IMPROVED DROUGHT EARLY WARNING AND FORECASTING TO STRENGTHEN PREPAREDNESS AND ADAPTATION TO DROUGHTS IN AFRICA

DEWFORA

A 7th Framework Programme Collaborative Research Project

Concept report describing the outline of a framework for drought warning and mitigation in Africa

WP5 – D5.1

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SUMMARY

The framework for drought warning and mitigation in Africa proposed will assist in establishing policy priorities based on scientific evidence that also strengthen existing institutions. Overall, a science-based approach is a useful guideline, but a number of challenges are recognized. Risk-based approaches to preparing for drought are focused on acquiring accurate probabilistic information about the events themselves. When this is not possible, the strategy fails. In contrast, understanding and reducing vulnerability does not demand accurate predictions of the incidence of extreme drought. Nevertheless, if may be politically difficult to justify drought vulnerability reduction on economic grounds.

To define an evidence-based approach to policy development the early warning system ideally should include four major phases, which are:

- What is the science available? Evaluating the detection of the signs of impending drought.
- What are the societal capacities? Evaluating the institutional framework that enables policy development.
- How can science be translated into policy? Linking science indicators into definition of risk levels and analysing the signs of drought in an integrated vulnerability approach. Here we also respond to the question: Can policy be enforced? Evaluation of policy implementation and giving effect to early warning.
- How can society benefit from the forecast? Evaluating the provision of information to potentially affected groups. Here we also answer: What should society do with the warnings? Linking the science indicators the actions/interventions that society needs to implement.

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1. INTRODUCTION

The final aim of DEWFORA is to develop a framework for improving drought early warning, with more effective drought mitigation measures that strengthens preparedness, increasing resilience, and enhancing adaptation to drought in Africa.

In WP5 drought risk and vulnerability (WP3) and forecasting (WP4) are combined and extended into a warning system based on appropriate and predictable indicators, related warning thresholds, and typical responses within the existing socio-political context in Africa. WP5 leads to the primary deliverable of DEWFORA: A framework to support drought early warning in Africa, responding to the technical and organisational structure of science and society. This framework is meant to support existing drought monitoring and warning institutions and agencies in the operation of drought early warning systems (DEWS).

D5.1 is a concept report outlining the framework for improved drought warning and mitigation in Africa. It outlines the main elements to be considered to get to a situation with improved drought warning and mitigation. This will be followed by D5.2 that will provide an organizational chart and describe the institutional responsibilities, and communication lines for drought responses from national to local levels, derived from case study experiences. D5.3 will be a guideline report, presenting the consolidated framework for drought forecasting, warning and mitigation from national to local scale. It will include the forecasting framework and the institutional framework. D5.4 will present recommendations for enhancing drought preparedness at the local, national and trans-boundary basin scales and coping with drought under a changing climate.

Early warning on drought conditions is a key element for reducing drought damage to society (UN ISDR 2004; Iglesias et al., 2009, Wilhite, 2005). Early warning relies on two main aspects that have to be linked: developing prediction tools of drought hazard and vulnerability that support a risk assessment and timely implementation of drought mitigation measures. In DEWFORA we consider the well established concept of the monitoring, forecasting, warning and response. This Deliverable focuses on warming. The creeping nature of drought means that early warning should be treated as work in progress i.e. that warnings need refinement at time intervals that allow corrective action.

Iglesias et al. (2007, 2009) defined drought management guidelines to support drought management plans linking drought characterisation to risk management and operational actions in the context of each institutional setting. Here we extend this concept to support early warning systems for Africa. Through provision of early warning at sufficient lead time, drought mitigation planning can be implemented at an earlier stage. These plans can then be developed and implemented in a more proactive and effective manner, and at best the actual emergency situation due to a persistent drought can be avoided (see **¡Error! No se encuentra el origen de la referencia.**). On return to normal conditions post drought recovery plans can be implemented to facilitate return to normal conditions as soon as possible. Drought awareness, education and preparedness will facilitate such rapid recovery, and is an important aspect of the response link in the chain. DEWFORA will address drought preparedness and education to drought, and propose approaches through which these can be enhanced. The official declaration of a drought requires strong evidence. It is therefore often delayed till the time when there is evidence of low rainfall, low dam levels or crop failure. The availability of reliable precipitation forecasts may not immediately bring forward the declaration of drought but may be a signal to update vulnerability assessments in preparation for the drought declaration.

