THE UNITED REPUBLIC OF TANZANIA

CLIMATE INFORMATION TRAINING OF TRAINERS MANUAL AND GUIDE

For Extension Officers on Interpretation and Use of Agrometeorological Information and Products for Climate-resilient Agriculture and Food Security

CLIMATE INFORMATION TRAINING OF TRAINERS MANUAL AND GUIDE

For Extension Officers on Interpretation and Use of Agrometeorological Information and Products for Climate-resilient Agriculture and Food Security

January 2020

Prepared by:
The Ministry of Agriculture of Tanzania Mainland; Ministry of Agriculture, Natural Resources, Livestock and Fisheries in Zanzibar; and the Tanzania Meteorological Authority

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Citation
Cite this publication as follows: "United Republic of Tanzania (2020). Climate information training of trainers manual and guide: For extension officers on interpretation and use of agrometeorological information and products for climate-resilient agriculture and food security. Dodoma. Tanzania."

Foreword

Tanzania, just like much of the globe, has continued to experience extreme weather events due to climate variability and change. Climate change has led to an increase in frequency and magnitude of extreme weather and climate-related events including floods, droughts, high incidences of strong winds and high temperature. As a result, reduced groundwater recharge, increased pest incidences, and disease epidemics have become a bigger challenge suppressing and distorting efforts to improve productivity in the agriculture sector. This means, national food security and development initiatives can be affected to the extent of jeopardising Tanzania's efforts towards achieving the Sustainable Development Goals (SDGs), specifically Goal 2 on Zero Hunger.

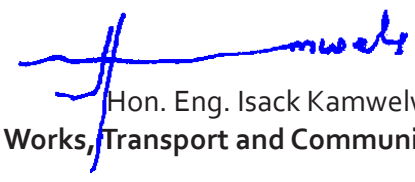
Presently, there are initiatives in place to respond to challenges and opportunities brought about by climate variability and change in Tanzania. These include the National Programme of Action (NAPA, 2007); National Climate Change Strategy (2012); National Agriculture Climate Resilience Plan (2014-2019); National Climate Smart Agriculture Programme (2015–2025); Climate-Smart Agriculture Guideline (2017); Climate-Smart Agriculture Country profile (2017), Agriculture Sector Development Programme Phase Two (ASDP II 2018) and the National Framework for Climate Services (2018-2023). These initiatives have laid down a roadmap for addressing challenges associated with the impact of climate variability and change in the agriculture sector.

Despite efforts mentioned above, there are still some gaps in understanding and proper utilization of climate services by the farming community. Appropriate use of climate services, particularly agrometeorological information and products provided by the Tanzania Meteorological Authority (TMA) is critical for enhancing agricultural resilience and food security in the face of climate variability and change.

In view of the above, the Ministry of Agriculture (MoA) of Tanzania Mainland, the Ministry of Agriculture Natural Resources Livestock and Fisheries (MANRLF) of Zanzibar, and the Tanzania Meteorological Authority (TMA) collaborated to develop this "Agrometeorological Training of Trainers Manual and Guide". This was achieved through the coordination and technical support of the Food and Agriculture Organization of the United Nations (FAO). The aim of the document is to provide extension officers (agricultural, fisheries, and livestock), farmers and intermediaries with appropriate knowledge on the utilisation of climate services provided by TMA, that is tailored for agrometeorological applications (agrometeorological services) in the country.

It is envisioned that proper use of this document alongside existing Climate-Smart Agriculture related documents will enhance the capacity of extension officers and farmers in addressing the challenges brought about by climate variability and change. This will ensure food security and support the government of the United Republic of Tanzania to achieve its obligation of attaining SDGs, particularly goal number 1 (No Poverty) and 2 (Zero Hunger).

Hon. Japhet Hasunga (MP)
Minister of Agriculture



Hon. Eng. Isack Kamwelwe (MP)
Minister of Works, Transport and Communications

Acknowledgment

Preparation of this Training Manual and Guide is a result of the continued cooperation between the MoA Tanzania Mainland, MANRLF of Zanzibar, and TMA. Their joint efforts seek to enhance proper utilization of science-based climate services tailored for the agriculture sector (agrometeorological services) in in the United Republic of Tanzania.

We wish to thank the United States Department of Agriculture (USDA) and FAO for the technical support and coordination during the preparation of this document. We also extend special thanks to the United States Agency for International Development (USAID) for their financial support, that made development of this document possible.

Special recognition is extended to the team of experts: Ms. Shakwaanande Natai (MoA), Dr. Ladislaus Chang'a (TMA), Mr. Diomedes Kalisa (FAO), Mr. Mathew Ndaki (TMA) and Mr. Mponda Malozo (FAO) among others, for spearheading the development of this manual and guide. Preparation of this "manual and guide" would not have been successful without the technical input from different Ministries, Departments, and Agencies (MDAs), research and training institutions, academia and farmers whose cooperation is highly appreciated.

In a very special way, we would like to thank Dr. Fidelis Myaka (IITA), Mr. S.M Nassor (MANRLF), Mr. Isack Yonah, Mr. Nassoro Mnanike, Dr. Habiba Mtongori, Ms. Hidaya Senga, Ms. Mecklina Merchades and Ms. Rose Senyagwa (TMA), Dr. K Gillah (LITA), Prof. Henry Mahoo (SUA), Mr E.Swai (TARI), Mr A. E Kissinga (MoA), Ms. J. Katunzi (MoA), Ms T. Massoy (from MoA/FAO), and Dr. John Recha (CGIAR Research Program on Climate Change, Agriculture and Food Security — CCAFS) who provided technical expertise in improving the document.

Finally, we would like to thank the Government of the United Republic of Tanzania for the political support in enabling the development of this manual.

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PERMANENT SECRETARY
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List of Acronyms

AEZ	Agro-ecological zones
CSA	Climate Smart-Agriculture
FAO	Food and Agriculture Organization of the United Nations
IITA	International Institute of Tropical Agriculture
ITCZ	Inter-Tropical Convergence Zone
LGAs	Local Government Authorities
LITA	Livestock Training Agency in Tanzania
MANRLF	Ministry of Agriculture, Natural Resources, Livestock and Fisheries of Zanzibar
MATI	Ministry of Agriculture Training Institute
MLF	Ministry of Livestock and Fisheries
MoA	Ministry of Agriculture
MP	Member of Parliament
NAPA	National Adaptation Plan of Action
SDG	Sustainable Development Goals
SUA	Sokoine University of Agriculture
TARI	Tanzania Agriculture Research Institute
TMA	Tanzania Meteorological Authority
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Glossary

Agriculture: The science of the production of plants and animals, including freshwater and marine species, for food, fuel, fibers or medicine, and other products to sustain and enhance life.

Agro-ecological zone: An area with similar soil, land and climatic characteristics suitable for agricultural production.

Agrometeorological information: Weather or climate data tailored for application in the agriculture sector. For example: information of the start of the season, expected rainfall performance, and agricultural advisories based on weather or climate characteristics of an area.

Agrometeorological product: Weather or climate product that contains weather or climate information in relation to agriculture, such as the onset of the season, expected rainfall performance, and advisories related to agriculture based on weather or climate characteristics. Examples of agrometeorological products include seasonal and dekadal agrometeorological weather bulletins produced by the TMA.

Normal Rainfall performance: This refers to rainfall performance between 75 percent and 125 percent of the long-term average in a given area.

Above Normal Rainfall performance: This refers to rainfall performance of above 125 percent of the long-term average rainfall in a given area.

Below Normal Rainfall performance: This refers to rainfall performance of less than 75 percent of the long-term average rainfall in a given area.

Unimodal areas: These are areas which receive only one rainfall season per year, normally starting in November to April or May of the following year within the United Republic of Tanzania.

Bimodal areas: These are areas, which receive two rainfall seasons per year, normally between March and May for the long rain season known as "*Masika"* and between October and December for the short rain season known as "*Vuli."* within the United Republic of Tanzania.

Climate: Average weather condition of a place recorded for a long period of not less than 30 years.

Weather: The state of atmospheric condition recorded for a short period e.g. hour, day, month, etc. Atmospheric conditions measured include rainfall, cloud cover, temperature, humidity, wind, etc.

Weather Forecast: A term used to describe the application of science and technology to predict future conditions of the atmosphere for a given location and time.

Climate Change: Refers to statistically significant variation either in the mean state of the climate or in its variability, persisting for an extended period (typically three decades or longer).

Climate Variability: The variation in the mean state and other statistics (such as standard deviation, the occurrence of the extremes, etc.) of the climate on a temporal and spatial scale beyond that of individual weather events.

Climate Services: Provision of one or more climate products, information, or advice to assist decision-making by farmers, individuals, or organization in a given area or agro-ecological zone.

Inter-Tropical Convergence Zone: This is a belt of converging trade winds and rising air that encircles the Earth near the Equator, it shifts North and South seasonally with the Sun and therefore has an influence on seasonal rains.

Climate System: This term is used in climatology to describe complex interactions between five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere, and the biosphere, which have influence on atmospheric conditions.

Synoptic: Scientific terminology used in climatology to describe an entire weather situation at a specific location.

Dekadal: Terminology used in meteorology to describe a ten-day interval.

Climate-Smart Agriculture: Agriculture that sustainably increases productivity and income, increases the ability to adapt and build resilience to climate variability and change impacts, and mitigates greenhouse gas emissions where possible as mitigation co-benefits.

Extension Officer: An intermediary person between researchers and farmers, who operates a as a facilitator and communicator in assisting farmers to make informed decisions based on appropriate knowledge and skills.

Farmer: An individual whose primary job involves raising crops, rearing livestock, managing fisheries, and/or fore

Lead Farmers: Self-motivated individuals who are willing to share knowledge and skills with other farmers.

Greenhouse gases: Gases that absorb and emit radiant energy within the thermal infrared range.

Table of Content

CHAPTER ONE

Overview of the Training Manual and Guide

Chapter summary

This chapter provides a general picture of weather and its effects in the agriculture sector. It explains briefly on the role of the Tanzania Meteorological Authority (TMA) as well as benefits of agrometeorological information and advisories in relation to agricultural production. The chapter also describes the objectives of the manual, its target audience, and the methodologies used in its development.

1.1 General information on weather

Weather is the state of the atmosphere, describing, for example, the degree to which it is hot or cold, wet or dry, calm or stormy, clear or cloudy. It plays a major role in determining the success of agricultural pursuits. Elements of weather include temperature, precipitation, solar radiation, humidity, and wind. All these influence crops, fish, and livestock production and productivity in different ways.

1.1.1 Effects of weather in crop production

Generally, for crop production, weather affects germination, photosynthesis, flowering, growth, and transpiration, and has influence on pests and disease pressures, soil moisture, and quality of produce. The quality of agricultural produce transported from field to storage and/or to the market also depends on favourable weather conditions. For example, bad weather events such as heavy rains, high temperature, and humidity may affect the quality of agricultural produce in terms of viability, vigour of seeds, or germination of planting materials at the transportation or storage stages.

1.1.2 Effects of weather in livestock production

Similarly, livestock and fish are also adversely affected by the detrimental effects of extreme weather variations. Extreme weather conditions and seasonal fluctuations have impacts on quality and quantity of pastures and fodders, which affects the well-being of livestock and leads to declining production and reproduction efficiency. Livestock and aquatic organisms depend on good weather for their comfort and quality food supply availability. Adverse weather conditions can cause production losses, especially if experienced during critical stages of growth. For example, extreme weather such as floods may exacerbate foot and mouth disease (FMD) in livestock. In addition, they affect fish breeding grounds.

1.2 Tanzania Meteorological Authority

TMA is a government body mandated to provide weather and climate services, including agrometeorological services. These services are important for assisting farmers in making rational decisions on "what to do" or "what not to do" to maximize weather-related advantages or minimize anticipated risks in production[1] due to bad weather.

1.3 Weather information in agricultural production

In recent years, agrometeorological information and advisories have become essential in the agriculture sector because of climate variability and change. In Tanzania, 65.5 percent[2] of the population depends on agriculture for livelihoods. This makes weather and climate related challenges among the main concerns to ensuring food and nutrition security. For example, extreme weather events such as prolonged dry spells and flooding may adversely affect socio-economic status, household food security, and the national economy at large. As such, it is key to assess and forecast the impacts of changes in weather parameters and climatic conditions during the short-, medium-, and long-term, in order to adapt to the effects of climate variability and change.

However, there is still much to do, not only to increase the accuracy of forecasts and advisories, but also the use of services provided.[3] Enhanced access to agrometeorological information and its proper utilization enable farming communities to plan more effectively and build the resilience

1 World Meteorological Organization, 2010, Guide to Agricultural Meteorological Practices 2012 updated Version
2 United Republic of Tanzania, 2017, Budget Speech for Ministry of Agriculture
3 World Meteorological Organization, 2011, Agrometeorological Services: Reaching All Farmers with Operational Information Products in New Educational Commitments

of the agriculture sector to the impacts of climate variability and change. Increased utilization of agrometeorological information and advisories in the agriculture sector also help ensure food and nutrition security in the face of climate variability and change by maintaining sustainable agro-ecosystems and natural resources. Collaboration and coordination between TMA, MDAs, extension officers, training institutions, and non-governmental organisations (NGOs) are instrumental in ensuring that there is effective communication and utilization of information by the agricultural stakeholders in the country.

This training manual and guide has been developed as a tool for strengthening the capacities of extension officers, lead farmers, and other agricultural stakeholders at all levels on appropriate use and communication of agrometeorological information and advisories provided by TMA. The document intends to ensure agricultural stakeholders in the country understand how to correctly interpret and utilize climate information and advisories along the entire agricultural value chain.

This training manual contains six chapters as follows:

CHAPTER ONE:	Provides general information on weather, objectives of the training manual, and methodologies used in its development.
CHAPTER TWO:	Enhances the capacity and understanding of an extension officer or lead farmer on the impacts of climate variability and change in the agriculture sector.
CHAPTER THREE:	Addresses roles of agrometeorological information in the development of the agricultural production calendars.
CHAPTER FOUR:	Describes common perceptions on meteorological or agrometeorological services and advisories and describes the credibility of the agrometeorological services in relation to the traditional weather forecast.
CHAPTER FIVE:	Describes different types of weather and climate services provided by TMA for the agricultural sector.
CHAPTER SIX:	Explains on access, communication, and effective utilization of agrometeorological services and advisories in practicing climate-resilient agriculture for food security in the country.

1.4 Manual's objective

The main objective of the training manual is to enhance the understanding of extension officers and lead farmers in the use of agrometeorological services and other climate services provided by TMA to ensure climate-resilient agriculture and food and nutrition security in Tanzania.

Specific objectives include:

1. To share knowledge on principles and basic concepts of climate variability and change in agriculture.
2. To describe and demonstrate the impacts of climate variability and change in the agriculture sector.
3. To identify how to integrate agrometeorological services and advisories in the implementation of climate-resilient agriculture.
4. To outline and elaborate the categories of products and services provided by TMA for the agriculture sector.
5. To equip trainers with a set of competencies that allows them to appropriately use of agrometeorological services and advisories in agricultural production.
6. To describe how communication of weather forecasts, agrometeorological services, and advisories can inform decision making by the agricultural stakeholders.

