WORKSHOP REPORT

Use of Climate Information in Malaria Stratification/Early Warning Systems/Impact Assessment for Malaria Interventions

A Training Workshop and Stakeholder Meeting hosted by the Tanzania Meteorological Agency

Dar es Salaam, Tanzania

October 16-18, 2013

Acknowledgements

Organizing Host

Tanzania Meteorological Agency (TMA)

Workshop Organizing Institutions

International Research Institute for Climate and Society (IRI), Columbia University
Columbia Global Center- Africa (CGC-Africa)
Health and Climate Foundation (HCF)

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Acronyms

ACMAD	African Centre of Meteorological Applications for Development
ACPC	African Climate Policy Centre
AfDB	African Development Bank
AFENET	African Field Epidemiology Network
AFRO	WHO Regional Office for Africa
AMMA	African Monsoon Multidisciplinary Analyses
AUC	African Union Commission
CCAA	Climate Change Adaptation in Africa
CCH	Climate Change & Human Health
CDC	Centers for Disease Control and Prevention, USA
CHICAS	Combining Health Information, Computation and Statistics
CGC	Columbia Global Center
CHWG	Climate and Health Working Group
CIESIN	Center for International Earth Science Information Network, Columbia University
CIPHA	Climate Information for Public Health Action
CIPHAN	Climate Information for Public Health Action Network
ClimDev-Africa	Climate for Development in Africa Programme
COPEH	Community of Practice in Ecosystem Approaches to Health
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRM	Climate Risk Management
CRED	Center for Research on Environmental Decisions
CSMT	Climate Suitability for Malaria Transmission
DfID	Department for International Development, UK
EIA	Environmental Impact Assessment
ENACTS	Enhanced National Climate Services
ENSO	El Niño–Southern Oscillation
EWS	Early Warning System
FELTP	Field Epidemiology and Laboratory Training Program
GCOS	Global Climate Observing Systems
GEO	Group on Earth Observations
GFCS	Global Framework for Climate Services
GIS	Geographic Information System
HCF	Health and Climate Foundation
HEP	Health Extension Program

HIA	Health Impact Assessment
HINARI	Health InterNetwork Access to Research Initiative
ICPAC	IGAD Climate Prediction and Applications Centre
ICT	Information and Communication Technology
ICTP	International Center of Theoretical Physics
IFRC	International Federation of Red Cross and Red Crescent Societies
IGAD	Inter-Governmental Authority on Development
IHR	International Health Regulations
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society, Columbia University
MAB	Ministerial Advisory Board
MACEPA-PATH	Malaria Control and Evaluation Partnership in Africa - Program for Appropriate Technologies in Health
MDGs	Millennium Development Goals
MERIT	Meningitis Environmental Risk Information Technologies
MEWS	Malaria Early Warning System
MODIS	Moderate-resolution Imaging Spectroradiometer
MoID	Ministry of Infrastructure Development
MoH	Ministry of Health
MoHSW	Ministry of Health and Social Welfare
MoU	Memorandum of Understanding
MUHAS	Muhimbili University of Health and Allied Sciences
NAPA	National Adaptation Programme of Action
NASA-SERVIR	National Aeronautics and Space Administration- Regional Visualization and Monitoring System
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NIH	National Institutes of Health
NIMR	National Institute of Malaria Research
NIR	Near Infrared
NMCP	National Malaria Control Program
NTD	Neglected Tropical Diseases
OND	October-November-December seasonal forecast
PHE	WHO Department for the Protection of the Human Environment
PSU-NMAIST	Penn State University-Nelson Mandela African Institute of Science and Technology
REACH	Regional East African Community Health
RTI	Research Triangle Institute

RVF	Rift Valley Fever
SACIDS	Southern African Centre for Infectious Disease Surveillance
SI-CIPH	Summer Institute on Climate Information for Public Health
SST	Sea Surface Temperature
Swiss TPH	Swiss Tropical and Public Health Institute
TAMSAT	Tropical Applications of Meteorology using SATellite data and ground-based observations
TDR	UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases
TMA	Tanzania Meteorological Agency
ToR	Terms of Reference
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNFCCC	United Nations Framework Convention on Climate Change
USAID-PMI	United States Agency for International Development – President's Malaria Initiative
VBD	Vector-Borne Disease
VES	Vectors, Environment and Society
VL	Visceral Leshmaniasis
WASP	Weighted Anomaly of Standardized Precipitation Index
WHA	World Health Assembly
WHO	World Health Organization
WMO	World Meteorological Organization

Executive Summary

In Tanzania, malaria continues to be a major public health concern with over 10 to 12 million clinical cases reported a year. Despite large-scale investments in prevention and control, opportunities to improve disease stratification and risk maps, early warning systems and impact assessments can still be further aided by leveraging climate and environmental information and by strengthening multi-sectoral partnerships to reduce the burden of this highly endemic disease.

Activities led by the Tanzanian Meteorological Agency (TMA) and the International Research Institute for Climate and Society (IRI) have recently combined available ground observations of rainfall and temperature with satellite and other proxies, pioneering new open-access products and creating one of the highest resolution and longest data records for Africa. In particular, outcomes of this work include:

- An unprecedented thirty-year time series of ten-daily rainfall and temperature data for every 10 km grid across the country;
- An online mapping service installed at TMA providing user-friendly tools for visualization, querying, and accessing information
- Increased technical capacity at TMA.

The new data products combined with other environmental factors, which can be readily monitored using remote-sensing products available through the National Aeronautics and Space Administration (NASA), can help deliver and support innovations in malaria prevention and control.

Recognizing that the generation of new information and decision-support tools does not necessarily guarantee their use, TMA, in collaboration with the World Meteorological Organization (WMO), the Health and Climate Foundation (HCF), NASA and IRI, proposed a critical stakeholder forum to solicit feedback on the data and recently launched products in support of climate resilience and improved health outcomes in Tanzania.

Workshop Objectives and Expected Outcomes

Overall meeting objectives

The primary objectives of the workshop were to showcase TMA's recently launched high resolution products, demonstrate examples of how they can be used in combination with NASA products for disease stratification, improved early warning systems and impact assessments, as well as to solicit critical feedback from the health community on their needs for climate, environmental and epidemiological information, in particular for use in malaria decision-making.

The three-day workshop consisted of four main components:

(i) Introduction to TMA's existing and new data, tools, and information products. This included presentations and discussion on the details of the new rainfall and temperature time series and visualization and analysis tools.

(ii) Training on the use of the tools for data analysis and visualization including environmental factors monitored using NASA satellite data. Technical sessions were dedicated to hands-on training where participants explored the different tools.

(iii) Engagement on the use of climate, environmental and epidemiological information to improve malaria stratification, early warning systems and impact assessments taking into account planning and budgeting cycles.

(iv) Soliciting feedback and needs from participants. This was envisioned to enable TMA, WMO, IRI and NASA to assess the value of the available tools and products to users and improve/add what is most relevant to stakeholders.

Expected outcomes

A key expected outcome of the workshop was to elicit a better understanding of current and future needs for climate, environmental and epidemiological information for use in malaria programs and other climate sensitive disease control efforts. In particular, a list of recommendations were sought on future research, implementation and product development for new and improved stratification maps, early warning systems and impact evaluations.

Organization and Sponsorship

The training and stakeholder workshop on the "Use of Climate Information in Malaria Stratification/Early Warning Systems/Impact Assessment for Malaria Interventions" was convened by TMA in collaboration with IRI, the Columbia Global Center for Africa (CGC-Africa) and Health Climate Foundation (HCF) with funding and technical support from WMO and NASA. Over 50 participants were invited to attend the three-day meeting in Dar es Salaam, October 16-18, 2013 with confirmed attendance by a total of 33 stakeholders. On the first day of the workshop, the Muslim holiday of Eid was observed by some participants.

Outcomes and Recommendations

Following presentations, technical hands-on sessions and open discussions, participants were asked for feedback in five priority areas. The following are the recommendations presented at the conclusion of the workshop:

1. What Can Be Improved in Terms of TMA Data and Products Going Forward?

- Standardize units across tools/products:
    - E.g. extraction unit – country, region (not province), district, ward, point, box, latitude-longitude.
    - Update shape files and maintain repository of old shape files for historical analysis.
    - Install hover capabilities for units (e.g. name of the district).
- Standardize legends across tools products:
    - Provide all relevant information in automated legend (e.g. for graphs).
- Standardize branding and citation for TMA products.
- Include information on distribution of met stations.
- Develop tools at ward level (in Zanzibar, at street level).
- Develop Enhance National Climate Services (ENACTS) at 5km resolution.
- Link global products onto TMA site from NASA-SERVIR and IRI Data Library (e.g. high resolution land cover and vegetation indices).
- Explore ability of TMA Map Rooms to serve other partner platforms (e.g. collecting malaria data platform developed in Zanzibar).

2. Future Needs for Climate, Environmental and Epidemiological Information for Use in Malaria Programs?

- Develop a district based Malaria Early Warning System (MEWS- based on WHO recommendations, including vulnerability, seasonal forecasts, climate/environmental monitoring and case surveillance) that can be tailored to specific needs of:
    - Tanzania mainland –for example, routine bulletin at district level twice a year.
    - Zanzibar –for example, high resolution analysis for hotspot identification.
- Impact assessment for malaria – improvements to methodology & validation in Tanzania.
- Risk mapping, Early Warning System (EWS), trend analysis and impact assessment for other climate sensitive health outcomes where relationships are known.
- Climate information for routine planning and to inform commodity alerts.

3. What type of capacity building and what skills are required?

- Capacity at the central expert operational level, provincial/district level.
- Capacity in the research community.
- Capacity at the community level to inform, interpret and use the information.
- Training vehicles for malaria control available to MoH and partners such as those developed by the International Center of Theoretical Physics, IRI Summer Institute, and AFENET, e.g.:
    - On-line courses
    - Dedicated modules
    - Manuals

4. Recommendations for future research?

- Climate science research (e.g. on rainfall onset and drivers of Tanzanian climate impacts at seasonal, decadal, and long-term climate change scales).
- Trend analysis of malaria decline and attribution.
- Identify and prioritize health outcomes for further research:
    - Vector borne disease
    - Infectious disease
    - Non-infectious disease and other outcomes

5. Recommendations for future collaborations?

- MoU between TMA and Ministry of Health needed (as being developed with Ministries of Water & Livestock), including data sharing policy.
- Meeting participants to identify core team (5 persons including TMA and MoH) to:
    - Explore concrete next steps
    - Draft ToR for Inter-agency Climate and Health Working Group
    - Ensure coordination with existing inter-sectoral structures (such as National Climate Change Adaptation for Health country team overseen by MoH and Ministry of Environment)
    - Support technical teams for specific deliverables – e.g. MEWS
- Joint proposal development for funding partnerships & future activities.
- Explore outreach to veterinary community (through SACIDS, One Health, etc).

Lesson Learned

In this section we present the lessons learned from the workshop based on the feedback provided during the sessions as well as a questionnaire that was administered at the end of the second day.

We divide the lessons learned into the following 3 categories:

1. Overall ratings of workshop participants' experience with TMA Map Room and IRI Data Library:

Workshop participants were asked to rate their overall experience with the TMA Map Room and IRI Data Library on a scale from 1 (very good) to 5 (very poor). The average rating provided by the workshop participants was 1.75. When asked to describe the rationale behind the rating they selected, the following comments are representative of those provided:

- "The TMA Map Room and IRI Data Library will provide a consistent source of temperature and precipitation data for all stakeholders."
- "The Map Room and Data Library will be very useful for risk stratification."
- "The Map Room will enable malaria stakeholders to forecast malaria epidemics."

2. Key products highlighted by workshop participants:

Workshop participants identified the following two products as potentially being most useful for malaria stakeholders: Malaria Early Warning System (MEWS) and Seasonal Climatic Suitability for Malaria Transmission.

