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

A 7th Framework Programme Collaborative Research Project

Work Package 2

Assessing existing drought monitoring and forecasting capacities, mitigation and adaptation practices in Africa

DELIVERABLE 2.3 – ASSESSMENT OF DROUGHT WARNING AND RESPONSE EXPERIENCES

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COOPERATION

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EXECUTIVE SUMMARY

This document presents an assessment of drought warning experiences in Africa and it contributes to the ***review the status of existing local, regional and continental drought*** *monitoring, forecasting,* ***warning and response systems in terms of infrastructure, data, models and capacities in Africa****. The assessment is done on case study basins selected across Africa namely; The Oum-er-Rbia River Basin, (Morocco), Eastern Nile Basin (Burundi, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda), Limpopo Basin (Botswana, Mozambique, South Africa and Zimbabwe) and part of the Niger Basin in Mali.*

The historical drought events for which warnings were issued and the actual warnings issued were identified, these are listed below. The warnings were assessed in terms of coverage as local, national, regional and continental.

Drought Period	Warning issued	Spatial Extend (Continental, Regional National, Local)	Study Coverage
1967 to1970	Seasonal forecasting using precipitation	National	South Africa – Limpopo Basin
1973 to 1794	The food needs of the country and resources to be mobilized. Food balance, the number of people at risk and vulnerable regions.	National	Ethiopia – Nile Basin Ethiopian Plateau
1981 to 1984	Seasonal forecasting using precipitation, food security situation,	Regional	South Africa, Zimbabwe – Southern Africa
	Rainfall forecasts and warm ENSO phase done b y AGRHYMET and France Meteo	National	Mali – Niger Basin
1987 to 1988	Seasonal forecasting using precipitation	Regional	South Africa – Southern Africa
1991 to 1995	Seasonal forecasting using precipitation, food security situation	Regional	South Africa, Zimbabwe – Southern Africa
	Rainfall forecasts, and warm ENSO phase, CILSS/SAP	National	Mali – Niger Basin
1993	Regionalization policy and bottom-up planning approach. Early warning systems and some drought contingency planning	National	Ethiopia – Nile Basin Ethiopian Plateau
1996	Food-insecurity	National and Local	Ethiopia – Nile Basin Ethiopian Plateau
1997 to 1998	FAO/WFP Crop and Food Supply. Assessment Missions (CFSAMs), rainfall forecast and warm ENSO phase	National and Local	South Africa, Zimbabwe – Southern Africa
2002 to 2005	Seasonal forecasting using precipitation, food security situation	Regional, National and Local	South Africa, Zimbabwe – Southern Africa
	CFSAMs ad rainfall forecast, SPIAC, SAP	National	Mali – Niger

Drought Period	Warning issued	Spatial Extend (Continental, Regional National, Local)	Study Coverage
			Basin
2005-2006	Default emergency intervention on food relief, and livelihoods protection	National	Ethiopia – Nile Basin Ethiopian Plateau
2008 2009	Contingency planning activities. Response to emergencies through food aid and diversification livelihoods assets.	National	Ethiopia – Nile Basin Ethiopian Plateau
2009 2010	Contingency plans developed for supplementary feeding, provision of animal health services and emergency water supply	National	Ethiopia – Nile Basin Ethiopian Plateau
2011	AGRHYMET/ PRESAO	National	Mali – Niger Basin

In most countries in Africa the national meteorological services provide weather forecasts. These are usually maps showing forecast precipitation or normal, below or above normal precipitation where normal precipitation is the long-term historical average precipitation. Some maps also communicate the likelihood of occurrence of a condition. Global and regional dynamical and statistical models are applied in generating weather forecasts.

