# REPORT OF THE WORKSHOP ON ANALYZING AND VALIDATING THE SOCIO-ECONOMIC BENEFITS OF WEATHER AND CLIMATE INFORMATION SERVICES FOR DISASTER RISK REDUCTION IN AFRICA

ADDIS ABABA, ETHIOPIA, 20-21 MARCH 2018.

FOR:
AFRICAN CLIMATE POLICY CENTRE
UNITED NATIONS ECONOMIC COMMISION FOR AFRICA,
ADDIS ABABA,
ETHIOPIA

B J Garanganga and G Pallaske, May 2018

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## ACKNOWLEDGEMENTS

The Workshop on Analysing and Validating the Socio-Economic Benefits of Weather and Climate Information Services for Disaster Risk Reduction in Africa was held in Addis Ababa, Ethiopia, 20-21 March 2018. This was a culmination of the work on Socio-Economic Benefits (SEB) for Climate Information Service (CIS) as applied to Disaster Risk Reduction (DRR) undertaken by a team composed of Georg Pallaske and me. We had excellent guidance from the UNECA Team led by Dr Frank Rutabingwa.

We, therefore, wish to gratefully acknowledge the opportunity offered by leadership of UNECA -ACPC for us to carry out the study. The supervisory team was outstanding in their patience and all-round support. In this connection, I wish to express my gratitude to Drs Denton, Murombedzi, Ahma, Johnson, Amousoubgo and others. Administrative support from Kidisa and others was invaluable to the success of the workshop.

The efforts and contributions of all other individuals and organisations which assisted are gratefully acknowledged. In particular, we greatly commend the efforts of Chairpersons of various sessions who ably steered the deliberations and the respective rapporteurs who diligently captured the discussion.

# ACRONYMS AND ABBREVIATIONS

ACMAD------------- Africa Centre for Climate and Meteorological Application for Development
ACPC-------------African Climate Policy Centre
AfDB------------- African Development Bank
AIDA ------------- Africa Industrial Development Plan
AMESD------------- African Monitoring of the Environment for Sustainable Development
BAU-------------Business as Usual
BCPR -------- Bureau of Crisis Prevention (of UNDP)
CAADP ------------- Comprehensive Africa Agriculture Development Programme
CBA---------- Cost Benefit Analysis
CCA------------- Common Country Assessment
CRED--------- Centre for Research on the Epidemiology of Disasters
CILSS------------- Permanent Interstate Committee for Drought Control in the Sahel
CIS------------- Climate Information Services
COMESA ------------- Common Market for Eastern and Southern Africa
CSIS------------- Climate Services Information System
DRR------------- Disaster Risk Reduction
EAC ------------- East African Community
ECA ------------- Economic Commission for Africa
ECCAS------------- Economic Community of Central African States
ECOWAP------ West African Agricultural Policy of the Economic Community of West African States
ECOWAS------------- Economic Community of West African States
EM-DAT------------- The OFDA/CRED International Disaster Database
FAO ------------- Food and Agriculture Organization of the United Nations
GAR ------------- Global Assessment Report
GFCS -------------Global Framework for Climate Services
GFDRR------------- World Bank Global Facility for Disaster Reduction Ad Recovery
GHACOF------------- Greater Horn of Africa Climate Outlook Forum
GDP ------------- Gross Domestic Product
HIV------------- Human Immunodeficiency Virus
IFRC------------- International Federation of Red Cross and Red Crescent Societies
IGAD------------- Intergovernmental Authority on Development
MCA--------Criteria Analysis
NADMO------------- National Disaster Management Agency
NEPAD------------- New Partnership for Africa's Development
NEMA ------------- National Emergency Management Agency
NGO------------- Non-Governmental Organization
NMHS-------------
NPCA------------- NEPAD Planning and Coordination Agency
OAU ------------- Organization of African Unity
OAS ------------- Organization of American States
OCHA------------- United Nations Office for the Coordination of Humanitarian Affairs
OFDA------------- Office of Foreign Disasters Assistance OF USA
OIC ------------- Organization of Islamic Cooperation
PDNA------------- Post Disaster Needs Assessment
PIDA ------------- Programme for Infrastructure Development in Africa

PRESAO------------- Regional Climate Outlook Forum for West Africa, Chad and Cameroon
RIASCO------------- Regional Inter-Agency Standing Committee
PRSP------------- Poverty Reduction Strategy Paper
SADC------------- Southern African Development Community
SARCOF------------- Southern Africa Climate Outlook Forum

SEB -------------Socioeconomic Benefits
SIDS------------- Small Islands Developing States
UNDP ------------- United Nations Development Programme
UNDAF ------------- United Nations Development Assistance Framework
UNECA ------------- United Nations Economic Commission for Africa
UNEP------------- United Nations Environment Programme
UNFCCC ------------- United Nations Framework Convention on Climate Change
UNISDR------------- United Nations Office for Disaster Risk Reduction
VCA ------------- Vulnerability Capacity Analysis
WFP ------------- World Food Programme
WISER-------------Weather Information and Climate Services
WMO------------- World Meteorological Organization.

**SUMMARY**

The negative impacts of hydrometeorological hazards on agriculture and food security, water resources oftentimes lead to disasters. Over 90% of natural disasters in Africa are a consecutive consequence of these hazards. There continues to be the in existence in many regions in Africa the ever-looming threats of these climate-induced disasters, (Urama & Ozor, 2010). It is, therefore, incumbent upon policy-makers to formulate appropriate strategies in order to minimize the effects of these devastating hydrometeorological hazards on communities. In this regard, there is need to provide communities and organizations with timely, tailored climate-related knowledge and information, as well as products that they can use to reduce climate-related losses and enhance benefits, including the protection of lives, livelihoods, and property (Vaughan and Dessai, 2014). Furthermore, studies indicate that weather and climate services improve smallholders' livelihoods in Africa (e.g. Patt et al., 2005; FAO , 2015).

As part of the process to demonstrate socio-economic benefits of Climate Information Services (CIS), the African Climate Policy Centre (ACPC) of the United Nations Economic Commission for Africa (UNECA) under the Weather Information and Climate Services (WISER) programme has developed an analysis framework to assess the Socioeconomic Benefits (SEB) of CIS within and across various socioeconomic sectors. The WISER framework assesses the economic and social benefits of CIS compared to the costs of investments with the aim to provide decision support and information to inform the design and prioritization of DRR interventions. WISER CIS is one of the key strategies that aim to ensure the utility of timely and accurate weather and climate information vital to the day to day decision making of Africa.

The SEB framework presents the steps required for the effective identification and use of indicators to support a sectoral and integrated analysis of SEB in CIS for the benefit of DRR. The SEB assessment framework allows the development of an integrated Cost Benefit Analysis (CBA), where social, economic and environmental impacts – as well as policy outcomes – are considered. The CBA considers three main analytical components: investment, avoided costs and added benefits. The integrated CBA includes the economic valuation of environmental consequences.

The validation workshop demonstrated that the WISER SEB model captures social, economic and environmental dynamics within and across various key economic sectors that are key for DRR and disaster prevention and can hence inform decision making for DRR. It includes climate variations in the analysis and has the capability to estimate the cascading effects of adverse climate events through all sectors. As a result, the performance of the system changes depending on the climate assumptions used and the effectiveness of implemented interventions. However, policy effectiveness has to be assessed using a variety of indicators, across sectors, actors, over time and space.

The WISER SEB model was found to effectively inform the assessment and preparation of disaster risk adaptation strategies or to expand existing national and sectoral policy and strategies. The study has laid the groundwork for discussions and analysis of the

effectiveness and viability of various measures to decrease economic vulnerability of the countries to the hydrometeorological risks.

## 1. INTRODUCTION

As part of the study a Workshop on Analysing and Validating the Socio-Economic Benefits of Weather and Climate Information Services for Disaster Risk Reduction in Africa, Addis Ababa, Ethiopia, 20-21 March, 2018. The Programme of the workshop is shown in Annex I. The workshop was attended by DRR and Climate Scientists/Producers from the SSA, as per attached List of Participants, Annex II. The workshop was officially opened by Mr. Frank Rutabingwa (WISER-PEEC, coordinator) and James Murombedzi (OiC, ACPC), who welcomed the participants and introduced the program for the two-day workshop. After the participants introduced themselves, Messrs. Bradwell Garanganga (ACPC) and Georg Pallaske (ACPC) provided an overview of the framework used to assess the SEBs of DRR. Participants engaged in deliberations around the presentations and also during breakout sessions whose deliberations were presented to the plenary for discussion and recommendations. The details of the deliberations are shown in Annex IV.

## 2. PRESENTATIONS

There were presentations of the model made to the participants of the workshop and breakout sessions during the two days. This was as per the programme of the workshop shown in in Annex I. The detailed deliberations for the plenary and breakout session are shown in Annex III (a) and (b), respectively. The presentation of the SEB on CIS for DRR model followed the manual as in Annex IV.