1.5 Methodology used to develop the manual

This manual has been developed following the outcomes of the scoping study that was carried out at the beginning of the implementation of the project. One of the key focus areas of the study included the use of agrometeorological services and advisories by the agricultural stakeholders in the agriculture sector. The study identified knowledge gaps encountered by farmers and extension officers on the interpretation and utilization of the information. The manual was developed through consultative meetings with stakeholders from both Tanzania Mainland and Zanzibar, and more specifically through stakeholders' consultative workshops and review of relevant documents.

1.6 Target audience

This training manual is primarily targeting agricultural extension officers, lead farmers, and other relevant stakeholders working in agricultural value chains. It is intended to be used as a training material and guide on the appropriate interpretation and utilization of agrometeorological services and advisories developed by TMA.

Training guide for chapter one

Duration: 30 min.

Topic: Introduction to the agrometeorological services Training of Trainers manual and guide.

Sub-Topics:

- Background information on the manual
- The objective of the manual
- Highlight on chapter contents
- The relevance of weather information in agricultural production

Main objective

To introduce the agrometeorological training manual and guide to trainees with the aim of providing background, objectives, and expected outcomes.

Specific objectives

It is expected that at the end of the lesson, participants will be able to:

- Describe the value and objectives of the training manual
- Describe the contents of each chapter in the manual
- Share knowledge and relevance of using agrometeorological services and advisories in agricultural production.

Lesson development

The lesson starts by showing the agrometeorological manual to the participant using a softcopy or hard copy. This is followed by a brief explanation of the manual's background and a question about whether anyone has ever come across or utilized any agrometeorological information or not.

If anyone has seen or utilized agrometeorological information or product, the facilitator can ask if he/she faced any challenges in understanding, interpreting, and/or utilizing it. Based on the response, the facilitator will explain the aim of the manual and objectives towards climate-resilient agricultural production and food and nutrition security in the face of climate variability and change.

Thereafter, the facilitator will give a summary of the different chapters contained in the manual in terms of what each chapter intends to achieve. Then, the facilitator will explain and show how to use the notes and guide sections of the manual to the participants.

Each chapter contains an introductory section of notes in relation to the objective of the chapter. This section provides information that can be utilized by anybody involved in the agriculture sector. Towards the end of each chapter, there is a training guide section. This section is to assist trainers in developing a lesson plan prior to commencing a training on each chapter.

After a brief explanation of the manual's content and guide, ask participants to mention the relevance of using climatic information in the agriculture sector. Briefly expand on their responses by explaining on the existing relationship between the agriculture sector and optimum weather conditions such as rainfall, temperature, wind, and humidity.

At the end, explain on who the intended audience and user is of the manual, by making reference to the extension officers and lead farmers and their role in promoting good agricultural practices.

Teaching methods

Lecture, question and answers, discussions, and use of power point on projectors.

Teaching aids/tools

Agrometeorological training of trainers (ToT) manual.

FAO/Granma

CHAPTER TWO

The Impacts of Climate Variability and Change in the Agriculture Sector

Chapter summary

This chapter aims at enhancing the capacity of extension officers to understand causes and impacts of climate variability and change in the agriculture sector, correctly interpret long-term climatic information presented in graph or maps in relation to the agriculture sector, and explain the impact of climate variability and change in crops, livestock, and fish production.

2.1 Understanding climate variability and change

Overwhelming scientific evidence agrees that climate variability and change is primarily caused by human activities such as excessive use of fossil fuels, deforestation, and uncontrolled burning of biomass, which releases carbon dioxide and other greenhouse gases into the air (atmosphere).

Greenhouse gases, which include carbon dioxide, tend to trap heat within the atmosphere. This leads to an increase in atmospheric temperature that influences climatic systems by changing air pressure and wind speed and direction, among other things. Changes in the climatic system has influence on the characteristics of the rainy seasons and rainfall distribution patterns.

Changes in weather characteristics or elements persisting for a period of not less than 30 years is referred to as climate change. Changes in weather patterns may result in untimely onset and cessation of the seasons, poor distribution of rain during the season, and increased frequency of severe weather events such as prolonged dry spells, drought, and floods. These incidences are challenging for sustainable agricultural production systems, community wellbeing, and food and nutrition security.

2.2 Impacts of climate variability and change on agriculture

Climate parameters such as rainfall exhibit inter-annual and inter-seasonal variations in most parts of the country because of climate variability and changes. High intra-seasonal variability, poor rainfall distribution, prolonged dry spell periods, and late onset and early cessation of seasonal rains negatively affect production of the agriculture sector.

Recurring and prolonged dry spell events reduce water availability for aquaculture, normal vegetative growth, and pastures for livestock production. Impacts of climate variability and change on the agriculture sector in Tanzania are extensively discussed in a number of documents including the National Climate Change Strategy of 2012, Agriculture Climate Resilient Plan of 2014, Climate-Smart Agriculture Programme of 2015, Climate-Smart Agriculture Guideline of 2017, Climate-Smart Agriculture Country Profile of 2017, and the National Framework of Climate Services (2018).

Below is a summary of key impacts as described in the documents mentioned above:

Shift in agro-ecological zones: Impacts of climate variability and change have caused shifts in agro-ecological zones in some parts of the country. Similar trends are expected to occur in other areas yet to be affected because changes in seasonal characteristics[4] are currently being observed there. An increase in average temperature by 2 to 4 degrees centigrade is known to be enough to cause a shifts in agro-ecological zones.[5] These changes may result into a shift from perennial crops to annual crops or change to new crop types or varieties because of the changes in weather pattern, season shortening and poor rainfall distribution within the season.

Increased number of extreme climatic events: Climate variability and change increased the severity, duration, and frequency of extreme weather-related events such as drought, prolonged dry spells, and floods by up to 70 percent in recorded natural calamities observed over the past 100 years.[6] While drought occurs with less frequency compared to other events in agriculture (such as erratic rains, pests, and diseases), its impact is often more severe.[7] The impact of drought

4 United Republic of Tanzania, 2017, Climate Smart Agriculture Guideline by Ministry of Agriculture
5 United Republic of Tanzania, 2014, Agriculture Climate Resilient Plan by Ministry of Agriculture
6 United Republic of Tanzania, 2017, Climate Smart Agriculture Guideline by Ministry of Agriculture
7 United Republic of Tanzania, 2014, Agriculture Climate Resilient Plan by Ministry of Agriculture

in agricultural production in Tanzania is severe for the production of maize, rice, and cotton,[8] and also in the livestock and fisheries sectors where mortality rates increase.

Figure 1: A maize field impacted drought

Loss in crop production: Crop models estimate an average decrease in yield of about 33 percent in the entire country by 2050. The decrease is expected to be as high as 84 percent in the central regions of Dodoma and Tabora, 22 percent in the North-Eastern Highlands, 17 percent in the Lake Victoria Zone, and 10 to 15 percent in the Southern Highland regions of Mbeya and Ruvuma, if carbon dioxide concentration in the atmosphere doubles. The reductions will be exacerbated by an increase in maximum and minimum temperature that can affect plant growth and shorten growing periods.[9],[10]

8 United Republic of Tanzania, 2014, Agriculture Climate Resilient Plan by Ministry of Agriculture
9 United Republic of Tanzania, 2014, Agriculture Climate Resilient Plan by Ministry of Agriculture
10 H.I. Mtongori, F. Stordal, R.E. Benestad, S.K. Mourice, M.E. Pereira-Flores and F. Justino, 2015, Impacts of Climate and Farming Management on Maize Yield in Southern Tanzania, African Crop Science Journal, Vol. 23, No. 4, pp. 399 - 417

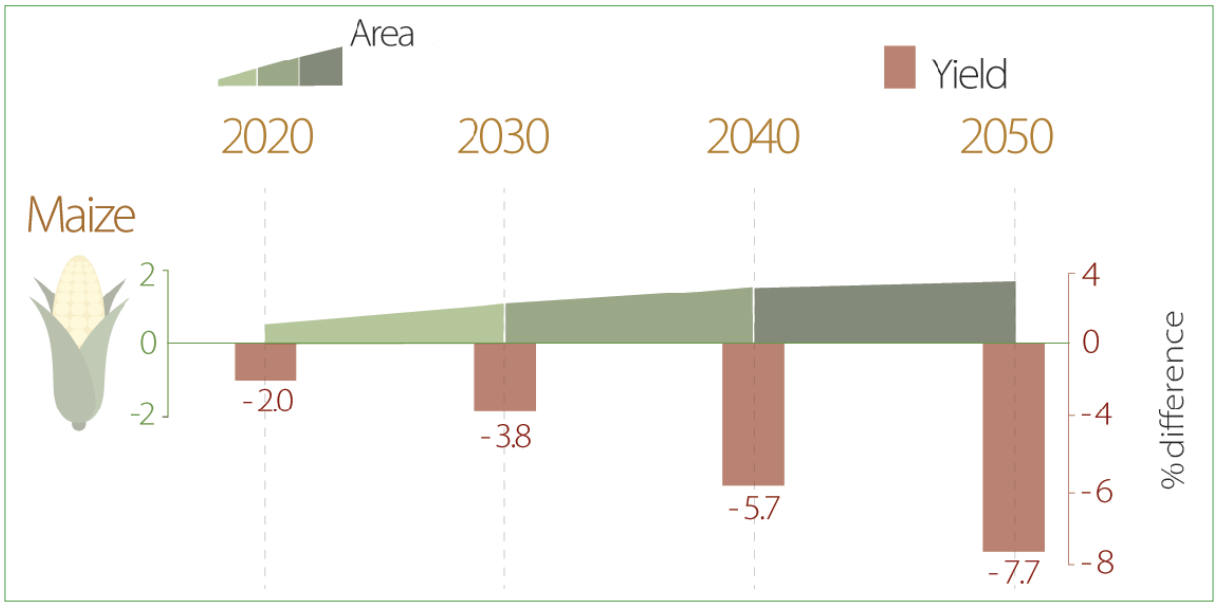

Figure 2: Projected impact of climate variability and change on maize yield in Tanzania based on area cultivated and yield between 2020 and 2050 (source: Tanzania CSA Country Profile[11])

Impact on livestock production: Climate variability and change will further shrink agricultural rangelands, which are important for livestock production in the country.[12] This is because of the anticipated increase in extreme weather-related events. These will result in a shortage of pasture and water for livestock, increased livestock mortality rates, and it will force livestock keepers to migrate from one area to the other,[13] Experience has shown that pastoral migration often results in conflicts between livestock keepers and crop producers in the country.

Figure 3: Rangeland affected by climate variability for sustainable livestock production

11 CIAT; World Bank. 2017. Climate-Smart Agriculture in Tanzania. CSA Country Profiles for Africa Series. International Center for Tropical Agriculture (CIAT); World Bank, Washington, D.C. 25 p.

12 United Republic of Tanzania, 2017, Climate Smart Agriculture Guideline by Ministry of Agriculture

13 United Republic of Tanzania, 2014, Agriculture Climate Resilient Plan by Ministry of Agriculture

Aquaculture productivity: Climate variability and change affects the biological, economic, and social aspects of the fishery sector in both positive and negative ways.[14] The impact differs according to the nature and extent of changes introduced in the aquatic ecosystem. Example, changes in temperature and rainfall amounts affect the availability of oxygen, water levels, and the availability of food for aquatic organisms. Most aquatic organisms require optimal conditions for growth and reproduction. Hence, an increase or decrease in temperature has direct effects on biological processes of aquatic organisms including their growth, reproduction, swimming ability, and population dynamics. Coral reef bleaching which disrupts fish breeding grounds is also known to be influenced by the increase in temperature.

Figure 4: Aquaculture farming in Kagera Region

Prevalence of pests and diseases: Climate variability and change aggravate the occurrence of pests and diseases in some parts of the country because they cause favorable weather conditions for the reproduction and growth of pests and disease pathogens. The presence of warmer, humid air and an elevated CO_2 level in the atmosphere favours the growth of pests and disease pathogens[15] in areas where they may not have existed previously and increases their prevalence in areas where they already existed. In turn, more financial resources and time are then needed to fight these pests and diseases, and thus there is an increase in production costs, compared to unaffected areas.

14 United Republic of Tanzania, 2017, Climate Smart Agriculture Guideline by Ministry of Agriculture

15 Lake, J. A., & Wade, R. N. (2009). Plant-pathogen interactions and elevated CO2: morphological changes in favour of pathogens. Journal of experimental botany, 60(11), 3123–3131. doi:10.1093/jxb/erp147

Figure 5: Effects of fall armyworms in maize production

Impact on water stress: Changes in rainfall patterns and worsening trends of minimum and maximum temperatures can have impacts on the availability of water resources in the agriculture sector and community wellbeing. Prolonged dry spell periods, droughts, floods, and poor distribution of rains increase scarcity of groundwater resources, reduces water flow in rivers, and lowers levels in the bodies of water needed for agriculture and other uses. Water scarcity induced by changes in weather and climate variability can result in the failure of agricultural production systems over time and increase costs of agricultural production using groundwater.

Figure 6: Maize fields affected by a prolonged dry spell in Dodoma Region.

Reduced nutritional value of most food crops: Studies have shown that an increase in CO_2 concentration and minimum temperature accelerates plant growth rates,[16] especially for C4 plants like maize. A high concentration of atmospheric CO_2 and accelerated growth may also reduce nutritional value of food crops by reducing concentrations of protein and other essential minerals in some crops such as wheat, soybeans, and rice. A decrease in the nutritional value of crops threatens human health and the welfare of animals depending on those crops as a food source.

2.3 Understanding and interpreting long-term climatic information

Historical climate information is important for informed decision making in the agriculture sector. Long-term climatic information for an area enables agricultural stakeholders to be aware of the appropriate times for land preparation, selection of seed or animal breeds, planting, weeding, application of fertilizer, and control of pests and diseases based on the climatic conditions.[17]

Long-term climatic information of an area, in most cases, is best presented in the form of graphs or maps. This is because graphs and maps can present data recorded over a long period in a simple form to reveal important information such as trends, variations and other changes over a specific time or space.

Key information to be understood in the graphs includes title or caption, type of graph or map, key or legend, parameters considered in the x and y-axis, and trends or patterns for the graph such as temperature or rainfall. In the map, one needs to also understand the scale.

Line graphs in Figures 7, 8, 9, and 10 represent how rainfall and temperature have changed over time in Mwanga District, Kilimanjaro Region, and in Arumeru District, Arusha Region. These types of graphs are used to demonstrate long-term (time series) changes or trends that are connected in each geographical area. For example, in the figures one can see seasonal or annual variations of rainfall and temperature between 1980 and 2010, rainfall totals for March to May (MAM), and those between October to December (OND) periods.

The rainfall trend (in linear dotted red line) in Mwanga District indicate high rainfall variability with a decreasing trend of 7.7 mm and 7.0 mm per year during *Masika* and *Vuli* rain seasons between 1980 and 2010, respectively. Similarly, annual minimum temperature (Tmin) for Arusha show an annual variability and an increasing trend of 2.9˚C, while maximum temperature (Tmax) show a slight decreasing trend of 0.8˚C in 100 years. The extent of either increasing or decreasing amount is based on the slope of a linear equation embedded in each graph.