From the historical drought events it was noted that other specific institutions issued drought early warnings. In Morocco the institutions which provide early warnings were as follows:

- *The Royal Centre for Remote Sensing which provided monthly maps*
- *The Secretariat of State in charge of Water and the Environment provided estimates of water resources for the forthcoming hydrological year (starting in September). Water was allocated according to availability at the end of the raining season*
- *The National Directorate of Meteorology, Seasonal provided long-term forecast of precipitation using large scale climate patterns such as the SST, NAO and ENSO.*
- *The Ministry of Agriculture and Maritime Fisheries provided an overview of the rainfall situation by comparison to the normal year*

In the Nile Basin-Equatorial Lakes Region national meteorological services provided weather forecasts and outlooks, including pre-season climate outlooks. For example Departments the Tanzania Meteorological Agency provided weather forecasts and *outlooks, including pre-season climate outlooks The Rwanda Meteorological Service provided seasonal weather forecasts.*

In the Ethiopian Plateau non-governmental organisations (NGOs) were responsible at the national level for early warning activities.

In the East Africa Nile basin the RIBASIM-Nile was applied in the Nile Forecasting System to assess impacts of upstream developments along the Nile River. The Sudan Meteorological Authority produced rainfall forecasts for two to three month before the rainy season.

In the Southern Africa, since 1997 the Southern Africa Regional Climate Outlook Forum has been bringing together national, regional, and international weather experts to build a consensus seasonal forecast for the region. The outlook has been provided as maps of expectation of above normal, normal and below normal rainfall.

In West Africa for the Niger Basin in Mali the following institutions provided early warning: AGRHYMET, National Directorate of Hydrology, National Directorate of Meteorology, National Directorate of Agricultural Engineering, National Department of Agriculture, Institute of Geography of Mali, National Directorate of Environment and NGOs.

The lead time for the precipitation forecasts has varied from a few days to a month in most study areas and in Southern Africa a lead of 5months has been applied by the South Africa Weather Services while the Southern Africa Regional Climate Outlook Forum (SARCOF) issues a 6months ahead forecast.

An assessment of ***the indigenous or local knowledge systems*** *was conducted. In Morocco proverbs, adages or observations related to climate and agricultural activities are used for drought early warning. This is illustrated in the following table.*

Period or season		Proverbs/ adages/observations
International year	**Moroccan/ Arabo-Berber, agricultural year**	
From 14 September to 13 October	*Ctember*	Increase in water level in wells.
		If gets cold in autumn, both strong and weak could perish.
		Autumn rainfall won't bring any guest.
		If fig's leaf size become like that of the mouse, the length of the day equals that of the night.
From 14 October to 13 November	*Tuber*	-
From 14 November to 13 December	*Wamber*	Who wants to store wheat grain for the next year should sow it in November.
		If three bright stars rise up in the evening in a vertical line, speed up cereal seeding and say the growing season is over
		Tillage without manure is like the missed without news.
		At this time, only barley could be seeded as wheat could be eaten by birds.
From 14 december to 11 january	*Jember*	The cold of December can reach liver.
		The cold of December makes bride looks like a monkey and the elderly like a skin. If the sun rises red, attach your donkeys and rest, and when the sky looks red, prepare your donkeys for a walk
		Saad Akl Boulaa", the sky is raining and the soil is absorbing.
From 12 January to 13 February	*Yennayer*	In "Saad Al Boulaa", feed a person he won't be satiated, and call him he won't hear you. *This means that the cold is causing appetite increase and makes a person less reactive.*
		Rain in February is a cure to all ills (of agriculture).
From 14 February to 13 March	*Furar*	In February, rain is generally pouring in large amounts.
		In February (the laugher), one sometime it is sunny & sometime it raining.
		The leave of "Layalli" (period of extreme cold) is a grace, and the leave of Smaym (period of extreme heat) is an indignation.
		During the period of "Lyalli", early sowing (Bakri) is like late sowing (Mazouzi).
		If it rains in March, fields blossom even it they were growing poorly.
From 14 March to 13 April	*Meyres*	The rain in March has the same impact as that of the rest of the year.
		March, talking to the other months: if I am present (if March is rainy), you can all disappear, but if I am absent (no rain in March), you have to be all present (it should rain in all the other months to compensate March's rain).
		If it is raining in March, if April isn't too sunny, and the skies are clear in May, the third of harvest could be saved for the next year even for the servile farmer who doesn't have land.
		Every tree should be planted before March, and all seeds should be seeded before Hayan (Ayyam alhoussoum).
		Don't count your baby's goat among other baby's goat until Hayyan days are over (*Ayyam alhoussoum*). This means that the cool weather and the scarcity of feed can kill baby goat.