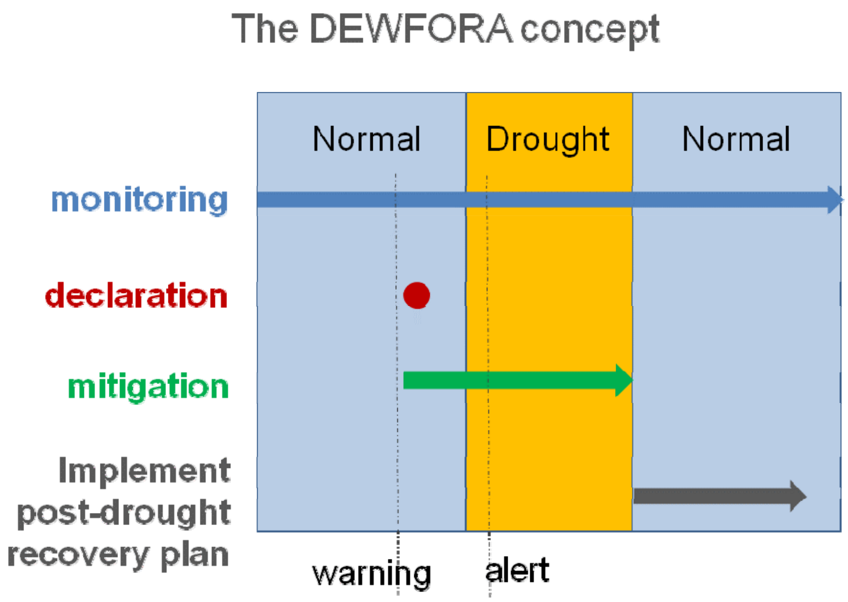

Figure 1 Sequential steps for implementing operational drought management actions combined with the provision of drought forecasting and warning

2. AN EVIDENCE-BASED FRAMEWORK FOR DROUGHT EARLY WARNING SYSTEMS

Early warning systems can make a substantial contribution to overall drought damage reduction objectives by enabling institutions and vulnerable groups to take timely action to mitigate loss and damage in advance of an impending hazard event. Existing early warning capabilities, however, are often limited due to limitations in the science and institutional, social and legal aspects that enable the application of the science.

To define an evidence-based approach to policy development (Figure 2), the early warning system ideally should include four major phases, which are:

- What is the science available? Evaluating the detection of the signs of impending drought.
- What are the societal capacities? Evaluating the institutional framework that enables policy development.
- How can science be translated into policy? Linking science indicators into definition of risk levels and analysing the signs of drought in an integrated vulnerability approach. Here we also respond to the question: Can policy be enforced? Evaluation of policy implementation and giving effect to early warning.
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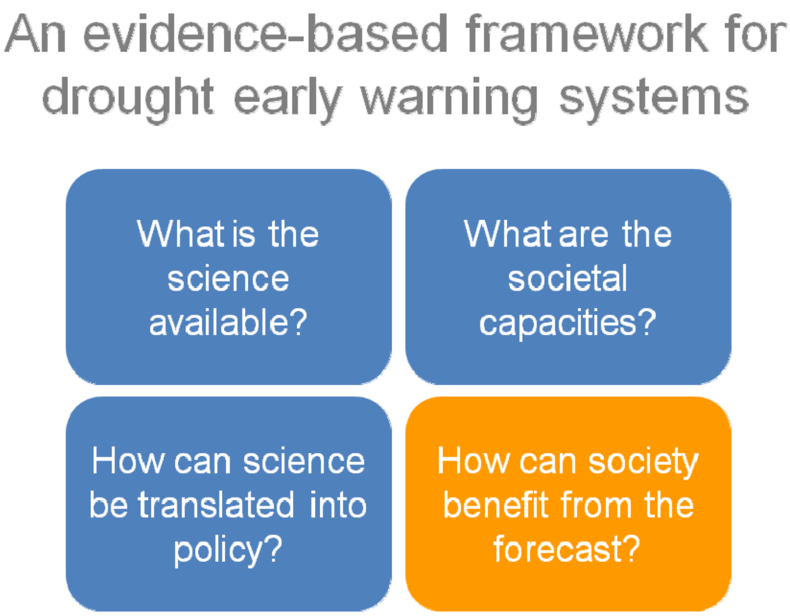

Figure 2 An evidence-based framework for policy development in drought early warning systems

3. WHAT IS THE SCIENCE AVAILABLE?

This phase evaluates the detection of the signs of impending drought. The objective is to quantify the probability of damage in each drought situation and validate the results with the observed impacts.

D2.1 provided evidence of drought indicators being applied in Africa. In D3.1 and D3.2 and D4.x we have responded to the following questions:

- What are the useful drought indicators for monitoring and for forecasting?
- What can we learn by analysing vulnerability?

It is important to recognise that indicators are sector/system/location specific. Indicators should be calibrated with observed impacts, risk level, and vulnerability reducing targets; therefore multiple indicators are needed.

3.1 DETECTION OF THE SIGNS OF DROUGHT

The main problem for developing effective early warning systems is the lack of means to predict climate conditions with sufficient skill and lead- time. Nevertheless, there has been remarkable progress in the science of climate and climate prediction in the last few decades that permits to mainstream the climate variable into the development planning. This requires an understanding of how climate variability impacts on society in a country, region, or community.

Atmospheric scientists can now predict some of the medium-term features of our climate with a reasonable level of skill. While the forecast in many regions of Africa is not expected to achieve a high level of seasonal forecast skill in the foreseeable future (see D4.x), research does suggest that sea-surface temperature forcing does yield some forecast skill for part of the rainy season, especially in the southern region where the latter part of the rainy season is correlated with the El Nino / Southern Oscillation (D4.3). Where forecasts skill is reasonable this provides specific opportunities for incorporation of forecast information into water management strategies. D4.2 acknowledges that while uncertainty in all the forcing data (mainly rainfall forecasts and perhaps temperature forecasts as well) can be minimised with the ensemble approach, hydrological models compound it by their inability to represent hydrological fluxes and the lack of good precipitation observations hydrological droughts. Thus further scientific advances on hydrological models that can use the seasonal forecasts to generate information for water management strategies in Africa.

