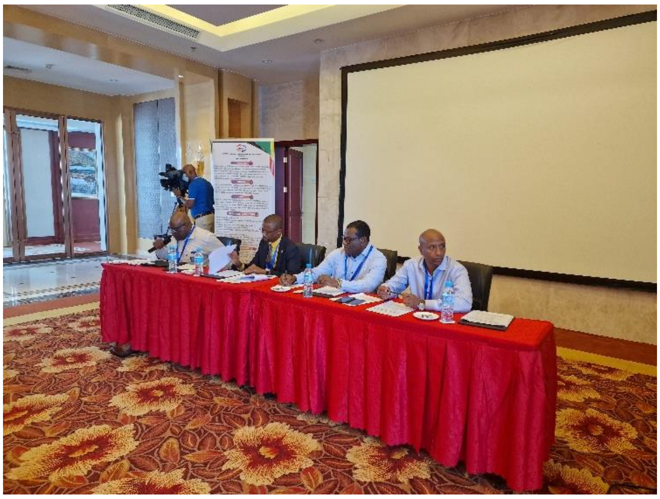
This crop capability prediction tool is critical for increasing agricultural productivity, identifying yield deficits and surpluses with exceptional leads-time, and providing greater opportunity for nations to attain food security. This tool can also be used in the livestock sector. For example, if poor fodder production is predicted as a result of the drought, it may help farmers make evidence-based decisions to destock or purchase extra stock feed to sustain their animals through the dry season. This suggests that improved access, uptake, and use of CIS can reduce the vulnerability of smallholder farmers against the impacts of climate extremes and changes.

In this context, training on how to utilize CIS effectively in decision-making processes is critical in order to limit the adverse effects of climate-induced risks; and enhance production under foreseen favourable climate conditions. This will yield enormous benefits to the economy. As a result, the Accelerating Impact of CGIAR Climate Research for Africa (AICCRA) in collaboration with UNECA-ACPC is building a cohort of CIS practitioners on CIS-Based Decision Support Tools to assist user communities in improving their decision in agricultural production systems. This is achieved by the organization of roving Training of Trainers (ToT) workshops in Zimbabwe followed by Mozambique. The specific objectives are to provide hands-on training on a modified CAMDT/DSSAT crop yield prediction model using a national data.

"A minute's silence was observed before the official opening ceremonies for Mrs. Lucy Samvura-Motsi, who was part of the team that developed the crop yield prediction model and died on April 10, 2023 in Venice, Italy, where she was pursuing her PhD study."

WELCOMING REMARK

Dr. Murombedzi of the ACPC welcomed all guests and participants to the workshop. In his welcoming remarks, he emphasized the significance of adopting CIS in addressing the impacts of climate change, with specific emphasis on the SADC region. He noted that the idea for this study arose during the *'Building Back Better'* workshop conducted in October 2020 in Harare, Zimbabwe, in response to Cyclones Idai and Kenneth, which had ravaged Malawi, Mozambique, and Zimbabwe. Dr Murombedzi stated that during that workshop, the late Minister of Lands, Agriculture, and Rural Resettlement – Rtd. Air Marshall Perence Shiri, urged that UNECA and its partners to develop a decision support tool (DST) that would allow the government to make informed decision in the agriculture sector. In response, the crop capability prediction model was developed and subsequently validated. He further stated that UNECA would continue to engage with AICCRA in organizing such capacity building ToT workshop for enhanced operationalization of the CAMDT-DSSAT model by end-users.

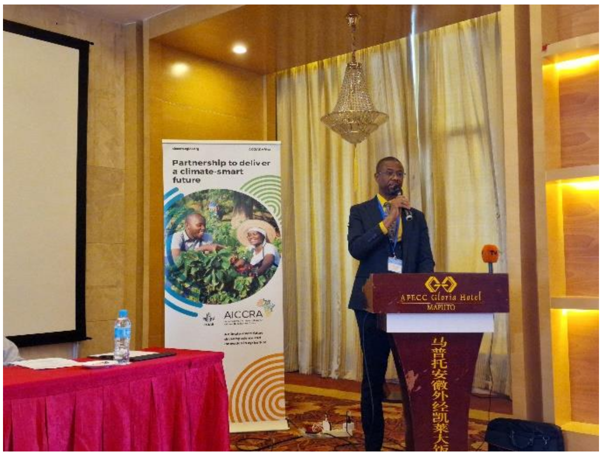


Dr. Solomon from AICCRA-ESA began his welcoming remarks by describing the functions of AICCRA and its partners. He informed that one of the objectives of AICCRA is to provide climate-smart agriculture (CSA) and CIS technologies to millions of African smallholder farmers. It operates in three sub-regions (West, Southern, and Eastern Africa) and three components (knowledge development, technology,and service sharing; partnership and capacity for delivery; CIS and CSA technology promotion, delivery for scaling methods for validated and customized CIS. AICCRA is grateful to the World Bank and other partners for their support in realizing its objectives. Specific to the workshop, he was happy with the model application including its potential in crop insurance scheme to hedge against agricultural output losses due to poor weather. In this context, AICCRA would continue to collaborate with regional partners and Digitron – the model's developer in the effort of enhancing forecasting capacities and crop capability prediction model/tool. Finally, he thanked all for coming to the ToT Workshop and wished them a successful hand-on training.