Period or season		Proverbs/ adages/observations
International year	Moroccan/ Arabo-Berber, agricultural year	
		Ears always develop after *Lyalli Hayyan* had elapsed.
		In *Batn Al Hout*, it should rain or we die.
		Rainy and sunny days alternate in April until ears come up from the cereal flag leaf.
From 14 April to 13 May	*Ibrir*	April’s cold makes the boar shaking. This means that the temperature may rise in April, but it can drop suddenly.
		If it doesn’t rain in April, my teethes become like the axes, and my eyes as big as the cup. This means that the people are afraid to have a low harvest.
		When May arrives, the orphans become independent. This means that with the warm temperature, the food becomes abundant and finding a shelter isn’t a problem.
From 14 May to13 June	*Mayyu*	In May, bring your sickle and get prepared for cereal grain harvest.
		If the sky is clear the third of harvest will be stored in the next near.
		In May, you can harvest cereals even if they are still green.
		If it rains in May, you can seed maize and be sure that the yield will be good.
		Leave the letter R (months not comprising the letter R in Arabic) and you can sleep outside under the sky.
		Summer cold is sharper than he sword.
		Figs become ripe from the inside.
From 14 August to 13 September	*Yust ou Awussu*	The beginning and the end of August are *mudd*.
		If thunder, which is the sound made by lightning takes place in August, use all your capital to buy livestock.
		If there is thunder in Smaim, the illness strikes either women or livestock.
		When figs are ripe, the *mudd* is close.

Drought early warnings are also generated from local knowledge as illustrated in the table below for Morocco:

Proverb/adage based on local knowledge	Description/Interpretation
Barley says: this is *Ntah*, irrigate me or I will fall.	Thin clouds are a premise for rain.
Warm sun is expelled.	Warm sun is followed by rain.
If it gets warm during summer, it will get cold in winter.	Warm summer is followed by cool winter.
If you notice fog, cereal will mature.	Fog will hasten cereal maturity.
If there is fog, take your kids to the forest.	Early fog during the day means the day will be warm.
As wind is strong, rain will be abundant.	Strong wind will bring abundant rain.
Don’t trust fire if it is extinct, and don’t	It may rain, even if the skies are blue in *Lyalli* season.

trust blue skies during *Lyalli* season.	
Don't take for granted guest's words and stars during *Lyalli* season.	Even if the sky is clear, rain may fall during *Lyalli* season.
Clouds are better than clear skies during *Lyalli* season.	Clouds help keep warmth while clear skies are responsible for cold nights as heat will be lost to the sky.
If you eat figs, buy yourself a burnous.	When figs are mature, it is time to get prepared to the cold season.
If fig is mature, be prepared to the rainy season.	When fig is mature, the rainy season is getting close.
If you see ripe figs, wait for the mud.	When fig is mature, the rainy season is getting close.
If the Heron shows up, the rain is close.	The arrivals of herons, means that rainy season is close.
If *Lyalli* season arrives, ask the vine tree, and if it is out, ask the vine tree.	Cold weather during *Lyalli* season makes vine tree to stop growing, and when it leaves, vine starts to re-grow.
When vine leaves have the size of mouse's ears, the length of the day is equal to that's of the night.	Equinox corresponds to the time when vine leaves have the size of mouse's ears.

The following warnings are generated from indigenous or local knowledge systems in Southern Africa.