Drought early systems based on local knowledge identified in D2.3 provide early warning on on-set of drought with varied lead times and overall period of seasonal outlook. Historical forecasts have not communicated the duration, magnitude and chance of occurrence of the drought. Evidence of consistent issuing of warnings is poor because of lack of documentation and this has limited the scientific advancement of these knowledge systems.

While the application of stochastically generated forecast trajectories (flow and storage), historical statistics (rainfall, flow and storage) and cyclical behaviour (rainfall and flow) for drought early warning are the preferred options by water managers in Africa as they offer improved confidence through learning from historical patterns there is an appreciation that future patterns may be different hence the need for new methods that incorporate seasonal forecasts (D2.3).

3.2 PRESENTING THE RESULTS OF CLIMATE MONITORING AND FORECAST

The main direct users of drought early warning information in Africa include the following (D2.3):

- Hydrological Services
- Research Agencies
- Catchment Management Agencies/Water Authorities

- Departments of Water – Water Resources Operation and Planning
- Departments of Agriculture – directorates responsible for communicating drought forecasts to users
- Disaster Management Organisations
- Municipalities/District councils – directorates responsible for communicating drought forecasts to users
- UN Agencies
- Large irrigation water users
- NGOs involved in drought monitoring and forecasting and
- USAID FEWSNET

NOAA forecasts and model predictions from ECMWF, the UK Met Office and the ECHAM3 dynamical model are being applied supported by radar and rain gauge measurements. There are challenges in simplifying, downscaling and packaging information to address user preferences, the use of language and media accessible to users. Hydrological drought forecasts are generated from models which use historical inflow or statistical methods. These are set up for local conditions.

There is generally a lack of urgency in responding to drought early warnings where they have been issued. Users generally attribute this to the fact that the warnings do come with information on what actions users should take. At the local level, poverty, lack of education, lack of funds and political influence also have had negative impacts while at the national level delays in decision making have been experienced.

It is evident from this study that early warning on food security to inform emergency food relief is important in Africa. Famine early warning systems and networks across Africa are coordinated by FEWSNET. These networks include regional, national and local vulnerability assessment committees. FEWSNET publishes a monthly bulletin on food security. Remote sensing and ground truthing techniques are applied in generating food security forecasts.

National MET provide weather forecasts as well as seasonal climate outlooks. Unfortunately on drought early warning the application of seasonal and long range climate forecasts for drought early warning still has a limited number of users. Most of the communication involves forecast precipitation versus long term historical precipitation, as an indicator, SPI is not widely applied. These are derived from …Forecasting precision decreases when the spatial focus is narrowed from global, to regional, to national, to local levels.

In contrast to this, indigenous knowledge systems are applied widely. In most cases the lead time for indigenous knowledge systems is very short. They typically detect the onset of drought or whether a drought is being experienced already. However drought early warnings from both formal and local knowledge systems do not provide adequate information on duration, magnitude of drought as well as the spatial extent. Information from formal knowledge system is too coarse for local application. The user response to early warning from local knowledge systems is fine-tuned through historical experiences and in most parts of Africa the history is quite long. As a result warnings and responses find expressions in local language and customs. The forecasting precision of local knowledge system decreases when the spatial focus is increased even at local levels.

The need to link formal systems to local knowledge systems is quite evident from this study coupled with methods which allow learning and adaptation.

The description of models and data that are used to derive the drought early warning information is very weak. This could be attributed to the limited time available for this study which constrained data gathering to small samples for questionnaire surveys and a few interviews. However, the low level of technical and scientific personnel in most of the organisations issuing early warning products suggests limitations in application of methods, tools and data. The scientific knowledge on drought forecasts obtained from atmospheric and hydrological conditions and potential impacts needs to be considered in drought management plans. This knowledge should be based on monitoring and prediction. The information should be presented to stakeholders as an "integrated monitoring and early warning" product and request their evaluation as an element of adaptation strategies. For example, an ideal integrated monitoring and early warning product for agriculture should incorporate information about climate, soil, water supply, and potential agricultural yields. Ideally, information should be in the public domain and it should be sufficient to gauge the level of risk and make informed decisions about the future.

An effective way of presenting the drought early warning is by a combination of maps, graphs, diagrams, tables and animations, which show the variations in probability of drought events of a given level of severity (e.g., the probability of a 50 per cent reduction in annual rainfall) and impacts of intervention actions (people what to see results of actions). A drought situation is not static over the season.

The monitoring of rainfall, water levels in rivers and aquifers and the depth of snow (in areas where snowmelt is an important source of water) can give warning of imminent or developing droughts.

3.3 MONITORING CAPACITIES AND DROUGHT MITIGATION PRACTICES IN AFRICA

The results of WP2 show that in general the status of rainfall monitoring systems in most countries Africa is deteriorating and the density of stations is inadequate for drought monitoring (D2.4) They are becoming less effective as a result of lack of investment or conflict causing the breakdown of recording and reporting systems. There is need to investigate and promote citizen-based rainfall monitoring systems to address this gap. The capabilities of analysing existing climate monitoring systems and prediction capabilities, and possibilities for incorporating the forecasts and monitored information into drought management plans in the DEWFORA Case Study areas will be evaluated in D5.2.