16 Impact of Carbon Dioxide, Trace Gases, and Climate Change on Global Agriculture accessed on https://dl.sciencesocieties.org/publications/books/abstracts/asaspecialpubli/impactofcarbond/45?access=0&view=pdf on 9th May 2019

17 Dorward P, Clarkson G and Stern R (2015). Participatory Integrated Climate Services for Agriculture (PICSA): Field Manual. Walker Institute, University of Reading. ISBN: 9780704915633

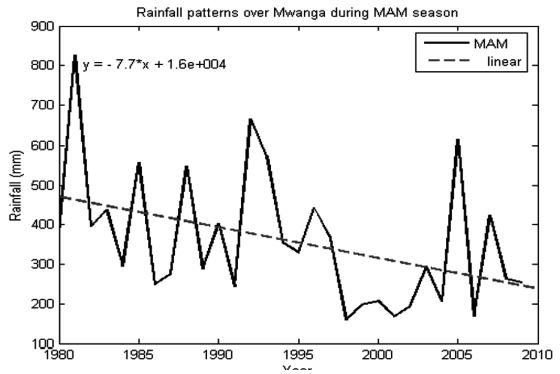

Figure 7: Annual rainfall totals (MAM) and trend in dotted red line over Mwanga District for March-May, during 1980 and 2010 (Source TMA)

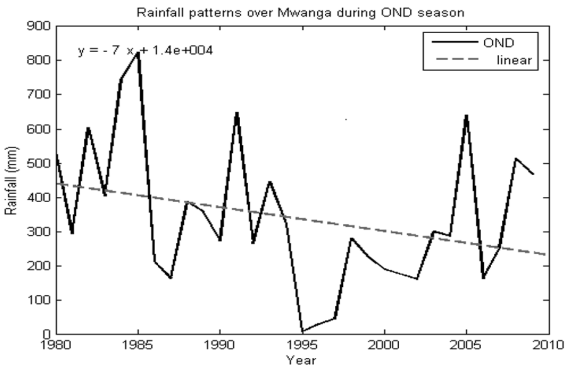

Figure 8: Annual rainfall (OND) and trend in dotted red line over Mwanga District for October – December from 1980 to 2010 (Source TMA)

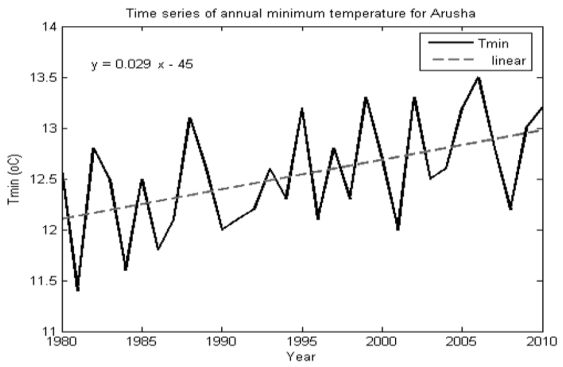

Figure 9: Annual minimum temperature (Tmin) and trend in the dotted red line in Arusha from 1980 to 2010 (Source TMA)

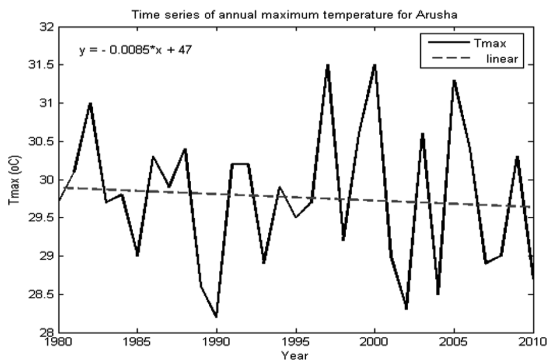

Figure 10: Annual maximum temperature (Tmax) and trend in the dotted red line in Arusha from 1980 to 2010 (Source TMA)

Some key information illustrated by maps includes the types and nature of parameters presented, like color representations, and what they try to represent in terms of the sign (positive or negative) and the magnitude (smaller to larger) of the values presented. This information is usually defined in the title and legend of the figure.

In many cases, only single values (like averages) are presented on a map regarding a monthly, seasonal, or annual basis. Average values are obtained from calculating the daily weather values. For example, Figure 11 below present's average annual rainfall by region in Tanzania, averaged for 30 years from 1971 to 2000. From the figure, one can see that Kagera Region in the North West receives an annual rainfall ranging from 1,200mm to 1,800 mm per year.

The use of a maps has an advantage over other means because they represent and visualize complex information over a large area within one image; and this makes it easier to compare and contrast different areas with their respective weather and climatic characteristics. For instance, in Figure 11 again we can say that areas in the central and northeastern parts of the country have low annual rainfall (between 400 and 800mm) compared to areas in the southern parts of the country (rainfall amount ranging from 800 to 2,400 mm) by just studying the color scale magnitude presented on the map.

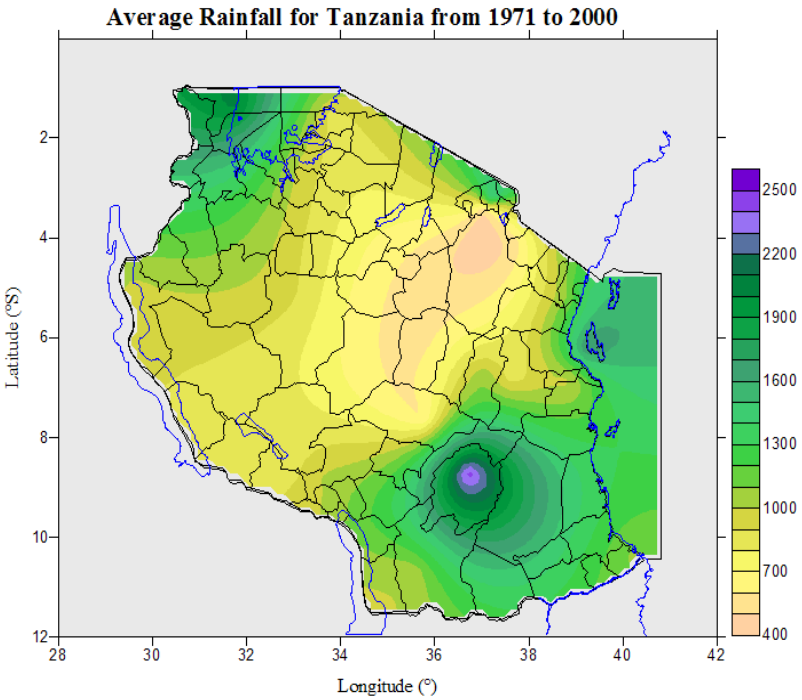

Figure 11: Rainfall climatological map of Tanzania from 1971 to 2000 (Source TMA)

The disadvantage of using a map is that users cannot see how weather/climate values have evolved over time, especially when compared to studying graphic representations of monthly, seasonal, or annual values. With maps, it is difficult to point to or explain the occurrence of extreme events or values in relation to climate variability across a period of observation.

When using maps, users need to have an understanding or knowledge of interpreting values presented as numbers and/or signs in relation to different color codes used in the map legend. For example, increasing trends in rainfall or temperature can be presented by positive value color gradients, and decreasing trends by negative value color gradients, with any color of interest clearly described in the legend or key. In Figure 12 below, temperature variation for Tanzania is shown for January through December 2018. The blue areas (parts of Central and Lake Victoria Zones) show annual maximum temperatures decrease by up to 1°C in 2018 compared to the long-term means, and other annual maximum temperatures for 2018 increase (red color) by up to 1°C compared to their respective long-term means.

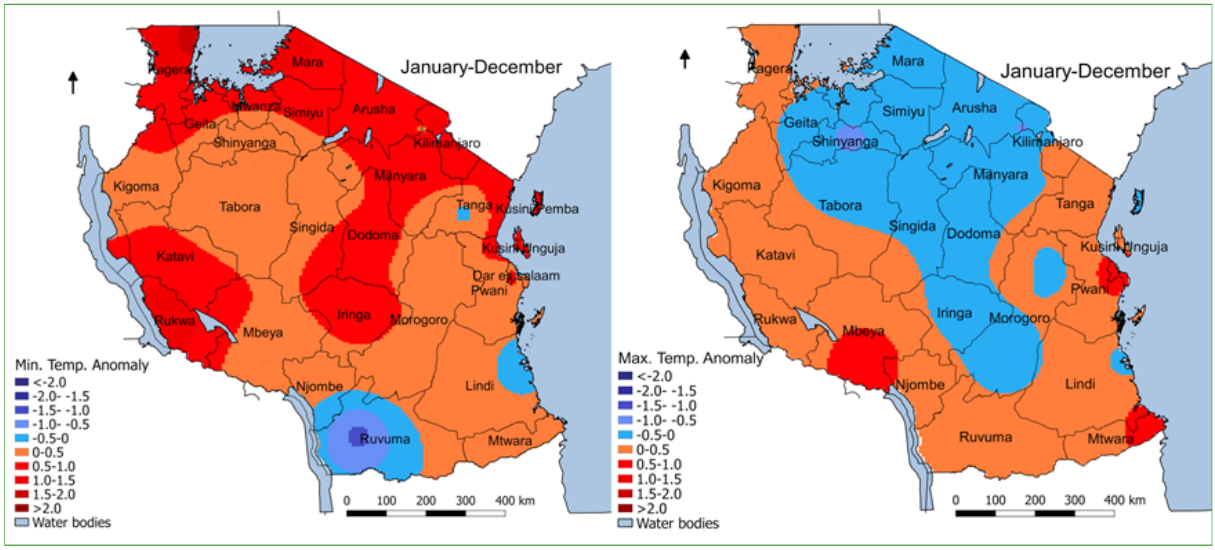

Figure 12: Temperature anomaly map of Tanzania between January and December 2018 (Source TMA)

Training guide for chapter two

Duration: 45 min.

Topic: The impact of climate variability and change on the agricultural sector.

Sub-topics:

- Understanding the concept of climate variability and change
- Impacts of climate variability and change on agriculture
- Understanding and interpreting historical climatic information

Main objective

The main objective of the lesson is to enable participants to interpret historical climate information and understand the impacts of climate variability and change on agriculture.

Specific objectives

It is expected that at the end of the lesson participants will be able to:

- Describe the concept of climate variability and change
- Analyse the impacts of climate variability and change on agriculture
- Describe and interpret historical climatic information presented on graphs and maps.

Lesson development

The lesson begins by asking the participants to write on manila cards on what they know about climate variability and change. The trainer will then ask participants to read what they wrote on the cards and put together cards with similar responses on the board.

In addition to what they have written and mentioned, the trainer needs to explain the concept of climate variability and change and its causes. Participants will then be given an opportunity to provide their personal experience in relation to climate variability and change in their areas.

The trainer continues by displaying historical climatic information of an area using powerpoint or printed copies of the climate products. These climate information products can be obtained either from the TMA website or by getting in touch with TMA.

Thereafter the trainer will clearly define features presented on graphs and maps, such as trends, variations, and maximum or minimum amounts. The trainer and participants should now try to explain the extreme events observed and give justification or share personal experience of events that occurred in their area.

As an exercise, the trainer will share another set of graphs for participants to describe the observed trends and variations. Key messages and feedback from the discussion should be noted for clarification or emphasis during plenary presentation and discussions.

Then, divide participants into groups and ask them to use a flip chart to write impacts of climate variability and change they have noted in crop, livestock, and fishery production and share experience on how they were able to respond to the challenges or opportunities within the past five, ten, or twenty years. Allow them to present their findings after discussions in plenary sessions with the rest of the groups.

At the end, show the impacts of climate variability and change in other parts of the country, region, or world in relation to the agriculture sector. Conclude the lesson by asking for factors which contribute to the changes in climate variability and change in their areas. Ask them to also discuss indigenous solutions towards curbing the identified factors. Write down the answers and let it be a take-home message after the session.

Teaching methods

Lecturing, plenary discussions, question & answers, and group work/discussions.

Teaching aids/tools

Pictures of climate variability and change impacts on agriculture, manila cards, PowerPoint slides, long-term climatic information graphs or maps, writing board, flipchart, and markers/pens/chalk.

CHAPTER THREE

The Role of Agrometeorological Information in the Agriculture Sector

Chapter Summary

This chapter aims at presenting the importance of using agrometeorological information and advisories in agriculture sector. It explains types of rainfall regimes that exist in Tanzania, elaborates on linkages between the agricultural production calendar in relation to climatic and weather information, and describes proper utilisation of agrometeorological information for better planning of seasonal agricultural activities.

3.1 Agrometeorological advisory for the agriculture sector

An agrometeorological advisory is an advisory given to agricultural stakeholders based on the climatic conditions of a local area, seasonal weather outlook, or forecasts before, during, and after the rainy season. Such advisories are important to assisting agricultural stakeholders in making informed decisions on the selection of crop varieties and animal breeds, appropriate CSA practices and technologies, and management of dry or wet spell periods during the agricultural production season. Advisory services need to be accurate and must be issued in a timely manner for integration in the agricultural production calendar.

An agricultural production calendar is a planning tool that provides information on the circle of agro-production[18] and appropriate agronomic practices in crop farming, livestock keeping, and fisheries in a certain timeframe (usually per season). In crop farming, the agricultural production calendar contains information on ideal windows for land preparation, sowing, weeding, fertilizer application, bird scaring, harvesting, drying, rainwater harvesting, and threshing times, among others. Each stage of the calendar is influenced by weather conditions. Hence, farmers need to know how to integrate agrometeorological information and advisories into the production calendar in relation to the agro-ecological dimensions of an area.

Agrometeorological information and advisories provide a solid base on which to make plans for reducing weather-related risks in agricultural production. Agronomic planning such as availability of appropriate agricultural inputs (fertilizer, seed varieties, planting materials, etc.) and construction of dams, for example, can be done more effectively and ahead of schedule if agrometeorological information is available, accessible, and utilized by agricultural stakeholders in a timely manner. Agro-dealers and other relevant stakeholders are required to make the necessary arrangements to ensure availability of relevant agricultural inputs and implements to allow farmers to take proper actions along the value chain. These actions may include land preparation, planting, and control of pests and diseases at the proper moments.

3.3.1 Understanding rainfall regimes in Tanzania

Tanzania has two rainfall regimes, known as **unimodal** and **bimodal**. The unimodal regime includes all areas within the country that receive only one rain season commonly known as *Msimu*. This season is six-months long, starting in November and ending in April of the following year.

Regions falling under the unimodal rainfall regime in Tanzania include: Kigoma, Katavi, and Tabora regions in the west; Rukwa, Iringa, Songwe, and Mbeya regions in the south-western highlands; Dodoma and Singida regions in central parts; Lindi and Mtwara regions on the south-eastern coast; and Morogoro South, Ruvuma, and Njombe regions in the south.

The bimodal rainfall regime, on the other hand, involves areas which receive two rain seasons per year, commonly known as *Masika* for the rains starting from March to May, and *Vuli* for the rains from Octobers to December in the same year. This regime is more prominent in Kagera, Geita, Kigoma North, Mwanza, Mara, Simiyu, and Shinyanga regions in the Lake Victoria Zone; Kilimanjaro, Arusha, and Manyara regions in north-eastern highlands; Dar es Salaam, Morogoro North, Coast, and Tanga regions; and the Islands of Unguja and Pemba on the northern coast.

Both unimodal and bimodal areas in the country are shown below in Figure 13.

18 http://www.fao.org/agriculture/seed/cropcalendar/welcome.do

Figure 13: Areas with greyish colour covering southern sector of the country represent unimodal areas, and brownish colour on the northern sector of the country represent bimodal areas. (Source TMA 2019).