.**Predictor/ signal**	**Description/Interpretation**
Cry of Cuculus solitarius bird	The cry of Cuculus solitarius bird between August and November is a sign of the beginning of the wet season
Abundance of some wild fruits	The abundance of some wild fruits that include Vanguer birrea during the period of December to February is taken as a sign of imminent famine
Cry of frogs	The cry of frogs during the summer season (September to March) is taken as a sign of approaching rainfall.
The position of the moon	When the moon is slightly tilted to the west and the crescent is facing down during the periods of August to December it is taken as imminent sign of rainfall within a week.
Abundance of certain insects	The abundance of butterflies, locusts and grasshoppers during the farming season is taken as a sign of imminent drought and famine
The lack of rainfall	Lack of rainfall is the major indicator of drought. Moreover, farmers do only not consider the total amount of rainfall but do also pay a special attention to its spread throughout the agricultural season

In past droughts, precipitation forecasts were the main formal warnings at local, national and regional levels. The difference between forecast precipitation and long-term normal/average precipitation has been used as an indicator. However in general the forecasts did not communicate the duration, magnitude and chance of occurrence of the drought as shown in the following table:

Drought Period	Extent of Drought (Continental/ Regional/ National/ Local)	Duration of Drought (not included in warning)	Duration x Magnitude (not included in warning)	Chance of occurrence of drought (not included in warning)	Warnings Issued
1984	National and Local	More than 2 years	Severe	High	Seasonal Forecasting using Precipitation
1988	National and Local	Less than and to 2 years	Not severe	High	Seasonal Forecasting using Precipitation
1991	National and Local	Less than and to 2 years	Not severe	High	Seasonal Forecasting using Precipitation
1996	National and Local	More than 2 years	Severe	Low	Seasonal Forecasting using Precipitation
2003	National and Local	2 years	Severe	High	Seasonal Forecasting using Precipitation
2004	National and Local	Less than and to 2 years	Not severe	Low	Seasonal Forecasting using Precipitation
2006	National and Local	More than 2 years	severe	High	Seasonal Forecasting using Precipitation
1972 – 2007 Central Region	National	More than 2 years consecutive drought	Mild to Severe	Medium	Seasonal Forecasting using Precipitation
1980 – 2008 Northern Region	National	More than 2 years consecutive drought	Severe	High	Seasonal Forecasting using Precipitation
1984 – 2008 Coastal Region	National	More than 2 years consecutive drought	Mild	Low	Seasonal Forecasting using Precipitation
1981 1984	Regional and National	More than 2 years consecutive drought	Severe	High	Seasonal Forecasting using Precipitation
1991 1994	Regional and National	More than 2 years consecutive drought	Severe	High	Seasonal Forecasting using Precipitation
2005 2006	National	Less than one year	Low	Low chance of occurrence, included in warnings	Standardised Precipitation Index, Seasonal Forecasting using Precipitation

In the Nile Basin-Equatorial Lakes Region the following are the main users of drought early warnings:

Stakeholders and Interest Groups	Interpretation and Use of Warnings
(ENSO) farmers, herders, and the government.	At the national level, surplus food could be stored for the next season, and additional food could be imported in anticipation of shortfalls. Herders might also sell off part of their herds before the arrival of drought.
El Niño government-farmers	The Ministry estimated that food production would be down by 40%, based on the weather forecast issued by the NMSA for the Kiremt season. It recommended the planting of drought-resistant crops, such as chickpea, and the replanting of failed crops with fast-maturing ones, such as teff and lentils. It also recommended the provision of seeds to farmers until the end of August and the protection of crops through the free distribution of pesticides.

In the Ethiopian Plateau the following are the main users of drought early warnings.

Stakeholders and Interest Groups	Interpretation and Use of Warnings
Christian Care, World Vision, Care International, Africare, World Lutheran Federation ORAP, Plan International, Catholic Relief, Save Children UK, Save Children USA	Preparation and provision of relief. Lobbying for relief fund. Reporting. Carrying out vulnerability assessment
USAID, DFID, GTZ, NORAD, AUSAID, Canada CIDA	Provision of relief fund

In the East Africa Nile basin the following are the main users of drought early warnings.