Dr. Ernest Afiesimama of WMO-ROA thanked AICCRA and UNECA on their efforts in supporting capacity-building activities in the SADC region through ToT and creating the tool, respectively. This ToT workshop is of greater importance for the operationalization of the tool so that user communities could benefit from it. The WMO official stated that agriculture is the backbone of the African economy, and that such decision-making support tools would be critical in directing pre-planning and on-farm planning. This training is compatible with most of WMO's pillars and confirms his commitment to such undertakings.

OPENING STATEMENT

Dr. Aderito Aramuge, Director General of INAM, greeted everyone and praised all institutions participating in the development of decision support tool (DST) for agricultural and food security. He stated that INAM's mandate in Mozambique is to safeguard lives and property from extreme weather and climate impacts, and voiced his belief that such DST will play a crucial part in achieving INAM's mandate.



He noted that incorporating CIS into policy, planning, and practices is critical for Africa to meet its socioeconomic development goals, such as developing resilient societies, improving trade competitiveness, reducing poverty, and achieving long-term economic growth. They are also critical in shaping our knowledge of climate risks and guiding decision-making at several scales. However, boosting the adoption and usage of CIS need an enabling environment that encourages investments in the production of CIS.

He further noted that the main hurdle to addressing present and future climate risks is the lack of accurate, reliable, and relevant weather and CIS by vast numbers of climate-vulnerable individuals. Another obstacle that diminishes resilience to climate risk and so weakens adaptation efforts is a mismatch between available knowledge and what is required to enable on-the-ground decision-making.

Dr. Adérito praised AICCRA and UNECA for their efforts on the development of crop capability prediction tool for SADC nations given the region's economy is agricultural based. He further emphasized the importance of supporting end users in the following areas:

- forecasting and crop capability prediction tool to benefit policymakers and the user community for the strategic provision of appropriate inputs to the agricultural (livestock and crops) and food security sectors, taking into account agro-ecological zone specificities;
- strengthening the platform for collaboration by key stakeholders involved in the production and application of timely climate data, and
- increasing end-user capacity for increased production, better access, and long-term CIS operations.

As a result, INAM will continue to play important roles in the generation, analysis, translation, and dissemination of timely and tailored CIS to end users. Finally, Dr. Aderito reaffirmed INAM's commitment to such capacity-building activities; and declared the ToT workshop is officially opened.

CROP YIELD PREDICTION MODELLING FOR OPTIMAL AGRICULTURAL PRODUCTION SYSTEMS

Dr. Yosef Amha of AICCRA presented the importance of crop yield prediction modelling for optimal agricultural production systems under the changing climate. In his presentation, the following points were covered:

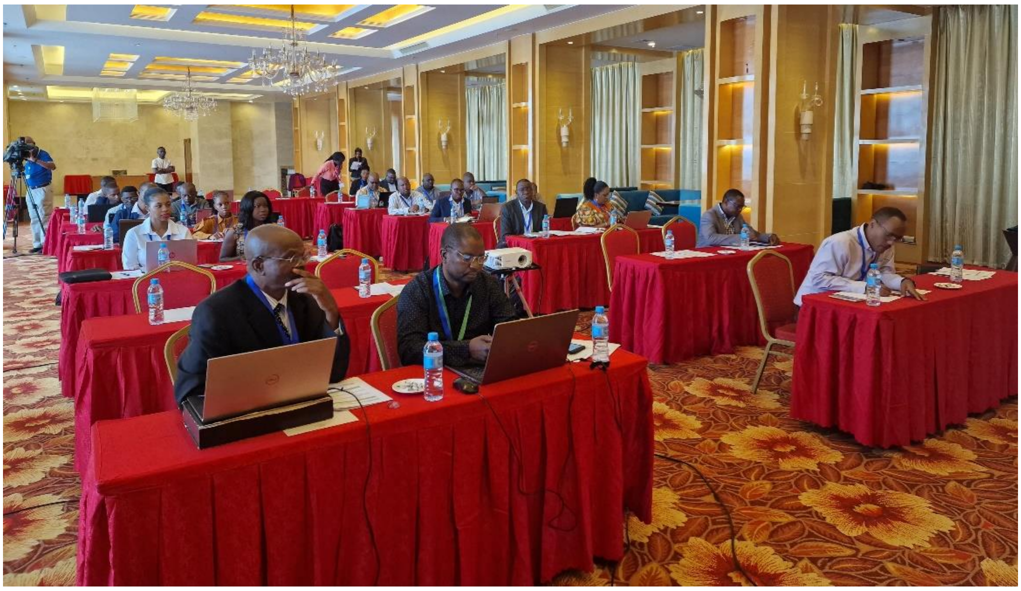
- *Agricultural production vs. climate change impacts* – how the sub-Saharan African (SSA) countries' agricultural productivity has been significantly decreased by climatic extremes and shocks, which are manifested through higher temperatures, floods, storms, unpredictable rainfall, and other phenomena;
- *Global temperature patterns vs greenhouse gases (GHGs)* – how the 1.1 ^{o}C mean global temperature increase above pre-industrial period is explained by the anthropogenic induced GHG emission mainly CO_2, N_2O and CH_4;
- *Justifications for enhanced CIS investment* – hydro-meteorological hazards accounted for 90% of total disaster losses worldwide and how improved uptake and use of CIS critical in agriculture sector. The claim is backed up with UNECA's findings showing the use of CIS in support of making strategic and tactical decisions resulted in a benefit-to-cost ratio of 10 to 1;
- *Types of crop growth simulation models* – background descriptions and how they become usual tools for agricultural research and production systems; and common types of crop growth model including those listed under statistical models, mechanistic models, deterministic models, stochastic models, and simulation models;
- *Climate Agriculture Modelling and Decision Tool (CAMDT) linked crop-yield simulation programme - the Decision Support System for Agrotechnology Transfer (DSSAT)* – How climate-informed crop intelligence technologies are critical in attempts to properly plan and direct agricultural adaption actions; and why CAMDT-DSSAT chosen for this study.
- *Applications of crop capability tool* – its roles in increasing agricultural productivity, improving farm-level and policy-level interventions, selecting potential management practices, estimating crop yield early enough, analysing the effects of climatic change, crop insurance scheme in estimating crop yield losses, and estimating the performance of different crops under different scenarios, among other things.
- *A concerted efforts is needed to establish a cohort of experts* – Rationale for AICCRA and its regional partners to take parts in the crop capability model initiative and training of trainers (ToT) workshop. Extending collaborations with national and regional institutions/initiatives and provision of sustained capacity-building training activities are, therefore, critical for efficient and resilient agricultural production systems.
- *Expected output of the ToT:* At the end of this training, the ToT's will able to:
  - analyze the expected impact of technology options and climate on crop yields,