3.2 Preparation of agricultural production calendar

Farmers and extension officers need to know the agricultural production calendar of their areas in relation to climatological conditions. Otherwise, they need to develop one based on local climatic conditions and seasonal weather outlook and advisories for the area. Agricultural production calendars usually start with the beginning of the agricultural season. To most people and in many places, the start of the season is marked by the onset of the rains. However, scientifically, the start of the season is confirmed if an area receives rains of at least 20mm in four consecutive days, with at least two days wet and not followed by a dry spell of more than ten days in the next 21 days. This means that not every rain signifies the start of the season even if it has come during times normally associated with the start of the season.

Key features of an agricultural production calendar include identification of times for land preparation, selection of crops and seeds for planting, sowing, vegetative plant growth phase, weeding, fertilizing, flowering period, maturity phase, and harvesting.

In the processes of preparing the seasonal agricultural calendar for crops, farmers need to clearly identify proper times when the key features mentioned above are likely to be implemented within the season in the local area based on climatological information and seasonal weather outlooks. The timing of the events must correlate with optimal weather conditions suitable for optimal output such as adequate soil moisture for land preparation and sowing.

In most cases, the calendar is drawn as a chart, which includes time scales in months or weeks, type of crops or agricultural products, and key activities (See Figures 15, 17, and 18) with respect to the rainfall regime, whether bimodal (Figure 14) or unimodal (Figure 16).

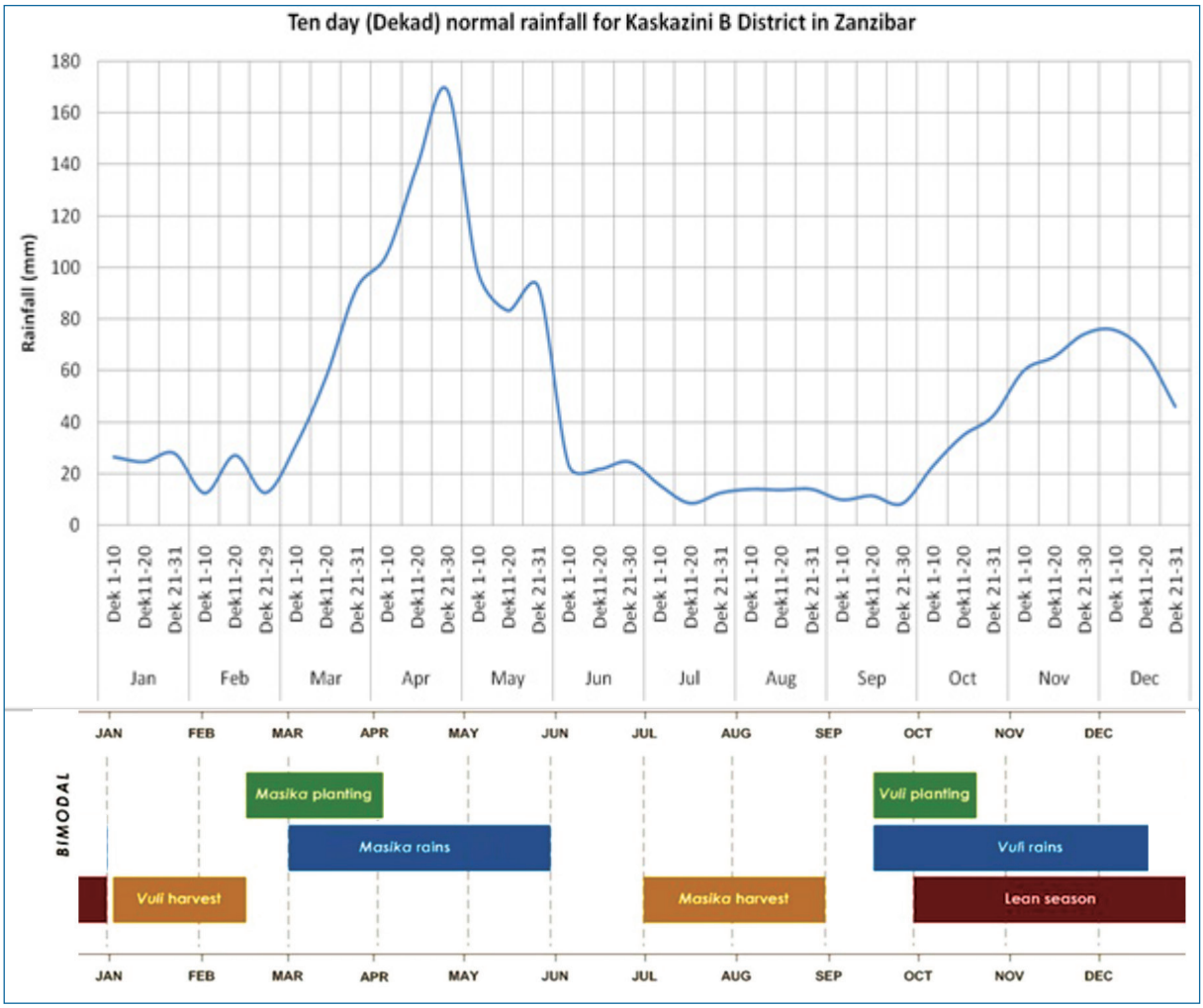

Figure 14: Annual rainfall characteristics for Kaskazini B District in Zanzibar which fall under bimodal rainfall regime (Source TMA). **Below:** An example of a generic agricultural production calendar for unimodal and bimodal areas in Tanzania (Source FEWSNET)

It is possible to develop agricultural production calendars of an area and identify suitable agricultural practices and technologies by using climatological information. Farmers have been using indigenous knowledge in deciding types of crop varieties, planting time, weeding, and harvesting. However, because of changes in weather and climate variability, use of indigenous knowledge alone has become less reliable, as some of the indicators have disappeared in recent years. Hence, there is a need to compliment indigenous knowledge with climatic and weather information obtained through scientific analysis that is more accurate and reliable for decision-making.

Agricultural production calendars for different agro-ecological zones in the country can be downloaded on the Ministry of Agriculture's website by visiting the footnote link[19] at the end of this page. An example of an agricultural production calendar for bimodal areas is shown in Figure 17 and for unimodal in Figure 18.

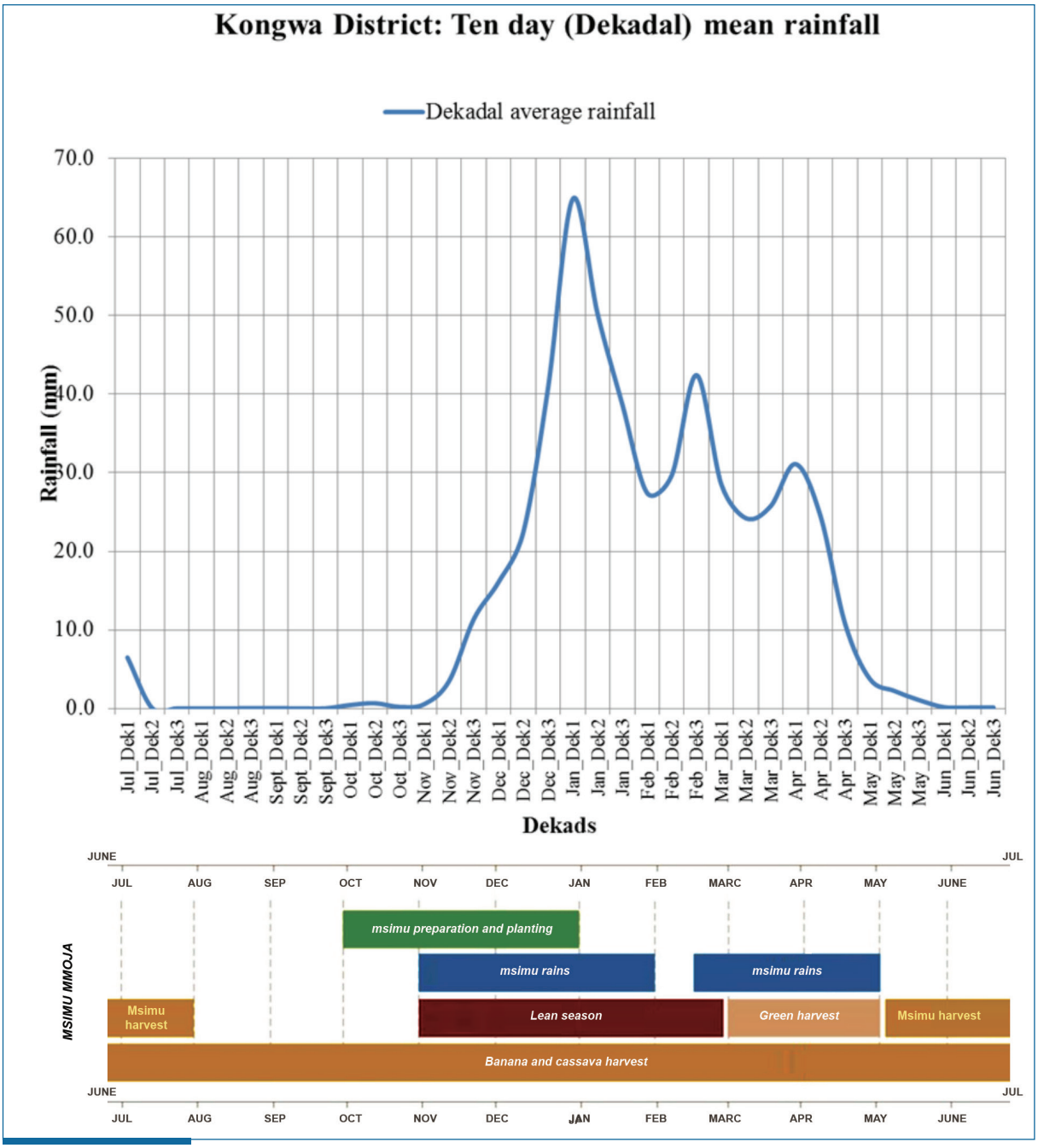

Figure 15: Annual rainfall characteristics for Kongwa District falling under unimodal rainfall regime (Source TMA). **Below:** An example of a generic agricultural production calendar for unimodal and bimodal areas in Tanzania (Source FEWSNET)

19 http://www.kilimo.go.tz/index.php/en/resources/category/tanzania-livelihood-baseline-profiles

Figure 18: Agricultural calendar for Tabora and Singida regions to represent unimodal areas, showing various agricultural activities at different times of the year (Source: www.kilimo.go.tz)

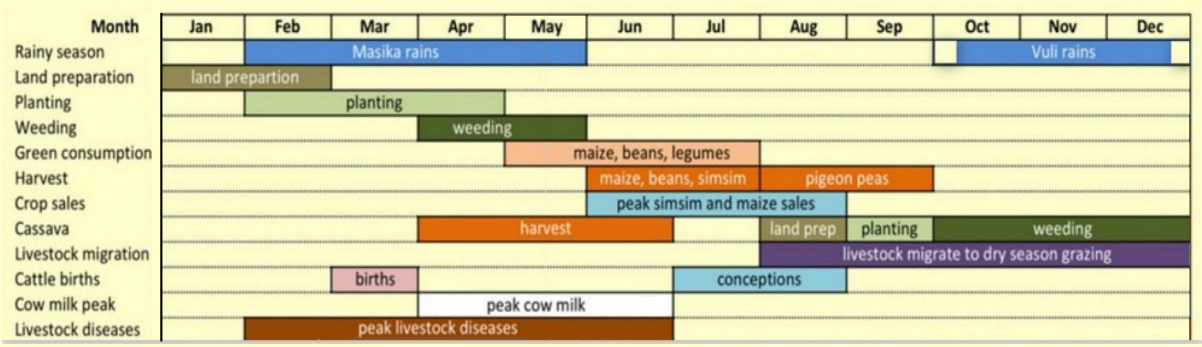

Figure 16: Agricultural calendar for Handeni-Pangani in Tanga Region to represent bimodal areas, showing suitable agricultural activities at different times of the year (source www.kilimo.go.tz).

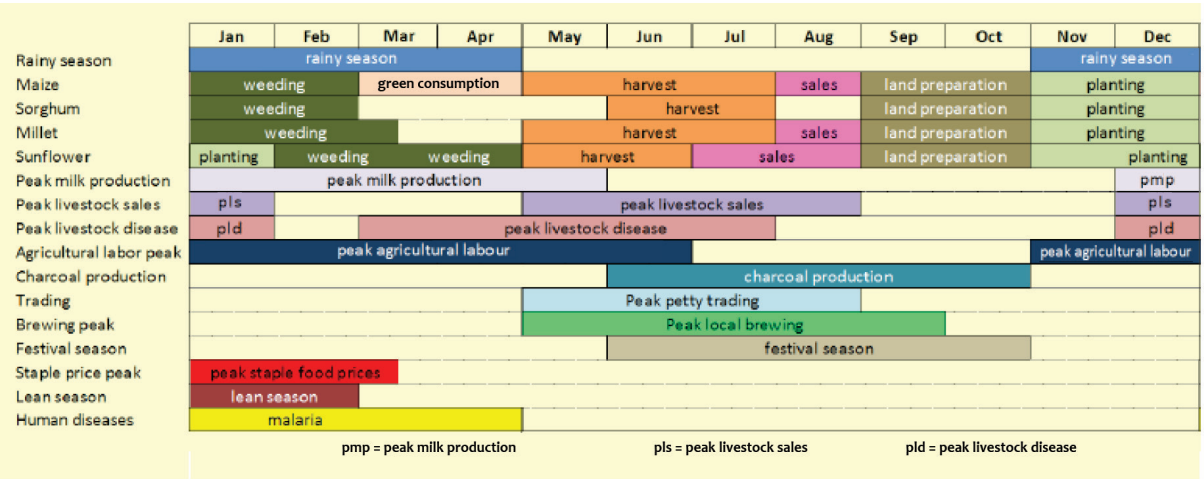

Figure 17: Agricultural calendar for Tabora and Singida regions to represent unimodal areas, showing various agricultural activities at different times of the year (source www.kilimo.go.tz).

3.3 Use of agrometeorological information and advisories in agriculture

TMA is mandated by law to monitor and update the public on changes in weather and climatic conditions regularly for different uses, such as in the agriculture sector for maintaining the food security of the country. In collaboration with other sector ministries, TMA provides advisory services based on climatological conditions, climate outlooks, and weather forecasts. The information provided is accessible through newspapers, TMA weather bulletins, mobile phone services, TMA website, emails services, radio and television stations, social media, and in-person communications upon visiting TMA offices.