4. WHAT ARE THE SOCIETAL CAPACITIES AND CHALLENGES?

This component evaluates the institutional framework that enables policy development. *D2.4* demonstrates that there is a disconnection between the institutional responsibilities for drought monitoring, forecasting and early warning in Africa and the end user requirements. There is also a disconnection between available resources and responsibilities. “State of the art” suggests that improved distribution of responsibilities as follows:

- Level 1: Institutions involved in monitoring but some also provide forecast information;
- Level 2: Institutions responsible for resources management, public services or Earth observation;
- Level 3: Institutions that process data and provide information to the public. Institutions that collate data and maintain databases also fall into this category;
- Level 4: Institutions that develop monitoring and forecasting methods and tools.

The institutional framework allows data to be passed to different institutions for value addition. A framework to address user requirements for drought monitoring and early warning was developed in D2.4. This framework recognizes that **users require** different types of information but this has to be usable and timely. This imposes certain conditions on the frequency and reliability of **outputs** from the monitoring and early warning systems. This information is generated through application of models or tools on **input** data, which has to be adequate, accurate and timely. **Resources** required to support this framework include funding, policies, procedures, methods, people and infrastructure. The analysis is done by focusing on the **outputs, inputs** and **resources** in order to understand the gap that exists between different systems in Africa and with 'state of the art" systems. The main requirements of users of drought monitoring and forecasting systems in Africa based on review of available literature and limited interviews can be summarised as follows:

- Seasonal forecasts which means forecasts with a lead time of 2 to 5 months depending on length of season;
- Reliable data for each system, level or resource, which should be preferably from a single source;
- Evidence of success rate of forecasts based on history to improve confidence of users should be included in forecasts;
- Predictions should be available at local scale (Forecasts should zoom to areas, which users can relate to);
- Users have experience with occurrence of rainfall, therefore the spatial scale for predictions should consider variability of rainfall;
- Easy to understand information (communicate risks of forecast clearly to enable users incorporate this information into their own risk management frameworks);
- Drought forecasts should include recommendations on how users should respond;
- A tool that translates forecasts into information on the availability of water in rivers and dams.

Meteorological Departments in Africa provide data to the ECMWF in Europe and the WMO. Monitoring systems in African countries are inadequate considering the variability of precipitation and flow, sizes of catchments/aquifers and variability of geophysical conditions. In addition, historical data is not readily available to users. There is a decline on the meteorological stations due to high maintenance costs. The main challenges to monitoring of drought in Africa are as follows:

- Meteorological and hydrological data networks are often inadequate in terms of the density of stations for all major climate and water supply parameters. Data quality is also problematic because of missing data or a short length of record;
- Data sharing is inadequate between government agencies and research institutions;
- High costs limits application of data in drought monitoring, preparedness, mitigation and response. Rainfall, temperature data and the derived parameters are costly, as the national meteorology agencies, which are public institutions, charge high fees even if the data is required by education and research institutions.

In Africa, the number of users of "state of the art" outputs is very small. The main challenges for drought forecasting and early warning systems in Africa are as follows:

- Early warning information where it exists is delivered on an occasion basis. End users do not get information in suitable format at the time they need it. Systems for disseminating or delivery or exchange of information in a timely manner are not well developed or inexistent, limiting their usefulness for decision support;
- Early warning information is often too technical, limiting its use by decision makers and farmers. End users are not involved in product verification. There are no customer's/users networks to ensure product verification and service feedback;
- Early warning information is often unreliable on the seasonal timescale and lacks specificity, reducing their usefulness for agriculture and other sectors;
- Drought impact assessment methodologies are not standardized or widely available, which limits the formulation of regionally appropriate mitigation and response programs;
- Drought indices are generally inadequate even for detecting the onset and end of drought;
- Integration of information into government structures is poor and focuses on emergency response rather than long-term planning;
- Users are not aware of the range of early warning products that they can use.

In Africa the infrastructure is generally inadequate (equipment, computers, software, etc.) although a few organisations such as the CSIR is South Africa are well equipped. There is a lack of enough skilled technicians, professionals and researchers to handle weather and climate information. In addition financial resources are very limited. It is very difficult to recover costs for forecasting products as they are generally free to those who want to take them up.

Institutions are trying to collaborate to combine skills available to improving the quality of the product. Effort has been made on water resources assessment in Africa and as well as hydrological modelling, data acquisition and compatibility for the use with various models. More skilled people are needed in Africa and this can be done through research programmes on analysis and interpretation of information and development of usable products.

The following observations were also made in this deliverable:

- The forecasting and early warning systems available in Africa are not adequately maintained; recalibration and troubleshooting of the systems are also inadequate;
- The limited involvement of scientist/specialists in Africa in designing and developing early warning and forecasting systems means that local knowledge is not incorporated in "state of the art", which results in unreliable products downs-calling to regional and local levels;
- Locally collected data is also useful for regional, continental and global forecasting and early warning systems. The current approach to financing data collection is therefore not appropriate;
- Capacity is required at all levels (researchers, meteorologists, technology transfer, farmers, policy makers, communities, etc) for effective interpretation and usage of forecasting and early warning products.