The rationale for how the MEWS would empower malaria stakeholders included:

- "It will enable stakeholders to project and estimate the periods of malaria transmission."
- "It will enable stakeholders to advocate for more resources to prevent malaria epidemics."
- "It will enable resources to be allocated more efficiently."

Participants provided the following reasons for how the Seasonal Climatic Suitability for Malaria Transmission would empower stakeholders:

- "It will inform the implementation of anti-malaria interventions."
- "It will facilitate more accurate mapping of malaria risk zones in Tanzania."

3. How products could be linked to existing anti-malaria activities in Tanzania:

Several workshop participants from Zanzibar noted that the anti-malaria activities on the island had shifted from a focus on controlling malaria to a 'pre-elimination' phase. Given that the vast majority of the mainland of Tanzania has not progressed to this pre-elimination phase, consideration should be given to tailoring some products to the specific challenges that Zanzibar will encounter as they attempt to eliminate malaria on the island. One way this could be achieved would be by integrating the climate products into existing integrated platforms that inform the decisions of malaria stakeholders on Zanzibar. Lessons from this experience could be used to develop a similar integrated platform for malaria stakeholders on the mainland.

Workshop participants from the mainland of Tanzania indicated that decision-making by malaria stakeholders was often done at the district level. Therefore, if the climate products could be modified so that information could be presented by district it would increase the ability of stakeholders to directly use the climate information in their decision making process.

While the questionnaire administered at the end of the second day of the workshop provides some insights into an improved understanding of user needs, the relatively low number of participant responses collected (14) suggests further outreach to the larger stakeholder community may be necessary for a representative survey and analysis.

Conclusion

This training workshop provided a unique opportunity to engage the Tanzanian climate and health communities, in particular on advancing current risk maps of malaria, integrating climate and environmental factors into ongoing stratification efforts, providing improved information and tools for critical early warning systems and impact evaluations of interventions towards malaria control and elimination. In addition, we believe the overall recommendations from this workshop provide a significant contribution to better understanding practitioner and stakeholder needs for the use of climate and environmental information in improved health decision-making.

Opening Session

Day 1:

October 16, 2013 9:00 am -10:30am

Chairs of Morning: Augustine Kanemba, TMA and James Ngeleja, TMA Ministerial Advisory Board
Rapporteur of Morning: Barbara Platzer, Columbia Global Center-Africa

Opening Remarks

Haleh Kootval, World Meteorology Organization

Haleh Kootval thanked and acknowledged the participation of James Ngeleja (Acting Chairman of TMA Ministerial Advisory Board), Ibrahim Nassib (Acting Director General of TMA), Madeleine Thomson (IRI Research Scientist) and distinguished colleagues for their support in opening the meeting. She also expressed gratitude to the Government of Tanzania and congratulated TMA on behalf of the WMO Secretary General for this engagement. Ms. Kootval elaborated that the Public Weather Service within WMO has been eager to support the establishment and strengthening of collaborations between the climate and health communities in Africa, citing current work in Madagascar as an example of WMO support through the national Climate and Health Working Group (CHWG) which has prioritized monitoring and control efforts in malaria and plague.

Recognizing the importance of dialog and active collaboration between users and providers of climate information, Ms. Kootval indicated that this activity fit well within WMO's Global Framework for Climate Services (GFCS) with health as a priority sector. She indicated that this workshop, with a balance of technical presentations, hands-on exercise and open feedback, would hopefully provide an important opportunity to assess currently available climate and environmental products and identify what may still be lacking and what is most needed. Ms. Kootval concluded by wishing the participants a successful workshop and stated that WMO looks forward to its continued involvement and hopes to provide support where it can add value to this multi-sectoral partnership in reducing the burden of malaria and other climate-sensitive health outcomes.

Madeleine Thomson, International Research Institute for Climate and Society

Madeleine Thomson thanked and welcomed participants and distinguished guests to the opening session on behalf of the IRI and Columbia University, also providing

some background on the genesis of the workshop, highlighting it as an outcome of side discussions with the Director General of TMA, Agnes Kijazi, in 2011 following a regional meeting held in Addis Ababa, Ethiopia at UNECA on "10 Years On: Climate and Health in Africa." She shared that the discussions focused very much on practical needs and on how to best support and improve health outcomes in Tanzania. Dr. Thomson also indicated that while the discussions have advanced and that this activity leverages over a decade of work at the interface of climate and health, current products in development and the meeting's agenda itself are very much intended to be responsive to what is most relevant nationally. She elaborated that malaria is an entry point, but that there may be other health outcomes of interest and that stakeholder feedback should also guide how risk mapping, early warning or evaluation tools are prioritized.

Dr. Thomson thanked WMO and NASA for their funding support. She also shared that NASA colleagues, while not represented at the meeting in person owed to the constraints of the United States federal government shutdown, would be briefed on discussions and feedback from the stakeholders. Dr. Thomson also highlighted the Columbia Global Center-Africa as a regional resource and identified Barbara Platzer as a key point of contact there, based in Nairobi to facilitate current and emerging engagements. Dr. Thomson also expressed gratitude to the organizing support of the Health and Climate Foundation and funding from USAID and the President's Malaria Initiative (PMI) for earlier support in Tanzania. She concluded by extending a warm welcome and indicated that she and colleagues from Columbia and TMA would be on hand in the coming days and following the workshop to respond to suggestions and needs of the participants.

Welcome and Official Opening

The Acting Director General of TMA, Ibrahim Nassib, provided brief welcoming remarks on behalf of the Director General, before introducing James Ngeleja, Member of the TMA Ministerial Advisory Board (MAB) to officially introduce and open the meeting as the Guest of Honor on behalf of the Board Chair. In particular, Mr. Nassib thanked the organizers and sponsors of the meeting for traveling to Dar es Salaam and choosing Tanzania as the host of the workshop and this ongoing activity. He emphasized that malaria continues to be a major health concern with over 10 million cases a year despite large-scale interventions. He indicated that the timing of the rainy season is understood to be critical, with temperature likely impacting on the survival of vectors and rainfall on their production. Mr. Ibrahim encouraged the use of climate and weather information along with other sources to provide an opportunity for mitigation and historical analysis. He thanked the organizing committee once again for making the workshop a reality and concluded by inviting the Guest of Honor to official convene the meeting. He also indicated the Opening Session speakers would be on hand to answer questions from the media before the morning coffee break.

James Ngeleja, Acting Chairman of TMA Ministerial Advisory Board

Official Opening Statement:

Dear Representative of the Director General of Tanzania Meteorological Agency,
Representatives from of the Secretary General of WMO,
Representatives from NASA,
Representatives from Health Climate Foundation (HCF),
Representatives from the International Research Institute (IRI),
Directors and Managers of Tanzania Meteorological Agency,
Workshop Participants, Media, Ladies and Gentlemen:

It is my great pleasure to be given this opportunity to address this very important workshop, which has significant impacts to social and economy of the country. First of all, let me thank all of you for coming and participating in this important workshop and stakeholder meeting on the use of climate information in malaria stratification/early warning systems/impact assessment for malaria interventions.

Dear Workshop Participants, Ladies and Gentlemen:
Many parts of Africa are prone to devastating malaria epidemics. United Republic of Tanzania has no exception and since it is mostly located in the tropical climate with high rainfall variability, malaria is susceptible. The pattern of disease transmission is also seen to vary considerably when extreme climatic events occur. This is evident for some areas of high grounds on Northeastern and Southwestern of the country. In such susceptible areas, malaria epidemics occur when climatic conditions suitable for transmission become unusually favorable. Such unusual circumstances exert exponential pressures on existing health systems' ability to cope. Not only the health resources adversely affected but there are also severe repercussions on the economy.

This situation further signifies the need of early warning system, which will enable the relevant health authorities to respond timely to such epidemics. Because malaria is highly associated with climate, climate based epidemic warning systems can help to reduce the impacts. To develop and test such a system, good long-term malaria and climate data are needed. Lack of meaningful long-term malaria data in the region makes prediction difficulty.

Distinguished Guests, Workshop participants, Ladies and Gentlemen:
The collaboration between Tanzania Meteorological Agency and these four institutions namely WMO, IRI, NASA and HCF on this program signifies importance, the country has attached to adaptation and mitigation measures of the changing climate particular on health.

I would also like to welcome all participants and resource persons to this workshop and express my sincere gratitude to you all for your willingness to attend this course in order to understand the science of climate change and its implications to health especially malaria so as reduce its impact and enhance people's health, ultimately will enhance sustainable socio-economic development of our country. It is obvious that climate has no political boundaries and similarly the impacts of climate change have no boundaries, its effect can be felt anywhere in the world. However, developing countries are more vulnerable due to limited resources and poor infrastructure to cope with the impacts of climate change. In this regard, there is a need to put extra effort in understanding the expected changes and suitable adaptation and mitigation measures to reduce the impacts of climate change on malaria in our country hence the importance of this training workshop.

Workshop Participants, Ladies and Gentlemen:
I am told that during the training workshop you will consider four main components:

- Introduction to TMA's existing and new data, tools, and information products. This will include presentations and discussion on the details of the new rainfall and temperature time series and visualization and analysis tools.
- Training on the use of the tools for data analysis and visualization including environmental factors monitored using NASA satellite data. Technical sessions will be dedicated to hands-on training where participants will explore the different tools.
- Engagement on the use of climate, environmental and epidemiological information to improve malaria stratification, early warning systems and impact assessments taking into account planning and budgeting cycles. Soliciting feedback and needs from participants. This will enable TMA, WMO, IRI and NASA to assess the value of the available tools and products to users and improve/add what is most relevant to stakeholders.

The Director General, Workshop Participants, Ladies and Gentlemen:
I am forced to believe that the output of this training workshop will be to get a better understanding of current and future needs for climate, environmental and epidemiological information for use in malaria programs and other climate sensitive disease control efforts, through capturing feedback and recommendations for further potential research, product development and collaborations.

As Guest of Honor, let me take this opportunity to say thank you once again for accepting my invitation, also to thank all participants and without forgetting the sponsors of this workshop which are TMA, WMO, and HCF, lastly the workshop organization committee for ensuring well placed issues.

Let me conclude by official opening of this workshop.

You are warmly welcome. Karibu sana!

Summary of Technical Sessions and Panel Discussion

Day 1: Overview

October 16, 2013 10:30 am – 12:30pm

Introduction to the Workshop

IRI's Pietro Ceccato opened the Technical Session by requesting that participants introduce themselves. He and Tufa Dinku then provided an overview of the workshop's objectives, its organizing institutions and format, including the four major components identified in the agenda (Introduction to TMA data and tools; Training on the use of the tools for data analysis and visualization; Engagement on the use of climate, environmental and epidemiological information to improve malaria decision-making; and Soliciting feedback from participants). Dr. Ceccato indicated that a final meeting report would be circulated within a few weeks of the workshop and that presentations and contact information of the participants would also be shared to facilitate further collaborations.

Abstract Title: **The Need for Climate and Environmental Information for Malaria Control in Tanzania**
Speakers: Renata Mandike, Ministry of Health, National Malaria Control Program

The burden of malaria in Tanzania is significant and a leading cause of malaria morbidity and mortality. Over the past decade, Tanzania has been able to scale up recommended preventive and curative interventions and achieved universal access. Overall, the scale up of interventions has contributed to the declining trend of the prevalence of malaria in under five children from 18% in 2007/8 to 10% in 2011; the contribution of other key parameters such as climate in these estimates remain unclear.

Furthermore, an analysis of malaria risk has been developed for 2000 and 2010 at district level, indicates that the population living in areas with intense malaria transmission has decreased and that there are still some areas of the country (western and southeastern Tanzania) where intense transmission still exists. In order to further reduce the malaria burden in the country, further understanding of the various factors that contribute to the heterogeneity in malaria risk, particularly in areas where limited change have occurred during the decade receives its importance. A more effective means of incorporating climate information into malaria policy making can enable us to address these challenges.