Agrometeorological information and advisories inform agricultural stakeholders on the expected weather conditions and their likely impact on the performance of the agricultural sector in relation to the conditions of the climate systems. Following assessment of the relevant climate system behaviours, TMA and agricultural experts agree on the necessary advisories to assist farmers in making informed decisions, as shown below in a quote from the seasonal outlook agrometeorological bulletin of 2018:

> *"Sufficient soil moisture condition is likely to feature over the northeastern highlands (Kilimanjaro, Arusha and Manyara regions), Lake Victoria basin (Kagera, Geita, Mwanza, Mara, Shinyanga, and Simiyu regions) and northern coast (Morogoro-North, Dar es Salaam, Coast, Tanga regions, and islands of Unguja and Pemba).*
>
> *Farmers in these areas are advised to go for normal Masika cropping season. However, the northern part of Tanga Region is expected to experience periods of moisture deficit and therefore farmers are advised to plant drought tolerant and early maturing crop varieties.*
>
> *Water and pasture conditions for livestock and food for fish are expected to improve due to the expected normal to above normal rainfall. However, for optimal use of the outlook, the farmers, fisherfolk and livestock keepers are strongly advised to seek advice from their respective extension officers and also harvest rainwater for future use during dry periods."*

It is important to note that TMA provides different types of weather forecasts at different time intervals ranging from seasonal, dekadal, and daily weather forecasts. These forecasts complement each other to enhance convenience and efficiency. The seasonal weather forecast is complemented by dekadal and daily weather forecasts. For better results, farmers and extension officers need to use all the forecasts together, because short-term forecasts are more accurate compared to medium-term and long-term forecasts. However, long-term and medium-term forecasts are more useful in making plans for agricultural activities as compared to short-term forecasts. Hence, long- and medium-term forecasts need to be more accurate, timely, and accessible to farmers for proper planning. Agrometeorological advisories provided in the medium- and short-term forecasts in most cases update the previous long-term forecasts, as shown below from the 2018 dekadal weather forecast bulletin:

> *"Soil moisture conditions are expected to continue improving significantly over much of bimodal areas enhancing growth and development of crops. However, excessive soil moisture due to ongoing rain is likely to affect crops, mainly maize and beans. In the unimodal areas, dry periods are likely to favour maize crop at maturity to harvesting stages specifically in Dodoma, Singida, Ruvuma and southern part of Morogoro.*
>
> *Excessive soil moisture and waterlogging are likely to affect nutrient uptake and damage to some of the crops. Wet and humid conditions are likely to favour the development of crop*

diseases including fungus. Therefore, farmers, fisherfolk and livestock keepers are advised to consult extension officers for optimal use of these forecasts and advisories. Water and pasture conditions are expected to continue improving."

The quoted examples of the weather forecast and advisories above have similar characteristics in providing information on previously forecasted weather conditions, explanations of what to expect based on the forecast, and an advisory on what to do where and how. This is all key information to agricultural stakeholders for informed decision making on appropriate actions to consider in maximizing agricultural productivity in the sector.

Training guide for chapter three

Duration: 75 min.

Topic: The role of agrometeorological services in the agriculture sector.

Sub-topics:

- Agrometeorological advisories and agricultural production
- Rainfall regimes in Tanzania
- Preparation of agricultural production calendars
- Use of agrometeorological information and advisories in agriculture

Main objective

The main objective of this lesson is to enable participants to understand agrometeorological information and advisories, by identifying major rainfall regimes in Tanzania and illustrating the integration of agrometeorological information into agricultural production calendars.

Specific objectives

At the end of the lesson, participants should be able to:

- Share knowledge on the use of agrometeorological advisories in the agriculture sector
- Identify the major rainfall regimes in Tanzania
- Describe key elements of an agricultural calendar in relation to weather and climatic information of an area.

Lesson development

Start the lesson by asking the participants if they know what an 'agro-meteorological advisory' is. Based on their responses, explain to them what an agrometeorological advisory is and elaborate on its usefulness for informed decision making in agricultural production.

Continue by asking participants to describe types of rainfall seasons they experience in their areas and if they know under which rainfall regime it falls. Following their descriptions, explain to them agrometeorological advisories provided by TMA,

types of rainfall regimes existing in the country, common names used for seasons in each regime, and the time periods for those seasons.

The trainer will then use the most recent advisories provided by TMA either on the dekadal or seasonal timescale, in the form of the bulletin or mobile SMS to discuss the scale on which TMA advisories are provided. The trainer will have to clarify that local conditions for individual areas can deviate from the regional-scale conditions and that there is a need for localization of the advisories. The discussion should focus on how to account for local variations in climate and how to account for this when interpreting the large-scale and more general advisories provided.

Ask participants to describe their agricultural production calendars by mentioning key activities before, during, and after the seasons. Discuss with participants on how climate variability and change have influenced changes in the agricultural production calendars they have described. At the end, explain how agrometeorological information can help farmers to cope with changes caused by climate variability and change in their areas.

Then, work with the participants to develop an agricultural production calendar using long-term seasonal climatic information and the most recent seasonal weather outlooks available, identifying key activities for the entire season. Ask participants to point out differences and similarities from what they used to do. Discuss with the participants on the reasons for the differences identified.

At the end, ask participants to develop agrometeorological advisories for their localities based on the seasonal forecast presented.

Teaching methods

Lecture, practical sessions, discussions, presentations, questions and answers

Teaching aids/tools

An example of an agricultural production calendar of an area for crops, livestock, and/or fish), long-term climatic information indicating parameters such as rainfall and temperature trends, flipcharts and/or writing board, power point projector, and markers and/or pens of different colours.

CHAPTER FOUR

Perception and Reliability of Weather Forecasts

Chapter summary

This chapter provides an overview of the general perceptions of people on the use of scientific weather forecasts in relation to indigenous knowledge of weather forecasting. It explains the reliability and limitations of scientific forecasts in Tanzania, and it shows the complementarity between the scientific weather forecasts and indigenous knowledge in weather forecasting for agricultural production.

4.1 Weather forecast

A weather forecast is an outlook or prediction of the future state of the atmospheric conditions for a given location and time. The outlook or prediction is done through the application of science and technology, using statistical and dynamical methods. Human beings have attempted to predict weather informally for millennia, and formally since the 19th Century.[20] Contrary to scientific

20 The birth of the weather forecast https://www.bbc.com/news/magazine-32483678 accessed on 30th August 2018.

forecasting, weather forecast using indigenous knowledge is informed through observation of the behaviours of local environment, animals, insect and plants.

4.2 Perception on the weather forecast

Studies conducted by TMA in the country on the use of indigenous knowledge in weather predictions provide an overall picture on the perceptions of farmers and communities on the use of scientific weather forecasts as compared to their indigenous knowledge. Before the establishment of the conventional weather and climate forecasting, older generations (especially in rural areas) have largely relied on indigenous knowledge to predict weather through observation and monitoring the behaviour of animals, birds, plants, and insects.[21] To date, some farmers still use indigenous weather and climate forecasts rather than scientific forecasts.

Perception of the reliability of the traditional forecast is attributed by the process in which an individual select, organizes, and interprets information to create meaning in relation to the local environment. Historical use of traditional weather forecasting in an area, contextualisation of information to the local environment, easy access, and spread of traditional information in the local communities increase the reliability of traditional forecasts at the local level.

A study conducted in Lushoto[22] revealed good correlation between traditional and scientific weather forecasts for the *Masika* season, between March and May. However, the traditional weather forecast was not reliable for the *Vuli* season of October to November compared to the scientific weather forecast provided by TMA. Chang'a *et al*,[19] concluded that an increase in climate variability has significantly reduced the accuracy and the reliability of indigenous forecasting and therefore it needs to be complemented by scientific forecasting.

Farmer and community perception of scientific weather forecasting is affected by the lack of timely access and a certain inability to obtain a proper interpretation of the information. Weather and climate forecasts provided at large scale sometimes compromise the accuracy of the weather forecast at the local level. There is therefore a need to downscale weather forecast for the specific area to increase accuracy. Due to the vastness of the country and limited resources, provision of downscaled weather forecasts for each district and village in the country is still limited.

However, significant progress has been observed on TMA's ability to provide accurate and timely climate and weather forecast services in the country through newspapers, short message services (SMS) commonly known as "FarmSMS", radio and television stations, emails, website, and social media services. The use of different channels in the dissemination of weather and climate services increases accessibility to various stakeholders in the country in a timely manner. It is, therefore, the responsibility of farmers and extension officers to know where, when, and how to access and utilize climate and weather information provided by TMA in a timely manner.

21 Ladislaus B. Chang'a, Pius Z. Yanda and James Ngana March, 2010 'Indigenous knowledge in seasonal rainfall prediction in Tanzania: A case of the South-western Highland of Tanzania'

22 Mahoo H, Mbungu W, Yonah I, Radeny, Maren A.O., Kimeli, P, Kinyangi, James 2015, 'Integrating Indigenous Knowledge with Scientific Seasonal Forecasts for Climate Risk Management in Lushoto District in Tanzania'

4.3 Reliability of weather forecast

Scientific weather forecasts are a result of constant observation of climatic systems. Changes in climatic systems result in changes to the atmospheric conditions, such as sea surface temperature, atmospheric pressure, and wind direction. Contrary to the traditional forecast, scientific weather forecast is based on scientific principles and standards used by meteorologists all over the world to understand changes in weather patterns, pressure dynamics, and air movements. Ground observation stations and satellite-based stations provide information on real-time changes in atmospheric parameters for better weather forecasting and agrometeorological services.

Through use of improved technologies, localized modals, and professional and skilled experts countrywide, TMA has improved on provision of accurate information and advisory services. Development of advisories based on the weather forecasts is a participatory process. It involves different agricultural stakeholders as indicated in Figure 18. Involving relevant agricultural stakeholders ensures appropriate use of released advisories to respond to the needs of the farmers and other stakeholders within a defined geographical location in the country. Co-production of agrometeorological products has increased credibility, reliability, and relevance of services provided by TMA to farmers, extension officers, and other relevant stakeholders.

Figure 18: Agricultural stakeholders preparing agrometeorological advisory at the national seasonal outlook forum for Masika in February 2019.

4.4 Climatological analyses and decision making in agricultural activities

Analysis of historical data and its presentation in a user-friendly form helps to better inform farmers and other users on local climatological conditions. Climatology, which means the study of climate, is a term derived from the word climate, which refers to an average weather condition of an area recorded for a period of 30 years or more. Climate-related statistics can be derived from the records of long-term (historical) weather conditions to provide valuable information at different timescales for an area. In most cases, climatological analyses compliment the local climatic experiences contained in indigenous knowledge. Historical climatic information is important to agricultural stakeholders and extension officers, and in the provision of relevant agrometeorological advisories, to better inform decision making in agricultural production. For example, knowing the average amount of rains received in a season historically can help determine the types and varieties of crops cultivated within a subsequent season at a particular location (see Figure 19).

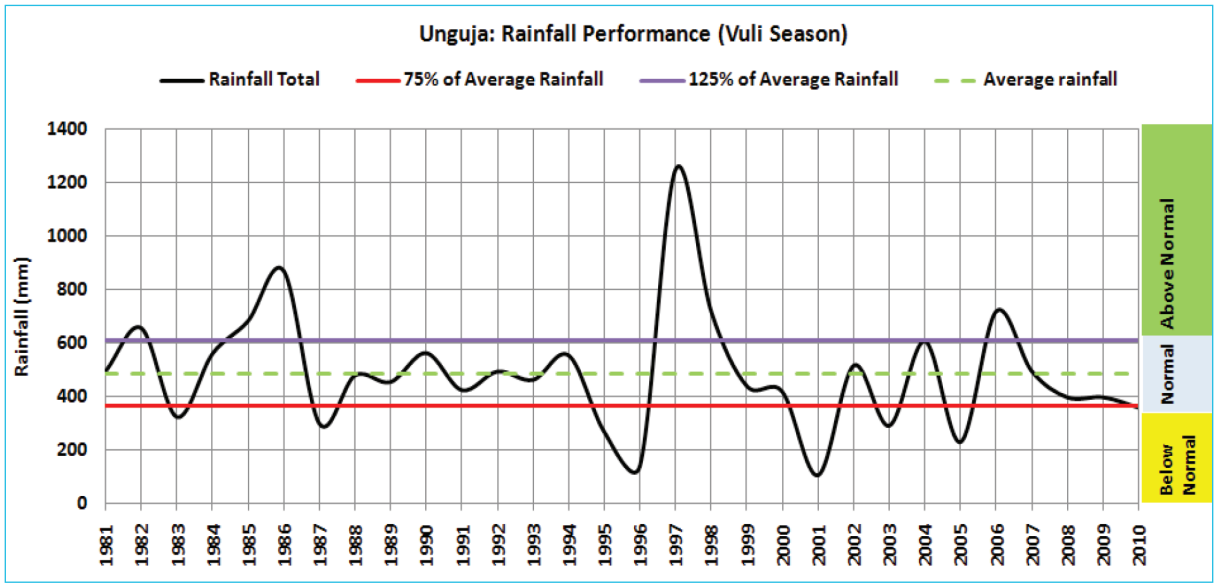

Figure 19: Seasonal rainfall characteristics in Kaskazini B District - Unguja, Zanzibar (source TMA)

For instance, an area receiving 400mm of rain per season is not suitable to grow a crop variety that requires 800mm to reach maturity, if not complemented by other sources of water. Similarly, an area with a seasonal duration of 80 days is not suitable for growing crops that requires 120 days to reach maturity.

In the presence of climate variability and change, it is becoming difficult to make informed decisions on agricultural production relying on indigenous weather and climate forecasting knowledge alone. The indigenous knowledge forecasting indicators have started to disapper and others have become less reliable because of the increased frequencies of changing weather parameters. Complimenting the traditional indigenous knowledge forecasting of the weather parameters with scientific information and weather observations based on data recorded over a long period is now becoming a necessity. Ignoring climatological information or relying on personal experience alone may lead to poor agricultural production.

Training guide for chapter four

Duration: 30 Min.

Topic: Perception and reliability of weather forecasts

Sub-topics:

- Weather forecasts
- Perception of the weather forecasts
- Reliability of weather forecasts
- Climatological analyses

Main objective

To describe perceptions of and complementarity between scientific and indigenous weather forecasting, understanding the reliability of weather forecasts, and the importance of climatological analyses in the agriculture sector.

Specific objectives

At the end of the training session, participants will be able to:

- Accurately describe what a weather forecast is
- Identify the complementarities of scientific and indigenous traditional knowledge weather forecasts
- Describe and demonstrate the reliability of weather forecasts
- Analyse climate data and interpret it for usefulness in agriculture production.

Lesson development

Ask participants on whether they have ever used weather forecasts to make an informed decision in agriculture. Discuss with them on reasons for different perceptions, contradictions, and complementarity between scientific and indigenous traditional knowledge forecasts in their areas.

Divide participants into groups and ask them to write their perceptions on the meteorological weather forecast, and the factors affecting their perceptions. Allow

plenary discussion after presentation of the group work. Summarize the discussion with causes of the perceptions, complementarity, and reliability of the forecasts.

Describe climatological analyses and relevant climatological information such as long-term seasonal rainfall averages. Explain how useful this information is in making informed decisions in the agriculture sector, especially for selecting agricultural practices or crop varieties.

Teaching methods

Question and answer, brainstorming sessions, group discussions, and lecture.

Teaching aids/tools

Flip charts, black/whiteboard, markers/pens, and climatological graphs.

CHAPTER FIVE

Weather and Climate Services for Agricultural Application

Chapter summary

This chapter describes different types of climate and weather information and products related to agrometeorological services provided by TMA, and their usefulness in the agricultural sector. The products include daily weather forecasts, severe weather warnings and advisories, seasonal outlooks, and dekadal weather bulletins.

5.1 Agrometeorological services

Agrometeorological services are weather and/or climate information provided with the potential to be used in informing agricultural activities by farmers, livestock keepers, fishermen, extension officers, or other agricultural stakeholders in the sector. Appropriate understanding and utilisation of the information should help agricultural stakeholders in making informed decisions during the

planning phase of agricultural activities, which will not only improve the quality and quantity of agricultural produce but also minimize production risks associated with weather and climate challenges.[23] Services provided by TMA for the agriculture sector include agrometeorological seasonal weather outlooks, dekadal agrometeorological bulletins, daily weather forecasts, severe weather warnings, and agrometeorological advisories.