- provide information on “what inputs to procure well before the agricultural season commences” to enhance agricultural productivity,
- optimize agronomic practices according to expected climate conditions, and
- reduce losses in agricultural production systems under different adaptation/mitigation scenarios.

SEASONAL CLIMATE FORECASTS FOR AGRICULTURE

Dr Afiesimama of WMO-ROA made a presentation on the importance of Seasonal Climate Forecasts (SCFs) in Agriculture. He discussed:

- *How the ocean-atmosphere system interacts* and influences seasonal forecasts over SADC region with focus on El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), etc;
- *Types of SCFs* – seasonal climate forecasts skills have improved recently with advances in technology where forecasting can be made using statistical forecasting; dynamical forecasting; analogue forecasting; indigenous traditional/natural forecasting; and hybrid-dynamical forecasting;
- *Regional Climate Outlook Forums (RCOFs)* – their roles and most of the publicly accessible SCF released by the RCOFs and other Centres are provided in tercile probabilities of the most likely category (for rainfall and temperature) i.e., below-normal (BN), near-normal (NN) and above-normal (AN) categories;
- *Messaging format for SCF outputs* – keys for messaging and communication of SCFs for maximum impacts as SCF are done in three-monthly averages while users take the forecasts in a deterministic manner;
- *Examples of producer-user interfaces* – The need for developing and strengthening platforms for producer-user interfaces in order make appropriate interpretation of SCF and other forecasts;
- *Benefits of using a holistic approach* – he describes the immense opportunities in taking a holistic approach in the provision of climate forecasts to smallholder farmers that would take into account context, socio-economic status of the farmer, and technical aspects of the forecasts, e.g. skill and format



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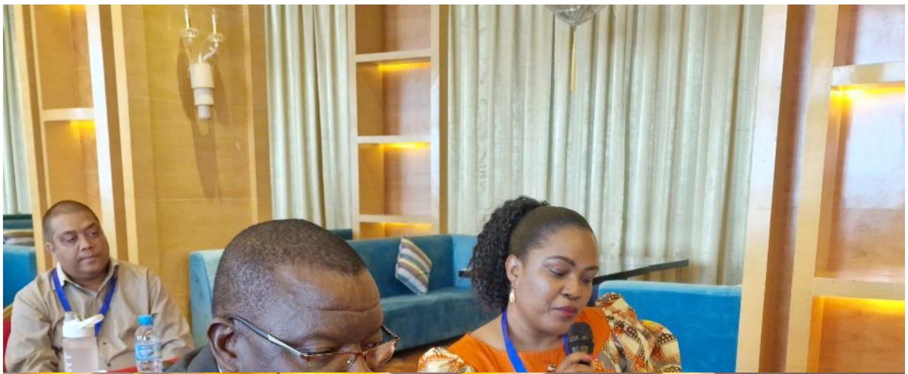
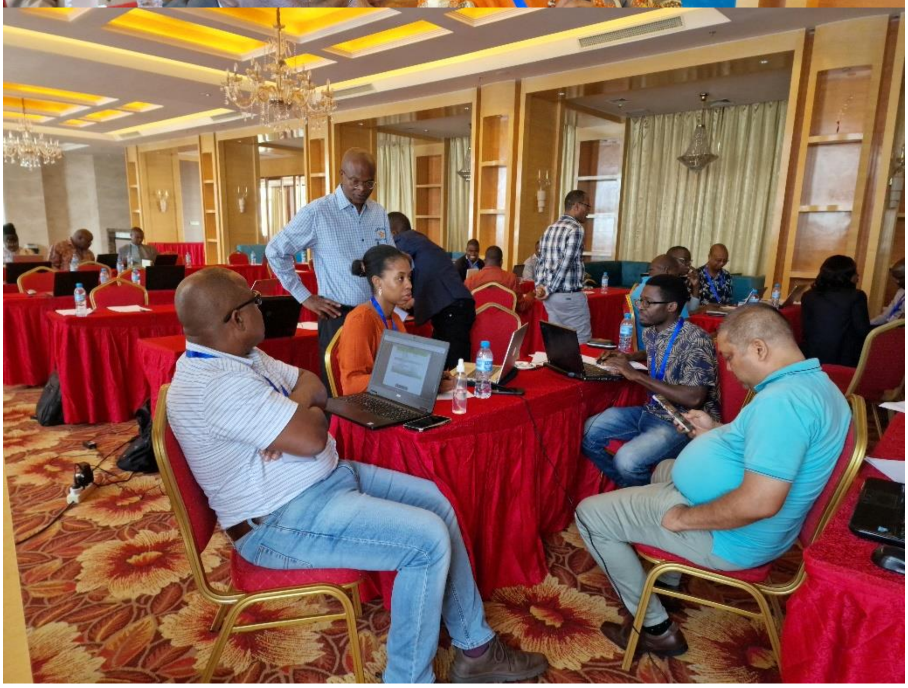
CROP CAPABILITY PREDICTION MODEL