### 2.1 Introduction to SEB Framework in DRR

Garanganga set the stage by providing information on the global economic cost of natural disasters, hydrometeorological hazards, forecast verification and CIS. Information on the economic damages caused by natural hazards, their frequency and causalities over Africa was provided. It was stressed that the negative impacts of hydrometeorological hazards on agriculture threaten food security and constrain water resources, resulting in disasters. CIS was recognized as crucial component to guide decision-making and to determine adequate investments to minimize potential negative impacts on economy, society and environment (prevention/mitigation). Additionally, investments in early warning systems and contingency planning for affected sectors is necessary to protect socio-economic welfare.

The rationale for the analysis of the SEBs that can be provided through timely and measured DRR interventions is that climate variability and change impacts negatively impact socio-economic performance and poses a threat to human and ecosystem health alike. If neglected, climate variability and change impacts will continue to force decision makers to react to the consequences of climate hazards, and hence being occupied by crisis management, as opposed to system governance. Figure 1 provides an overview of the average GDP growth rate in the Business as Usual (BAU) scenario (orange line), in which a reactive approach to climate impacts and adverse events is taken.

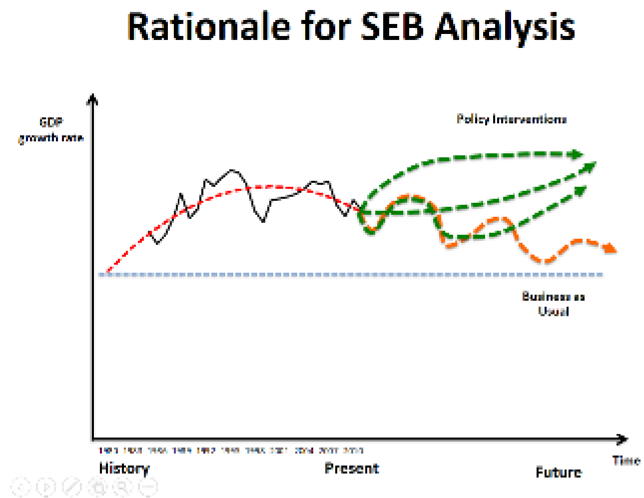


*Figure 1: Rational for SEB Analysis*

A preventive approach to climate change and climate change impacts focuses on the implementation of policy interventions (green lines) to strengthen the resilience of human-environmental systems to climate shocks, and hence to increase economic performance by reducing the cost of crisis management.

**Socio economic benefits** (SEB) of using CIS to inform DRR can be categorized as direct (e.g. weather information, rainy days), indirect (e.g. higher yield) and induced (e.g. higher tax revenues). Furthermore, benefits can be attributed to certain actors. Some affect households (e.g. avoided damage to private property), others impact on businesses (e.g. avoided supply chain disruption) and the government (e.g. reduced infrastructure expenditure). The obtained benefits from increasing the resilience towards adverse weather cut across social, economic and environmental dimensions. The benefits of proactive DRR interventions such as CIS need to be assessed on different time scales, as some incur immediately, and on a continuous basis, while others emerge over time.

## 2.2 The assessment framework

The challenge is to estimate required **investments**, resulting **avoided costs** as well as **added benefits**. An opportunity would be missed if decisions only aim at mitigating costs and passively adapt to climate change. If a more proactive approach is taken, new opportunities may emerge, and avoided costs could be reinvested in more resilient economic activities. The framework used for the assessment of SEBs of DRR compares the required **investments**, both initial capital expenditure and continuous operations and maintenance (O&M) costs, to the **avoided costs** and **added benefits** resulting from active adaptation to climate variability and change impacts. Figure 2 provides an overview of the assessment framework and illustrates some of the socio-economic and environmental avoided costs and added benefits that are considered in the framework.

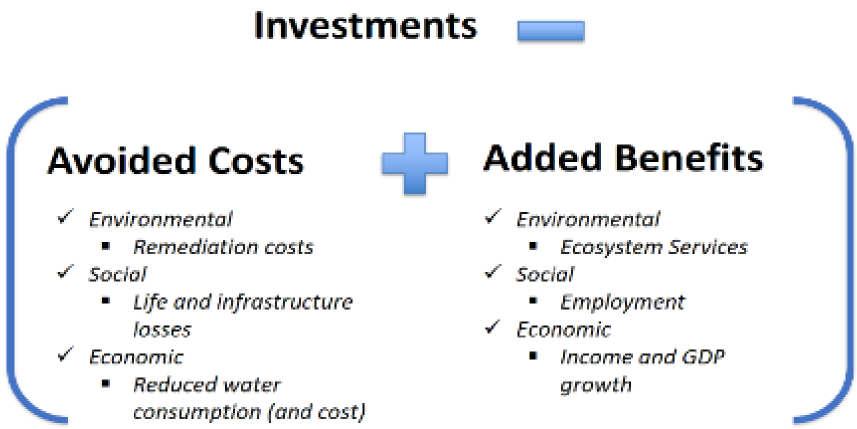


*Figure 2: SEB assessment framework*

The WISER model, a systems model developed during the WISER project, was customized for the assessment of SEBs on CIS for DRR. The model uses a combination of methods, such as for example optimization, econometrics and simulation. The underlying framework used for the integration of multiple methods is called System Dynamics and was developed by Jay Forrester in the late 1950s at the MIT. System Dynamics is an integrated and quantitative (modelling) approach utilized to understand situations for (complex) real world issues to guide decision making over time for achieving sustainable long-term solutions *(SD class, SPL – 2012)*. The underlying drivers of change in this type of models are stocks and flows, feedback loops and delays, and nonlinearity. System Dynamics models are used to simulate "What if" scenarios and serve as a learning platform that allows for the assessment of policy effectiveness before implementation. These "What if" scenarios contribute to identifying robust policy options and inform decision making about policy impacts and potential negative side effects.

Causal relations, stocks and flows, and auxiliary variables expose the structure of the system and contribute to the development of an intuitive understanding of how the model structure generates the system's behaviour. Simulations are capable of capturing dynamics and changes across multiple time scales (semi-continuous runs, using differential equations) and allow for spatially disaggregated assessments based on using GIS information as input. In general, System Dynamics is a highly integrative method that allows for using formulations from various disciplines and modelling schools within the same model.

System Dynamics provides a high degree of customization and allows for the integration and unification of perspectives from various stakeholder groups and disciplines. During the integration process, the method emphasizes causal relations within and between various sectors, and the inclusion of key indicators to measure and monitor the performance of critical variables over time. System Dynamics constitutes an integrated and dynamic modelling framework (starting simulations in the past to improve validation), leading to informing better policy formulation. An added benefit of the approach is its transparency (both for indicators and model) and accessibility.

## 2.3 Climate impacts from a system's perspective

The proper assessment of benefits emerging from DRR mitigatory measures need to be assessed within and across sectors. Climate impacts are many, and adverse consequences cut through multiple sectors, which reinforces the need for a systemic approach. Figure 3 provides an aggregate view of the systemic model, which uses capital, labour and productivity to assess macro-economic performance. The three highlighted feedback loops illustrate key drivers of systemic change.

The red feedback loop captures investments in capital based on economic performance (GDP). This, in turn increases productivity and contribute to an increase in economic performance, reinforcing feedback. The yellow feedback loop captures the exploitation of natural capital needed to sustain economic activity, whereby the availability of natural resources support growth and hence increase the future demand for resources (reinforcing feedback). The green feedback loop represents the carrying capacity of the system in terms of resource availability and biodiversity, whereby an overexploitation of natural capital a) reduces ecosystem services, and b) contributes to ecological scarcity, which in turn reduces productivity and can have counteracting effects, reducing growth in the long term. The underlying assumption is that the three highlighted feedback loops (red, green and yellow) need to be balanced to achieve sustainable socio-economic and environmental performance in the long run.

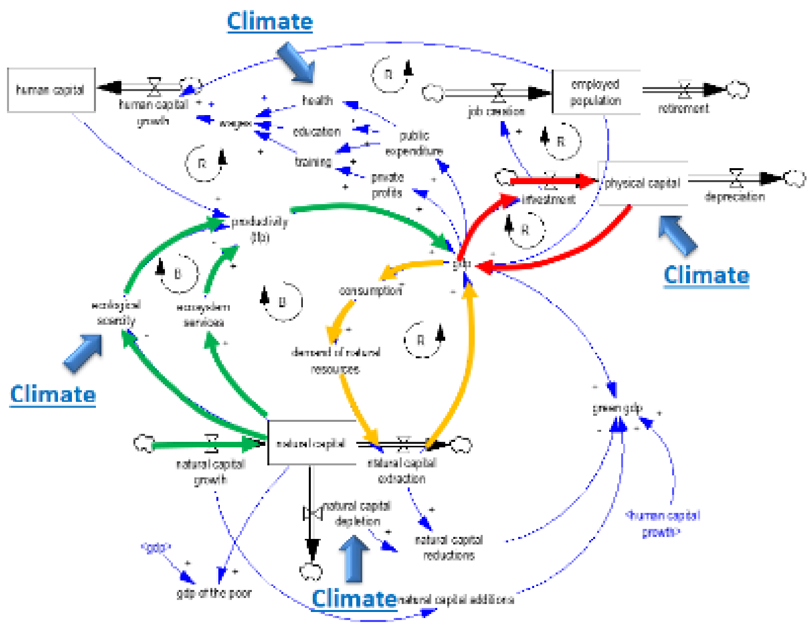


*Figure 3: Aggregate system's perspective and climate impacts*

In addition, Figure 3 indicates where climate impacts affect macroeconomic performance. Extreme weather and climatic events can have detrimental impacts on human health (e.g. waterborne diseases after floods, starvation after droughts), damage physical capital (e.g. loss of roads, machinery), contribute to ecological scarcity and natural capital depletion (e.g. loss of key ecosystems or species).