Stakeholders and Interest Groups	Interpretation and Use of Warnings
All those involved in fish industry	Anticipation of the fishing season
Users are the socio-economic organizations and local communities, NGOs, decentralized services of the state, rural and urban districts	The information is interpreted by the technical officers.
Users (farmers, fishermen, farmers)	Decision for the planning of activities (period of plowing period sown,).
Local communities, Technical Services of the State and NGOs	The information is interpreted by the technical officers.

In the Southern Africa the following are the main users of drought early warnings

Stakeholders and Interest Groups	Interpretation and Use of Warnings
Department of Water Affairs	Use of El Nino and La Nina, also the historical dam inflow data and water allocation relative to the dam level
Department of Agriculture	Seasonal forecast issued by South African Weather Services for the below normal to above normal rainfall
Municipalities	Warnings are given by the department of water affairs for any availability of water
Catchment Management Areas	No warnings issued
Water Users Association	Some application of self-restrictions is applied by some water users or practice physical observation of stream
Disaster Management Centres	Seasonal forecast issued by South African Weather Services for the below normal to above normal rainfall
Food and Nutrition Council.	nutritional status of infants and other people
Parliamentary Portfolio, Committee on Lands, Agriculture, Water Development, Rural Resources and Resettlement President's Office	Timing of declaration of the drought. Mobilising funding Appealing for funding

In West Africa-Niger Basin the following are the main users of drought early warnings

Stakeholders and Interest Groups	Interpretation and Use of Warnings
All those involved in fish industry	Anticipation of the fishing season
Users are the socio-economic organizations and local communities, NGOs, decentralized services of the state, rural and urban districts	The information is interpreted by the technical officers.
Users (farmers, fishermen, farmers)	Decision for the planning of activities (period of ploughing period sown, etc.).
Local communities, Technical Services of the State and NGOs	The information is interpreted by the technical officers.

The main direct users of drought early warning information include the following

- *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. These observations will be elaborated further in the gap analysis in Deliverable D2.4

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 information presented here is not exhaustive however additional information is expected from the Stakeholder Platform(s) and other stages of this project.

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LIST OF ABBREVIATIONS

AGRHYMET	Regional Training Centre for Agro-meteorology and Operational Hydrology
CAMELIS	Capacity Added by Mending Early and Livelihoods Information Systems
CARE	Cooperative for Assistance and Relief Everywhere
CFMSAMS	Crop and Food Supply Assessment Missions
CFSAMs	Crop and Food Supply Assessment Missions
CFU	Commercial Farmers Union
CGMS	Crop Growth Monitoring System
CICs	Community Information Centres
CILSS	Inter-State Committee for the Fight against Drought in the Sahel
CRTS	The Royal Center of Remote Sensing
DESA	Drought Emergency in Southern Africa
DESA	Drought Emergency in Southern Africa
DGH	General directorate of Hydraulics
DHA	Department of Humanitarian Affairs
DMC	Drought Monitoring Centre
DMN	National Directorate of Meteorology
DPA	Regional Directorates of Agriculture
DPPA	Disaster Prevention and Preparedness Agency
EAC	East African Community
EMOP	Emergency Operation
ENSO	El Niño – Southern Oscillation
EWRD	Early Warning and Response Directorate
EWWG	Early Warning Working Group
FAO	Food and Agricultural Organisation
FAO	United Nations, Food and Agricultural Organization
FEWSNET	Famine Early Warning Systems Network
FSAU	Food Security Analysis Unit
GIEWS	Global Information and Early Warning System on Food and Agriculture
GOR	Government of Rwanda
GTZ	German Agency for Technical Cooperation
HEA	Household Economy Approach