Dr. Bradwell Garanganga of DIGITRON made a presentation on the conceptual framework of crop capability prediction modelling. His presentations were made in two sessions where he discussed about the overview of weather and CIS and their utility for crop yield prediction, motivation for developing actionable DST in agriculture, brief overview of methodology, concepts and application of DSSAT, and and rationale for using CAMDT. The following main points were highlighted:

- *Overview of crop capability model* – the DSSAT is not just a software programme but an ecosystem for crop model users, crop model trainers, and crop model developers and how the model is important for predicting growth in food, feed, fiber, and fuel crops etc;
- *DSSAT model architecture* – it takes into account the environment (weather, soils), genes and phenology of crops and management (fertilizers, irrigation) in order to simulate crop yields with required measure of fidelity.
- *Growth simulation* – the simulation models are constructed using series of historical data of relevant parameters. DSSAT requires environmental parameters: solar irradiance; minimum and maximum temperature and precipitation, soil type and its profiles; seed variety and management system to run the required crop simulations.
- *Running DSSAT* – it required database management system for soil, weather, genetic coefficients, and management inputs, crop phenology simulations, and series of other utility programmes.
- *Why SCF important inputs in crop yield prediction models* – in order to have long planning window, SCFs are critical. However, the utility of SCFs for driving DSSAT requires weather generators. These are algorithms used to reconfigure SCF into daily weather realizations as input into crop growth simulation models to predict yield. An example of such weather generators is the CAMDT developed by Han and co-workers at International Institution for Climate and Society. CAMDT converts tercile-based SCF into daily weather sequences which are critical inputs needed by the crop yield prediction models.
- *Applications of the training manuals* – these manuals is a combination of two User Guides to be used in tandem. The crop capability prediction modelling platforms used in this User Guide are the CAMDT as the weather generator for the DST for DSSAT, the crop weather simulation model. CAMDT/ DSSAT platforms are very sensitive to the data formats. In this regard, there is a need to carefully manipulate the climatological data for exporting into CAMDT/DSSAT programmes to be compatible for ingestion into these environments.
- *Introduction to CAMDT software* – the agricultural systems are basically modified ecosystems that need to be managed through systems models which are possible only through classical engineering expertise of modelling. It was noted that models have interacting components such that a change in one component affect changes in other components.

- *Assumption made in CAMDT as a weather generator* – by their very nature, there were assumption that were made in developing CAMDT model. It is used to drive DSSAT to simulate crop yields. In the crop capability prediction model the following assumptions made are fidelity in seasonal climate forecasting: good hit rate; thresholds of above/below normal probabilities; crop cultivars used will replaced by local ones after calibration work; and limitations of predictability.
- *Some inherent uncertainties in any model* – There will some uncertainties due to the fact that, for instance: the model is applied in a new situation (e.g., switching to a new variety); the processes are not all fully understood to be always ideally simulated; and model performance is limited to the quality of input data of parameters to be modelled: e.g., (meteorological data used in the model need to be reliable and complete).
- *Downscale SCF to daily realization* – the distribution of rainfall episodes, for instance, taking into account intensity, amount or duration are assumed by the scheme of the model. The validation of the model is done through routinely analyzing the model outputs and assessing whether they are consistent with realistic crop yield products. There was also a demonstration of how generated outputs from running CAMDT-DSSAT can be presented as actionable products to the user community.





HANDS-ON EXERCISE ON CAMDT/DSSAT ANALYSIS

The trainers have given a URL to participants to download the software, which includes Python, DSSAT 4.6, and an instruction manual comprised of two User-Guides. In addition, Digitron built a data gathering and processing programme in response to requests from previous workshop attendees. The trainers demonstrated the key steps in acquisition of NASA data and preparing it for ingestion into the model. Automated data handling techniques in this respect include saving into appropriate pre-configured hierarchical folders. Following that, trainers demonstrated how to execute CAMDT/DSSAT analysis using the instruction manual. In this regard, participants were then guided through the processes necessary for running the simulation of crop yield prediction. The following sections were covered during the hand-on exercise:

Data and Model Implementation

Following the usage of the digiSoft tool, participants were taught data collection frameworks for crop yield prediction modeling, namely the CAMDT/DSSAT template. Participants were shown how to perform simulations of agricultural yield prediction, data analytics, including quality control, and missing data concerns. This was a participative session with questions aimed at clarifying the procedures to take to correct errors that happened at times.