Table 1 provides an overview of the climate impacts that are included in the model at the current stage, and potential impacts which might be added in the model during later stages.

| **Climate variability** | |
|---|---|
| *Included* | *Potentially* |
| • Temperature | • Sea level rise |
| • Precipitation | • Fires |
| | • Extreme winds |
| **Infrastructure impacts** | |
| *Included* | *Potentially* |
| • Road networks | • Education |
| • Electricity supply | • Health care |
| **Health impacts** | |
| *Included* | *Potentially* |
| • Weather-related mortality | • Air quality – Respiratory diseases |
| • Total affected population | |
| **Agriculture impacts** | |
| *Included* | *Potentially* |
| • Crop yields | • Soil quality |
| • Irrigation demand | • Fertilizer application |
| • Loss of agriculture land | |
| • Impacts on agriculture production | |
| **Forest impacts** | |
| *Included* | *Potentially* |
| • Total forest | • Forest composition |
| | • Geographic range of forests |
| | • Forest health and productivity |
| **Water resource impacts** | |
| *Included* | *Potentially* |
| • Water supply | • Water quality |
| • Competition for water | |
| **Impacts on coastal areas** | |
| *Included* | *Potentially* |
| | • Additional costs to protect coastal communities |
| **Species and natural areas** | |
| *Included* | *Potentially* |
| | • Loss of habitat and species |

*Table 1: Climate impacts included and potentially included in the SEB on CIS for DRR model*

## 2.4 Climate assumptions and causal relations in the model

The SEB on CIS for DRR framework was based on the capability of the model to include precipitation and to accommodate assumptions on changes in, and climatological variability of, precipitation. Figure 4 illustrates (a) a baseline simulation with constant seasonal precipitation and without variation (left), and (b) a climatological scenario assuming a decreasing trend in annual precipitation and an increasing variability in precipitation.

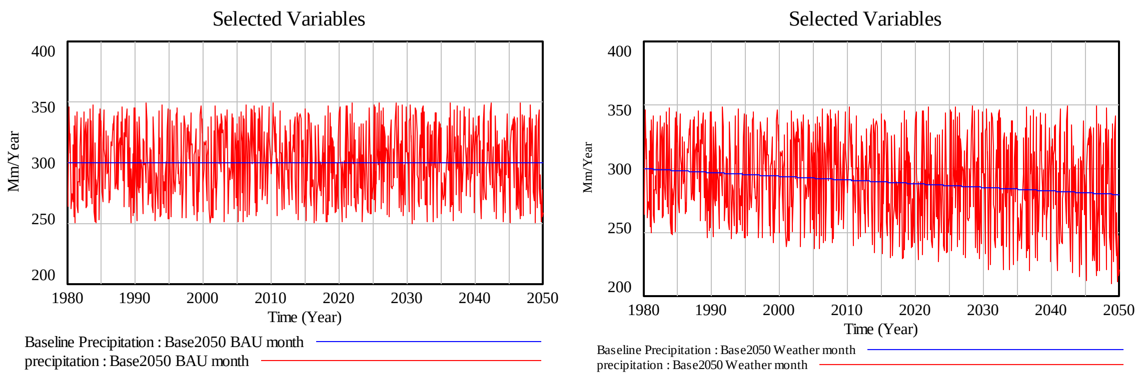


*Figure 4: Precipitation (a) constant, and (b) decreasing trend with increasing variability*

A sensitivity analysis with the current parameterization of the model stressed that small variabilities in seasonal precipitation can, over the total area, cause large variations in the total amount of water resources produced internally. This can have significant consequences for water resource management and sectors which are heavily depending on water to be productive (e.g. agriculture). Furthermore, it was demonstrated that the model has the capability to accommodate and analyse the effects of shifting seasons (rainy and dry season), which is an emerging problem observed all over Africa, and threatens the livelihood of especially rural small scale farmers.

The water demand from agriculture is hereby assessed by comparing monthly precipitation to the monthly water requirements of various crops (Illustrated in Figure 5). Crop water demand data was obtained from CROPWAT and integrated into the model to refine the simulation of water demand and more accurately assess the amount of water required for irrigation purposes.

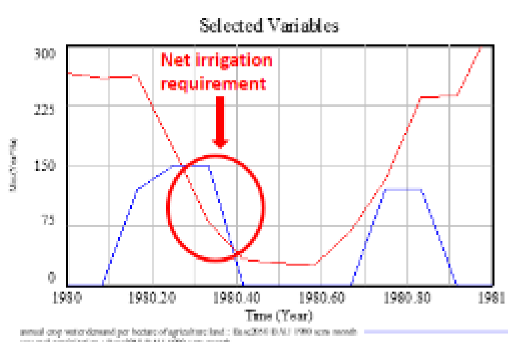


*Figure 5: Assessment of irrigation requirements*

## 2.5 Sectoral dynamics and climate impacts captured

After introducing the capacity to capture different climate trends and climate variability and change related impacts on precipitation, key causal relationships of the agriculture, infrastructure and macroeconomic sector were presented in form of Causal Loop Diagrams (CLDs).

## 2.6 Agriculture

Figure 6 illustrates the causal relationships in the agriculture sector. The model assumes population as the key driver for agriculture land conversion. The desired amount of agriculture land is based on total population and a per capita value for agriculture land. The desired amount of agriculture land is compared to the current amount, which provides an indication on whether there is a gap in agriculture land. If the desired amount is higher than the current amount, land conversion for agriculture is assumed to take place at the expense of other land types such as forest or fallow land in order to close the existing gap. The (B) in Figure 6 illustrates a balancing feedback loop that aims at maintaining the current amount of agriculture land at the desired levels. The existing agriculture land is assumed to be productive and total agriculture production depends on the yield per hectare.

Two types of climate impacts on the agriculture sector are captured in the model, (1) the loss of agriculture land due to floods or droughts, and (2) the impact of floods or droughts on agriculture productivity (read: yield). The loss of agriculture land due to adverse events reduces the total amount of agriculture land and triggers additional land conversion in order to close the gap between existing and desired agriculture land. This indicates that the model accounts for agriculture land erosion resulting from floods and droughts, and the subsequent need to re-establish this land to maintain livelihoods. The impact of floods and droughts on agriculture yields captures the loss of production that farmers experience if their farmland is affected by these adverse events.

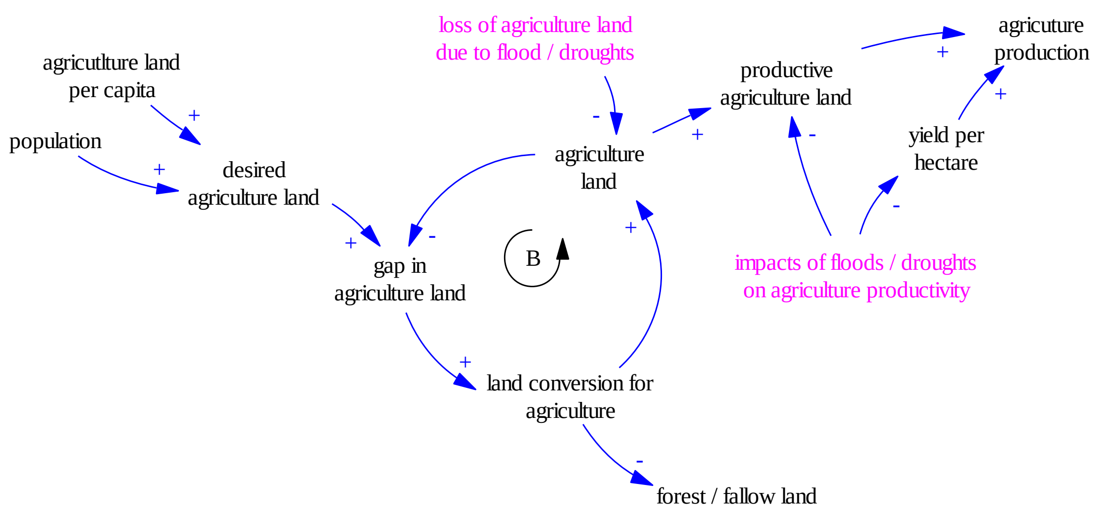


*Figure 6: CLD agriculture*

## 2.7 Infrastructure

Figure 7 illustrates the causal relationships in the infrastructure sector. Total production represents the total value added (GDP) that is generated in the system, and depends on active capital and total factor productivity. The model assumes that an increase in total production stimulates investments, which in turn increases gross capital formation and the amount of active capital. The (R) represents a reinforcing feedback loop, which captures the effect that an increase in total production ultimately increases total active capital, which in turn leads to an increase in total production. Further, the model assumes that an increase in total production leads to an increase in the available budget for roads construction, which, based on the costs per kilometre, leads to the construction of additional roads. The expansion of the road network is assumed to have beneficial impacts on total factor productivity, which in turn increases total production and hence resources available for roads construction. The (R) represents the expansion of the roads network based on available resources, while the (B) captures the saturation of roads, and causes road production to slow down as soon as the desired amount of roads is constructed.