5.1.1 Daily weather forecasts

A daily weather forecast is a 24-hour forecast that contains detailed information on expected weather conditions for the next 24 hours. In most cases the forecast includes information related to precipitations, maximum and minimum temperature, wind speed and direction, thunderstorms, sunrise and sunset hours, and advice on precautionary measures. Currently, forecasts are provided daily through TVs, radios, newspapers, the TMA website, and on social media like the TMA YouTube channel.

Usefulness

The daily weather forecast is useful in agricultural production activities because it provides expected weather condition for the next 24 hours. Sunny, cloudy, rainy, and wind speed and direction forecasts are important to farmers in planning field operations within the next 24 hours such as fishing, livestock management activities, weeding, agro-input applications (such as fertilizer, manure, and pesticides), harvesting, drying, and transportation of agricultural produce. Warnings and advisory on bad weather conditions are provided to enable appropriate precautionary measures to be taken by the respective agricultural stakeholders. For fishermen, information on wind speed and direction is critical for safe navigation in water bodies such as ocean and lakes.

5.1.2 Severe weather warnings and advisory

Occasionally, changes in dynamic weather systems can indicate the possibility of severe weather conditions such as large waves, strong winds, heavy rainfall, and hailstones. Such conditions may result in loss of lives, damage of crops, livestock mortality, and destruction of property, in the absence of timely warnings. TMA provides warning alerts on severe weather once they observe signs of severe weather conditions in a given locality and warn the public to take necessary precautions to avoid or minimize associated risks. The warnings are usually communicated using all possible communication channels including TVs, Radios, social media and FarmSMS, as shown here in Figure 21.

23 V.R.K. Murthy and C.J. Stigter. 2013. Operational Agrometeorological Services for Extension Needs and the Supportive Role of Agricultural Research

Usefulness

Severe weather warnings are important in the agriculture sector because extreme weather conditions can result into loss of human lives and properties, sinking of dhows and other fishing vessels, crop damage, an outbreak of pests and diseases, livestock mortality, soil erosion, landslides, and disruption of transportation and/or communication infrastructures. Timely dissemination of and access to severe weather warnings is important for appropriate mitigation measures on avoiding or minimizing negative impacts and ensuring food security.

Figure 20: Severe weather warning message for strong winds and large waves through FarmSMS (source TMA)

5.2 Agrometeorological bulletins

The agrometeorological bulletins are products released by TMA just before the beginning of the season, and again after every ten days. These products are dekadal (ten day) and seasonal agrometeorological bulletins containing information on seasonal weather outlooks and ten-day weather updates in relation to the agriculture sector and focusing on crops, livestock, and fisheries production. It also provides information related to water scarcity and availability for agricultural production, expected soil moisture conditions, and general agricultural advisories.

Seasonal agrometeorological bulletins are available for *Masika* and *Vuli* seasons in bimodal areas and *Msimu* season for unimodal areas. The seasonal bulletin is complimented by dekadal agrometeorological bulletins released after every ten days.

5.2.1 Seasonal agrometeorological bulletin

The seasonal agrometeorological bulletin is released by TMA just before the start of the agricultural (rainy) season in the month of February for the *Masika* season, September for the *Vuli*, and October for the *Msimu* season. The bulletin contains information on the outlook of weather conditions for the entire seasonal length, impacts, and advisories for the agricultural sector within the season. The bulletin covers a period of three months for the *Masika* and *Vuli* seasons and six months for the *Msimu* season between November to April. The bulletin is disseminated through registered emails and available at TMA[24] and WMO[25] websites in Swahili and English languages.

Usefulness

The seasonal agrometeorological bulletin contains important weather information to guide extension officers, farmers, and other stakeholders in preparation and planning purposes for the agricultural seasons. The bulletin contains information on the start and end of the season, length of the season, spatial rainfall distribution and probability of expected rainfall performance described as above normal, below normal, and normal, (see Figure 22) and advisory for the season.

24 http://meteo.go.tz/pages/brochures#
25 http://www.wamis.org/countries/tanzania.php

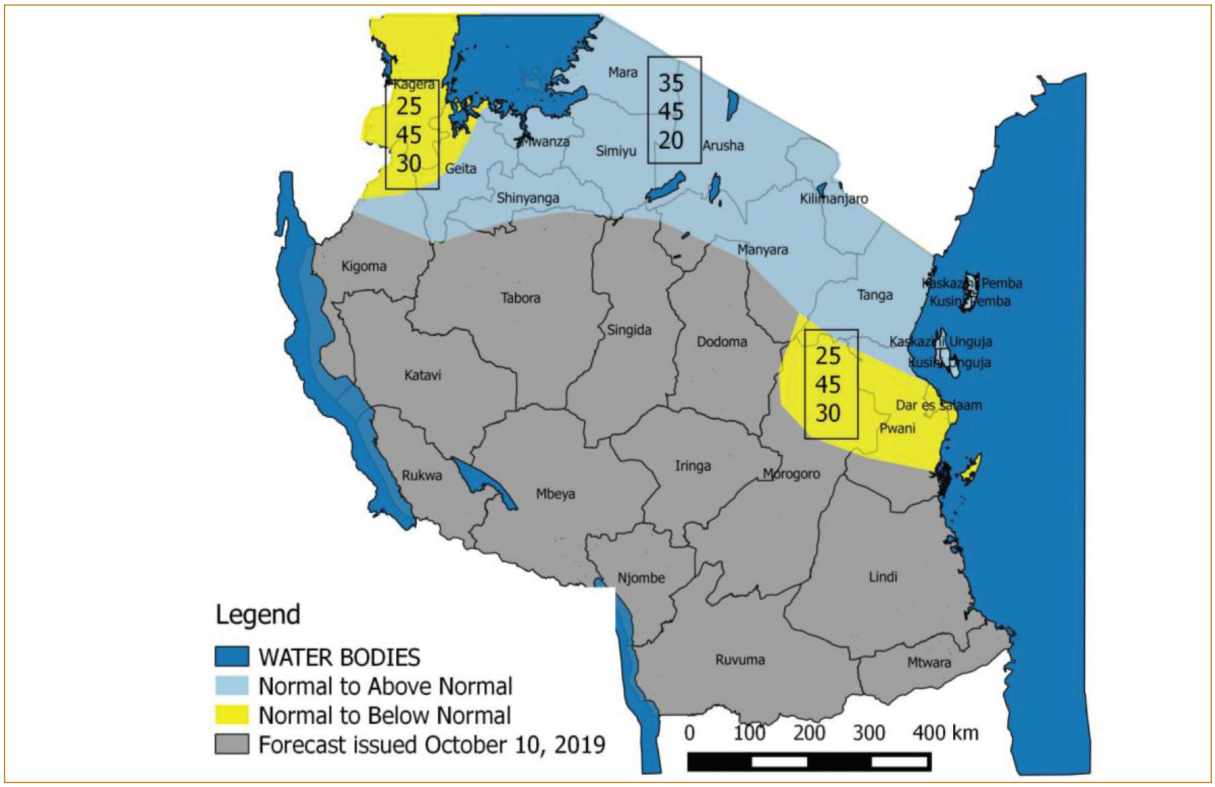

Figure 21: Probabilities of expected seasonal rainfall in the bimodal areas of the country for the Vuli 2019 rainy season (source TMA seasonal forecast bulletin).

Information within the seasonal agrometeorological bulletin informs key preparatory measures and planning by the agricultural stakeholders at different levels in a geographical area. This way, the seasonal agrometeorological information and advisories in the bulletin contribute to building adaptive capacity of the agriculture sector against the impacts of climate variability and change, which ensures food security of a local community and the country at large.

Information on seasonal outlook is important to farmers, extension officers, and a wide range of agricultural stakeholders along the value chain. It contributes directly or indirectly to the sustainability of agricultural production in each geographical area. Agro-dealers, extension officers, NGOs, LGAs, and the private sector are all responsible for ensuring necessary preparations and planning are done and based on the informaiton and advisories provided in the seasonal agrometeorological outlook bulletins. These bulletins are especially important to extension officers, as they are responsible for advising farmers on appropriate preparatory measures such as planting time, selection of appropriate seed and crop varieties, relevant agronomic practices, good animal husbandrly, and pest and diseases control measures.

5.2.2 Dekadal agrometeorological bulletin

The dekadal agrometeorological bulletin is released every ten days. It contains information on weather performance for the past ten days and an outlook for the upcoming ten days. It

includes information on the impact of the expected weather conditions and gives advisories in relation to the agriculture sector. Information in the dekadal bulletin complements seasonal agrometeorological outlook information. This is needed because climate systems are not static, and hence closer monitoring of climate systems reveal changes in the system and their influence on a predicted weather condition. Annex 2 of this document shows an example of the dekadal weather bulletin for April 21-30, 2018. The bulletin was disseminated through registered emails and available at TMA[26] and WMO[27] websites in Swahili and English languages.

Usefulness

The dekadal agrometeorological bulletin is useful in providing weather updates for the past ten days and weather forecasts and advisories for the subsequent ten days to farmers, extension officers, and other agricultural stakeholders. Information such as dry and wet spell periods for the next ten days, and experiences of the previous ten days in different parts of the country, are all captured in the dekadal bulletin. This information is important because it provides an early warning sign on food security status in different parts of the country and informs on the need for necessary preparations. In recent years, farmers have experienced prolonged dry spell periods, above-normal wet spell periods, and abnormal rains lasting for more than ten days within the season, sometimes followed by more intense above-normal rains in a short time. An understanding of the dry or wet spell period within the season ahead of time provides room for the farmers to take necessary actions by considering appropriate Climate Smart Agriculture practices and technologies available for the local area.

5.3 Access to weather information and agrometeorological services

Weather bulletins and agrometeorological information are available in both English and Kiswahili for farmers, extension officers, and other agricultural stakeholders in the country. This information is available through different products and services produced and disseminated by TMA through a mobile phone message service known as FarmSMS, radio, television stations, newspapers, TMA and WMO websites, emails, and social media including Twitter, YouTube, Instagram, WhatsApp, and Facebook, as well as at meteorological stations in the country.

To access the information via mobile phones or email, one needs to register her/his telephone number and/or email address in the TMA database by contacting nearby TMA offices in the country. An agricultural extension officer is advised to register in the TMA email database and FarmSMS system for timely access to relevant weather information, advisories, and warnings directly from TMA.

FarmSMS is a databased system with phone numbers of registered agricultural stakeholders throughout the country that allows them to receive agrometeorological information, weather

alerts, and advisories directly from TMA through their mobile phones. The system allows farmers, extension officers, and other agricultural stakeholders to receive localized weather information, alerts, and advisory services in timely manner for appropriate actions. Recipients of information through the system can use the system to make inquiries and get more clarification from TMA.

26 http://meteo.go.tz/pages/brochures#
27 http://www.wamis.org/countries/tanzania.php

Agrometeorological information can also be obtained by visitng TMA headquarter offices and zonal offices in Morogoro for the eastern zone, Dodoma, Kilimanjaro, Unguja, Mtwara, Songwe, Tabora, and Mwanza, as shown in Figure 23 below.

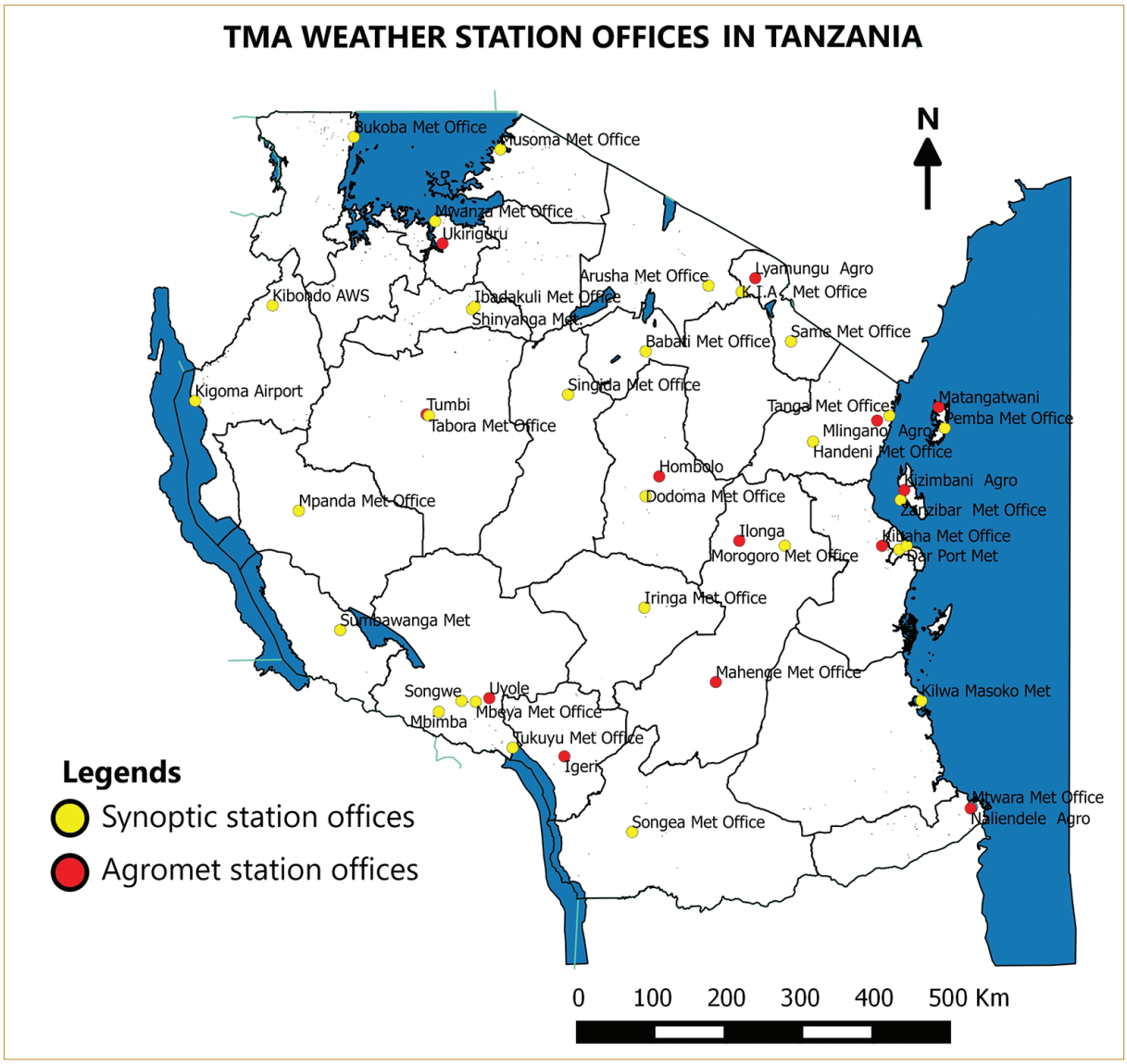

Figure 22: Map showing the spread of meteorological stations in the country (source TMA)

Training guide for chapter five

Duration: 30 Min.