Data Acquisition and Processing

Once the appropriate suite of software was installed and operational, participants were directed to NASA's data sources website. They retrieved the necessary data for ingestion onto the CAMDT/DSSAT platform from the website in order to generate crop capability predictions. These were historical daily climatological characteristics (solar irradiance, minimum and maximum temperatures, and rainfall) for a specific meteorological station from January 1, 1984 to December 31, 2022. This time frame was chosen because developing a crop yield prediction model required at least 30 years of consistent daily data in those four parameters. Participants downloaded data as an Agro-Climatology Community in order to receive the required files, particularly solar irradiance values, which change depending on the needs of distinct community users. The files had to be saved into CSV formats. The use of digiSoft App for data handling, however, dispensed with the previous intermediate manual process of “Formatting and Splitting NASA Data to CAMDT Format” and “Exporting to Text Format and Renaming WTH (file with one year’s daily Weather data) Files”. These procedures used in the early version of the Manual that took up to a whole day for the users/trainees to master. The use of the new App saved considerable time which made it possible for participants to begin running CAMDT much earlier than previously, within a few hours.

Downloading the needed software

Trainers guided participants on how to download the digiSoft CAMDT NASA Autoformat software tool used to split and format the NASA file into *.WTD (global data) and into *.WTH (yearly data) files as provided in the, MS OneDrive/Google Drive as in the provided link. This entailed the**:**

- Running of the installation by double clicking shortcut digiSoft; or typing
- Or searching for digiSoft on the search box.

Trainees were also guided to download the Python software package used for the modelling environment https://www.python.org/downloads/release/python-383/ by carrying out:

- Running a custom installation ensuring that PIP option is selected;
- Using the Python PIP utility to add the options required by CAMDT; and
- Locating the given CAMDT files and TEST RUN the Graphical User Interface display

Instructions to connect to NASA website

- Connect to the NASA Climate Data Web Portal;(https://power.larc.nasa.gov/data-access-viewer/)
- Download and format NASA Data for Maputo and desired data range (Jan 1984- Dec 2022) and the parameters required for ingesting into CAMDT.

Running the digiSoft NASA Data Tool in order to:

- Create CAMDT Data folders for the Weather station
- Run the extraction process to produce *.WTD (global data) and *.WTH (yearly data) files into CLIMATEDATA folder
- Verify the climatological parameters data files
- Copy extracted climatological parameters data to CAMDT Working folders

Identify appropriate tabs to run crop yield projection

Trainees were given instructions on how to identify appropriate tabs to run crop yield projection through:

- Selecting a simulation set up
- Selecting a target station
- Selecting a disaggregation mode
- Providing a seasonal climate forecast
- Input for DSSAT
- Writing scenario set up
- Providing additional "what if scenarios"
- Selecting appropriate working directory
- Determining threshold
- Creating DSSAT experimental files
- Running DSSAT for all scenarios
- Displaying graphs
- Simulation horizons
- Downscaling process; and
- Above-normal and below-normal rainfall terciles; and
- Required iterations for test runs

Trainees were also guided to

- Copy CAMDT system files to the Working Directory;
- Run Rice and Maize Automated Modelling for Maputo;
- Generate Simulated Rice/Maize Crop Yield Graphs; and
- Duplicate and modified Maputo Model to other Stations

Running CAMDT graphical user interface

Participants were taught about model descriptions and model analysis. However, some of the participants encountered difficulties installing applications owing to hardware limitations. These were resolved through assisting them with downloads to guarantee that all participants had the necessary software on their laptop computers.

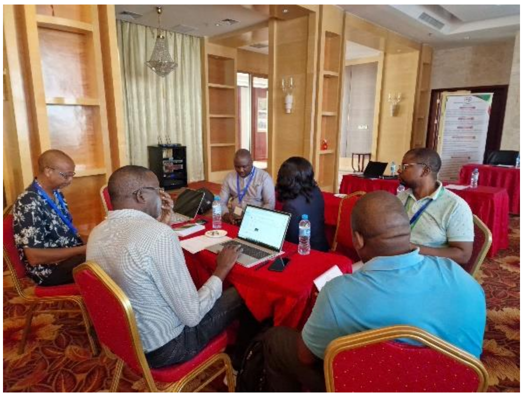
Creating folders for storage

Participants were also instructed how to create two folders, and named them as CAMDT and DSSAT, in the laptop's C: directory. Within the CAMDT folder, there were sub-folders for rice, maize, and sorghum, each of which had sub-folders for the relevant meteorological station, down to two sub-folders for above-normal rain and below-normal rain at the same level of hierarchy. These were the working directories where CAMDT would be pointed to for necessary information to simulate specific crop yield predictions depending on whether the anticipated seasonal forecast for the station in above-normal or below-normal rain. The results from the simulation would be output to the respective working directory.

Running rice crop yield simulation

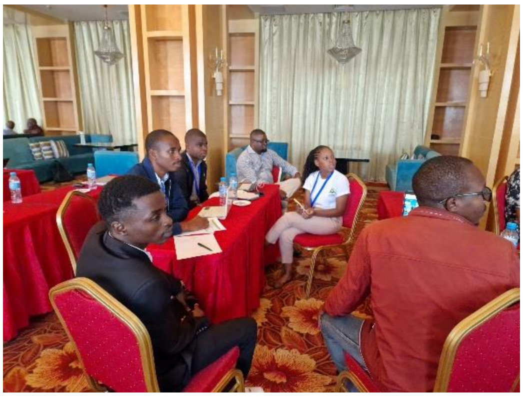
The 2017 edition of CAMDT is only automated for the RICE crop and was originally developed to model rice production in the Philippines, mostly the PILI meteorological station. The participants were shown how to add working directory related to their meteorological station into file "CAMDT_2017_0310-py". As part of continuous improvements Digitron changed the codes in the programme in order for CAMDT to automatically run other crops without recourse to MS Windows Explorer or Command Prompt environments made use of previously to enable the user to successfully run maize and sorghum probability of yield exceedances. Participants familiarised with CAMDT displaying some of interesting outputs (predicted yields, water stress and gross margin) easily.