Two types of climate impacts are indicated in the infrastructure sector, (1) capital depreciation due to floods, and (2) depreciation of roads due to floods and droughts. Capital depreciation due to floods captures the loss of physical capital, such as machinery, equipment, or buildings that occurs during flood events. Damages to or loss of capital reduces the total capacity to produce, thus the loss of capital ultimately translates in a reduction of total production. The depreciation of roads due to floods or droughts increases the maintenance costs for roads and leads to extrabudgetary expenditure for re-establishing the roads network. Further, the loss of roads translates in a reduction of total factor productivity and consequentially a negative impact on total production.

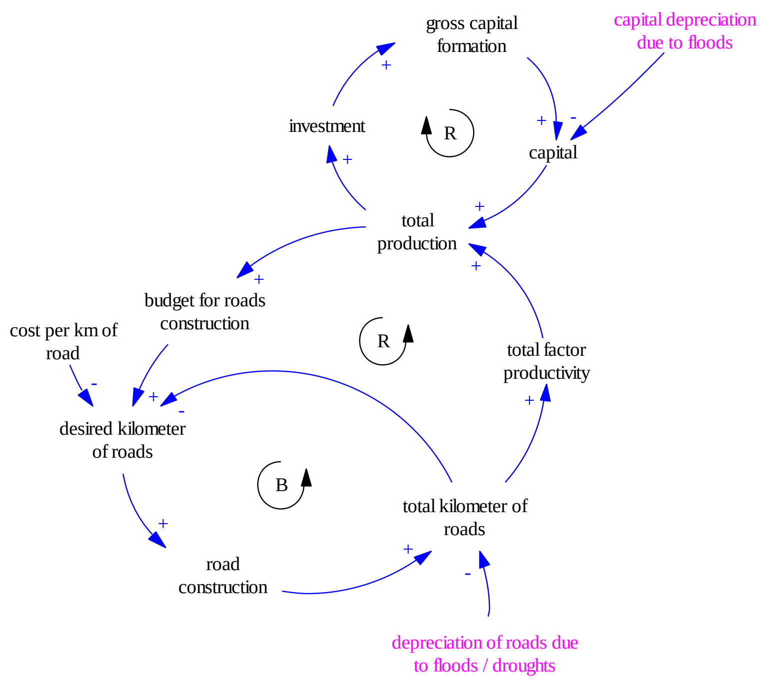


*Figure 7: CLD Infrastructure*

## 2.8 Macroeconomy

Figure 8 illustrates the causal relationships in the macroeconomic sector. The workings of capital formation loop (R) in top of Figure 8 are described in the previous paragraph. The macroeconomic sector assumes that literacy rate, energy prices, and access to health care are affecting total factor productivity. The model assumes that the available budget for health care is depending on total production (GDP), which implies that an increase in total production increases the budget for health care. The access to health care depends on the available budget and the required health care expenditure, which depends on total population and per capita implemented health care expenditure. The (R) indicates that a growth in budget increases access to health care, which in turn increases total factor productivity and total production.

The additional climate impact introduced in the macroeconomic sector is the impact of adverse events on access to health care through the share of population affected. In case of disaster, it is assumed that the affected share of the population is in need of additional resources to maintain access to health care, which increases the required budget for health care. If resources are unavailable, this will lead to a reduction in access to health care for the affected part of the population, which will negatively impact total factor productivity, reduce total production, which reinforces the problem by reducing the budget for health care.

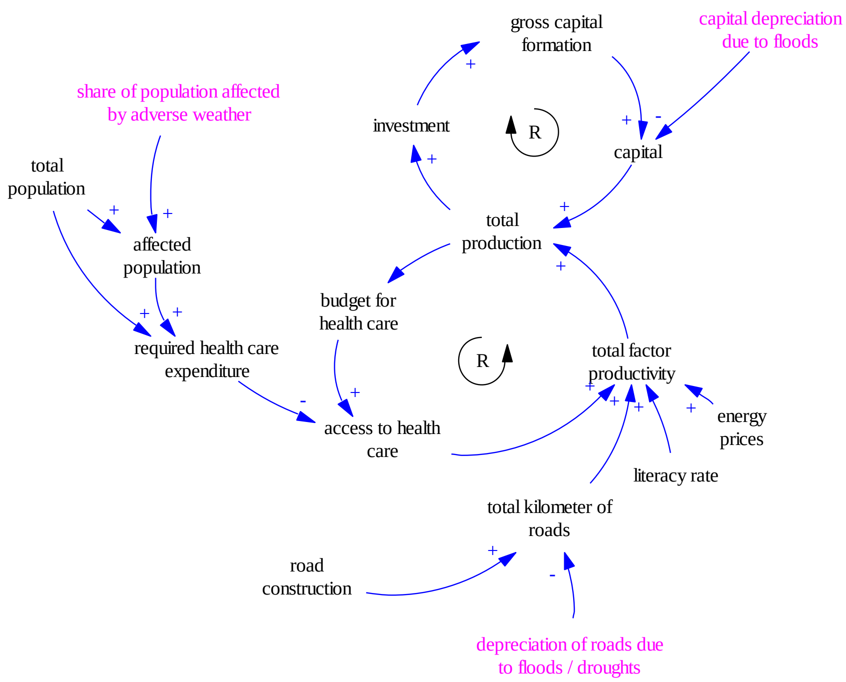


*Figure 8: CLD Macroeconomy*

## 2.9 Data analysis for SEB of DRR

The data used for the parameterization of the model was calculated based on a dataset providing climate related impacts across multiple African countries. The main data source for respective country disaster profiles was obtained for the UNISDR sources. In particular, extensive use was made of DesInventar, the Disaster Information Management System on the following web site; http://www.desinventar.net/data_sources.html. Were available, data from other international agencies, including national authorities were also used. The provided dataset was incomplete for many events, which required averaging the information that was available. Damages from recorded incidences (e.g. affected populations, affected agriculture land, loss of livestock) are compared to the respective stock values during the year in which the event occurred (e.g. total population, total agriculture and, total livestock) to assess the fractional impacts, or magnitude of the respective event. Subsequently, the fractional impacts were related to an extreme event indicator which is based on average monthly precipitation. Threshold values of 25% above and 25% below normal precipitation were used to determine extreme event indicators for floods and droughts respectively. These were based on determined indicator values and the fractional impacts of the events. Figure 9 illustrates the estimated impacts of floods on agriculture land (left) and the loss of livestock due to droughts (right).

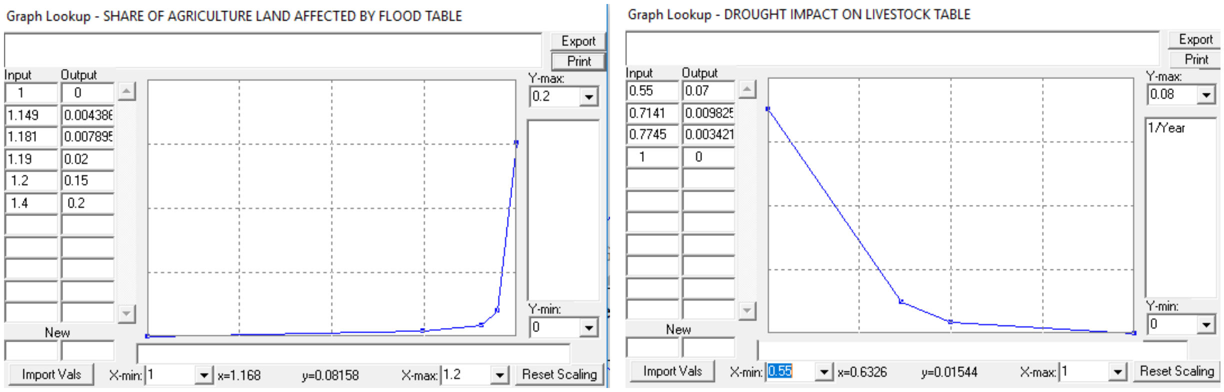


*Figure 9: Estimated non-linear functions for loss of agriculture land due to floods and loss of livestock due to droughts*

Consequentially, the model is using average parameters to calculate climate impacts of floods and droughts on various sectors. Furthermore, the model uses monthly averages for precipitation and confidence ranges provided by from climatological expertise to determine the frequency of adverse climate events.