Thus the strengths and challenges (impediments and weaknesses) that stand against drought preparedness are quite significant. The capacity to develop and carry out drought early warning systems (DEWS) is limited as is demonstrated by the observed disconnections in the current institutional arrangements.

Following the analysis, tentative recommendations as to what specific institutional or organisational changes would be needed to improve the existing preparedness plans can be made. In some cases, specific identified changes may take place within the current political and administrative context in each country.

NOTE: Some of information referred to in this section is closely linked with the information provided in WP2 and WP6.

Here we propose a method for evaluating institutional capacity that includes mapping the organizations and institutions relevant to DEWS (defined in WP2) and evaluating the process of DEWS development according to a mental model provided in here (Figure 3). The model includes the analysis data and information systems, legal framework, linkages among relevant institutions, organizations and stakeholders and summary of the proactive and reactive plans and actions. The model structure needs to be validated with participation of the stakeholders. The final output will be a discussion of the challenges and opportunities for improving current drought management plans.

The conclusions of the societal analysis should be concise and specific about the institutions' or organisations' performance (both based on past episodes and future contingencies) in relation to mitigation of drought impacts and anticipatory measures.

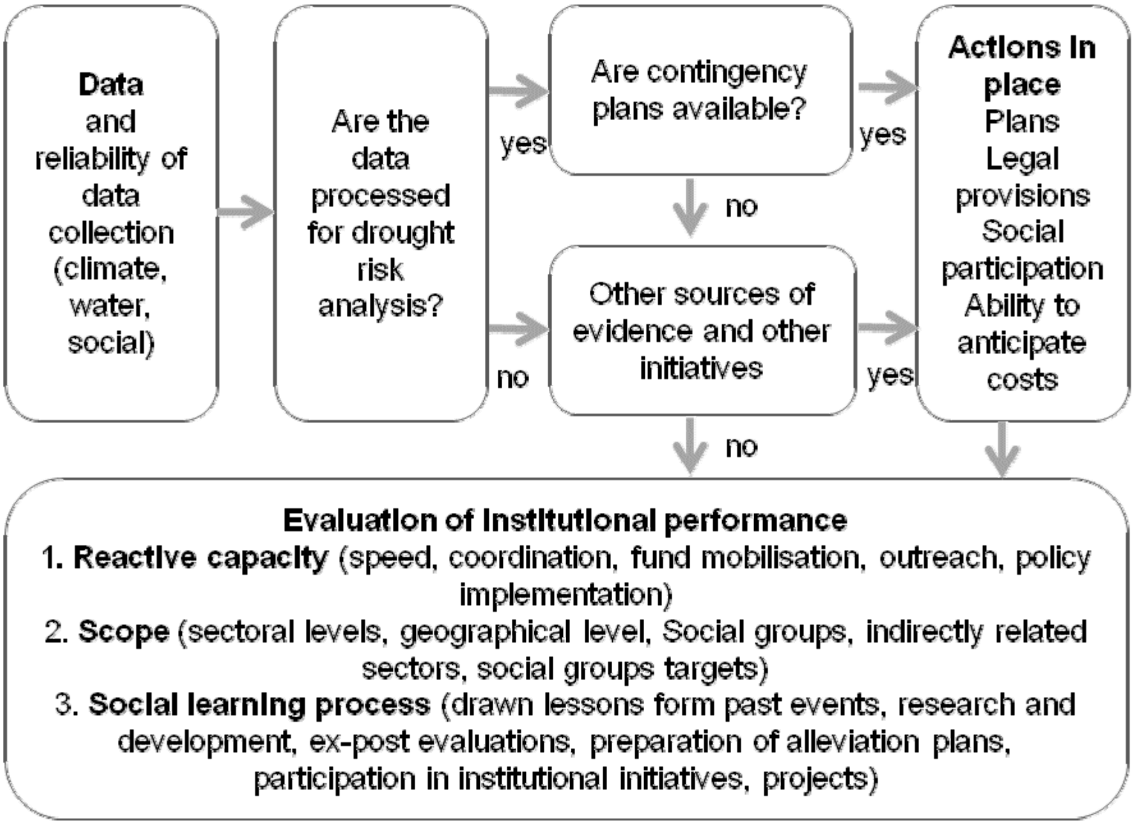

Figure 3 Overview of the institutional framework within which DEWS may be developed

The Institutional Frameworks for effective drought warning and mitigation presents all organizations and institutions related with the management of water resources. The institutions are classified into policy-level institutions, executive-level institutions, user-level institutions and the NGO's institutions, at national, regional, district and local levels.

Institutional analysis is important to understand the concept, to identify the institutions and map them to ensure the relevance of subsequent drought management analysis. The analysis aims to provide insights to the following key questions:

- Are all stakeholders included into the network?
- Do the organisations and institutions interact within a formal or an informal network?
- Are there networks to provide communication and hierarchical flows of command?