Running CAMDT/DSSAT crop modelling for non-rice cereals



Digitron made changes to some of the CAMDT system file in order to enable the automatic simulation of other crops yield prediction. Participants were shown how to copy the successful outputs of the working directory as per an appropriate seasonal climate forecast, say that related to above-normal rain into a corresponding working directory for the new crop variety. After that, participants were shown how to make the necessary changes to some of the rice output files. This was so that respective working directory now had the specifications of the new cereal, maize or sorghum, such as the cultivar variety type its variety number, its population distribution at planting. Once the working directory had these new specifications, participants were made to run CAMDT. The outputs were now for the respective crop, either maize or sorghum. The participants were shown how to process the outputs further in order to display graphical information on the non-rice cereal.

Techniques for synthesizing data for seasonal climate forecasting



The trainers demonstrated that in addition to SCF, CAMDT also requires near-realtime observed data up to the month preceding month for planting. Typically, this takes an additional two months after RCOF Statement (Forecast). Digitron are testing a scheme that needs to be perfected and implemented in the CAMDT simulation to achieve an additional two months lead-time. In this connection, Digitron developed some techniques and conducted initial tests over a meteorological station, Chinhoyi, Zimbabwe. The tests were run for two back-to-back RCOFs and it was found the technique yielded viable results such that the synthesized data product and actual data (two-months later) has very little discrepancies for all the crops. With resources permitting, this scheme needs to be developed across other meteorological stations in order to increase the crop capability prediction lead-time by an additional two months at every specified location. The benefit to the economy will also be immense.

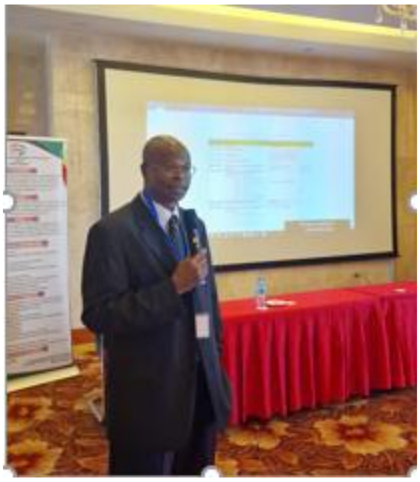
GENERAL DISCUSSION AND RECOMMENDATIONS

There were three breakout groups to deliberate on four questions:

- *Question 1. What is needed to improve the model?*
- *Question 2. Is this crop model important?*
- *Question 3. What should be done for wider usability?*
- *Question 4. Who should take the responsibility?*

The breakout session was followed by a reporting to the Plenary and summarized below. However, the specifics of which are included in Annex I.

- There was a need to simplify computing aspects of both hardware and software in order to increase the simplicity for the model to function smoothly. For example, a ***container system*** should be used to reduce the amount of time spent manually configuring software before testing and executing the model.
- To eliminate back and forth operations, material needed to be kept in a single folder. Copying information/folders from one folder to another might lead to confusion and become a source of errors. When a mistake is made, the model should give immediate feedback to show where the error(s) has occurred instead of getting the error feedback when at a point there is a failure in generating the graphs.
- It was noted that the model helps in planning the cropping for the season in terms of which crop and/or varieties to plant. The model is robust and useful for decision making on agricultural sector and to improve the production.
- More training for people at all levels of government should be organized. There is also a need to include crop models into higher education curricula so that the model could be demonstrated at an early level.



- Validation of model findings against ground truth is always required. It is critical to bring together the team to train experts across the country. In the case of Mozambique, the model must be translated into Portuguese where the National Institute of Meteorology (INAM) and the Ministry of Agriculture (MADER) supported the usage of the model, with academia providing required backstopping.

There were additional observations as follows:

i) *Need to specify specification on the compatibility of the computers*: It could be difficult to have homogeneous computer systems for the training of this nature as some computers had difficulties running MS Windows and Excel efficiently, periodically slowing down and freezing. Hence, specify the computer specification compatible to the Python software for the follow-up ToT workshop.

ii) *Need to customize the model to capture local crops*: The capacity in DSSAT is there but localization of crop varieties will require obtaining the specifications from the Ministry of Agriculture and other stakeholders such as the country's Seed Houses. DSSAT is not limited to the three crops shown in the demonstrations, rather over 20 crops that can be modelled by this tool.

iii) *Need to strengthening linkage with policy makers*: There is need to look at how to strengthen relationships between policy makers, stakeholders, practitioners and end users – last mile. The model is believed to help end-users if efforts made to disseminate information from the model outputs swiftly and effectively. A case in point is – how long it took for information to reach communities.

iv) *Need for sustained capacity building training for better model's uses in the region*: There is a need to upskill producers and users of CIS through a series of Training of Trainers workshops.

v) *Need for championing the use model uses in the region at national level*: There is a need to upskill producers and users of CIS through a Training of Trainers workshop. In this regard, Digitron committed themselves to be available for any such request. However, the Countries will take leadership roles in order to maintain the momentum in the application of the model.