For a better, down-scaled assessment of climate impacts and the SEB of CIS, country specific data on macroeconomic variables (e.g. GDP by sector, employment, health care) is necessary to customize the model.

## 2.10 The assessment of SEBs resulting from DRR interventions

SEBs of DRR interventions are assessed through the simulation of multiple intervention scenarios, which are then compared to a 'Reference scenario'. The Reference scenario is the scenario in which no DRR interventions are assumed, which implies that 100% of damages in all sectors occur. The 'CIS scenario' represents the status quo, in which some CIS is available and hence DRR interventions can be implemented somewhat effectively, which reduces damages caused by climate impacts. The 'CIS Investment scenario' assumes that initially some CIS is available (same as CIS scenario) and that investments in CIS contribute to the implementation of 100% of the CIS required to effectively dampen the strength of climate impacts across all sectors.

The economic assessment of SEBs resulting from DRR interventions is based on the cumulative damages incurred in the respective scenarios over a 20-year period. Figure 10 illustrates the cumulative damages from re-establishing the road network and the cumulative loss from livestock due to extreme events. Total sectoral cumulative damages that incurred in the CIS (red line) and CIS investment (blue line) scenario are compared to the damages incurred in the Reference scenario (green line). The difference in cumulative damages between the scenarios are the costs that can be avoided if CIS is available and is a DRR intervention that is implemented ahead of time.

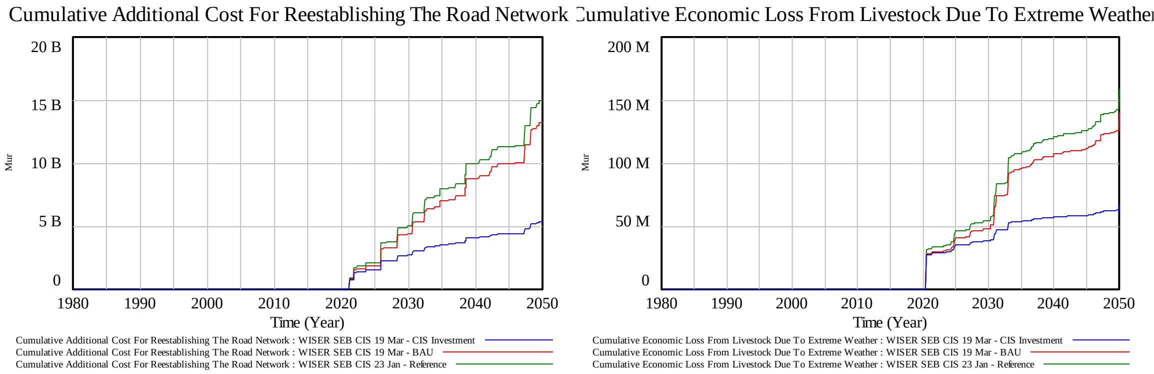


*Figure 10: Cumulative climate impacts in the roads and livestock sector*

Validation of model outputs took place on a per impact level and is based on multiple data sources. The dataset used for the estimation of impacts was also used to determine whether the magnitude of the impacts is in within the range resulting from the conducted calculations. Furthermore, sectoral and combined impacts were validated based on international literature to ensure that the generated outputs provide estimations that are conform with empirical observations across Africa. Lastly, peer reviewed papers served for the validation of climate impacts.

### 2.11 Limitations of the approach

The proposed assessment tool underlies the following limitations. First, it uses average data that was obtained from a dataset covering 8 African countries (The data were obtained from UNISDR web site[1]). The customization of the tool to a country context requires more specific data, such as, among others, the share of area affected, and local price assumptions on agriculture produce, livestock, roads, health care, etc. Second, the impacts of adverse weather are estimated on monthly precipitation, which is a problem as one of the main causes of floods are dry spells followed by 2-3 days of heavy rain. Third, the model uses a relatively high level of aggregation for the assessment of impacts, and the effectiveness of interventions. Some impacts (e.g. on capital) might be caused by a combination of factors and require more detailed causal relationships. Finally, at this stage, investments in CIS are based on a fraction of GDP, not on specific costs of interventions. More information is required on the cost of specific interventions to further refine the workings of the model and to improve the granularity of the model concerning (a) the CIS requirements, (b) cost of various interventions, and (c) the respective effectiveness of the interventions to be implemented.

## 3. MAIN OUTCOMES OF THE WORKSHOP ON ANALYSING AND VALIDATING THE SOCIO-ECONOMIC BENEFITS OF WEATHER AND CLIMATE INFORMATION SERVICES FOR DISASTER RISK REDUCTION IN AFRICA

After providing the workshop with the rationale of the SEB models premised on System Dynamics approach, there was a demonstration of the SEB on CIS for DRR model to the participants. The

[1] http://www.desinventar.net/data_sources.html

workshop endorsed the study on SEB on CIS for DRR and other applications. In particular, the workshop noted the following as some of the main outcomes of the workshop:

- The ‘Proof of the Concept’ was highly endorsed by the participants, it is a significant tool to assisting all stakeholders;
- There is need to engage sub-regional national authorities in charge of relevant data depositories to gain access to updated data, including data/mapping on vulnerability, exposure demographics;
- Training and capacity building needs to be organized for the specific sector professionals at sub-regional and national level;
- The projects should seek partnerships with research institutions/universities and RCC in order to refine the SEB on CIS models;
- Pilot studies need to be carried out at sub-regional levels across SSA; and
- The study results should assist in the investment on CIS for SEB

ANNEX I PROGRAMME OF THE WORKSHOP

**A Validation Workshop on Analysing and Validating the Socio-Economic Benefits of Climate Information Services for Disaster Risk Reduction in Africa**

**Place: Addis Ababa, Ethiopia**
**Date: 20-21 March 2018**

| **DAY 1: Tuesday 20 March 2018** | | | |
|---|---|---|---|
| **Time** | **Events** | **Responsible** | **Chair** |
| **08:00 – 09:15** | **Registration** | Organizers | |
| **09:15 – 09:25** | **Welcoming Remarks** | Frank Rutabingwa (*WISER-PEEC, coordinator*) | Mr. Frank R. (ACPC) |
| **09:25 – 09:35** | **Official Opening** | James Murombedzi (*OiC, ACPC*) | |
| **09:35 – 10:00** | **Introduction of Participants** | Participants | |
| **10:00 – 10:30** | **Introduction to SEB Framework in DRR**<br>– Overview of Weather and Climate Information Services and Their Utility for DRR<br>– Concepts and Application<br>– Rationale for using SEB framework<br>– The Key Steps in the SEB Analysis | Dr. Bradwell Garanganga (ACPC)<br>Mr. Georg Pallaske (ACPC) | Dr. Ernest A. (*WMO*) |
| **10:30 – 11:00** | **Discussion** | Participants | |
| **11:00 –11:30** | **COFFEE/TEA BREAK (Group Photo)** | | **Organizers** |
| **11:30 – 12:30** | **The SEB Data and implementation into the model**<br>– Data Collection Framework and Template Specific to DRR<br>- Data management: Quality Control and Missing Values | Dr. Bradwell Garanganga (ACPC)<br>Mr. Georg Pallaske (ACPC) | Mr. Frank R. (ACPC) |
| **12:30 – 13:00** | **General Discussion** | Participants | |
| **13:00 – 14:00** | **Lunch** | | **Organizers** |
| **14:00 – 15:00** | **Breakout session**<br>- Sub-regional perspective on the applicability of the SEB assessment | Participants | Dr. Nyenzi B (Climate Consult (T) LTD, Tanzania) |
| **15:00 – 16:00** | **Reporting back to plenary** | Participants | |
| **16:00 – 16:30** | Coffee/Tea | | Organizers |
| **16:30 – 17:30** | Vensim Software to be loaded onto participants laptops | | Georg P. |
| **17:30** | End of Day 1 | | |
| **Day 2: Wednesday 21 March 2018** | | | |

| Time | Events | Responsible | Chair |
| --- | --- | --- | --- |
| 09:15 – 10:00 | **Introduction to SEB CIS-DRR modelling on Vensim software**<br>– Recap on breakout sessions<br>– Model descriptions (*causal relationship, assumption and uncertainties*)<br>– Model analysis (Parameterization, simulation and validation) | Dr. Bradwell Garanganga<br>Mr. Georg P | Mr. Frank R. |
| 10:00 – 10:30 | **Discussion/Q&A** | | |
| 10:30 – 11:00 | **Hands on exercise with Vensim software**<br>– Steps to follow<br>– Quantifying model results | | |
| 11:00 – 11:30 | **Coffee/Tea** | | Organizers |
| 11:30 – 13:00 | **Hands on exercise with Vensim software**<br>– Steps to follow<br>– Quantifying model results | Dr. Bradwell Garanganga<br>Mr. Georg P | |
| 13:00 – 14:00 | **Lunch** | | **Organizers** |
| 14:00 – 15:00 | **Breakout session and feedback**<br>– Workings of the model<br>– Limitations of the model<br>– Potential improvements for country adaptation | All participants | |
| 15:00 – 16:00 | **General Discussion** | All Participants | |
| 16:00 – 16:30 | **Coffee/Tea** | | **Organizers** |
| 16:30 – 17:30 | **Recommendations to facilitate country uptake** | | |
| 17:30 – | **Wrap-up and Vote of Thanks** | Dr. James M | |
| **For more information, contact Yosef Amha via amhay@un.org** | | | |