Topic: Weather and climate services for agricultural application

Sub-Topics:

- Agrometeorological services
- Agrometeorological bulletins
- Accessing agrometeorological bulletins and information

Main objective

To provide an understanding of weather and climate services provided by TMA for application in agricultural activities and different ways of accessing agrometeorological information.

Specific objectives

At the end of the lesson, participants should be able to:

- Describe and categorize agrometeorological services provided by TMA
- Share knowledge on the use of the agrometeorological information contained in different bulletins
- Identify different methods of accessing agrometeorological information provided by TMA.

Lesson development

Ask participants to explain whether they have ever used agrometeorological services for decision making in agriculture production or not. If the answer is 'YES', ask them to explain what types of service they used and who provided the information. Relate information provided with agrometeorological services provided by TMA. If the answer is 'NO' continue mentioning different types of agrometeorological information and services provided by TMA starting with the daily forecasts, weather alerts, and agrometeorological bulletins (both Seasonal and Dekadal).

After that, ask participants to explain whether having more than one agrometeorological product is helpful for planning agricultural activities. Let them discuss for a few minutes with an adjacent partner, then provide an explanation on why it is necessary to have more than one product, explaining that weather systems are not static, and no one has control over them. Thereafter, explain the usefulness of the information contained in different products and how they can be used to make informed decisions in planning of agricultural activities.

Following these explanations, show to them the most recent seasonal and dekadal agrometeorological bulletins and show to them how they can find relevant agrometeorological information and advisories in the bulletins. If possible, let them keep copies of these bulletins for future reference.

After, describe different ways of accessing agrometeorological services and weather forecasts provided by TMA by visiting TMA website and social media accounts. Encourage participants to get in touch with TMA to receive agrometeorological and advisories through the FarmSMS system and by email.

Teaching methods

Lectures, discussions, question, and answer.

Teaching aids/tools

Powerpoint presentation, projector, most recent copy of the agrometeorological seasonal and dekadal bulletins by TMA, computer and/or smartphone with internet access.

FAO/Julianus Thomas

CHAPTER SIX

Use of Agrometeorological Information and Advisory for Informed Decision Making

Chapter Summary

This chapter aims at enhancing the knowledge of extension officers, farmers, and other relevant agricultural stakeholders on the use of agrometeorological information and advisories for informed decision making before, during, and after the rainy (agricultural) season. It highlights the responsibilities of an agricultural extension expert on how to communicate and provide timely and appropriate agrometeorological advisories based on the needs of local geographical area and in relation to climate and weather information provided by TMA.

6.1 Use of agrometeorological information and advisories before the rainy season

Often farmers make decisions for preparation for agricultural seasons before the actual start of the season. In most cases, such decisions include a wide range of aspects, including and not limited to what to plant and how to plant in relation to the local climatological conditions.

The seasonal agrometeorological weather outlook bulletin is usually released a few weeks before expected onset dates. Usually, the release time is advanced enough for agricultural stakeholders, planners, and extension officers to disseminate the information and advisories in a timely manner to relevant stakeholders along the agricultural value chain so that they in turn may make necessary preparations for the season. Decisions on seasonal preparations should always be based on the seasonal outlook and advisories provided in the agrometeorological bulletins and complemented by advice from extension officers. This will allow farmers to build self-confidence in the choice of crops, seed varieties, and good agricultural practices, and to plan better for key activities during the season, which results in better output at the end of the season. Given this, the use of seasonal agrometeorological weather outlook information and advisories is highly recommended for better yields. An example of a Seasonal Agrometeorological Bulletin is shown in Annex 1 of this document.

Advisories are relevant and actionable information or options that different actors can take advantage of to manage risk and uncertainties, and explore opportunities based on agrometeorological information for the season. Rather than being 'instructions' to be followed, advisories are presented as an option for actors to consider when making their own decisions and plans for the season. The challenge is that some advisories may be broad, covering an entire sector or large geographical area, and may not consider all uncertainties in each forecast. Yet, agrometeorological advisories are still crucial in making informed decisions towards better management of climate- and weather-related risks in the agriculture sector, for food security, and in climate resilient production systems. It is not enough to rely on personal experience or historical experiences in a local area to prepare, make plans, and enact decisions for the upcoming agricultural season. Extension officers and farmers should make these choices and decisions based on the seasonal forecast and advisories prepared and released by TMA.

TMA seasonal weather outlooks use probabilistic forecasts, which classify the expected rains in the season into normal, below-normal, or above-normal, as described in chapter five. Often, an advisory is provided for the forecast with the highest probability of occurrence; however this does not mean those with medium and lower probabilities are not likely to happen. It is for this reason that TMA also provides dekadal forecasts and advisories to help guide agricultural stakeholders on seasonal progress. This means agricultural stakeholders should not be satisfied with the seasonal forecast alone and should make use of other types of forecasts as described in chapter five.

6.1.1 Normal rains

A normal rainfall probability forecast means that the forecasted seasonal rain is expected to be within the range of the long-term seasonal average of rains historically received in a geographical area during the season. In such a case, a normal rainfall amount is to be expected for agricultural

activities in that area within the season. It is expected, with this forecast, that there will be normal soil moisture for optimal crop production and water available for livestock during the season. In this regard, normal times for land preparation and planting and harvesting should be expected in the agriculture sector for the season.

However, even with a normal rainfall forecast, agricultural stakeholders should make use of agrometeorological advisories, since the forecast does not necessarily talk of spatial and temporal distribution or variations of the seasonal rains for a given area. This means we do not know exactly when or where the rain is expected at all times within the season. Such information is obtained by following up on other weather forecasts and updates such as daily and dekadal weather alerts. It is for these reasons that advisories from TMA and local experts are necessary and important for agricultural stakeholders.

6.1.2 Above-normal rains

An above-normal rainfall probability forecast means that the forecasted rain in a season is expected to exceed the long-term average recorded for a geographical area during the season historically. In this type of forecast, impacts such as excessive rains may result in floods, excess soil moisture, waterlogging, and soil erosion may be some of the associated characteristics of the season. Under such a forecast, farmers are advised to consider agronomic practices which are adapted for excessive water conditions or intense rains. Such practices include contour farming, avoiding farming in low land areas without use of good practices to allow aeration, preparation for the control of pests and diseases in livestock production, and the covering of soil to prevent soil erosion. Even with such a forecast, agricultural stakeholders need to make use of the advisory service because spatial and temporal variation of the seasonal rains are still uncertain. The use of intermediary weather forecasts and agrometeorological products is needed to compliment information provided in the seasonal forecast.

6.1.3 Below-normal rains

A below-normal forecast probability means that forecasted rain for the season is expected to be less than the long-term average rainfall received by a given geographical area in the season historically. This type of forecast is associated with characteristics such as inadequate soil moisture, prolonged dry spell periods, scarcity of water for livestock, prevalence of pests and diseases, and conflicts between livestock keepers and farmers in some areas. Under such forecast, farmers are advised to consider agronomic practices that conserve soil moisture and choose seed or crop varieties with high water-use efficiency and livestock breeds which are resistant to drought conditions. Even with a below-normal forecast, agricultural stakeholders should be watchful for intense rainfall events that can damage agricultural production systems and properties. This is because temporal and spatial distribution is still not certain during the seasonal forecast release period. This information is usually complemented with more accurate information developed for a shorter period such as daily and dekadal weather alerts and warnings.

6.2 Use of agrometeorological information and advisories during the rainy season

Within the season, dekadal and daily forecasts are released by TMA to inform decision making on preparation of agricultural activities, such as relevant times for weeding, application of fertilizer, mulching, harvesting of rainwater, use of drip irrigation, and preparations for disaster impact reduction measures. Information and advisories enable agricultural stakeholders to adjust decisions and choices made at the beginning of the season based on how the season is progressing. For instance, information and advisories in the dekadal bulletin allow for flexibility to switch from one activity to another depending on the prevailing weather conditions outlook.

6.3 Use of agrometeorological information and advisories after rainy seasons

At the end of the rainy seasons, crops and pasture are usually at the maturity stage and ready for harvesting, storage, and transportation to the markets. At this stage, agricultural produce no longer faces challenges associated with nutrient deficiency, but instead challenges associated with post-harvest handling and management and ensuring food safety and quality. It is therefore important for farmers to consider appropriate post-harvest handling and storage technologies to preserve the quality of produce. Weather conditions such as out of season rains, high humidity, strong winds, hailstones, and high temperatures can cause spoilage, affect the quality, and cause losses of produce. Communication and transport infrastructure like roads, railways, mobile phone towers, and telephone lines are vulnerable to the impact of bad weather, all of which is inhibiting to transportation of agricultural produce from one point to another. It is because of this that agricultural stakeholders should continue to follow up and make use of weather information in making key decisions even after the end of the season, so as to avoid losing their harvests or affecting produce quality before sale at markets.

6.4 Considerations in communication and dissemination of weather information at local level

Weather and climate information, in relation to agriculture, is especially key in all aspects of food security. As such, it attracts a wide variety of audiences from the government sector, agro-dealers, agro-entrepreneurs, farmers, and food processors. The diversity and nature of these agricultural stakeholders make a difference in the information provided and required by each along their section of the value chain. Hence, there is a need for different channels of communication, timeliness, access to, and trust in the information provided. The language of communication should also be easily understandable for the general audience and for the integration of the information and advisories into agricultural production activities.

Because of differences in literacy level among agricultural stakeholders, there are differences in interpretation and application of agrometeorological information and advisories. Therefore, there is also a need to package and communicate information and advisories based on the target user

for effective articulation and utilization of the information. This ensures that agrometeorological information is accessed and utilized by a wide range of agricultural stakeholders in the country for informed decision making in the implementation of agricultural activities.

Effective communication and dissemination of information has been achieved through diversified communication channels including use of community radio, television, social media, websites, and mobile phones as described in chapter five. However, for further dissemination of the information at local levels there is a need to choose other means of communication channels preferred by the local population, to distribute agrometeorological information more effectively at local level. These means may include local meetings, workshops, and traditional gatherings.

It is important to understand the social setting and communication structure of communities at the local level, to ensure that information can reach different gender groups, ages, and social classes within the target community. This increased adherence to local traditions and culture enhances effective communication and avoids communication barriers. Below are examples of key considerations in choosing different means of communication at the local level:

a) Face-to-face communication through meetings, religious or traditional gatherings, and sports events may be preferred at the community level. However, in such events, issues related to gender and youth engagement needs to be carefully considered. In some societies, women prefer to have their own meetings separate from men to be fully engaged, and in others, religious or traditional gatherings could be more effective to involve the entire community, while sports or entertainment gatherings could be more attractive to youth. It is therefore important for a communicator to consider these aspects in reaching out to target audiences.

b) Sectoral, political, and government events or meetings such as farmer field day, councillors meetings, agricultural training workshops, and planning meetings are appropriate events where agrometeorological information and advisories can be communicated to reach more audiences at the community level. In such meetings, with prior engagement with the organizers, climate and weather information could be included in the agenda. These meetings can help ensure that climate and weather-related issues are integrated into planning processes.

c) Agricultural stakeholder meetings are another avenue where agrometeorological issues should be presented at local levels. These meetings usually target and involve diverse groups of agricultural stakeholders in a particular value chain. Decisions and actions in such meetings often focus on improving the agriculture sector, which is not immune to the impacts of weather and climate change. Prior to an engagement, the organizers should be able to understand the key roles of weather in their deliverable and the need to include an element of weather in the program to meet the goals of food security and economic growth at the local and national level.

d) Information and communication technologies such as mobile phones and community radio should be fully utilized for timely and wider outreach to community members. One can identify key information at the community level and assign responsibility for timely dissemination of agrometeorological information to agricultural stakeholders at the local level. Use of communication structures such as WhatsApp groups can be integrated to ensure

timely dissemination of seasonal, dekadal, and weather alerts within the local community. Depending on the setting of the community, local radio can be employed to explain weather information and advisories in local language, which enhances the penetration of information to all community members.

6.5 Use of agrometeorological information in selection of appropriate climate-smart agriculture practices or technologies

In relation to the seasonal, dekadal, and daily forecasts, extension officers, farmers, and other agricultural stakeholders should be in a positon to understand appropriate CSA practices and technologies which reduce risk and maximize agricultural production potential in the season. Extension officers and farmers should make use of appropriate CSA practices and technologies described in the CSA Guidelines from the Ministry of Agriculture in Tanzania. The document is accessible through the Ministry of Agriculture website (www.kilimo.go.tz). In the table below, a few examples of appropriate CSA practices and technologies are described for before, during, and after the rain seasons.

Table 1: An example of CSA Practices and Technologies in relation to seasonal weather information before, during, and after seasonal onset.

S/N	Farming Phase	Activities
1.	Before rain onset	Selection of appropriate crop and seed varieties, identification of land preparation and sowing dates with good germination potential, selection of appropriate agricultural practices based on seasonal forecast and an area topography, development of agricultural seasonal calendar and planning for destocking, vaccination, shifting of livestock from vulnerable areas, and strengthening of fishpond and irrigation infrastructures.
2.	During Rains	Control of soil erosion, harvest of rainwater, planting/ transplanting, conservation soil moisture, control of pests and diseases, application of fertilizer/manure, management of dry spells, increased storage of livestock feed, pasture management, and weeding.
3.	After rain /rain cessation	Bird scaring, use of better harvesting techniques, drying, storage, transportation, value addition, and marketing of agricultural produce.

Before the season: An extension officer should access in a timely manner (as described in chapter five) and disseminate seasonal agrometeorological bulletins and advisories at the local level. Thereafter, the officer is responsible for assisting farmers in developing seasonal agricultural calendars (as described in chapter three) and advising on relevant agricultural practices based on the forecasts provided by TMA.

During the season: An extension officer should access and use in a timely manner the dekadal agrometeorological bulletins and daily forecasts to advise farmers in relation to seasonal progress and changes. The officer is also responsible for ensuring that the bulletin is widely disseminated in his community using different channels including WhatsApp group, among others. Advice should be provided on either maximizing agricultural opportunities or minimizing risks associated with the weather forecast provided.

Farmers need to consult the local extension officer on correct interpretation and appropriate use of the seasonal forecasts and advisories at their local level as soon as they receive or access the information. In the same manner, when an extension officer receives relevant agrometeorological information, they should immediately convene a meeting to explain the information and advisories at the local level. Additionally, the officer can have a social media group like WhatsApp to further dissiminate the information. The advisories developed during the meeting should be printed and posted in public spaces for easy access.

6.6 Monitoring, evaluation, and feedback

Monitoring, evaluation, and feedback on the use of agrometeorological information by the agricultural stakeholers is crucial for enhancing learning. This information can be gathered through regular assessments or soliciting feedback from agricultural stakeholders and the developers of agrometeorological information. Assessments and evaluation should focus on identifying the benefits obtained by farmers through the use of the agrometeorological information and advisories as well as the key challenges they faced.

The objective here is to evaluate the positive and negative changes that come out directly or indirectly, either intended or unintended, due to the use of agrometeorological information and advisories in the agriculture sector. The following are some possible questions regarding the impacts of using agrometeorological services in the implementation of agricultural activities.

a) What are the results obtained from the utilization of agrometeorological information?

b) What changes in knowledge, attitudes, and practices occurred because of the use of agrometeorological information?

c) Are there changes in the adaptive capacity of the agriculture sector to the impacts of climate change resulting from the use of agrometeorological information and advisories?

d) What are the drivers of the observed changes?

e) Are there unintended impacts and effects?