Availability of Climate and Environmental Data and Information:

Abstract Title: **The Seasonal Forecast for September-November 2013 and its Implications for Public Health**
Speakers: Hellen Msemo, TMA

Climate and climate extremes affect human health in a number of ways, both direct and indirect. Weather and climate forecasts on the other hand, if given in good time provide an opportunity to plan mitigation measures before the season begins. Nevertheless, user needs depend on the sector and the intended application of a forecast, for example, predictions of monthly averaged precipitation for periods of a season to a year in advance can be highly useful for applications to agriculture, hydroelectric power generation, flood control, and mosquito control, etc.

In the health sector, seasonal weather forecasts can be useful in various activities including in improving surveillance on diseases that are affected by climate variability such as malaria, dengue fever, meningitis, diarrhea, etc. This information can be leveraged to develop climate-related early warning systems as part of adaptation measures to cope with climate variability. It can also be used to undertake aggressive targeted public awareness, set alerts, preparedness and response measures to the identified risks to enhance public resilience and mitigate against the burden from weather extremes and can help to intensify cross border collaboration for common challenges.

The October, November, December (OND) 2013 rainfall seasonal forecast, for example, issued by the Tanzania Meteorological Agency in early September this year indicated that most areas are expected to receive normal to below normal rainfall. In the upcoming rainfall season forecasted disease outbreaks such as cholera, malaria epidemics, diarrheal diseases, and communicable diseases such as skin infection, eye conditions, malnutrition and respiratory tract infections are anticipated to occur.

However, for increased utilization and optimal benefit from weather and climate forecasts, there is a need to undertake a deliberate effort to advocate with decision-makers to better understand the contribution of weather and climate information to health outcomes and thus prioritize adequate resource allocation. There is also a need to enhance collaboration for improved interactions and information sharing for risk reduction and coordination at regional and international levels and between relevant national institutions in order to succeed in the development and effective application of climate products and forecasts for the health sector. Furthermore, there is a need for all sectors to agree on data sharing for the optimal benefit of both partners and the public in general.

Abstract Title: **Presentation of New Climate Information and ENACTS Products for Tanzania**
Speakers: Augustine Kanemba, TMA, and Tufa Dinku, IRI

Climate observation networks in Tanzania face many challenges that limit the ability to use climate information in development practices. The number of weather station is insufficient and has been declining. The distribution of existing stations is uneven, with most stations located in cities and towns along major roads. Thus, lack of coverage tends to be worse in rural areas where livelihoods are the most vulnerable to climate variability. Where station records exist, data quality and access is often lacking and records can suffer from gaps in space and time.

Satellite proxies, particularly for rainfall, are therefore often used. Satellite data sets provide spatially continuous coverage, but have limitations that include accuracy, temporal in homogeneity, and length of time series.

TMA in collaboration with the IRI has been making efforts to alleviate these problems. Data availability has been improved by combining available ground observations of rainfall and temperature with satellite and other proxies. Data access and use has been improved by pioneering new open-access through TMA's web page. The outcomes of this work include:

- An unprecedented thirty-year time series of ten-daily rainfall and temperature data for every 10 km grid across the country;
- An online mapping service installed at TMA providing user-friendly tools for visualization, querying, and accessing information
- Increased technical capacity at TMA.

The online tool currently includes three map-rooms for: Climate Analysis, Climate Monitoring, and Climate Forecast. The Climate Analysis Map Room provides information on the mean climate (in terms of rainfall and temperatures)- at any point national and sub-national levels. It can also show the performance of the rainfall seasons over the years as compared to the mean. The Climate Monitoring Map Room enables monitoring of the current season. Different maps and graphs compare the current season with the mean or recent years. This information could be extracted at any point or for any administrative boundary. Data is updated every ten days, thus enabling close monitoring of the season. Extracting and presenting information at any administrative level enables focusing on specific area of interest. The Climate Forecast Map Room translates the seasonal forecasts to values that can be easily understood by users. It presents the forecasts in the context of historical rainfall data. This information can be analyzed and extracted at national or sub-national levels.

Questions and Discussions:

Key questions/items raised following the individual presentations included:

- TMA requested clarification from the MoH National Malaria Control Program (NMCP) on what indicators are used to measure progress. Dr. Renata indicated that these are set by the WHO Rollback Malaria partnership and vary by country. Some national efforts, and also Zanzibar, are prioritizing complete elimination. For the mainland in Tanzania, the strategy and targets are based on control and include slide positivity rates as a key indicator.

- WMO emphasized that while malaria and seasonal climate information may be an entry point, severe and extreme weather may also be relevant, including for other health outcomes. WMO also indicated that TMA is able to provide severe weather forecasting in partnership with the WMO East and Southern Africa Regional Office based on high quality Global Modeling outputs and that these could also contribute to robust early warning systems.

- RTI requested clarification on whether refined data was available for forecasting at the district and sub district level and what was understood to be a timely dissemination of data. TMA clarified the methodology of the seasonal forecast and indicated that the October-November-December (OND) forecast was available in September. NIMR-Tanga also requested information on what constitutes normal, below/above normal rainfall. TMA and IRI provided an explanation of how the probabilistic forecast is broken into tercile categories based on what is normal based on historical averages for that data point.

- NIMR-Tanga requested further information on point forecasts and also asked to clarify if there are areas where sentimental health data as well as climate observations are being collected. TMA indicated that there are observations in each district but that the spatial distribution is still limited in terms of raw rainfall and temperature data within some districts and that the ENACT tool provides a resolution now of 10km. RTI offered the example of Zanzibar as an area of investment where malaria and microclimate data is being collected to better identify and understand hotspots.

- NIMR-Tanga also asked how TMA currently disseminates information beyond occasional media communications. TMA clarified that sector advisories are issued and bulletins shared on its website in English and Kiswahili. Stakeholder meetings are also held when the seasonal forecast is issued and invitations to these are sent to the Permanent Secretary of each Ministry. Recognizing that not all users are being reached with these traditional means, TMA expressed interest in better understanding how users receive or prefer to receive information.

- The availability of continuous data records for the health and climate sectors

was also discussed. Health stakeholders inquired why there was a focus on 30 years of climate data. IRI clarified this was an agreed standard variable, but mostly a convention and that it was also possible to focus on 15 or 20 years of data. The ENACT product was available specifically for 30 years owed to the access of satellite information over that period but that this would be updated moving forward to create an even longer time series. NIMR-Tanga asked specifically if there was an absence of observational data for an area of interest over a specific time period, if an estimate could be provided based on modeled data. TMA responded that this was possible and the training over the coming days would provide insight into how this could be done. TMA shared that it also had experiences of gaps in health data and constraints of access. MoH-NMCP indicated that malaria data was mostly available through the 1980s and to some extent the colonial period and that partnership was needed to work together on a climate-malaria historical analysis.

Chair of Afternoon: Haleh Kootval, WMO
Rapporteur of Afternoon: Derek Willis, IRI/CRED-Columbia University

October 16, 2013 2:00 pm – 3:15 pm

Abstract Title: **The Use of Climate and Environmental Products for Stratification Maps/Early Warning Systems/Impact Assessment– including Multiple Timescales**
Speaker: Madeleine Thomson, IRI

Malaria is widely identified and studied as the most climate sensitive vector-borne disease. This ancient disease occurs in geographic malaria parasite: the seasonality of disease, differences form one year to another and in some regions long term trends, are often governed by climatic factors such as rainfall, temperature and humidity.

Public health policymakers and practitioners are increasingly concerned about the potential impact of climate, environmental and social changes on the effectiveness of current and future control and elimination programs. Climate change adaptation program are increasing in scope and resourcing. However, many control programs) of climate sensitive diseases (such as malaria) and much of climate change adaptation is not informed by grounded knowledge and information on the climate.

Climate is only one of many important drivers of malaria (others include education, migration, land use change, control measures etc.). However, climate is unusual in that it has the potential to be integrated into health sector information systems because a) the nature of climate: its climatology, seasonality, diurnal rhythm and potential predictability at multiple time scales (weather, seasonal, decadal and climate change) and b) the fact that it is routinely measured in a systematic way by land observations, remote sensing and global model outputs all around the world.

Consequently climate information has the potential to inform a wide range of health decisions. Enhanced National Climate Services products in Tanzania (rainfall and temperature) have the potential to transform the capacities of the National Meteorological Agency (TMA) in its delivery of services to the health community. Here we outline the potential of using climate information for improved health decision-making, using malaria as an example. Climate information could be used to improve the following:

- *Mechanisms*: Improved understanding of the mechanisms of disease transmission which can help identify new opportunities for intervention.
- *Spatial Risk*: Understanding the geographic locations of populations at risk can improve the targeting of interventions.
- *Seasonal Risk*: Understanding the seasonal timing of risk in an average year can improve timing of routine interventions.
- *Sub-seasonal and Year to Year changes in risk*: Understanding when changes in epidemic risk are likely to occur can help initiate appropriate prevention and response strategies.
- *Trends in risk*: Understanding long term drivers of disease occurrence (including climate changes) can help plan long term prevention and response strategies.
- *Assessment of the impacts of interventions*: As part of prudent impact assessment exercise climate can be factored in as it enables or limits disease transmission.

Opportunities for the use of climate information in malaria prevention, control and elimination in Tanzania are discussed based on experiences to date in Tanzania and other African countries.

Questions and Discussions:

A key question raised following the presentations included:

- NIMR-Tanga asked if a tool could be developed that could quantify the number of heavy rain days above a defined threshold to identify breeding sites that may be flushed out.

Day 1: Panel Discussion

October 16, 2013 3:45 pm – 4:45 pm

A moderated discussion was facilitated by Martha Lemnge, NIMR Tanga Centre, and Augustine Kanemba, TMA, to stimulate discussion on opportunities for collaborations between the climate and health communities. Each also presented initial slides on examples of existing partnerships and ideas for further exchange.

Dr. Lemnge highlighted during her presentation the importance of developing a stronger collaboration between the National Malaria Control Program and the TMA. She also noted that Clim-Health Africa, as well as other emerging networks and consortia, could provide an effective means of strengthening communication and engagement with policy makers. Finally, Dr. Lemnge indicated that areas for future collaboration include: development of sentinel sites for surveillance of malaria transmission, cross-border malaria surveillance, the development of malaria early warning systems, the evaluation of the impact of anti-malaria interventions and capacity building.

Mr. Kanemba presented a framework for understanding the inter-disciplinary approach that would be necessary in order to link the climate and malaria communities. This inter-disciplinary framework would include contributions from the following disciplines: climate science, epidemiology, statistical modeling, entomology and parasitology.

Questions and Discussions:

Key items raised during the moderated discussion:

- Several workshop participants indicated the potential need to incorporate climate data into new initiatives aimed at improving cross-border surveillance of malaria. The WMO is also considering new means of sharing information in border areas so that residents receive consistent messages from neighboring countries.

- Given the high quality of data available for the location of malaria cases in Zanzibar, climate products could potentially facilitate the identification of 'hot spots' on the island. Once identified, these 'hot spots' could then be targeted by anti-malaria interventions and, potentially, enable Zanzibar to achieve its goal of eliminating malaria transmission.

- The quality of data available from surveillance activities on the mainland of Tanzania is not as high as the data available on Zanzibar. Therefore, a different set of climate products may be necessary for the mainland of Tanzania that are tailored to the current needs of the malaria stakeholders.

- The need for an ongoing communication between TMA and malaria stakeholders was highlighted by several participants in order to continue to learn how the climate products could be tailored to the needs of the stakeholders.

- Several participants who are researchers noted that linking the climate data with malaria data collected at sentinel sites could be one means of conducting a more rigorous evaluation of the relationship between climate and malaria transmission.