WRAP-UP AND VOTE OF THANKS

As part of the wrap-up session, reflections were sought from principal delegates. Some of the points that were made included:

- AICCRA wanted to strengthen partnerships in order to expand the utility of the tool to other relevant sectors within the PPP spaces, such as crop insurance for purposes of improving mitigation of adverse weather risks to farmers. In this regard, AICCRA would continue to engage Digitron, the developers of the model.
- INAM was happy with the development of this tool and would like to have more capacity building on the tool so that it can be expanded to other SADC Member States taking into account the roles played by SADC institutions such as CSC.
- CCARDESA was happy with the development of the tool which was timely as it would help the policy makers in crafting strategies to minimize risks of food insecurity due to perennial adverse weather and climate in the SADC region. CCARDESA would prepare documentation to sensitize SADC Policy Structures, in particular, Ministers responsible for Agriculture and Food Security, on the availability of, and training needs for using, the model. In this regard, there will be need to finalize a Policy Brief to submit to the Ministers. Furthermore, CCARDESA would source funds in order to engage the Digitron for them to train SADC MS to be able to use the tool.
- WMO noted that the development of tool was timely as it was consistent with the UN SG request of to WMO to provide leadership in ensuring early warning for early action for especially the members of the UN that are more vulnerable extremes of climate variations. In this regard, there is need for concerted efforts to capacitate NMHSs and Regional Climate Centres in Africa to utilize the tool for early warning.
- ACPC would continue to support the wide application and improvements of the tool. In this connection, ACPC would sensitize the Policy Bodies in the Region to the availability of the tool.
- Department of Agriculture Mozambique was happy of the tool; however, they underscored the need for continuing improvements so that there is greater user-friendliness in the application of the tool.
- Dean of Agriculture at UEM was happy about the tool. UEM would embark on conducting similar training on the tool as early as possible.

Closing remarks

On behalf of AICCRA, Dr Solomon commended the participants for their dedication to duty in efforts to understand the workings of the model. He also acknowledged the trainers in their efforts in skill transferring. He expressed gratitude to the organizers, trainers and participants for their dedication and commitments for the success of the ToT Workshop. He expressed readiness of AICCRA and partners to source for resources to continue with scaling up this activity to other countries and for the demand-driven continuation of improvement of the crop capability prediction model.

On behalf of WMO, Dr Afiesimama noted the enthusiasm of the participants in efforts to learn the skills of the trade in crop yield modelling. This would help in the acceleration of capacity development efforts for the operationalization of the tool so that its benefits reach the last mile, the rural community. WMO-ROA is ready to engage other divisions in order to obtain support for the initiative of capacity building through review of the outcome of the implementation of the tool in Member States within SSA. He thanked everyone for their dedication in acquiring skills in the crop yield prediction modelling for the purposes of furthering climate resilience of communities.

Dr Adérito Celso Félix Aramuge and Mr. Mussa Mustafa (DDG-INAM) both noted that the ToT workshop was a success but the model needs to include local conditions and local cultivar.

Finally, Dr Adérito thanked the organizers, trainers and participants for their dedication and commitments and declared the closing of the ToT Workshop.

ANNEX I: PARTICIPANTS FEEDBACK

(Break out session Group Presentations)

#Q1. What is needed to improve the model?

Group I:

- Model should be adjusted to our specific country context in terms of seed varieties, soil types/parameter, etc.
- Having information in one folder to avoid processes of back and forth. Copying of information/folders from one folder to another which creates confusion and sources of errors.
- When a mistake is made, the model should give immediate feedback to show where the error(s) has occurred instead of getting the error feedback when generating the graphs.
- When the python is run, the window generated is small and need to be maximized. In addition, the green tab should show the progress in percentage.

Group II:

- It is necessary to develop a container version of the model, more user friendly
- Customizations should be made, so it allows imputing additional parameters from the interface. eg.: include local varieties of crops, which are important for the country, soil properties
- Pre-processing should be made through soft links
- The model should save the generated graphs

Group III:

- Is difficult to install and run the software for the first time, so the software must be update and fix some errors that appears when it is begging install.
- Some parameters should be include such wind speed and direction, pests and diseases.
- Must show the data history to compare the production, like we observed and the predicted.

#Q2. Is this crop model important? (All groups said it is greatly important)

Group II

- It helps to estimate the crop yield based of different forecast (AN or BN).
- It helps in planning the cropping for the season in terms of which crop and/or varieties to plant.

Group III

- The model is robust and useful for decision making on agricultural sector
- Helps to make the best decisions, and form strategy to improve the production

#Q3. What should be done next for wider usability?

Group I:

- Training more people from different levels within the country.
- Include crop model in the tertiary education curriculum to introduce the model at an early stage.

Group II:

- Validate the model results against the ground truth
- Consolidate the training team to replicate it through the country
- Translate the model to Portuguese version

Group III

- Should be made a capacitation for all players (all the producer-user value chain)

#Q4. Who should take the responsibility? All groups said…

- The major role should be taken by Agriculture with Meteorology and Academia providing the necessary support.
- The model can be tested and validated from both academia and Government institutions.