IFSHPC	Integrated Food Security and Humanitarian Phase Classification
IGEBU	Geographic Institute of Burundi
ILRI	International Livestock Research Institute
KWAMP	Kirehe Community-based Watershed Management Project
LEWS	Livestock Early Warning System
LIU	Livelihoods Integration Unit
LPCI	Livelihood Protection Cost Index
MAMF	Ministry of Agriculture and Maritime Fisheries
MINAGRI	Ministry of Agriculture
MINATTE	Ministère de l' Amenagement du Territoire, du Tourisme et de l'Environnement
MINITRANSCO	Ministrere des Transports et des Communications
MOH	Ministry of Health
NBCBN	Nile Basin Capacity Building Network
NC EW	National Committee for Early Warning
NCHS	National Center for Health Statistics
NEWU	National Early Warning Unit
NGOs	Non-Governmental Organizations
NISR	National Institute of Statistics of Rwanda
NMHS	National Meteorological and Hydrological Service
NUR	National University of Rwanda
OMS	World Health Organization
PAPSTA	Support Project to the Strategic Plan for the Agriculture Transformation
PARIMA	Pastoralist Risk Management Project
PLI	Pastoralist Livelihoods Initiatives
PRESAO	Seasonal rainfall forecasting in West Africa
RAB	Rwanda Agriculture Board
REMA	Rwanda Environmental Management Authority
REWU	Regional Early warning Unit
RMS	Rwanda Meteorological Service
RNRA	Rwanda Natural Resources Authority
ROA	Regional Offices of Agriculture
RRC	Relief and Rehabilitation Commission
RRSP	Regional Remote Sensing Project

SADC	Southern Africa Development Community
SADC	Southern Africa development community
SAP	Early Warning System
SARCOF	Southern Africa Regional Climate Outlook Forum
SAWS	South Africa Weather Services
SC-UK	Save the Children– United Kingdom
SPI	Standard Precipitation Indices
SPIAC	Prediction System of Information and Early Warning on floods in the Inner Niger
SPSS	Statistical Package for Social Sciences
SSD	Secretariat for the Drought Disaster
UN	United Nation
UNDP	United Nations, Development Programme
USAID	United States agency for International Development
USAID	United States of Agency International Development
VAC	Vulnerability Assessment Committees
VAM	Vulnerability Analysis Mapping
WB	World Bank

1. INTRODUCTION

This deliverable assesses drought warning and response experiences in Africa. It uses the study areas considered in D2.1. The case study basins are comprised of; the Oum-er-Rbia River Basin, (Morocco), Eastern Nile Basin (Burundi, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda), Limpopo Basin (Botswana, Mozambique, South Africa and Zimbabwe) and Niger Basin (Algeria, Benin, Burkina-Faso, Guinea, Ivory Coast, Mali, Niger and Nigeria).These basins are shown in **Figure 1**) and historical droughts identified in D2.2 to review the experiences on drought warning. The warnings are classified warnings by type of drought, type of data/information etc. Warnings from indigenous or local knowledge systems are also captured. This assessment is supported by limited surveys and interviews conducted with stakeholders and users of warnings.

Method(s), tools and data used to derive each warning are outlined. Drought warnings and direct users of the warnings are listed in this document. The interpretation of warnings by users and how they then respond to the drought is assessed. It is one of two deliverables which address one of the objectives of Work Package 2, to review the status of existing local, regional and continental drought monitoring, forecasting, warning and response systems in terms of infrastructure, data, models and capacities in Africa.