Day 2: Hands-On Training

October 17, 2013 8:30 am -12:30 pm

Chair of Morning: Madeleine Thomson, IRI
Rapporteur of Morning: Wilbert Timiza, TMA

Access to Data and Information Products:

Abstract Title: **Introduction to Remotely-Sensed Data**
Speaker: Pietro Ceccato, IRI

This lecture introduced the basis to understand remotely-sensed images derived from satellites at different spatial and temporal resolutions. The lecture also provided background information about methods developed to monitor and estimate: *i*) rainfall, *ii*) temperature, *iii*) water bodies and *v*) vegetation for integration into human health analysis. The introduction included the concept of electromagnetic wave spectra (with the visible, thermal and near infrared wave lengths identified as useful for vegetation monitoring and the microwave length identified as useful for monitoring water content). The lecture also provided background on sensors and which ones are available through certain satellites (e.g. MODIS available on Aqua and Terra through NASA), as well as information on which satellites are geostationary (fixed at a location above the equator and able to take a picture every 15 minutes) and which are polar orbiting. Examples of operational applications at different spatial resolutions were given (with free and commercial products). Remotely-sensed temperature and rainfall estimates and monitoring of water bodies (using Landsat) and vegetation (using the Normalized Difference Vegetation Index) were presented for their application in malaria control and prevention.

Abstract Title: **Introduction to NASA SERVIR & Online Demonstration**
Speaker: Pietro Ceccato, IRI

Inter-annual and seasonal climate variability influences the physical and biological environment and provokes changes that threaten socio-economic systems and livelihoods. Health is a prime example where drought, or flooding, can have profound implications for vulnerable populations in the developing world. Information on these changes is useful for the operational agencies that try to mitigate the adverse impacts of such events. This presentation showed how remote sensing is used at NASA SERVIR and IRI Data Library to monitor rainfall, vegetation, temperature and water bodies and how these products are integrated into Early Warning Systems for Human Health Management and made accessible to user community. More information and NASA SERVIR data Library can be accessed through the link; www.servirglobal.net/africa.

Questions and Discussions:

Key items raised following the presentations included:

- NIMR-Tanga expressed interest in vegetation tools for monitoring malaria transmission, seeking further clarification how water bodies could be monitored in Tanzania in higher risk areas and how these tools could also be used to assess previous outbreaks (e.g. in 2006).

- Participants sought clarification on availability of data over certain periods and at different resolutions (rainfall, temperature, ENACT product, MODIS-vegetation, Landsat). IRI provided background on the history of remotely sensed products (available from the late 1970s on) and on what spatial resolutions are currently possible and which may be pursued with further product development. The issue of access to metadata was also raised, along with data storage and protocols for access. NIMR-Tanga also inquired about how to select the best data and tools, with increased resources available- in particular how to sort through and analyze satellites images for operational impact. RTI asked about how to reference and integrate geo-spatial information that is compatible with currently collected health data.

- TMA raised the question of how satellite estimation products are able to overcome the challenge of measuring rainfall in the tropics with the presence of warm clouds. IRI indicated that satellites systematically underestimate rainfall over Tanzania, but that ground observations allowed these products to be better calibrated along with algorithms that define thresholds for which and where clouds might produce rain (e.g. this will be different in highland and cold regions like Arusha versus Dar es Salaam).

Abstract Title: **Introduction to the IRI Map Rooms & Online Demonstration**
Speakers: Tufa Dinku and Rémi Cousin, IRI

This talk presented the IRI Data Library[1] and the Climate and Health Map Rooms[2]. The Data Library is a powerful and freely accessible online data repository and analysis tool that allows a user to view, manipulate, and download the world's broadest collection of accurate climate data together. It contains a wide variety of publicly available data sets, including station and gridded atmospheric and oceanic observations and analyses, model-based analyses and forecasts, and land surface and vegetation data sets, from a range of sources. It also has a suite of analytic tools and an unmatched ability to transform and integrate that data with sectoral data to meet user needs. The Data Library facilitates data exchange between systems and communities and its use was specifically demonstrated in epidemiological research

[1] http://iridl.ldeo.columbia.edu
[2] http://iridl.ldeo.columbia.edu/maproom/Health/

and public health planning. The broader IRI Map Rooms were also briefly introduced, specifically on: Climate Analysis, Monitoring and Forecasts; IFRC Forecasts; El Niño/Southern Oscillation (ENSO); Food Security; Climate and Agriculture; Climate and Fire; Climate and Health.

Abstract Title: **Introduction to the TMA Map Rooms & User Interface**
Speaker: Tufa Dinku and Rémi Cousin, IRI, and Victor Masam, TMA

This talk presented the TMA Data Library[3] and the TMA Climate and Health Map Rooms[4] and introduced current products available for Tanzania. Importing IRI technology, TMA currently offers a Climate Map Room, along with a dedicated Climate and Health Map Room. The Climate Map Room itself has three components: Climate Analysis, Climate Monitoring, and Climate Forecast. The Climate Analysis Map Room provides information on the mean climate (in terms of rainfall and temperatures), at dekadal and monthly time scales and for any point or administrative boundary. It can also show the performance of the rainfall seasons over the last 30-years as compared to the mean. The Climate Monitoring Map Room enables monitoring of the current season. Different maps and graphs are available to compare the current season with the mean or recent years. This information can be extracted at any point or for any administrative boundary. Data is updated every ten days, which enables close monitoring of the season. The Climate Forecast Map Room translates the seasonal forecasts to rainfall values that can easily be understood by users. It presents the forecasts in the context of historical rainfall data. Another Map Room in this section highlights the connections between ENSO phases and rainfall distribution in Tanzania, however only derives from Pacific Ocean temperatures. There is the opportunity to further develop this product with other variables impacting on Tanzanian climate, but the current Climate Forecast Map Room can serve as a resource to policy makers and the public for its translation of probabilistic forecasts to expected rainfall amounts.

Practical Exercises and Training:

At the end of the morning session of Day 2, participants were guided through practical exercises on the TMA Map Rooms and IRI Data Library that included the Climate Analysis Map Room, Climate Monitoring Map Room and Climate Forecast Map Room. This session was led by IRI's Tufa Dinku and Rémi Cousin, as well as by TMA's Victor Masam.

[3] http://maproom.meteo.go.tz/maproom/
[4] http://maproom.meteo.go.tz/maproom/Health/index.html

Questions and Discussions:

Key items raised following the presentations included:

- Participants raised the question again of access to raw data behind the visualization tools. Items such as cost sharing and data policies were discussed, along with how tool development could be prioritized in terms of user needs.

- Participants inquired if further information on the distribution of met stations and observations could be provided and asked for clarification on how the ENACT product performs in areas where stations are not dense (and the impact on rainfall and temperature data for Zanzibar and border regions in particular).

- RTI requested confirmation that analysis could be done on both a grid selection and point. NIMR-Tanga requested further information on the mechanics of what drives climate in Tanzania and the linkages of seasonal rainfall to Sea Surface Temperatures in the Pacific Ocean.

Chair of Afternoon: Tufa Dinku, IRI
Rapporteur of Afternoon: Anna Estes, Nelson Mandela African Institute of Science and Technology

October 17, 2013 2:00 pm -3:30 pm

Practical Exercises and Training continued:

During the afternoon of Day 2, participants continued with practical exercises on the TMA Map Rooms and IRI Data Library that included the Climate Suitability for Malaria Map Room, Weighted Anomaly of Standardized Precipitation Index (WASP) tool and monitoring resources for vegetation and water bodies. Participants were actively encouraged to compare the IRI and TMA products and evaluate their use relevant to their needs. This session was led by IRI's Madeleine Thomson, who additionally provided background on early adoption of web-based climate information tools for malaria control.[5]

October 17, 2013 4:00 pm -5:00 pm

Q&A and Open Feedback on Data and Products

Participants were asked for any clarifying questions related to the day's

[5] http://www.malariajournal.com/content/5/1/38

presentations and feedback was solicited on the relevance and functionality of the data and products discussed. Key questions/items raised included:

- The need for a national Malaria Early Warning System (MEWS) was raised by RTI and participants discussed this area of potential investment and collaboration as a means of preparing for seasonal outbreaks and understanding drivers, also at the district level.

- The question of how to quantify the impact of climate as a confounding variable was raised. IRI indicated that understanding the contribution of climate versus other interventions and factors was a difficult exercise that requires modeling (and cited an example from Ethiopia, in which a detailed analysis attributed roughly 60% of the decline in malaria cases to rainfall).

- The issue of dissemination of climate information and alerts was raised with participants underscoring the need to consider end-users and experts in diverse sectors, as well as ultimately beneficiaries. The metaphor of building a bridge to support partnerships and different levels of expertise was used. A twice yearly bulletin with information at the district level and on the onset of the rainy seasons was prioritized as a concrete next step for TMA to take. Participants also gave examples of already existing technical inter-agency project driven discussions.

- Swiss TPH emphasized that the TMA Map Rooms and products should serve other platforms already in use and in development in disease mapping and prevention. It was also emphasized that TMA tools should be updated (e.g. with forthcoming shape files from the Bureau of Statistics) and data archives maintained.

- Specific feedback on TMA products and tools included the request for standardization of units of interest (also labeling of regions, not provinces in Tanzania), being able to select sub-regional and administrative geographic areas of interest and not just grid points, the need for national trend and WASP analyses and an identified interest in extending the ENACT product to 5km resolution or ward level (especially in Zanzibar). The importance of baseline selection to final analysis was emphasized by the Ministry of Health and IRI reinforced that beyond product development there may also be key research questions to follow up in better understanding climate drivers in Tanzania.

- TMA indicated a Memorandum of Understanding (MoU) should be advanced with the Ministry of Health to support collaborations. Participants also urged for a clear articulation of data access and sharing protocols.

- Participants indicated a next step may also be to identify priority diseases and health outcomes beyond malaria control and prevention, including the engagement of the veterinary community and One Health agenda (e.g. on RVF).

Workshop Questionnaire & Assignment:

At the end of Day 2, participants were given a brief anonymous questionnaire, included here in the Appendix, intended to assess the value of the workshop and to better understand which of the products presented were most useful, how these could further be improved and the ability of participants to access them and integrate them into their decision making processes.

Additionally, participants were asked to reflect on the assignment below before final recommendations were drafted during the Closing Session on Day 3.

Questions included:

1. What can be improved in terms of TMA data and products already developed?
2. Identification of future needs for climate, environmental and epidemiological information for use in health programs?
3. What type of capacity building and what skills are required?
4. Recommendations for future research?

Day 3: Hands-On Exercises

October 18, 2013 8:30 am -10:00 am

Practical Exercises and Testing of TMA Products:

During the morning of Day 3, Madeleine Thomson reviewed the history of the IRI Gap Analysis done in 2006, in which the decision making community identified gaps in malaria policy practices. These included: 1) gaps in integration of climate into policy, 2) gaps in integration of climate risk management into practice at scale, 3) gaps in climate services and 4) gaps in underlying data. While the products presented had partly addressed the gaps in services and data, the incorporation into district level decisions (gap 2) had repeatedly been mentioned throughout the workshop.

Pietro Ceccato reviewed an outline for a Malaria Early Warning System, which had been discussed throughout the workshop as a necessity on the district level. The

Early Warning System includes four components: 1) case surveillance 2) rainfall monitoring 3) seasonal climate forecast 4) vulnerability, pre-season assessment (risk stratification, seasonality, resistance, control measures, drought that creates vulnerability, floods, and hotspots). He highlighted that rainfall and temperature monitoring is already available on the IRI website, and the TMA website at a higher resolution. The IRI website also has some limited vulnerability information on insecticide and drug resistance as well as vegetation, vectoral capacity, and observed malaria morbidity at a pan-African level. An example was given of an early warning system for locusts which gives detailed current weather and ecological conditions as well as the forecast. Tufa Dinku pointed out that most of the components are already there for malaria early warning, and need to be assembled into a bulletin.

During the follow up discussion RTI stated that the next step is to develop the tools and that training will be required, which could be facilitated by NMCP and TMA. IRI clarified that these trainings would need to take place on the district level. RTI mentioned that a chapter on MEWS already exists in the National Malaria Standards but it needs to be operationalized. RTI also stated that a necessary first step would be the ability to download the climate data from the Map Room. TMA suggested that a team of both health and climate experts would be necessary to facilitate this process. IRI suggested that this process must take place on multiple levels: the need to complete the project by a certain date as well as need to build broader community capacity for response in the long-term.