ANNEX II: List of Participants for the Validation Workshop on SEB framework on CIS for DRR, Addis Ababa, Ethiopia, 20-21 March 2018:

| | Title | First Name | Family Name | Organization | Country |
|---|---|---|---|---|---|
| 1 | Mrs. | Amani | Abdelmahamoud Ali Mohamed | Ministry of Environment, Forestry and Physical Development | Sudan |
| 2 | Dr. | Ernest Asi | Afiesimama | Offices for Africa and Least Developed Countries, WMO | Switzerland |
| 3 | Mr. | Ali Mohamed | Ali | Disaster and Risk Management Executive Secretariat | Djibouti |
| 4 | Dr. | Dhoimiri | Anwar Maeva | Ministere de l'Interieur, de l'Information, de la Decentralisation, Charge des Relations avec les Institutions | Comoros |
| 5 | Mr. | Abdulkadir Nur | Arale | National Tsunami Disaster Management Bureau | Somalia |
| 6 | Mr. | Alkaly | Bangoura | National Service for Disaster Management and Environmental Emergencies | Guinea |
| 7 | Mr. | Garanganga | Bradwell | Ex-SADC Climate Service Centre | Zimbabwe |
| 8 | Mr. | Apuuli | Bwango | IGAD Climate Prediction and Applications Centre | Uganda |
| 9 | Mrs. | Rose Nakabugo | Bwenvu | Prime Minister's Office | Uganda |
| 10 | Mr. | do Sacramento | Cecilio | Conseil National de Prevention et Reponses aux Catastrophes | Sao Tome and Principe |
| 11 | Mr. | Momodou BK | Ceesay | The Gambia National Disaster Management Agency | Gambia |
| 12 | Mr. | Dalitso | Chikoti | Poverty and Disaster Mgmt Affairs Commissioner for | Malawi |

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| | | | | Disaster Preparedness, Relief & Rehabilitation | |
| 13 | Mr. | Goodman | Chiloane | Disaster Risk Reduction and Intervention Coordination | South Africa |
| 14 | Dr. | Dejene Teferi | Demissie | BERGEN UNIVEERISTY | Norway |
| 15 | Ms | Phiwinhlanhla Prudence | Dlamini | Policy Development and Regulatory Frameworks | South Africa |
| 16 | Mr. | Salumu Mulenda | Dougs | Prevention and Reduction of the R.sque | Congo, The Democratic Republic Of The |
| 17 | Dr. | Nsadisa | Faka | SADC Secretariat | Botswana |
| 18 | Dr. | Kone Cheick | Fanta Mady | Ministry of Internal Security and Civil Protection | Mali |
| 19 | Mr. | Mduduzi Sunshine | Gamedze | SADC Climate Services Center (formerly DMC) | Botswana |
| 20 | Mr. | Mohamed | Hamatan | AGRHYMET | Niger |
| 21 | Mr. | Kabengela Nyamabu | Hubert | ACMAD | Niger |
| 22 | Mr. | Clement Herbert | Kalonga | SADC Secretariat | Botswana |
| 23 | Mr. | Andre | Kamga Foamouhoue | ACMAD | Niger |
| 24 | Mr. | James Wewa | Kivuva | East African Community | Tanzania |
| 25 | Ms | Hellen Njeri | Kuria | Pan African Climate Justice Alliance | Kenya |
| 26 | Dr. | Stephen Maxwell | Kwame Donkor | Holland Africa Research & Development Ltd | Netherland |
| 27 | Dr. | Cush Ngonzo | Luwesi | Health College of Kenge | Congo, The Democratic Republic Of The |
| 28 | Mrs. | Tesse Mbia | Mabilo | la Protection Civile du Tchad Ministère de l'Administration du Territoire et de la Sécurité Publique | Chad |

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| 29 | Mr. | Protus Onyango | Mabusi | Pan African Media Alliance for Climate Change | Kenya |
| 30 | Mr. | Edmond Paul | Makimouha | Ministère de l'Economie Forestière et du Développement Durable | Congo |
| 31 | Mrs. | Njoupouo Yap | Mariatou | Ministry of Territorial administration and decentralization | Cameroon |
| 32 | Mr. | Niyungeko | Methode | Humanitarian Action Against Mines and Engines | Burundi |
| 33 | Mr. | Abdel Kader | Mohamed Lemine | Ministèr de L'Environnement et du Développement Durable | Mauritania |
| 34 | Mrs. | TOGO Hortense épouse | Moussounda | Direction Général de la Prévention des Risques | Gabon |
| 35 | Dr. | John | Mungai | WISER-EA | Kenya |
| 36 | Ms | Sibusisiwe | Ndlovu | Civil Protection | Zimbabwe |
| 37 | Mr. | Titus | Ng'andu | Office of the Vice President | Zambia |
| 38 | Mr. | Louise | Niyirora | Ministry for Disaster Management and Refugees | Rwanda |
| 39 | Mr. | Stephen | Njoroge | WMO | Kenya |
| 40 | Dr. | Mariano Efua | Nsue Ada | Ministry of Environment | Guinea Equatorial |
| 41 | Dr. | Buruhani Salum | Nyenzi | Climate Consult (T) Ltd | Tanzania |
| 42 | Mr. | Ernest | Nzachhimana | Ministry for Disaster Management and Refugees | Rwanda |
| 43 | Prof. | Laban | Ogallo | ICPAC | Kenya |
| 44 | Mr. | Georg Markus Franziskus | Pallaske | KnowlEdge Srl | Norway |
| 45 | Mr. | Selvan Arul | Pillay | Department of Energy and Climate Change | Seychelles |
| 46 | Mrs. | Marguerite NZAPAOKO | Ramadan | Service Premier Ministre | Central African Republic |

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| 47 | Mr. | Mbaye | Seck | | Senegal |
| 48 | Dr. | Zewdu Tessema | Segele | IGAD Climate Prediction and Applications Centre - ICPAC | United States |
| 49 | Mr. | Tinni Halidou | Seydou | AGRHYMET | Niger |
| 50 | Dr. | Mouhamadou Bamb | Sylla | WASCAL | Senegal |
| 51 | Dr. | Debalkew Berhe | Tedla | IGAD Secretariat | Ethiopia |
| 52 | Dr. | Abonesh | Tesfaye | CGIAR Research Program on Climate Change | Ethiopia |
| 53 | Ms. | Tirhas | Meberhatu | Ministry of Environment, Forest and Climate Change | Ethiopia |
| 54 | Dr. | Therese Flaviane | Tonfack Kenfack epse Belval | Economic Community of Central African States | Cameroon |
| 55 | Mr. | Banak Joshua Dei | Wal | Ministry of Humanitarian Affairs and Disaster Management | South Sudan |
| 56 | Mr. | Mauricio | Xerinda | Nacional Emergency Operative Center | Mozambique |
| 57 | Ms | Maryam Abubakar | Yau | National Emergency Management Agency | Nigeria |
| 58 | Mr. | Bakouan | Yipenè Florent | Secrétaire Permanent Conseil National de Secours D'urgence et de Réhabilitation | Burkina Faso |
| 59 | Mr. | James | Murombedzi | ACPC | Ethiopia |
| 60 | Mr. | Thierry | Amoussougbo | ACPC | Ethiopia |
| 61 | Mr. | Frank | Rutabingwa | ACPC | Ethiopia |
| 62 | Mr. | Linus | Mofor | ACPC | Ethiopia |
| 63 | Mr. | Charles | Muraya | ACPC | Ethiopia |
| 64 | Mr. | Yosef | Amha | ACPC | Ethiopia |
| 65 | Ms. | Yodit | Balcha | ACPC | Ethiopia |
| 66 | Ms. | Kidist | Belayneh | ACPC | Ethiopia |

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| 67 | Mr. | Tariku | Agoji | ACPC | Ethiopia |
| 68 | Mr. | Amanuel | Gebremariam | ACPC | Ethiopia |
| 69 | Mr. | Bruk | Tekie | ACPC | Ethiopia |
| 70 | Ms. | Charlotte | Remteng | ACPC | Ethiopia |
| 71 | Mr. | Epherem | Girma | ACPC | Ethiopia |
| 72 | Mr. | Adeladay | Solomon | ACPC | Ethiopia |

# ANNEX III (a): DISCUSSIONS ON THE WORKSHOP PRESENTATIONS

## Key issues raised during the first presentation:

**If recommendations are brought back to the respective countries, there is often an implementation gap. How do we make decision-makers aware of DRR issues and how do we make governments aware?**

*The core of this model is to communicate to decision makers that investments in CIS and preventive DRR interventions pay back multiple times in terms of avoided damages and added benefits. However, at this stage, the model is still in the development phase and input from DRR experts and managers is needed to improve the model. The questions at this point is less about implementation and more about what additional outputs the tool needs to generate in order to be useful to DRR managers and decision makers.*