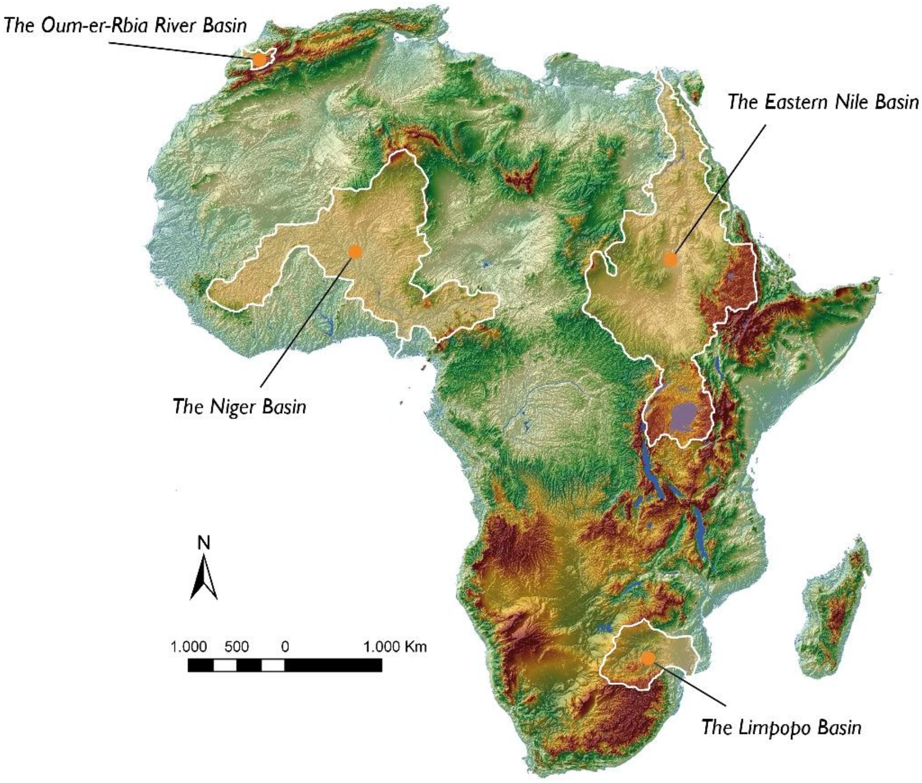

Figure 1: Location of case study basins

However in order to get to the level of detail required the focus of this study was on specific areas/countries in the basins.

2. IMPORTANT DEFINITIONS

The following definitions apply to this document:

- **Drought** – a condition that originates from a deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector
- **Meteorological drought –** occurs when annual precipitation is between 70% and 85% of the long-term annual mean precipitation.
- **Hydrological drought** - a deficit in runoff in rivers, surface reservoirs and ground water
- **Agricultural drought** - a situation of inadequate soil moisture for rain-fed crops
- **Socio-economical** - a drought which results in social stress and economic hardships
- **Drought mitigation –** the reduction in the classification of a drought in terms of frequency and magnitude of risks and resulting from reduction of the potential impact of a drought
- **Drought adaptation –** a process of being able to survive in a drought condition. It refers to changes in processes, practices, and structures to moderate potential impacts of future drought.
- **Desertification** - a process of land degradation in arid, semi-arid and dry sub-humid areas, resulting from various factors, including climatic variation and human activities. Land degradation manifests itself through soil erosion, water scarcity, reduced agricultural productivity, loss of vegetation cover and biodiversity, drought and poverty.

3. LIST OF DROUGHT WARNINGS FROM HISTORICAL EXPERIENCES

3.1 MOROCCO AND THE OUMER ER-RBIA BASIN

The assessment of drought warnings from the institutional side was achieved through literature search and surveys.

Current drought prediction capabilities as to set up onset, persistence, intensity or end of a drought are still at a modest level in Morocco and a lot of research-action is still needed to proceed forward with drought early warning. Indeed, regarding drought early warning, the main systems being developed in Morocco are as follows:

- The weekly and seasonal weather forecasts, based on the use of global and regional dynamical models and statistical models and elaborated by the National Directorate of Meteorology (DMN)
- The agro-meteorological data which are the basis of the simulation models of crop growth, the irrigation models and the phyto-pathological models that are developed by different institutions;
- The guidelines for drought preparedness plans: in Morocco, a characterization and evaluation of numerous drought indices was started for Oum Rabia river basin in the framework of the Mediterranean Drought Preparedness and Mitigation Planning (MEDROPLAN) project.
- The prediction of cereals grain production before the harvest period, using modeling and remote sensing;
- The monthly monitoring crop report based on remote-sensing data;
- The achievements of the SMAS (*Système Maghrébin d'Alerte précoce à la Sécheresse*) project whose aim was to establish a Maghreb-wide system for early warning to drought.