Impact assessments and stakeholder feedback are key to leveraging support for investment in the use of agrometeorological information and advisories in the agriculture sector.

Training guide for chapter six

Duration: 60 Min.

Topic: Use of agrometeorological information and advisory for informed decision-making

Sub-Topics:

- Use of agrometeorological information and advisories before the rainy season
- Use of agrometeorological information and advisories during the rainy season
- Use of agrometeorological information and advisories after the rainy season
- Consideration in communication and dissemination of weather information at local level
- Use of agrometeorological information in selection of appropriate climate-smart agriculture practices and technologies
- Monitoring, evaluation, and feedback in the use of agrometeorological information

Main objective

To enhance the capacity of extension officers to communicate and disseminate agrometeorological information and advisories and evaluate the use of the information by the agricultural stakeholders.

Specific objectives

At the end of the lesson, participants will be able to:

- Describe the use of agrometeorological services before, during, and after the rain season
- Describe the factors to consider in communicating agrometeorological information and advisories at local level
- Share knowledge on how to use weather information in the selection of CSA practices
- Evaluate the learning results achieved by the target audience by collecting feedback and conduct continuous monitoring to gauge the impacts of agrometeorological services.

Lesson development

Ask participants a few questions on how they have been integrating agrometeorological information and advisory in their farming activities. Thereafter, how they can present to farmers different information from different agrometeorological bulletins and forecasts before, during, and after the rain season.

Describe to participants three seasonal rainfall probabilities forecasts (normal, above-normal and below-normal). Use actual and most recent seasonal forecast bulletin and work with the participants to discuss seasonal agricultural activities to be conducted using a high rainfall probability for the season. To enhance understanding, repeat the exercise for the other two scenarios with medium and low probability of occurrence. Work with the participants to identify difference in activities on different probabilities. Organize participants into groups and ask them to propose suitable CSA practices and technologies based on rainfall under all three scenarios.

Pick at least three key advisories and discuss with the participants on key channels and key considerations for effective communication and dissemination at a local level and develop a communication plan for the advisories.

Afterward, remind the participants about the need to make use of the dekadal and daily weather forecasts during the season and the need to use them in guiding short-term agricultural operations. Encourage them to use any form of gathering at the local level to discuss on the integration of dekadal and daily weather forecasts in the implementation of the seasonal agricultural calendar.

At the end, describe the roles of an extension officer and farmers in ensuring timely access and proper utilization of the agrometeorological information and advisories, and in seeking advice for further dissimination of agrometeorological information in the society. Use of social media such as WhatsApp groups can be one of the channels to effectively disseminate and receive the information.

Teaching methods

Lecture, question and answer, group work, and practical sessions.

Teaching aids/tools

Seasonal, dekadal, and daily weather forecasts, CSA training manuals and guide, flip chart, markers, and pens.

TANZANIA METEOROLOGICAL AGENCY

SEASONAL WEATHER FORECAST

No. 19 Special Issue: **March to May *(Masika)*, 2018 Rain Season Outlook issued on 15th February, 2017**

Summary

- The March to May (MAM) rainfall season (*Masika*) is more significant for the areas over the northeastern highlands, northern coast including the Isles of Unguja and Pemba, Lake Victoria Basin and the northern parts of Kigoma and Morogoro regions.
- *Masika* season is expected to commence in the first week of March over the Lake Victoria basin and northern coast and cease in the third week of May
- *Masika season* rains are likely to be mainly normal over most areas. However, there is likelihood of elevated periods of below normal rainfall over parts of Northern Tanga region.
- Normal to above normal rainfall is expected over most areas of Mwanza, Shinyanga, Mara, Arusha, Manyara, Pwani, Tanga, northern Morogoro and extreme northern Kigoma (Kibondo district).
- The northern part of Tanga region is expected to experience periods of moisture deficit and therefore farmers are advised to plant drought tolerant and early maturing crop varieties.

CLIMATE SYSTEMS OUTLOOK DURING MAM, 2018

The observed gradual cooling over central equatorial Pacific Ocean is likely to persist through the season. Mostly neutral Sea Surface Temperature (SST) conditions are expected over much of western Indian Ocean. However, there is an enhanced warming condition over south western Indian Ocean during the season. As the March to May rainfall season progress, the warming over southwestern Indian Ocean is likely to enhance occurrence of tropical cyclones during the months of March to April. Cooling over southeast Atlantic Ocean near Angola coast is likely to enhance westerly wind flow from Congo Basin towards the country resulting into moisture influx into the country thus contributing to the enhancement of rainfall over the country.

SEASONAL RAINFALL OUTLOOK DURING MAM, 2018

The March to May (MAM) rainfall season (*Masika*) is more significant for the areas over the northeastern highlands, northern coast including the Isles of Unguja and Pemba, Lake Victoria Basin and the northern parts of Kigoma and Morogoro regions. The *Masika 2018* rains are expected to be normal to above normal over the eastern and western parts of the Lake Victoria Basin and mainly normal over the southern parts of the Lake Victoria basin, northern parts of Kigoma and northeastern highlands. The northern coast (Dar es Salaam, Pwani and northern Morogoro together with Unguja and Pemba Islands) are expected to feature normal to above normal rainfall while pockets of below normal rains are expected over Tanga region.

Lake Victoria Basin: (Kagera, Mara, Mwanza, Geita, Simiyu and Shinyanga regions)

Rains are expected to start during the first week of March in Mwanza region and spread to other regions of Geita, Mara, Kagera, Simiyu and Shinyanga during the second to third week of March. The rains are expected to be normal to above normal over Kagera, Mara and northern parts of Geita, Mwanza and Simiyu which are closer to the Lake Victoria. Otherwise, Shinyanga region and the southern

parts of Geita, Mwanza and Simiyu regions are expected to feature mainly normal with pockets of below normal rains.

Northern Coast and its Hinterlands: (Dar es Salaam, Tanga, and Coast regions, Islands of Unguja and Pemba and northern Morogoro)

Rains are expected to commence in the first week of March. The rains are expected to be normal to above normal over Dar es Salaam and Pwani regions together with the Isles of Unguja and Pemba, northern part of Morogoro and southern parts of Tanga regions. However, below normal rains are expected over northern parts of Tanga region.

Northeastern highlands: (Kilimanjaro, Arusha and Manyara regions)

Rains are expected to start over most areas in the second week of March and are likely to be mainly normal over most areas.

Seasonal Rainfall (November to April) over Unimodal areas:

Seasonal rains, which started in November, 2017 are expected to progress as forecasted in unimodal areas (Dodoma, Singida, Kigoma, Tabora, Katavi, Rukwa, Mbeya, Songwe, Njombe, Iringa, Ruvuma, Lindi, Mtwara regions and southern part of Morogoro region). The rains are likely to be normal to above normal.

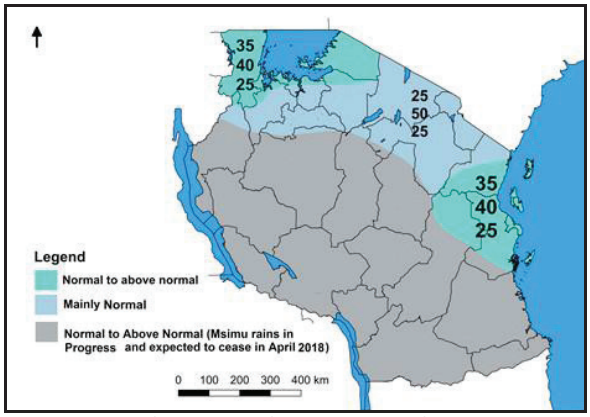

Figure 1: Rainfall outlook for coming rainfall season March to May, 2018.

EXPECTED IMPACTS AND ADVISORY DURING MAM, 2018

Agriculture, Fish and Livestock Production

Sufficient soil moisture condition is likely to feature over the northeastern highlands (Kilimanjaro, Arusha and Manyara regions), Lake Victoria basin (Kagera, Geita, Mwanza, Mara, Shinyanga, and Simiyu regions) and northern coast (Morogoro (north), Dar es Salaam, Pwani, Tanga regions, and islands of Unguja and Pemba). Farmers in these areas are advised to go for normal *Masika* cropping season. However, the northern part of Tanga region is expected to experience periods of moisture deficit and therefore farmers are advised to plant drought tolerant and early maturing crop varieties.

Water and pastures conditions for livestock and food for fish are expected to improve due to the expected normal to above normal rainfall. However, for optimal use of this outlook, the farmers, fishers and livestock keepers are strongly advised to seek advice from their relevant extension officers and also carry out rainwater harvesting for future use during dry periods.

Disaster Management

Disaster management authorities, humanitarian responders and other stakeholders are advised to take necessary mitigation measures to ensure preparedness for effective response to address potential negative impacts that may result from the expected rains.

NOTE: The current status of seasonal forecasting allows for prediction of spatial and temporal averages over larger areas and may not fully account for all physical and dynamical factors that influence short-term climate variability. Users of this outlook are, therefore urged to make good use of daily, ten day and monthly updates issued by the Tanzania Meteorological Agency.

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Annex 2: An example of Dekadal Agrometeorological Bulletin

TANZANIA METEOROLOGICAL AGENCY

DEKADAL WEATHER REVIEW

No: 21: 2017/18 cropping season **Review for April 21-30 and Outlook for May 1-10, 2018**

HIGHLIGHTS

- Dry periods are likely to favour maize crop at maturity to harvesting stages over some parts in the unimodal areas
- Excessive soil moisture and water logging are likely to affect nutrient uptake and damage to some of the crops.
- Wet and humid conditions are likely to favour crop diseases.

SYNOPTIC SUMMARY DURING APRIL 21-30, 2018

The northern high pressure systems (Azores and Siberian) relaxed while the southern high pressure systems (St. Helena and Mascarene) continued to intensify. The position of Inter-tropical Convergence Zone (ITCZ) shifted towards northern sector of the country. Over the southwest Indian Ocean, sea surface temperatures (SSTs) were neutral to slight cool resulted into less cyclonic activities. Northeasterly to easterly winds over the northern sector of the country and southeasterly to easterly winds over the southern sector of the country indicated the presence of the ITCZ over the region. The southeast Atlantic Ocean (near Angola coast) SSTs were neutral to slight warm resulting into easterly wind flow and retraction of the Congo Air mass thereby reducing rainfall making mechanism over the western sector of the country especially during the second half of the dekad.

RAINFALL PERFORMANCE DURING APRIL 21-30, 2018

During the ten days (dekad), most parts of the country received above normal rains, except in some parts of Mara, Tabora, Katavi, Rukwa, Mbeya, Dodoma, Iringa, Morogoro, Pwani, Dar es Salaam, Lindi and Mtwara regions received normal to below normal rains as indicated in Figure 1.

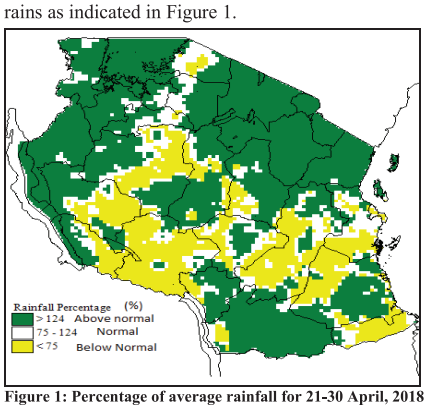

Figure 1: Percentage of average rainfall for 21-30 April, 2018

AGROMETEOROLOGICAL SUMMARY DURING APRIL 21-30, 2018

During the period under review, many areas experienced rainfall activities which favored crop growth and development. For unimodal areas maize crop was reported at wax ripeness to full ripeness stages specifically in Iringa, Mbeya, Dodoma, Singida, Tabora, Kigoma, Ruvuma, Mtwara and Rukwa regions. However in Ruvuma (Mbinga district) and Mtwara (Newala district) have started harvesting maize crop. In Mbeya region planted beans were at flowering stage, and damage due to water logging was reported over some areas.

In bimodal areas specifically in Mara, Kagera, northern part of Morogoro and Arusha (Longido district) regions farmers were engaged in weeding and pesticide application. Maize crop was between third and ninth leaf stage. However, in Mwanza, Arusha and Manyara regions maize was reported to be at full ripeness. Armyworms were reported to affect crops in Morogoro region (Ilonga- Kilosa District). In some areas of Mara, and Manyara (Babati district) there was reduction of armyworms as a result of pesticides applications. In Kagera region excessive rains affected pod filling in bean crop. Water and pasture availability were in good condition over much of the country.

HYDROLOGICAL CONDITIONS DURING APRIL 21-30,2018

Water levels in dams and river flow discharges continued to improve over much of Lake Victoria, Tanganyika, Ruvuma, Nyasa, Rufiji and Rukwa basins due to ongoing seasonal rains.

EXPECTED SYNOPTIC CONDITIONS DURING MAY 01-10, 2018

The Azores and Siberian highs are expected to relax further while the St. Helena and Mascarene highs are expected to

continue to intensify. This is expected to move the ITCZ gradually towards the north. SSTs over the southwest Indian Ocean are expected to be neutral which reduces the possibility of occurrence of tropical cyclones. The dominant wind flow pattern is expected to be south easterly to easterly which will enhance precipitation making mechanism over the northern coast especially during the first five days. The southeast Atlantic Ocean (near Angola coast) SSTs are expected to experience neutral to slight warm resulting into easterly wind flow, which is likely to reduce the intensity of precipitation making mechanism mover the western sector of the country.

EXPECTED WEATHER CONDITIONS DURING MAY 01-10, 2018

In view of the expected synoptic conditions, **Lake Victoria Basin (Kagera, Geita, Shinyanga, Mwanza, Simiyu and Mara regions); Northeastern highlands (Arusha, Manyara and Kilimanjaro regions)** and **Western regions (Kigoma, Katavi and Tabora)** are expected to feature showers and thunderstorms over few areas.

Northern coast (Tanga, northern part of Morogoro, Pwani and Dar es Salaam regions together with isles of Unguja and Pemba) are expected to feature showers and thunderstorms over some areas.

Central areas (Dodoma and Singida regions); southwestern highlands (Rukwa, Songwe, Mbeya, Njombe and Iringa regions); southern coast (Mtwara and Lindi regions) and **southern region (Ruvuma and southern part of Morogoro regions)** are expected to feature light showers over few areas.

AGROMETEOROLOGICAL OUTLOOK AND ADVISORY DURING MAY 01- 10, 2018

Soil moisture conditions are expected to continue improving significantly over much of bimodal areas enhancing growth and development of crops. However, excessive soil moisture due to ongoing rains is likely to affect crops mainly maize and beans. In the unimodal areas dry periods are likely to favour maize crop at maturity to harvesting stages specifically in Dodoma, Singida, Ruvuma and southern part of Morogoro. Excessive soil moisture and water logging are likely to affect nutrient uptake and damage to some of the crops. Wet and humid conditions are likely to favour development of crop diseases including fungus. Therefore, farmers, fishers and livestock keepers are advised to consult extension officers for optimal use of this forecast and advisory.

Water and pasture conditions are expected to continue improving significantly across the country.

HYDROLOGICAL OUTLOOK AND ADVISORY DURING MAY 01-10, 2018

Water levels in dams and river flow discharges are expected to improve across the country due to expected rains. However, water users are advised to ensure robustness of water harvesting infrastructures to avoid damage due to overflow.

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