It was pointed out that the National Framework for Climate Adaptation already exists, and NIMR asked for clarification as to whether the climate/health committee being proposed would be different than the one formed as part of the strategic plan and emphasized the importance of having the Ministry of Health involved. NIMR also stated that typically the NMCP leads the way and identifies experts that can contribute and emphasized the importance of identifying a lead in the effort to minimize fragmentation of efforts. NIMR emphasized the importance of involving research early in the implementation process, and RTI stated that they have several key research areas within their surveillance activities.

RTI inquired whether Zanzibar and mainland will have two different MEWS systems, due to the differences in the two situations i.e. Zanzibar already has a platform in place and is working towards elimination. IRI suggested that experiences in Zanzibar can inform the development of a system for the mainland. RTI and IRI emphasized that for Zanzibar in particular high spatial resolution and a strong research component to understand the factors that are driving malaria is required. RTI mentioned that a strong relationship already exists between the Zanzibar Malaria Control Program and TMA.

After this a more technical discussion ensued in which Tufa Dinku clarified how the rainfall data is combined between the TMA station data and the satellite data. NIMR

asked for clarification on whether this technique was sufficient to not require any further stations placed in the country. TMA and IRI clarified that the values in proximity of the stations are the most accurate and that while more stations would be ideal the distribution of stations was as important as the number of stations. IRI also suggested that adding more stations could be a way to test the ENACT product and clarified that ENACT is best used when aggregating points at some spatial scale whereas station date is best for point data.

When asked for feedback as to which tool was most problematic NIMR stated temperature. IRI stated that temperature satellite data going back 30 years is not available and thus a 10-year average of MODIS data and elevation is utilized. The WASP tool was also identified as necessitating further explanation. Madeleine Thomson clarified that the WASP tool was developed to demonstrate the importance of choosing a baseline to clearly define droughts and was meant for national level analyses. Thus the WASP tool exemplifies the importance of context but is not intended as a simple decision making tool.

Feedback and Closing Session

October 18, 2013 10:30 am -12:30 pm

Chair of Morning: Jeremiah Ngondi, RTI International Tanzania
Rapporteur of Morning: Nada Petrovic, IRI/CRED-Columbia University

Potential Uses of Climate and Environmental Information in Health:

TMA's Augustine Kanemba and IRI's Pietro Ceccato facilitated an open discussion on feedback and IRI's Derek Willis provided a summary of inputs collected from the workshop questionnaire. The group also explored the creation of a Climate and Health Working Group, an inter-agency collaboration active in Ethiopia, Kenya and Madagascar.

RTI opened the discussion by asking what skills were required for capacity building, a theme that was raised continuously throughout the workshop. NIMR asked for clarification in terms of the type of capacity required and then indicated that while malaria-specific data is currently being collected, climate indicators are not.

NIMR also emphasized the need for tailor-made training and workshops that should be co-organized to minimize duplication, as well as a need for practical training for PhD students. IRI offered examples of practical training opportunities they have offered including a Summer Institute at IRI, in which health practitioners were trained, as well as modules it has developed, including for a climate modeling workshop held at the International Centre for Theoretical Physics (ICTP). Victoria Mwakalinga, a participant in the ICTP workshop, emphasized the usefulness of this

experience. IRI also mentioned the possibility of other opportunities available through partnering with the African Field Epidemiology Network (AFENET).

TMA inquired whether it was possible to accommodate more people using online learning. IRI responded that there are some interfaces (including http://ciphan.iri.columbia.edu/), but that funding is often a limiting factor. NIMR mentioned other online epidemiological courses that are available internationally. NIMR emphasized the need to register more Masters and PhD students and the need to include local academic institutions.

TMA emphasized the importance of strengthening coordination on the ground and evaluating whether the data and products available through the TMA Map Rooms are sufficient and how they can best be utilized within the framework of an early warning system. TMA also mentioned the potential to expand to other climate sensitive diseases (e.g. Rift Valley Fever, cholera) as well as the importance of bringing in the Ministry of Health. NIMR and RTI stated that it is vital to understand what kinds of products would be best for end-users, to understand what would be the next step beyond the Map Rooms.

IRI spoke about the experience in Ethiopia and emphasized the importance of maintaining collaboration in the region rather than having one-off workshops. RTI summarized that in addition to high level training opportunities, there was a need for regular workshops that could create products that could be disseminated and a need for training for consumers and end-users of this information. IRI supported the previously raised suggestion of a bulletin at the district level. TMA emphasized that users must define what they need in order to make the product, while the Ministry of Health and Social Welfare (MoHSW) echoed the need to link information to a district system that could be easily accessible, and could link to other diseases.

This session also included a discussion of platforms for integrating data from different facilities, with an emphasis on a reciprocal process in which mobile phones could be used to send and receive climate and health data. TMA mentioned that there is already use of mobile phones to disseminate agricultural information and weather warnings. RTI inquired whether it would be possible to use this infrastructure to send health-related climate information.

Finally, NIMR emphasized that in order to achieve these goals, it was important to ensure funding and develop joint proposals in specific areas of common interest.

Key items discussed during this session included:

- The need for training modules to increase local capacity, both technical training for academics (including PhD students) and training for district-level end users to understand how to use these products in a decision making context.

- The need for platforms to integrate available data and distribute it to end-users, as well as possibilities for taking up data from end-users using mobile technologies.
- The need for writing joint proposals in order to ensure there is funding for research and applications in these common areas of interest.

Final Recommendations:

Below is a summary of final recommendations that were presented at the conclusion of the workshop, capturing feedback from the participants over the course of the three day workshop. Discussion on the recommendations was led by CGC-Africa's Barbara Platzer, TMA's Augustine Kanemba and IRI's Pietro Ceccato. The draft recommendations were also circulated to participants by email following the closing session, allowing for additional comments and feedback before inclusion in the final report.

1.What Can Be Improved in Terms of TMA Data and Products Going Forward?

- Standardize units across tools/products:
    - E.g. extraction unit – country, region (not province), district, ward, point, box, latitude-longitude.
    - Update shape files and maintain repository of old shape files for historical analysis.
    - Install hover capabilities for units (e.g. name of the district).
- Standardize legends across tools products:
    - Provide all relevant information in automated legend (e.g. for graphs).
- Standardize branding and citation for TMA products.
- Include information on distribution of met stations.
- Develop tools at ward level (in Zanzibar, at street level).
- Develop Enhance National Climate Services (ENACTS) at 5km resolution.
- Link global products onto TMA site from NASA-SERVIR and IRI Data Library (e.g. high resolution land cover and vegetation indices).
- Explore ability of TMA Map Rooms to serve other partner platforms (e.g. collecting malaria data platform developed in Zanzibar).

2. Future Needs for Climate, Environmental and Epidemiological Information for Use in Malaria Programs?

- Develop a district based Malaria Early Warning Systems (MEWS- based on WHO recommendations, including vulnerability, seasonal forecasts, climate/environmental monitoring and case surveillance) that can be tailored to specific needs of:

        - Tanzania mainland –for example, routine bulletin at district level twice a year.
        - Zanzibar –for example, high resolution analysis for hotspot identification.
- Impact assessment for malaria – improvements to methodology & validation in Tanzania.
- Risk mapping, Early Warning System (EWS), trend analysis and impact assessment for other climate sensitive health outcomes where relationships are known.
- Climate information for routine planning and to inform commodity alerts.

3. What type of capacity building and what skills are required?

- Capacity at the central expert operational level, provincial/district level.
- Capacity in the research community.
- Capacity at the community level to inform, interpret and use the information.
- Training vehicles for malaria control available to MoH and partners such as those developed by the International Center of Theoretical Physics, IRI Summer Institute, and AFENET, e.g.:
    - On-line courses
    - Dedicated modules
    - Manuals

4. Recommendations for future research?

- Climate science research (e.g. on rainfall onset and drivers of Tanzanian climate impacts at seasonal, decadal, and long-term climate change scales).
- Trend analysis of malaria decline and attribution.
- Identify and prioritize health outcomes for further research:
    - Vector borne disease
    - Infectious disease
    - Non-infectious disease and other outcomes

5. Recommendations for future collaborations?

- MoU between TMA and Ministry of Health needed (as being developed with Ministries of Water & Livestock), including data sharing policy.
- Meeting participants to identify core team (5 persons including TMA and MoH) to:

    - Explore concrete next steps
    - Draft ToR for Inter-agency Climate and Health Working Group
    - Ensure coordination with existing inter-sectoral structures (such as National Climate Change Adaptation for Health country team overseen by MoH and Ministry of Environment)
    - Support technical teams for specific deliverables – e.g. MEWS
- Joint proposal development for funding partnerships & future activities.
- Explore outreach to veterinary community (through SACIDS, OneHealth, etc).

Closing Remarks:

Closing remarks were given by Augustine Kanemba (TMA) and Pietro Ceccato (IRI).

Augustine Kanemba (TMA) thanked the participants and indicated the workshop would inform TMA's provision of climate information and tools to the health community and other sectors, as well as support further product development. He thanked each of the institutions represented for their participation and highlighted IRI's support of the meeting, along with funding from WMO and NASA-SERVIR. He indicated new opportunities for collaboration had been identified and that TMA was eager to cooperate further and was committed, as needs were articulated, to respond to these and move key items discussed forward.

In addition, Pietro Ceccato (IRI) provided a recap of the workshop and closed the meeting with his thanks for the collaborations and expressed his wish for the group to remain active and develop partnerships and reiterated that the potential of this group is immense. He also indicated the forthcoming workshop report would be shared with all participants for their review within a few weeks.

Appendix

Appendix 1: Agenda

Use of Climate Information in Malaria Stratification / Early Warning Systems / Impact Assessment for Malaria Interventions

Dar es Salaam, Tanzania
16 - 18 October 2013

Location: TMA (Blue Pearl Hotel)

Day-1 (Oct 16):
8:00-8:45 Registration Opening Session *Chair of Morning: James Ngeleja, TMA Board* *Rapporteur of Morning: Barbara Platzer, Columbia Global Center-Africa* *9:00* Arrival of Guest of Honor *9:00-9:20* Opening Remarks by WMO Representative (Haleh Kootval) Opening Remarks by IRI Representative (Madeleine Thomson) *9:20-9:30* Acting Director General of TMA to Welcome a Member of Ministerial Advisory Board to Introduce Permanent Secretary or Representative from the Ministry of Transport.