- What is the degree of influence and dependence of the stakeholders' decisions on the institutions' core themes?

A correct definition of the roles of the different levels of government in planning and co-ordination is a primary need in the preparedness and management processes. This component of the mental model includes a topology-type graph and a written description.

D2.2 identified the different types (distinguished by role) of institutions involved in drought mitigation. The most common actions being agriculture extension services, food aid, policy, advocacy and water supply. However the most common institutions in the formal institutional frameworks for drought mitigation are agriculture extension services, food aid, policy and funding; advocacy and water supply are excluded.

The organizations and institutions to be included are those within the formal framework of the political and government structures in each country (i.e., Ministries, General Directorates, Commissions, etc.) and the Official Institutes and Offices with relevant roles in drought preparedness and management, including water management organisations (e.g. municipal supply agencies, irrigation district consortia), institutions responsible of disaster's defence and ad-hoc drought emergency Committees or Offices. The analysis includes: a topology-type map and a description.

We propose that the institutional and organisational analysis also includes information on data collection, accessibility and reporting to address the need to have broader participation at different levels as identified in D2.4. Table 1 may be a guideline for the collection of information. .

Table 1 Types and characteristics of the institutional data relevant to drought early warning systems

Type of information	Description and variables to be included in the analysis
Data Types	Biophysical data: climate, soils, water, land, agriculture Socio-economic data: water and land uses supplies and demands, economic indicators (i.e., GDP), demographic indicators.
Data Suppliers	List the organisations and institutions that have the responsibility of data collection and processing, and describe the strategic mandates or policies that dictate the data collection policies.
Data Acquisition	Description of the instrumental base for data collection, processing, and recording. For example for climatic data, the information should include the number of weather stations, variables collected, length of the data series, etc.
Data Accessibility	Description of the accessibility conditions of data: costs, regularity, format. Documentation of the metadata, location, and publications.
Data Reporting	Mention the mandatory dependencies that exist with regards to data reporting among official organisations, stakeholders and NGOs.
Data Users	List the organisations and institutions that receive data on a regular basis

A range of drought mitigation actions were identified in D2.2 the most common ones being food aid, drought relief programs, growing of drought tolerate crops, saving livestock, improved water use efficiency and installation of boreholes, wells and small dams. We propose an evaluation of the institutions strengths and weaknesses for implementing or developing drought preparedness and management plans which include concrete mitigation actions. The analysis may consider all aspects of the model; Table 2 may be a guideline for the major issues to be evaluated.

Table 2 Summary of the major issues to be evaluated in the analysis of the model structure

Topic	Relevant issues
Data and Information	Representation (spatial and temporal) Adequacy for risk analysis Appropriate for historical analysis Accuracy Handling Accessibility Legal data: Water right-holders records Updated registries Socio-economic data: Water users Sectorial distribution Demographics Other
Institutional Organization	Organisational set-up Legal set-up Personnel capacity and training Coordination among institutions Information flows and utilisation Units in charge of drought preparedness actions Bodies in charge of developing proactive and reactive management plans NGOs and stakeholders participation
Institutional Performance	Based on the most recent drought episode Based on the present state of approved contingency plans Based on the strategies developed as a response to recent drought episodes Based on the capacity to conduct risk analysis Based on the capacity to pool risks and ensure compensation mechanisms at the lowest cost
Conflict Resolution	Levels at which conflicts are faced and solved Means to solve conflicting issues Stakeholders and users participation Groups left unattended or disenfranchised

4.1 IMPROVING THE INSTITUTIONAL AND ORGANISATIONAL FRAMEWORK

In order to develop national and local capabilities for early warning systems, it is recommended that in line with the distribution and responsibilities that allow effective participation, the strategies for the institutions, agencies and social organisations which deal directly with affected users should include the following components:

- A vulnerability information system, which can enable drought management authorities to generate vulnerability scenarios. These should indicate the potential impact of an impending drought event on specific vulnerable groups and sectors of the society.
- A preparedness system, in which drought preparedness strategies are developed that indicate actions required to reduce the loss and damage expected from an impending drought event.
- A communication system, which allows the communication of timely information on impending drought events, potential risk scenarios and preparedness strategies to vulnerable groups, so that they may take appropriate measures.

Embedding these components within existing institutions may also reduce costs, strengthen existing institutions and allow them to plan properly.

5. HOW CAN SCIENCE BE TRANSLATED INTO POLICY?

A science-based approach for preparedness and early warning is the key for later operational management and determines the success of the overall DEWS. The following aspects need to be considered:

1. Definition of the actions to reduce social vulnerability (permanent measures).
2. Identification of the alert mechanisms/signals based on thresholds of indicators that allow raking of risk levels in agriculture, ecosystems and water supply systems

We propose a science-based approach to identify alert mechanisms. For example, when probability of drought damage exceeds a minimum threshold, mitigation actions are taken and implemented (Figure 4)