**There is hydrological information and meteorological information, however oftentimes there seems to be a missing link between the two. In addition, user groups often cannot deduce from the provided information whether there might be the risk of flooding.**

*The proposed tool integrates many different types of information, and hydrological and meteorological information are part of this. Uptake and understanding by user groups needs to be enhanced through awareness raising, training and capacity building exercises once the model has been customized to a local context. However, the aspiration of the model is to increase the availability of resources for DRR managers to take preventive action, and to prevent damages before they occur. In the light of user groups comments, outputs from the model are useful for educational purposes, if the simulated "What if" scenarios are very powerful if communicated through narratives that the local population can identify with.*

**There needs to be a contingent assessment of DRR, however, often the estimated avoided costs appear to be exorbitantly high. Hence, how are avoided costs estimated and how can they be made relevant to decision makers?**

*The model calculates the avoided costs and added benefits on sectoral and cross-sectoral level by using simulation of different scenarios. A Business as Usual (BAU) scenario serves hereby as the baseline for the assessment. The BAU scenario assumes no preventive action or investments, which implies that the full amount of damages will occur over time. Damages resulting from climate variability and change impacts in the different sectors accumulate over time. At the end of the simulation, the cumulative damages resulting from climate variability and change impacts are summed up. To assess the avoided costs from DRR interventions and preventive action, alternative scenarios are simulated, which assume that policies are implemented ahead of time, which mitigate part of the damages from climate variability and change impacts. This implies that the cumulative damages in the alternative scenario are, depending on the effectiveness of interventions, lower compared to the BAU scenario. The difference in cumulative damages, sectoral (e.g. roads, agriculture production, livestock, health care, etc.) or total (sum of all cumulative damages) represents the amount of avoided costs.*

*The relevance for decision makers emerges from the comparison of initial investments to the total avoided costs and added benefits, as the model provides an indication on the amount of 'extrabudgetary expenditure' that can be avoided through upfront investments.*

**The importance of language was pointed out as a key issue, as policy makers must understand the language and recognize the outputs in order to deem them useful.**

*For the presentation of the approach and the model itself, a technical language was used to ensure that the model is validated through experts based on its underlying workings. For the presentation of the tool to decision makers and practitioners, a different language will be used, and the focus of the presentation will be on the outputs rather than the technicalities of the tool.*

### Key issues raised during the second presentation:

There is a need to bring out the nexus between the developed tool and the DRR frameworks to facilitate uptake in the DRR community. There seems to be a missing link between the proposed approach and key DRR frameworks (e.g. Sendai), as it seems to miss out on aspects of vulnerability and exposure. Currently, there is more time and money spent fixing the impacts than preventing them. The benefits of certain interventions are often unclear, and governments do not see the need to invest.

At the core of this model is demonstrating that investments in disaster prevention can pay back many times, if necessary DRR interventions are implemented before events happen.

Forecasts are often generated in a deterministic manner, which raises the following two key questions: Who are we talking to if we generate such an analysis? And, can we generate a sensitivity analysis?

How do we assign damages to a certain weather event? The thresholds for determining events are clear, but where do they come from? Has a historical analysis on cities been conducted for the calibration of the tool?

At this stage, it seems to be a presentation of a concept model. It is recommended for modelling experts and sectoral experts to come in to further develop and strengthen the framework.

What is meant by CIS and what are the investments necessary to make the required services available?

DRR looks at different aspects (social, economic, and environment), as for example hazard analysis. So how can the presented tool be translated into a more DRR based model? The disaster loss database is proposed for refining the model.

A lot of focus seems to be on agriculture land. Is this enough to estimate environmental impacts?

### Key issues raised after the presentation of the model:

**If the model has been applied to Mauritius and Tanzania, is it capable of capturing context specific issues?**

*The model underlying the proposed DRR model was originally developed and calibrated to the Mauritius country context, and some structural components have been successfully applied in the SAGCOT project in Tanzania. If applied in another context, the model is typically developed from scratch under consultation of local decision makers and experts to ensure that the model is as close to the local context as possible. Some of the underlying structure might remain the same, but all parameters are customized to the new local context.*

**In order to increase the applicability of the model to DRR, some gaps in terms of inputs and concepts need to be filled in. If hazards emerging from this kind of events want to be captured, we need to make sure that the relevant inputs, concepts and variables are captured. It was recommended to closely work with the UNISDR to improve the applicability of the model. Databases and country specific profiles on exposure and vulnerability exist and could be integrated into the model.**

*Taken into consideration, and the proposal for collaboration is very much appreciated and will be explored moving forward.*

**The model is using many different assumptions and different data sources. However, the current formulation of thresholds to determine whether a flood or drought is happening is insufficient for the identification of whether an extreme event happens. Statistically, there are other ways to determine whether a flood or drought is an extreme event, namely through the use of risk assumptions, and the underlying definition of risk.**

*The currently used thresholds are based on the experience of experts in the field of climatology and will be adapted to the local context. At this stage, these average values are used to enable the modelling of floods and droughts respectively, and the consultants are open for suggestions on how to improve the formulations of climate events to make the model more realistic.*

**To judge the usefulness of the model, it was asked where in the four phases of prevention, preparedness, intervention and recovery the tool needs to be placed. Further, who is the intended audience for the outputs of this tool.**

*The tool can be used for all four of the mentioned phase. When thinking about prevention and preparedness, 'what if' scenarios on different climate impacts can contribute to the identification of necessary interventions that can increase landscape resilience and hence prevent (mitigate) impacts from adverse events. Furthermore, it can be assessed whether the existing capacity (e.g. health care centres, social workers, or military) would be sufficient to manage the impacts that a major event would cause, or whether additional capacity is needed to ensure a smooth response. Regarding DRR interventions, the simulation of 'What if' scenarios provides insights into the effectiveness of potential interventions and whether potential negative side effects would emerge. Furthermore, information on cost effectiveness of interventions can be obtained prior to implementation. In the area of recovery, the tool can contribute to the identification of priority interventions (in case of crisis, or for exploration purposes) that need to be deployed to assure a speedy recovery.*

*The intended audience for this tool are primarily decision makers, as the initial intent is that it is an advocacy tool that increases funding for CIS and DRR departments. However, the tool can be used by DRR experts and/or departments for the assessment of the four stages as outlined above.*

**It was pointed out that the visual appearance of the tool needs to be improved to ensure proper representation and readability of the causal relationships. Furthermore, it was pointed out that through the use of multiple sketches, it became difficult to assess what interconnections there are between the sectors. In other words, the question on 'What system are we talking about' was posed by one of the participants.**

*The distribution of the model on several sketches contributes to breaking down complexity to a manageable level per sketch. It was recognized that splitting up the model in sketches increases the difficulty of assessing what feedback loops are in place, and the development of a Causal Loop Diagram (CLD) for the whole model was proposed.*

**Can the tool capture (a) the benefits that can be obtained from interventions, (b) losses from climate** *variability and* **change impacts resulting from inaction, and (c) contribute to the identification of the most relevant regional interventions? Furthermore, how can the portfolio be expanded?**

*The model is capable to capture the three aspects outlined above. An expansion of the tool requires more information on climate impacts in different sectors, and specific interventions that can be deployed to counteract certain climate impacts. Discriminating between interventions is crucial as interventions differ in terms of cost, effectiveness, and required implementation time. To ensure a proper assessment of the SEB resulting from DRR, the tool needs to be refined in those areas.*

**Is it possible to downscale the tool?**

*The tool can be up- and downscaled to any given level as long as information for its calibration is available. At this stage, the model is set up to run simulations on national level, however it can be upscaled to a regional level, or downscaled to provincial or local level.*

**There seemed to be a contradiction between the implementation and assessment of SEBs from DRR and the statement that additional research is needed to customize the model. What would need to be done first, and is the model doing what it is supposed to do?**

*The current version of the model is set up to capture the SEBs of DRR interventions assuming average impacts. This means that the strength, or magnitude, of climate impacts is currently based on data derived from a dataset covering 8 African countries. In order to provide reliable information in any local context, data from the local context is required to calibrate the climate impacts accordingly. In other words, the model is capable to assess the SEBs of DRR interventions, but its application to any given context would involve additional research and calibration activities to ensure the model is as close to the given local context as much as possible.*

**Does a country need to use the model every now and then, and if so, in what frequency should the model be used? What would be the costs for establishing and maintaining such a model, does it need to be developed from scratch for every application?**

*In the worst case, the model (or attention to the model) is required every election cycle that causes the government to change for DRR experts and managers to convince the new government that funding for disaster prevention and management is crucial. However, the model can be applied as often as desired, and can serve as a learning platform for DRR managers. Costs for model development are mainly incurred during the initial calibration stage which is time and research* *intense. After the initial model development, only small to no cost would be incurred, as capacity building activities could develop the in-house expertise needed to update and maintain the model.*

## ANNEX III (b) : Breakout sessions II

East Africa

1. From different perspectives (policy, DRR, and climate), what does need to be added to the model to add value to the generated outputs?
   Read: What aspects are not (sufficiently) addressed in the tool that need to be included to increase regional/country uptake?