Group compositions

- All groups have experts from MADER, INAM and Academia

ANNEX II: LIST OF PARTICIPANTS

	Name	Organisation	Title	Email Address
1	Adérito Celso Félix Aramuge	Instituto Nacional de Meteorologia (INAM, IP)	General Director	acelso73@gmail.com
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ANNEX III: DRAFT PROGRAMME

Title: Workshop on the training of trainers on crop yield prediction modelling for Mozambique

Venue: Serena Polana Hotel, Maputo, Mozambique

Date: May 2 – 5, 2023

DAY 1: 2 May 2023			
Time	**Events**	**Responsible**	**Chair**
08:30 – 09:00	Registration	AICCRA-ESA	Dr. James Murombedzi (ACPC)
09:00 – 09:15	Welcoming Remarks	Dr. Dawit Solomon (AICCRA-ESA) Dr. Ernest Afiesimama (WMO-RoA)	
09:15 – 09:30	Official Opening	Dr. Adérito Celso Félix Aramuge (Director Mozambique, INAM)	
09:30 – 10:00	Introduction of Participants	Participants	
10:00 – 10:15	Introduction of the workshop objectives and agenda	Dr. Bradwell Garanganga (DIGITRON)	
10:15 – 11:00	Crop Yield Prediction Modelling for Optimal Agricultural Production Systems – Overview of agriculture and food security challenges in Sub-Saharan Africa – Need for a crop prediction model under the changing climate – Overview of crop simulation models	Dr. Yosef Amha (AICCRA-ESA)	
11:00 – 11:30	COFFEE/TEA BREAK (Group Photo)	Organizers	Dr. Dawit Solomon
12:00 – 12:30	Importance of Seasonal Climate Forecasts (SCF) in Agriculture: – The RCOFs process – Methodologies – Datasets Used by different RCOFs Seasonal Climate Forecast Reliability	Dr. Ernest Afiesimama	
12:30 – 13:00	General discussion	Participants	
13:00 – 14:00	Lunch	Organizers	
14:00 – 15:00	Introduction to DSSAT Model – Background and concepts – Minimum data set for DSSAT crop modelling – Key Steps in the DSSAT Analysis – Examples of its application	Dr. Bradwell Garanganga/ Mr. Trymore Nyakutambwa (DIGITRON)	Dr. Yosef Amha
15:00 – 15:30	General Discussion	Participants	
15:30 – 16:00	Coffee/Tea	Organizers	
16:00 –	DSSAT/CAMDT Software to be loaded onto participants' laptops and testing	Dr. Bradwell Garanganga/ Mr. Trymore Nyakutambwa (DIGITRON)	

Day 2: 03 May 2023

Time	Events	Responsible	Chair
09:00 – 11:00	**Introduction to CAMDT Software** - Model/Software description (*assumption and uncertainties*) - Temporal downscaling of seasonal climate forecasts (SCF) - Linking SCF with DSSAT through CAMDT user-interface - Model analysis (simulation and validation) - Examples of its application	Dr. Bradwell Garanganga Mr. Trymore Nyakutambwa (DIGITRON)	Dr. Ernest Afiesimama
11:00 – 11:30	**Coffee/Tea**	**Organizers**	
11:30 – 13:00	**Techniques for Synthesizing Data for Seasonal Climate Forecasting (SCF)** – Observed data – Synthesized data – Forecast data – Simulation horizon set up – Using Chinhoyi, Zimbabwe for forecast simulation example – Discussion/Q&A	Dr. Bradwell Garanganga Mr. Trymore Nyakutambwa (DIGITRON)	
13:00 – 14:00	**Lunch**	**Organizers**	
14:00 – 16:30	**Hands-on exercise with CAMDT software using data** – Steps to follow – Data sources sites; downloading; – Data preparations – Data analysis – Modifications in the original (Rice) model – Running the model – Analyzing model results	Dr. Bradwell Garanganga Mr. Trymore Nyakutambwa (DIGITRON)	Dr. Yosef Amha
16:30 –	**Coffee/Tea**	**Organizers**	
	Day 3: 04 May 2023		
Time	**Events**	**Responsible**	**Chair**
09:00- 16:30	**Hands-on exercise with CAMDT software using data** – Steps to follow – Data sources sites; downloading; – Data preparations – Data analysis – Modifications in the original (Rice) model – Running the model – Analyzing model result	Dr. Bradwell Garanganga/ Mr. Trymore Nyakutambwa (Digitron)	Dr. Yosef Amha
11:00 – 11:30	**Coffee/Tea**	Organizers	
13:00 – 14:00	**Lunch**		
16:30 –	**Coffee/Tea**		

Day 4: 05 May 2023			
Time	**Events**	**Responsible**	**Chair**
09:00 - 10:00	**Recap on Hands-on Exercise**	Dr. Bradwell G.	Dr. James Murombedzi
10:00 – 11:00	**Breakout session and feedback** – Workings of the model – Limitations of the model – Potential improvements for country adaptation	All participants	
11:00 – 11:30	**Coffee/Tea**		
11:30 – 12:00	**Reporting back major points on** – Model workability – Limitation – Suggestion for improvement	All Participants	
12:00 – 12:50	**General Discussion and Recommendations to Facilitate Country Uptake**	Dr. Adérito Celso Félix Aramuge (Director, INAM)	
12:50 – 13:00	**Wrap-up and Vote of Thanks**	Dr. Dawit Solomon	
13:00 –	**Lunch**	Organizers	
For more information, contact: • Dr. Yosef Amha (amhay@un.org); • Dr. Brad GARANGANGA bjgaranganga@digitron.co.zw; bjgaranganga@gmail.com • Engr. Trymore NYAKUTAMBWA: trymoren@digitron.co.zw; trymoren@gmail.com			

About AICCRA

Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) is a project that helps deliver a climate-smart African future driven by science and innovation in agriculture.

It is led by the Alliance of Bioversity International and CIAT and supported by a grant from the International Development Association (IDA) of the World Bank.

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