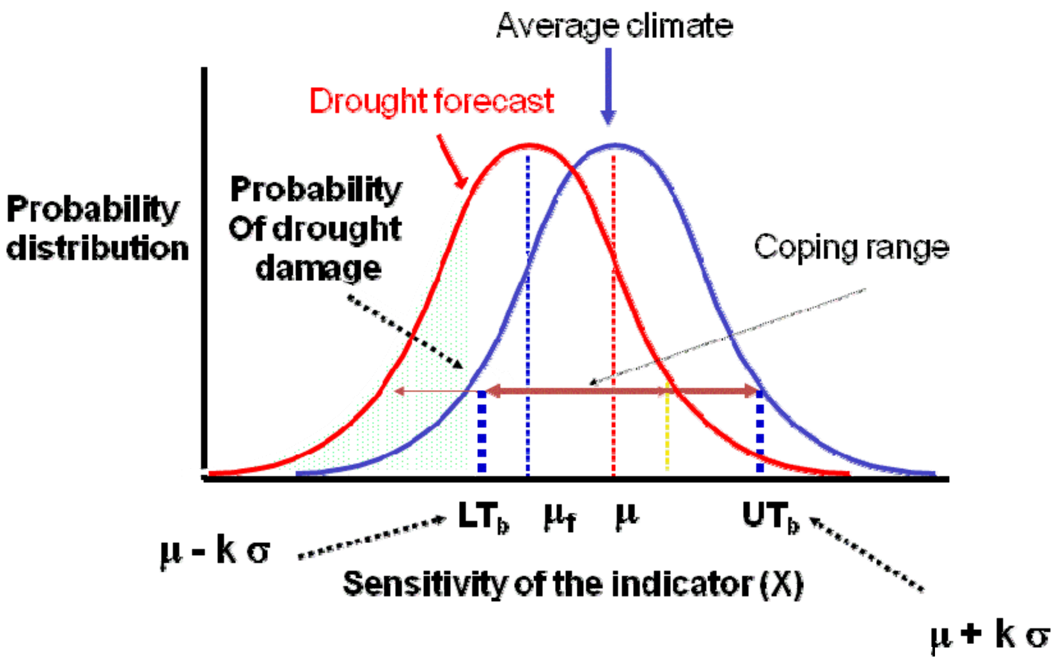

Figure 4 Example for definitions of thresholds to trigger drought alert

Communicating probabilities is a difficult task. From the academic point of view, the probability distribution functions (see example in Figure 5). Nevertheless, this is not effective for communication with some stakeholders groups and the work in WP2 and WP6 need to provide insights on how to communicate probabilities in the various levels of stakeholders involved in DEWS. The historical experiences of drought in D2.2 provide a good benchmark for communicating impacts of future droughts. An effective way of presenting the drought early warning is by a combination of maps, graphs, diagrams, tables and animations,

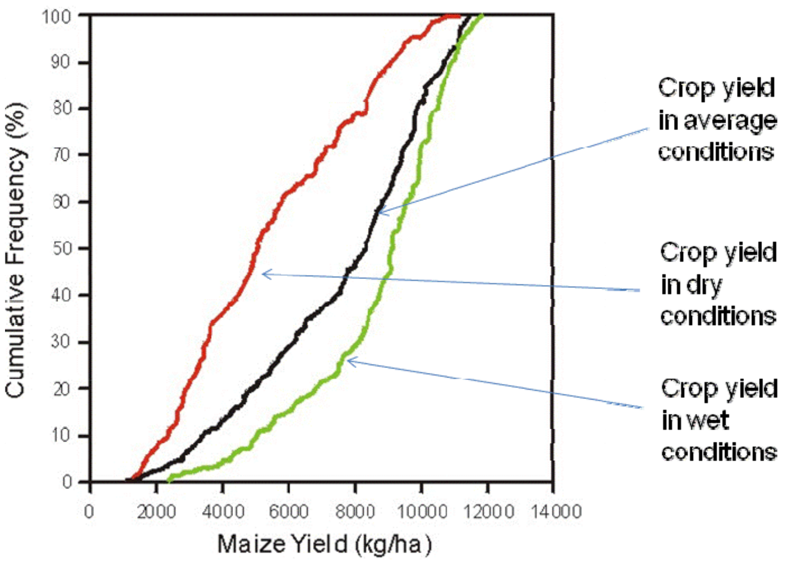

Figure 5 Example of probability distribution functions of crop damage during drought

The challenge is to ensure that complex models are transparent and provide insight to users. This will have to be analysed in the case studies.

6. HOW CAN SOCIETY BENEFIT FROM THE FORECAST?

The provision of information to potentially affected groups is the final step for effective DEWS; this includes the following aspects:

1. Define the actions to be taken upon drought, establishing priorities during water scarcity situations.
2. Evaluate the process to implement the actions, the political process, and the links between drought, water and development policies.
3. Define of the process to ensure communication.
4. Review process

6.1 PRIORITISING POTENTIAL ACTIONS

Potential actions have two components (Figure 6): (1) drought prevention, which concerns those measures aimed at preventing drought causing damage; and (2) drought preparedness, which concerns those measures which enable societies to respond rapidly to drought.

Drought mitigation actions may range from increasing the security of water supplies through water storage schemes (such as dams or micro-level water harvesting schemes), increasing the proportion of food production which is irrigated, increasing the efficiency with which available water sources are utilised, introducing or ensuring the retention of crop varieties which are drought-resistant, encouraging the greater use of adaptive strategies by farmers, to diversifying the sources of employment and income in an area into activities which are less vulnerable to the effects of drought. Reference can be made to the range of actions identified from historical drought given in D2.2.