9:30-9:45

Official Opening by Guest of Honor

9:45-10:30

Group Photo & Coffee Break

Technical Session: Overview

10:30-11:15

- Introductions to the Workshop (Tufa Dinku & Pietro Ceccato, IRI)
- The Needs for Climate and Environmental Information for Health in Tanzania (Renata Mandike, Ministry of Health, National Malaria Control Program)

11:15-12:30

Availability of Climate and Environmental Data and Information:

- The Seasonal Forecast for September-November 2013 and its Implications for Public Health (Hellen Msemo, TMA)
- Presentation of New Climate Information and ENACTS Products for Tanzania (Augustine Kanemba, TMA& Tufa Dinku, IRI)
- Questions and Discussions

12:30-2:00

Lunch

Technical Session: Overview

Chair of Afternoon: Haleh Kootval, WMO

Rapporteur of Afternoon: Derek Willis, IRI/CRED-Columbia University

2:00-3:15

- The Use of Climate and Environmental Products for Stratification Maps/Early Warning Systems/Impact Assessment – including Multiple Timescales (Madeleine Thomson, IRI)
- Questions and Discussions

3:15-3:45

Coffee Break

Panel Discussion

3:45-4:45

- Moderated Discussion on Opportunities for Collaborations between the Climate and Health Communities (Facilitated by Martha Lemnge, NIMR Tanga Centre, and Augustine Kanemba, TMA)

4.45- 5.00

- Wrap-up (Morning/Afternoon Chairs)

Day-2 (Oct 17)

Technical Session: Hands-On Training

Chair of Morning: Madeleine Thomson, IRI

Rapporteur of Morning: Wilbert Timiza, TMA

8:30-10:00

Access to Data and Information Products (Pietro Ceccato & Rémi Cousin, IRI)

- Introduction to Remotely-Sensed Data
- Introduction to NASA SERVIR & Online Demonstration

10:00-10.30

Coffee Break

10:30-12.30

Access to Data and Information Products cont. (Tufa Dinku, Rémi Cousin, IRI& Victor Masam, TMA)

- Introduction to the IRI Map Rooms & Online Demonstration
- Introduction to the TMA Map Rooms& User Interface

Practical Exercises and Training on the TMA Map Rooms and Data Library (Tufa Dinku, Rémi Cousin, IRI& Victor Masam, TMA)

- Climate Analysis Map Room
- Climate Monitoring Map Room
- Climate Forecast Map Room

12.30-2:00

Lunch and Distribution of the Questionnaire

Technical Session: Hands-On Training

Chair of Afternoon: Tufa Dinku, IRI

Rapporteur of Afternoon: Anna Estes, Nelson Mandela African Institute of Science and Technology

2:00-3:30

Practical Exercises and Training cont. (Pietro Ceccato & Madeleine Thomson, IRI)

- Climate Suitability for Malaria Map Room – Comparison of IRI and TMA Data Libraries
- Weighted Anomaly of Standardized Precipitation Index (WASP)– Comparison of IRI and TMA Data Libraries
- Introduction to Monitoring Vegetation and Water Bodies

3:30-4:00

Coffee Break

4:00-5:00

- Q&A and Open Feedback on Data and Products.
- Workshop Questionnaire.

5:00-5:15

- Wrap-up & Assignment (Morning/Afternoon Chairs)

Assignment:

5. What can be improved in terms of TMA data and products already developed?
6. Identification of future needs for climate, environmental and epidemiological information for use in health programs.
7. What type of capacity building and what skills are required?
8. Recommendations for future research.

Day-3 (Oct 18)

Technical Session: Hands-On Exercises

Chair of Morning: Jeremiah Ngondi, RTI International Tanzania

Rapporteur of Morning: Nada Petrovic, IRI/CRED-Columbia University

8.30 -10:00

Practical Exercises and Participants to Test TMA Products for their own Applications (Rémi Cousin, Tufa Dinku, Pietro Ceccato, IRI& Victor Masam, TMA)

10:00-10:30

Coffee Break

10.30 -12:00

Feedback & Closing Session

Potential Uses of Climate and Environmental Information in Health (Pietro Ceccato, IRI and Augustine Kanemba, TMA)

- Group Discussions about Assignment
- Feedback from Questionnaire
- Exploring the Creation of a Climate and Health Working Group

12:00-12:30

Final Recommendations to TMA, NASA, WMO:

- What Can Be Improved in Terms of TMA Data and Products Going Forward.
- Future Needs for Climate, Environmental and Epidemiological Information for Use in Malaria Programs.
- Further Potential Research, Product Development and Collaborations.

12:30-13:00

Closing Remarks (TMA & IRI).

Appendix 2: Participant List

	Last Name	First Name	Title/Role	Institute	Email	Gen-er
1	Mlacha	Yeromin	Research Scientist	Ifakara Health Institute	ymlacha@ihi.or.tz	M
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Appendix 3: Workshop Organizing and Funding Institutions

Tanzania Meteorology Agency (TMA)

The TMA is a government agency under the Ministry of Transport (MoT). The Director General who is the Chief Executive Officer reports to the Permanent Secretary. A Ministerial Advisory Board (MAB) consisting of eight members and one ex-officio advises the Minister of Infrastructure Development on the day-to-day activities of TMA. Functionally, TMA is divided into four divisions headed by Directors. The divisions are Forecasting; Business Support; Technical Services and Applied Meteorology and Research. These divisions are also subdivided into sections headed by Managers. The country is divided into 8 zones each headed by a Principal Meteorologist. Currently there are 28 Synoptic Observing Stations and 13 Agrometeorological stations.

TMA is the designated National Meteorological Authority which is entrusted with the task of provision and regulation of weather and climate services in Tanzania. The mission of TMA is to provide quality, reliable and cost effective meteorological services that meet stakeholders' expectation thereby contributing to the safety of life and property, and to the national poverty eradication goal.

World Meteorological Organization (WMO)

WMO is a specialized agency of the United Nations. It is the UN system's authoritative voice on the state and behavior of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources. WMO has a membership of 191 Member States and Territories.

The vision of WMO is to provide world leadership in expertise and international cooperation in weather, climate, hydrology and water resources and related environmental issues and thereby contribute to the safety and well-being of people throughout the world and to the economic benefit of all nations. The mission of WMO is to:

- Facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology, and to promote the establishment and maintenance of centers charged with the provision of meteorological and related services;
- Promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;
- Promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics;
- Further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities;
- Promote activities in operational hydrology and to further close cooperation between Meteorological and Hydrological Services;

- Encourage research and training in meteorology and, as appropriate, in related fields, and to assist in coordinating the international aspects of such research and training.

National Aeronautic and Space Administration-SERVIR (NASA-SERVIR)

The SERVIR initiative is a joint venture between the U.S. National Aeronautics and Space Administration (NASA) and the U.S. Agency for International Development (USAID), which provides satellite-based Earth observation data and science applications to help developing nations in Central America, Africa and the Himalayas improve their environmental decision making and enhance resilience to climate change within their member nations. It aims to support response in eight areas of societal benefit identified by the Group on Earth Observations (GEO): disasters, ecosystems, biodiversity, weather, water, climate, health, and agriculture.

Health and Climate Foundation (HCF)

The mission of HCF is to reduce health risks due to the impact of climate and of inequities in mitigation and adaptation strategies by facilitating and convening dialog and interaction between the health sector, climate services, research and development institutions, decision makers and community groups. The core values of HCF are to:

- Maintain a "facilitator" responsibility (avoiding substitution of institutional and managerial responsibilities);
- Ensure relevance of HCF support is related to public health impacts, especially to the most vulnerable;
- Support inclusiveness by helping ensure that partnerships have adequate composition with priority given to missing critical partners or disciplines;
- Focus on demand oriented services (information technologies, operational research, capacity building, training).

International Research Institute for Climate and Society (IRI)

The mission of the IRI is to enhance society's capability to understand, anticipate and manage the impacts of climate in order to improve human welfare and the environment, especially in developing countries. The IRI conducts this mission through strategic and applied research, education, capacity building, and by providing forecasts and information products with an emphasis on practical and verifiable utility and partnership.

The IRI was founded in 1997 on the belief that scientific breakthroughs in our understanding of climate can help developing countries defeat persistent and often devastating problems. Climate has an impact on health, water, agriculture and most other vital sectors, giving us the opportunity to help societies confront a whole range of hardships-from malaria epidemics to food shortages. Population growth, changing livelihoods, rapid urbanization, and climate uncertainty put pressure on

resources and ecosystems. Under these heightened stress conditions even minor climate fluctuations are significant.

The IRI is a catalyst for the creation and provision of science that meets the needs of the developing world. We collaborate with partners in Africa, Asia and Latin America, with local institutions that understand local needs and capacity. Our research and tools are "demand-driven" in that they help solve specific development, adaptation and research management issues.

Appendix 4: Workshop Glossary

Glossary of Terms

Absolute Humidity: the quantity of water vapor expressed as grams per cubic meter of air. Absolute humidity, also expressed as dew point, is a measure of the amount of water in the air independent of temperature. So while relative humidity drops when temperature goes up in a data center, absolute humidity stays the same.

Adaptation: "a process by which strategies to moderate, cope with, and take advantage of the consequences of climate events (as opposed to just anthropogenic climate change) are enhanced, developed, and implemented" UNDP's Adaptation Policy Framework

Bimodal Rainfall Distribution: an annual cycle of rainfall that has two rainy seasons and two dry seasons.

Climate: the average values and frequencies of the weather including its extremes (*e.g.,* rainfall, air temperature, relative humidity, solar radiation and wind speed) over periods longer than a month (*e.g.,* a season, a year, a decade, 30 years, and so on). *For example:* The average September to December rainfall at Entebbe from 1902 to 1992 is 438mm.

Climate Change: long-term changes in the climate. Climate change can be natural (*e.g*., ice ages were caused by changes in the distance between the Earth and the sun), or anthropogenic *i.e.* caused by changes people have made to the land and atmosphere (e.g., urbanization, pollution).

Climate Information: Information about historically observed climate (*e.g.,* the average and typical range of variability of the rainfall total for a given location for a given month or season), or a forecast of the climate for a future time (whether for an immediately forthcoming season, or on a much longer time-scale such as 30 years into the future). An important part of climate information is its probabilistic aspect, which pertains to what is most likely, what is relatively less likely, and what would be considered rare (extremely unlikely).

Climate Risk Management: the use of climate information in a multidisciplinary scientific context to cope with climate's impacts on development and resource-management problems. Climate risk management covers a broad range of potential actions, including: early-response systems, strategic diversification, dynamic resource-allocation rules, financial instruments, infrastructure design and capacity building.

Climate Variability: Deviations in the mean state of the climate on temporal and spatial scales beyond that of individual weather events, owed to both natural processes within the climate system and variations in anthropogenic forcing. Anomalies may, for instance, be observed at the monthly, seasonal to interannual scale.

Climatology: the long-term average of a given weather parameter (variable), often over time periods of approximately 30 years.

Community: A group of people who occupy a defined territory under common leadership, with access to shared local resources, as the base for carrying out the greatest share of their daily activities. Such a group may vary by country to include villages, quarters, groups of hamlets, mobile populations, and temporary settlements.

Community expectations: Prospective opinions that people have about the roles and outcomes of responsive health systems.

Community participation: The process by which people are enabled to become actively and genuinely involved in defining the issues of concern to them, in making decisions about factors that affect their lives, in formulating and implementing polices, developing and delivering services and in taking action to achieve change.

Community perception: The view that individuals and communities have about health services. It can be influenced by outcomes of previous health care experiences.

Community perspectives: The sum of collective knowledge, attitudes, valuation, awareness, perceptions and experience of the community with respect to health and the delivery of essential health services. Research to ensure that communities that are usually not part of the process should be involved in the development of policies and systems for their own health: ownership – go beyond perception

Decision Analysis: application of probability theory with the aim of calculating the optimal strategy from a series of alternative decisions, which are often expressed graphically in the form of a decision tree. Decision analysis is a tool to help decision-makers choose from several options which is the optimal choice for treatment or control of a disease.

Deterministic Model: a mathematical model in which all the relationships are fixed and the concept of probability is not involved, so that a given input produces one exact prediction as an output. See also: Stochastic Model.

De-trending: to remove the general long-time drift, tendency, or bent of a set of statistical data in relation to time. Regression and other statistical techniques are

used to remove the effects of a long term trend in order to show only the absolute changes in values and to allow potential cyclical patterns to be identified. An example would be to subtract a moving-average (*e.g.,* for five years) from the value of the variable.

Drought: defined as a prolonged period of poor rainfall distribution resulting in deterioration of natural resources.

Ecosystem resilience: a measure of how much disturbance (like storms, fire or pollutants) an ecosystem can handle without shifting into a qualitatively different state. It is the capacity of a system to both withstand shocks and surprises and to rebuild itself if damaged.
http://www.stockholmresilience.org/research/whatisresilience/resiliencedictionary.4.aeea46911a3127427980004355.html

Endemic Disease: the perennial or seasonal presence of a disease, or infectious agent, within a given geographic area, or population group. It also implies a prevalence that is usual in the area or in the population. When applied to meningitis—there is a constant measurable incidence both of cases of the disease and of its natural transmission in an area over a succession of years.