It is recognized as having a high potential for informing decision making and being very useful for the assessment of SEBs from applying CIS in DRR. However, the concepts of policy and resilience need to be strengthened in the model to increase the granularity and its usefulness. Furthermore, it was recommended to add the mining sector, which was recognized to also have a high significance for certain countries. In addition, it was recommended to add internal migration as a consequence of climate impacts to the model.

2. What causal relationships would you challenge and why? Further, how would you improve the formulation(s)?

Climate *variability and* change scenario was not judged since the participants did not have enough time to familiarize themselves with the model and the underlying data/assumptions. It was highlighted that floods can also happen during a drought, as a consequence of an extremely dry spell, followed by multiple days of rain (flash floods). It should be assessed whether and how this can be better included in the model.

3. If this model wants to support the different stages of the Sendai framework, what aspects are still missing?

It seems that all the aspects from the Sendai framework are captured and the model has the potential to contribute to DRR analysis if abovementioned concerns are addressed.

4. How would you present the workings and the results of the tool to decision makers?

Develop a summary tool that can condense the model outputs for decision makers, since the causal structure is not easy to understand. Outputs need to be provided in a way that decision makers can identify themselves with it.

5. How did you perceive the usability of the model?

Can very well be applied on a project level and on different levels of aggregation, and was deemed useful in order to receive funding from the government. Furthermore, it could be used for sensitizing the broad public towards potential climate *variability and* change impacts, their magnitude, and mobilize people to take preventive action.

The most relevant areas where this tool can be applied are preparedness and rebuilding/rehabilitation, as it can serve for the assessment of what mitigation and/or recovery measures are needed in case of an extreme event.

**Additional comments:**

Seasonality can also be data driven. A collaboration with regional climate institutions could provide data that allows for endogenizing climate aspects and make climate simulations in the model data driven.

Central African Group

1. From different perspectives (policy, DRR, and climate), what does need to be added to the model to add value to the generated outputs?
   Read: What aspects are not (sufficiently) addressed in the tool that need to be included to increase regional/country uptake?

It seemed that the model misses the capacity to capture really extreme events. However, with more data, refinements can be made to enable better simulation of extreme events.

2. What causal relationships would you challenge and why? Further, how would you improve the formulation(s)?

Add a formulation that allows for capturing the impacts of extreme climate events, and add internal migration to the model. Both aspects should be added to the model since the costs of such events are huge, and rehabilitation efforts can pose additional challenges.

3. If this model wants to support the different stages of the Sendai framework, what aspects are still missing?

It seems that all the aspects from the Sendai framework are captured and the model has the potential to contribute to DRR analysis if abovementioned concerns are more fully addressed.

4. How would you present the workings and the results of the tool to decision makers?

The tool contributes to supporting decision making for DRR through the capacity to simulate different intervention- and climate scenarios.

5. How did you perceive the usability of the model?

The interface is user-friendly and provides relevant information. However, the variables displayed on the interface should be customized according to local/regional priorities to increase perceived usefulness uptake. Information from the respective local context needs to be provided in the interface for the tool to be more useful to local level decision makers.

**Additional comments:**

It would be good to include additional climate risks, such as extreme winds, erosion, and additional anthropogenic pressures, such as population movements and fires.

Data for the model and the calibration of parameters can be obtained from the national statistical institutions and regional climate centres.

West Africa

1. From different perspectives (policy, DRR, and climate), what does need to be added to the model to add value to the generated outputs?
   Read: What aspects are not (sufficiently) addressed in the tool that need to be included to increase regional/country uptake?

The coordination aspect between CIS and DRR interventions needs to be strengthened, and additional variables capturing environmental aspects should be included in the model. In order to increase the uptake of the model, the ones using it need to own the model, and should hence have to contribute to the development of the model.

2. What causal relationships would you challenge and why? Further, how would you improve the formulation(s)?

The areas of agriculture and energy were highlighted, especially when it comes to capturing environmental impacts. Impacts of the two sectors on forest resources (and vice versa) should be assessed more in depth. It was proposed to clearly identify input variables to ensure that experts can find and review them when assessing the model. Migration should be added to the model and infrastructure should be standardized. It was proposed to use meteorological and health data to refine impacts of adverse events and the assessment of health impacts in the model.

3. If this model wants to support the different stages of the Sendai framework, what aspects are still missing?

It seems that all the aspects from the Sendai framework are captured and the model has the potential to contribute to DRR analysis if abovementioned concerns are more fully addressed.

4. How would you present the workings and the results of the tool to decision makers?

It was proposed to provide small comments next to the output graphs that indicate what the graphs display and from what part of the model the behaviour emerges. The model should be applied on a daily basis (a) in order to keep it up to date, and especially (b) to have it set up and calibrated in case of an emergency, so that the most appropriate disaster management strategies can be assessed.

The tool should first be customized to the respective local context and then ownership of the tool should be provided. The sequence should hence be local level customization, and then dissemination and capacity building.

5. How did you perceive the usability of the model?

The model should be simple enough for non-System Dynamics experts to understand and use it. More time for the exploration of the model and capacity building is required to convince people to adapt and adopt it. The model needs to be properly understood before it can be applied.

**Additional comments:**

Two days were insufficient to explore the model and its workings, consequentially a network should be set up for following up to maintain communication and contribute to the improvement of the tool.

Southern Africa

1. From different perspectives (policy, DRR, and climate), what does need to be more explicitly added to the model to add value to the generated outputs?
   Read: What aspects are not (sufficiently) addressed in the tool that need to be included to increase regional/country uptake?

The past climate might not be capturing the variability and change in the future, which implies that more precise climate scenarios are needed to make the model more realistic. The assumption of a random uniform model as in nature it is not always the case. There is need to also consider using a logarithmic or exponential model approach for climate and the assessment of extreme events. The DRR perspective is not sufficiently clear, the model appears currently confusing for most DRR practitioners.

2. What causal relationships would you challenge and why? Further, how would you improve the formulation(s)?

Climate variability and change rate should consider different representative concentration scenarios (RCPs). The use an econometric model for macroeconomic variables such as the elasticity of capital to flood analysis should be considered. The proposed equation is

$$elasticity\ of\ capital\ to\ floods = \frac{d(GDP)}{d(flood - Impact)}$$

3. If this model wants to support the different stages of the Sendai framework, what aspects are still missing?

DRR effectiveness does not appear to clearly consider major that occur between 2000 and 2020 i.e. La Nina and El Nino. The model / tool addresses two aspects of the disaster risk management continuum (Preparedness / Mitigation and Recovery (BBB)) and is missing the Response part which may require assumptions on policy interventions. It was strongly recommended to add more detail to the intervention suites of the model, to make the model useful for the assessment of various interventions.

4. How would you present the workings and the results of the tool to decision makers?

By presenting how investing in CIS can reduce present and future expenditure levels that were incurred during a specific disaster in the past.

5. How did you perceive the usability of the model?

If the above proposed changes are taken into consideration, the models usefulness and usability for DRR and DRR experts will increase. Establishing a DRR Decision Support System interface was proposed to increase the ease of usage by policy / decision makers. Capacity building was identified as essential for different users of the model.

**Additional comments:**

Two days were insufficient to explore the model and its workings, consequentially a network should be set up for following up to maintain communication and contribute to the improvement of the tool.

**Final comments**

At a later stage, there might be the need for regional and sub-seasonal applications, which indicates that there might be a potential link to the CR4D programme which is working on sub-seasonal forecasting. In addition, it seems that there are funds that could be accessed.

Since the tool supports the assessment of avoided costs, the way that they are calculated should be communicated in a simpler way. Furthermore, what of the generated information will be taken to decision makers? The outputs of the tool should be packaged as a product, not a model, which raises the question how outputs can be packaged to be acceptable for decision makers. Overall, it is a very good and powerful tool, which will add to the toolbox of DRR tools, products and services. To develop a product, and refine the formulations in the model, some days of capacity building exercises with modellers and administrators should be planned so that technical and operational know how flow into the development of the tool.

Specific interventions need to be included in the tool to make it more useful, as the aspirations of interventions are multiple. The two questions raised in addition were: How available will the model be? Will there be additional costs involved if the tool is to be developed and customized to regions. And second, what will be these added costs to obtain the full service?

*It was indicated that the degree of complexity might be overwhelming and that it might be easier to focus on sectoral dynamics and sectoral impacts to reduce the amount of complexity to a manageable level.*

It is necessary to consider all sectors and to embrace complexity if cascading effects of adverse weather and climate events want to be captured and the full range of SEBs wants to be assessed. An application on sectoral level is possible, but it would likely ignore important feedback effects between multiple sectors, and hence likely underestimate impacts and benefits.

ANNEX IV: Manual for the SEB on CIS for DRR Model

## Manual for the socioeconomic benefits of climate information service for disaster risk reduction in Africa model