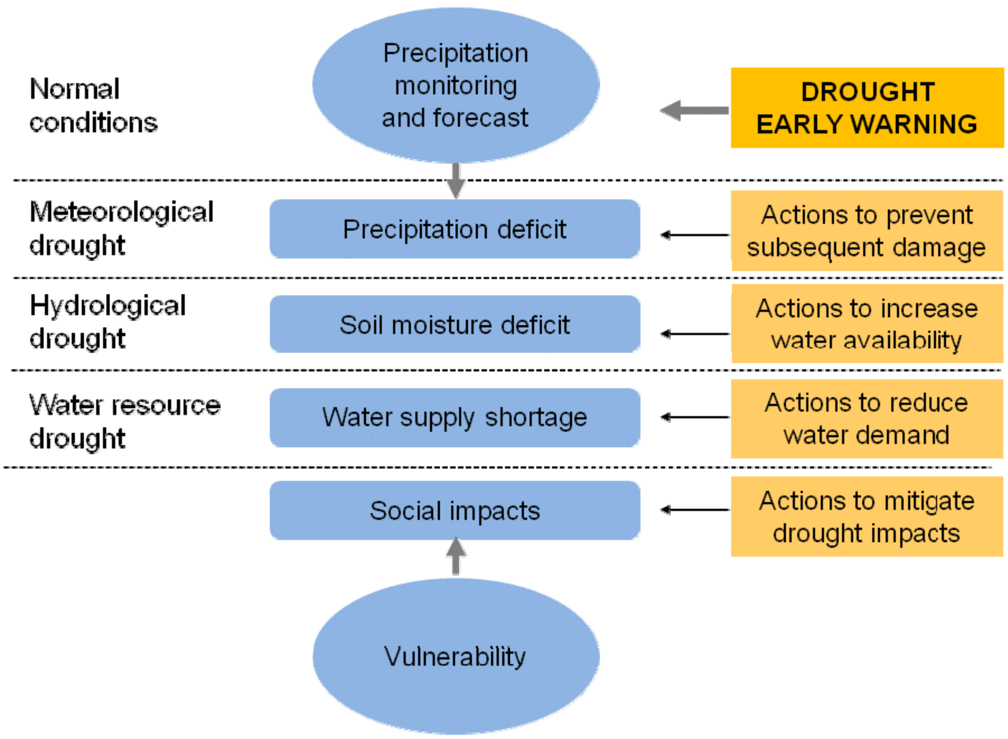

Figure 6 potential actions that may be included in a DEWS

Priorities may be established based in on such concerns as feasibility, effectiveness, cost, and equity. In choosing the appropriate actions, it might be helpful to ask some of the following questions:

- What are the cost/benefit ratios for the actions identified?
- Which actions does the general public deem feasible and appropriate?
- Which actions are sensitive to the local environment (i.e., sustainable practices)?
- Are your actions addressing the right combination of causes to adequately reduce the relevant impact?
- Are your actions addressing short-term and long-term solutions?

- Which actions would fairly represent the needs of affected individuals and groups?

A tool to rapidly assess the cost and benefits of mitigation actions should be implemented to help give effect to the vulnerability assessments.

6.2 PROCESS TO IMPLEMENT THE ACTIONS

The following aspects may be considered:

- Assess the availability of skilled human resources needed for drought preparedness planning
- Educate policy makers and the public on the need for improved drought preparedness as an integral part of water resources management
- Support creation of regional drought preparedness networks to enhance regional capacity in sharing lessons learned
- Enhance regional and international collaboration
- Recognize the role of WMO, ISDR, NMHSs, and regional/national institutions in drought early warning and preparedness

The implementation of drought mitigation actions should be embedded within existing institutions.

6.3 COMMUNICATION

Effective communication and public participation will increase the quality and acceptance of the DEWS, since this: (a) ensures acceptance of or trust in the science that feeds into the planning; and (b) provides essential information and insights about drought preparedness, since the relevant wisdom is not limited to scientific specialists and public officials.

Participatory methods, such as interactive approaches, or structured dialogues, are recommended.

6.4 REVIEW PROCESS

Developing DEWS is not and end-to-end process, but needs to be revised and reviewed in light of new science and evolving institutions and societies.

7. CONCLUSIONS

The framework for drought warning and mitigation in Africa proposed will assist in establishing policy priorities based on scientific evidence that also strengthen existing institutions. Overall, a science-based approach is a useful guideline, but a number of challenges are recognized. Risk-based approaches to preparing for drought are focused on acquiring accurate probabilistic information about the events themselves. When this is not possible, the strategy fails. In contrast, understanding and reducing vulnerability does not demand accurate predictions of the incidence of extreme drought. Nevertheless, if may be politically difficult to justify drought vulnerability reduction on economic grounds.

8. NEXT STEPS

The next step to obtain feedback from the teams involved in WP3, WP4 and the Case Studies in WP6 on this document. We need to ensure that it captures the main elements (at concept and framework level) to be considered in getting to improved drought earning and mitigation.