Ensemble forecasts: An ensemble is simply a group of model forecasts that are valid over an identical time period. These forecasts provide information on the different ways in which the atmosphere may evolve over the next few hours or longer. Ensembles are needed because we do not have enough information to accurately depict the present state of the atmosphere. Even with all the information we obtain from satellites, radars, weather balloons, surface instruments, and other data sources we are unable to provide a perfect three-dimensional picture of the atmosphere at any given time. This means that the information we use to start a numerical weather forecast model, called an initial condition, is imperfect. By analyzing different scenarios, we can determine the most likely evolution of the atmosphere and determine the odds that certain weather events will occur. Numerous studies have shown that ensembles are more accurate than providing a single forecast from the best initial condition, and we also know that ensembles provide more useful information to decision makers.

ENSO: Stands for El Niño–Southern Oscillation. ENSO refers to an irregular cycle of warming and cooling of the sea surface temperatures (see definition) of tropical Pacific Ocean. The cycle has an average length of about 4 years, and is a natural part of the Earth's climate system. The oceanic warming and cooling is accompanied by changes in air pressure above the tropical Pacific Ocean (the "Southern Oscillation"). These changes in the Pacific Ocean's temperatures and the atmosphere above it affect the global climate system, and therefore can affect the climate in regions that are far away from the Pacific (like Africa).

Epidemic: the occurrence in a population or region of cases of disease clearly in excess of normal expectancy for that area and time period. When applied to malaria this includes the occurrence of malaria among a population in which the disease was unknown or an unusual seasonal rise or other unusual increase of clinical malaria cases in an area with low or moderately endemic malaria (based on an epidemic thresholds derived from historic data).

Epidemic Curve a histogram in which the X-axis represents the time of occurrence of disease cases and the Y-axis represent the number of disease cases. It is a useful tool to determine the epidemiology of disease occurrence in an outbreak investigation.

Epidemiology: the study of the distribution and determinants of health related states and events in populations.

Evapotranspiration rate: of actual loss of water from soil through a combination of evaporation and transpiration by plants over a given area with time.

Factor: an event or characteristic that brings about a change in health condition - a causal role is often implied.

Geo-reference: record of data's location in a known mapping co-ordinate system (such as degrees Latitude and Longitude) or projection.

Geographic Information System: a computer-based database designed to store, manage, analyze and System (GIS) visualize geo-referenced data in locational relation to each other. Grid uniform matrix of discreet values – used in some GIS (grid-based) to represent continuous data surfaces such as mean temperature or rainfall estimates or other attributes associated with mapped entities. Some GIS use the term "raster" in place of grid.

Health system: "A health system is the sum total of all the organizations, institutions and resources whose primary purpose is to improve health. A health system needs staff, funds, information, supplies, transport, communications and overall guidance and direction. And it needs to provide services that are responsive and financially fair while treating people decently." http://www.who.int/features/qa/28/en/

Immunity: the resistance of an individual to infection, or disease, due to a particular agent. Immunity may be innate (natural), passive (e.g., maternal or through administration of immune serum), or active (acquired from previous exposure or vaccination).

Incidence: the number of new cases of disease or other condition, which occur in a specified population during a given period of time.

La Niña: the cold phase of the El Niño Southern Oscillation. Like its "brother" El Niño it is associated with periodic variability in regional climatic processes (See also El Niño). Recent La Niña events occurred in 2007, 2000, 1999, 1998, 1996, and 1988. Typically, La Niña events last into the beginning of the following year.

Microclimate: the mean values and frequencies of the weather including its extremes (*e.g.,* air temperature, relative humidity, solar radiation and wind speed) in a small geographic area.

Normalized Difference Vegetation Index (NDVI): a commonly used proxy for vegetation condition. NDVI is derived from a manipulation of data from two satellite wave bands presented as a ratio [NDVI = (near infrared—red)/(near infrared + red)]. NDVI is often used in routine monitoring of seasonal vegetation development in response to regional rainfall distribution.

Outbreak: occurrence of disease in a population, at a level greater than normally expected where the epidemic is limited in terms of population and geographic area affected.

Population (Herd) Immunity: the resistance of a group of subjects to invasion and spread of an infectious agent based on the resistance to infection of high proportion (but not all) members of the group. Also called "herd" or "population" immunity.

Potential evapotranspiration (PET): may be used as a proxy measure for soil moisture budget. It describes the amount of evapotranspiration that could occur if a limitless supply of water were available in the soil. It is based on weather conditions such as wind and temperature and biological factors such as vegetation cover.

Predictability: A technical term that describes how well we can predict the future weather or climate in a particular region. Predictability varies depending upon how far into the future the forecast extends. In a region with high seasonal predictability (mainly in the tropics) we can make good forecasts of what the climate will be in the next few months given what is happening now. There is no place on Earth that has perfect predictability. There are also some places that have no seasonal predictability at all.

Prevalence: the proportion of cases of a disease or other condition present in a population at a point in time without any distinction between old and new cases. When used without qualification the term usually refers to the number of cases as a proportion of the population at risk at a specified point in time (point prevalence).

Probability: The chance or degree of likelihood that an event will occur. *For example:* In Entebbe, below normal rainfall in the September to December season has occurred in 10 out of 30 years. If we assume that September to December

rainfall in Entebbe in the future will have the characteristics as in the past, then there is a 10 in 30 chance (or 33%) that rainfall will be below normal in the coming season.

Probabilistic Forecast: measure of the degree of likelihood that a given event will occur. A probabilistic forecast type includes an objective measure of certainty. This type of prediction may be more reliable than a deterministic forecast that gives no indication of certainty.

Public Health Surveillance: the ongoing, systematic collection, analysis, interpretation and dissemination of health data used by public health authorities to monitor the health of their communities. Its purpose is to provide a factual basis from which health authorities can appropriately set priorities, plan programs, and take action to promote and protect the public's health. See also: Surveillance.

Rainfall: the quantity of rainfall measured by a rain gauge during a fixed period of time (*e.g.,* 24-hour period for daily rainfall). The term "precipitation" may be used which is inclusive of water as snow, sleet, hail, *etc.*

Rainfall estimates: (RFE) estimates of rainfall derived from satellite data combined with ground station data and model outputs.

Relative humidity: (%) is the amount of water vapor in a sample of air, divided by the amount that the sample could hold if it were saturated, multiplied by 100.

Relative Risk: the ratio of the disease incidence in individuals exposed to a hypothesized factor to the incidence in individuals not exposed.

Reliability: (for probabilistic forecast system). "If the system forecast is 30% above, 10% normal and 60% below normal rainfall then in 100 years, 30 years should be above normal, 10 years should be normal and 60 years should be below normal in order to be thought of as being perfectly reliable".

Remote Sensing: observation of the earth's surface and its physical, biological, hydrological and atmospheric processes from a distance. Usually means data collected from airborne sensors on aircraft or satellites.

Resilience: the capacity to deal with change and continue to develop.
http://www.stockholmresilience.org/research/whatisresilience/resiliencedictionary.4.aeea46911a3127427980004355.html

Risk: the probability that an event will occur within a fixed time period *e.g.,* that an individual will become infected, become seriously ill or die within a set period, or by certain age.

Risk Factor: an attribute, or exposure that increases the probability of occurrence of the specific risk outcome.

Risk Indicator: a risk factor that can be monitored routinely for use in an early warning system.

Satellite Proxies: satellite-derived estimates of environmental variables.

Saturation Deficit: the pressure exerted by water vapor that could exist in saturated air (saturation vapor pressure) minus the actual vapor pressure (the actual pressure exerted by the water vapor present).

Saturation Vapor Pressure: The partial pressure exerted by water molecules in a parcel of air if saturated at a given temperature (may be calculated from wet and dry bulb temperatures).

Seasonal Climate Forecast: A forecast for how rainfall or temperature in a coming season is likely to be different from climatology (see definition). Seasonal climate forecasts can be made in several different ways (*for example,* using statistical or dynamical method). Because the climate system is so complex, it is almost impossible to take all the factors that determine the future seasonal climate into account. Therefore, climate forecasts are generally given in terms of the probability (see definition) that rainfall or temperature will be either below normal, near normal, or above normal.

Seasonality: Changes in patterns (of a disease, for instance) which occur predictably at given times of the year.

Sea Surface Temperature: is the temperature of water at the ocean surface—often derived as a proxy from thermal satellite channels. SSTs are an important influence on seasonal rainfall and temperature over land.

Sensitivity: a statistical measure of how well a binary classification test correctly identifies a condition, *e.g.,* how well a medical screening tests identifies a disease compared to some absolute (Gold standard); for example, for a medical test to determine if a person has a certain disease, the sensitivity to the disease is the probability that if the person has the disease, the test will be positive. The sensitivity is the proportion of true positives of all diseased cases in the population.

Social change: Paradigmatic change in socio-economic structure, can affect social institutions, social behaviors and social relations.

Social resilience: the ability of human communities to withstand and recover from stresses, such as environmental change or social, economic or political upheaval.

Resilience in societies and their life-supporting ecosystems is crucial in maintaining options for future human development.
http://www.stockholmresilience.org/research/whatisresilience/resiliencedictionary.4.aeea46911a3127427980004355.html

Social-ecological systems: linked systems of people and nature. The term emphasizes that humans must be seen as a part of, not apart from, nature — that the delineation between social and ecological systems is artificial and arbitrary. Scholars have also used concepts like 'coupled human-environment systems', 'ecosocial systems' and 'socioecological systems' to illustrate the interplay between social and ecological systems. The term social-ecological system was coined by Fikret Berkes and Carl Folke in 1998 because they did not want to treat the social or ecological dimension as a prefix, but rather give the two same weights during their analysis.
http://www.stockholmresilience.org/research/whatisresilience/resiliencedictionary.4.aeea46911a3127427980004355.html

Social vulnerability in relation to environmental change: "the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt". (Adger 2006)

Spatial Distribution: the relationship of disease events to location of individual subjects or clusters of subjects.

Specificity: in diagnostic tests, the proportion of people that tested negative of all the negative people tested (true negatives); that is (1-false positives).

Stochastic Model: a mathematical model founded on the properties of probability so that a given input produces a range of possible outcomes due to chance alone c.f. deterministic model.

Surveillance: observation of a susceptible (uninfected) population aimed at the early detection of cases of a particular disease so that control action can be quickly instituted (see also monitoring). Surveillance is often subdivided into two categories, passive and active: passive surveillance is the secondary use of routinely collected data, which was generated for some other purpose such a diagnostic service; active surveillance is the routine collection of data whose primary purpose is for surveillance. See also Public Health Surveillance.

Vector: arthropods that transmit disease pathogens following a multiplication and a maturation cycle occurring in their bodies; *e.g.,* mosquitoes, sand flies, ticks. Key determinants of vector distribution are their feeding, resting and habitat preferences. Vectors that prefer to feed on humans are referred to as *anthropophilic*. In general, the vectors of African malaria bite at night and after feeding, some will rest in shady areas outside houses. Such vectors are termed *exophilic* i.e. they prefer

to rest outdoors after feeding. Others are endophilic and rest indoors on walls and in hidden corners after feeding. These vectors are dominant around human settlements. Other vectors may bite humans and thus transmit malaria but they prefer to bite animals (i.e. they are *zoophilic*). Such vectors are often most abundant where livestock is kept.

Vector-borne disease: disease caused by pathogens that are transmitted by insects or other arthropods.

Virulence: the degree of severity of disease produced by an agent in a given host. Epidemiologically, it is measured as the proportion of individuals with disease who become seriously ill or die. The case-fatality rate is a measure of virulence.

Vulnerability refers to the propensity of social and ecological system to suffer harm from exposure to external stresses and shocks. Research on vulnerability can, for example, assess how large the risk is that people and ecosystems will be affected by climate changes and how sensitive they will be to such changes. Vulnerability is often denoted the antonym of resilience.
http://www.stockholmresilience.org/research/whatisresilience/resiliencedictionary.4.aeea46911a3127427980004355.html

Weather: the short-term variations of the atmosphere in terms of pressure, wind temperature, moisture, cloudiness, precipitation and visibility. It is a phenomenon that varies very much from day to day, even hour to hour and we experience it as wet or dry, warm or cold, windy or calm.

Appendix 5: Workshop Survey Questionnaire and Summary of Responses

Workshop Survey Introduction:

The questions below are meant to assess the value of this workshop. We want to understand which of the products presented are most useful, how we can improve the products and your ability to access them and how they can be better integrated into your decision making process.

The survey is anonymous. Your answers will help us understand how to improve the integration of climate and environmental information into your decision process.

Thank you for your participation.

Questions:

1. **How would you rate your overall experience with the TMA Map Room and IRI Data Library on a scale with 1-Very good, 2-Good, 3-Fair, 4-Poor, 5-Very Poor?** *Please explain why you chose this rating.*

2a. Which products did you find most useful?
Please list products in order of most useful first.

Product	**2b. What did you find useful about this product?** **2c. What decisions will you be making from the information gained from this product?**
	2b. **2c.**

	2b. **2c.**
	2b. **2c.**

3. How would you best describe your expected use of the TMA Map Room and IRI Data Library?

TMA Map Room:

a. Check one or more of the following:

- ○ Identifying a problem
- ○ Assessing a situation
- ○ Research
- ○ Aiding in a decision
- ○ Providing the definitive answer for a decision

b. Please provide additional information on how you expect to use the TMA Map Room:

IRI Data Library:

c. Check one or more of the following:

- ○ Identifying a problem
- ○ Assessing a situation
- ○ Research
- ○ Aiding in a decision
- ○ Providing the definitive answer for a decision

d. Please provide additional information on how you expect to use the IRI Data Library:

4. Will you be sharing any of the information in the TMA Map Room or IRI Data Library with other groups?

If Yes:

4a. Please name each group that wi receive the information:	**4b. How they will benefit from the information:**	**4c. How the presentation of the information will be modified when it is shared with each group:**

If No, please skip to question 5.

5. Which parts of the TMA Map Room and IRI Data Library did you find difficult or confusing?

TMA Map Room:

IRI Data Library:

6. In what ways can the TMA Map Room and IRI Data Library be improved to fit your specific needs?

TMA Map Room:

IRI Data Library:

7. How do you or could you use the climate forecast in your work after this workshop?

8. Feel free to share any other feedback or advice regarding your experience during this workshop.

Thank you for your participation.

Detailed Summary of Responses to Workshop Survey Questionnaire:

Questions:

1. **How would you rate your overall experience with the TMA Map Room and IRI Data Library on a scale with 1-Very good, 2-Good, 3-Fair, 4-Poor, 5-Very Poor?** *Please explain why you chose this rating.*

The average response to this question was 1.75. Of the 14 surveys that were completed by participants, only 1 did not provide explanation for the rating they assigned for this question. Most responses indicated that participants felt that the TMA Map Room and IRI Data Library were positive developments and would support anti-malaria activities in Tanzania. Three participants noted that they would like to have access to the actual data and that without the actual data it would be difficult to link these tools to other data sets.

2a. Which products did you find most useful?
Please list products in order of most useful first.

One participant did not provide a response to this question and 6 participants did not identify a product in their responses. Of the responses provided by the other participants, the Climatic Suitability for Malaria Transmission product and the MEWS product were identified as potentially being most useful. The CSMT was noted as being useful by participants due to its potential to inform the mapping of risk areas, predicting when malaria transmission seasons would begin and for the development of a malaria early warning system. Reasons for how the MEWS product could be useful included a more efficient mobilization of resources and increased accuracy in predicting malaria epidemics.

3. How would you best describe your expected use of the TMA Map Room and IRI Data Library?

TMA Map Room:

The number to the right of each choice below indicates the number of times participants selected that choice as an expected use of the TMA Map Room.

a. Check one or more of the following:

○ Identifying a problem	8
○ Assessing a situation	9
○ Research	8
○ Aiding in a decision	9
○ Providing the definitive answer for a decision	3

b. Please provide additional information on how you expect to use the TMA Map Room:

Three participants did not answer this question. The expected use of the TMA Map Room that was most commonly mentioned by the other participants was the prediction of malaria epidemics. Several participants also noted that they expected to use the TMA Map Room in order to improve the implementation of anti-malaria programs and stratify malaria risk within the country.

IRI Data Library:

The number to the right of each choice below indicates the number of times participants selected that choice as an expected use of the IRI Data Library.

c. Check one or more of the following:

○ Identifying a problem	7
○ Assessing a situation	11
○ Research	9
○ Aiding in a decision	5
○ Providing the definitive answer for a decision	4

d. Please provide additional information on how you expect to use the IRI Data Library:

Five participants did not answer this question. The expected use of the IRI Data Library noted by the other participants ranged from linking the Data Library with other data sets, studying the spatial distribution of malaria cases and mapping malaria risk zones within the country.

4. Will you be sharing any of the information in the TMA Map Room or IRI Data Library with other groups?

If Yes:

Seven participants did not answer this question, one participant responded with 'No' and all other participants selected 'Yes.' None of the participants provided information on how the presentation of information would be modified when shared with a group. The groups listed by the participants that would receive the information included: research groups studying malaria vectors, district health management teams, the Zanzibar Malaria Control Program, the Tanzanian National Malaria Control Program, the Ministry of Health and groups using GIS in Tanzania.

The potential benefits of the information for each group were: improved targeting of anti-malaria interventions, improved malaria stratification and risk maps and the development of a malaria early warning system.

If No, please skip to question 5.

5. Which parts of the TMA Map Room and IRI Data Library did you find difficult or confusing?

TMA Map Room:

The participants indicated that the part of the TMA Map Room that they found most confusing was how to identify the appropriate baseline year(s) to use as a baseline for evaluating the impact of anti-malaria interventions.

IRI Data Library:

The part of the IRI Data Library that participants found most confusing was the WASP product. Several participants also noted that they were unsure of how to use the products in the Data Library in order to identify the appropriate baseline year for evaluating interventions. The MEWS was also noted as being confusing by 2 participants. Four participants did not respond to this question.

6. In what ways can the TMA Map Room and IRI Data Library be improved to fit your specific needs?

TMA Map Room:

The most common responses for ways to improve the TMA Map Room were the need to simplify the Map Room and to make it possible to access the actual data. The ability to conduct analyses via the Map Room at the district level was also noted as a need by several participants.

IRI Data Library:

Seven participants did not provide information on how the IRI Data Library could be improved. Of the participants that did respond, the most common suggestion for how to improve the Data Library was a desire for more examples of how the products could be linked to their work.

7. How do you or could you use the climate forecast in your work after this workshop?

Almost half of the participants indicated that they plan on using the climate forecasts in order to predict 'hotspots' or malaria epidemics while several

participants also specified that these predictions would be at the district level. Two participants noted that they would use climate forecasts in order to stratify malaria risk zones and one participant indicated that forecast would be incorporated into their research.

8. Feel free to share any other feedback or advice regarding your experience during this workshop.

The most common response to this question was that more time to practice the products that were presented during the workshop would have been helpful. One participant also noted a desired for more interaction among participants during the workshop would have been helpful. Four participants did not respond to this question.

Appendix 6: Media Coverage

News Article in The Guardian:

Tanzania to use climate info in malaria control

Use of climate and environmental information as well as strengthening multi-sectorial partnership is still crucial in prevention and control of malaria in the country.

In a speech read on her behalf by TMA Acting Director General, Ibrahim Nassib, Tanzania Meteorological Agency (TMA) Director General, Dr Agnes Kijazi said the use of climate information in controlling malaria along with early warning systems and impact assessment for interventions can make a huge difference.

The speech was read yesterday in Dar es Salaam during a workshop on 'Climate information in controlling malaria, early warning systems and impact assessment'.

Dr. Kijazi said malaria continues to be a major public health concern with over 10 to 12 million clinical cases reported each year this despite massive investment in prevention and control.

She however noted that opportunities to improve disease stratification and the plotting of risk maps, early warning systems and impact assessments can still be further aided by leveraging climate and environment information and by strengthening multi-sectorial partnerships to reduce the burden of this highly endemic disease.

"The natural environment affects human health, in the case of malaria where temperature affects survival of mosquitoes and water stagnation enhances production. To reduce outbreaks, cooperation of the various sectors is important, especially those affiliated with weather, environment and medics" she said.

As an example she said weather information can assist the health sector in mitigating and planning storage of drugs to deal with the problem when arises.

"To fight malaria, health organizations must be very much aware of the nature and timing of the rain seasons. This could be possible with the availability and proper use of weather information," she said.

In Tanzania there are two main rainfall peaks, the March-May rain season commonly known as 'Masika' and October-December rains locally termed 'Vuli'.

Before TMA experts issue seasonal forecasts to the public, it conducts a stakeholders

meeting including participants from the health sector to discuss the seasonal forecast prepared.

TMA's Board Member, Dr James Ngeleja said many parts of Africa are prone to the devastating malaria endemic, "Tanzania is no exception, and since it is mostly located in the tropical climate with high rainfall variability it is very much susceptible to malaria."

"Because malaria is highly associated with climate, climate based epidemic warning systems can help reduce the impacts," he said.

"To develop and test such a system, long-tem malaria and climate data are needed," he explained pointing out that "…lack of meaningful long-term malaria data in the region makes prediction difficult."

IRI representative from USA, Dr Madeleine Thomson said the responsibility of fighting malaria should not be left to the Ministry of Health and Social Welfare alone but everyone should take part and in this regard, she called on TMA to provide relevant information that would help control the disease.

"We don't have malaria in our country because of control but before, maybe 100 or 50 years back there was Malaria but the US government invested in controlling the disease and was able to eradicate it." Dr Thomson pointed out.

However, to compliment these suggested efforts, he also called on the government to provide anti-malaria drugs as a way of controlling malaria in the country.

Citation: Mwachang'a, Devota. "Tanzania to use climate info in malaria control." *TheGuardian* 17 October 2013: Page(s). *IPP Media.*Web. 24 October 2013. **<**http://www.ippmedia.com/frontend/index.php?l=60485**>.**

TMA Blog Entry:

TMA and IRI in collaboration with WMO, NASA and HCF are hosting a training workshop

The Tanzanian Meteorological Agency (TMA) in collaboration with the International Research Institute for Climate and Society (IRI) with support from WMO, NASA and HCF are hosting a training workshop and stakeholder meeting on the "Use of Climate Information in Malaria Stratification / Early Warning Systems / Impact Assessment for Malaria Interventions" in Tanzania, from October 16-18, 2013 at the Blue Pearl Hotel.

In Tanzania, malaria continues to be a major public health concern with over 10 to 12 million clinical cases reported a year. Despite large scale investments in prevention and control, opportunities to improve disease stratification and risk maps, early warning systems and impact assessments can still be further aided by leveraging climate and environmental information and by strengthening multi-sectoral partnerships to reduce the burden of this highly endemic disease.

Activities led by the Tanzanian Meteorological Agency (TMA) and the International Research Institute for Climate and Society (IRI) have recently combined available ground observations of rainfall and temperature with satellite and other proxies, pioneering new open-access products and creating one of the highest resolution and longest data records for Africa. In particular, outcomes of this work include:

- An unprecedented thirty-year time series of ten-daily rainfall and temperature data for every 10 km grid across the country;

- An online mapping service installed at TMA providing user-friendly tools for visualization, querying, and accessing information

- Increased technical capacity at TMA.

The new data products combined with other environmental factors, which can be readily monitored using remote-sensing products available through the National Aeronautics and Space Administration (NASA), can help deliver and support innovations in malaria prevention and control.

The workshop will showcase TMA's recently launched high resolution products and will demonstrate examples of how they can be used in combination with NASA products for disease stratification, improved early warning systems and impact assessments.

Citation: Mutoni, Monica. "TMA and IRI in collaboration with WMO, NASA and HCF are hosting a training workshop." *Vijimambo.* Blogspot, 17 October 2013. Web. 24 October 2013. <http://lukemusicfactory.blogspot.com/2013/10/tma-and-iri-in-collaboration-with-wmo.html>.