3.2 EAST AFRICA- NILE BASIN EQUATORIAL LAKES REGION (BURUNDI, KENYA, TANZANIA, RWANDA AND UGANDA)

3.2.1 Rwanda

For Rwanda, historical droughts events have been reported and were often associated with food insecurity and displacement of people and some cases of deaths in the past. Droughts warning are done by Rwanda Meteorological Service (RMS) through data publication to stakeholders, researchers, public through printed media, meetings, radios, and TV. Famine Early Warning System Network

(FEWSNET) is another initiative that is regularly contributing to early warning particularly for food security with a monthly bulletin published on food security. FEWS NET focuses on Famine Early warning since nineties and does not focus on drought in a specific way and its reports are produced every month. In addition even RMS does not focus its predictions on drought itself, but on weather and climate. In addition, since eighties, FAO and FWP are also contributing to Food Security Warning through GIEWS and VAM respectively. This is an activity operated in many countries including Rwanda under a financial support from the USAID (United States of Agency International Development). Drought Early warning in history is not well documented. A historical drought background can be studied using data available at RMS and **Table 1** gives a picture on the historical occurrence of drought in Rwanda.

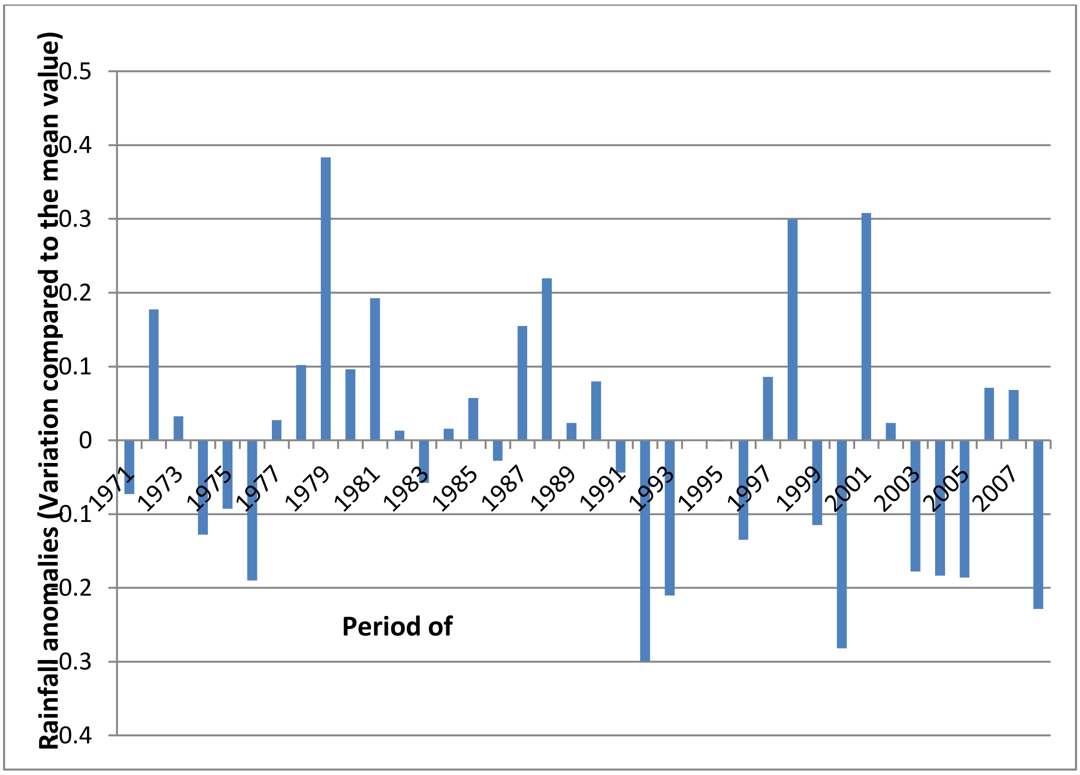

Figure 2: Rainfall anomalies in Rwanda for the period 1971 until 2008 at Kigali synoptic station.

Source: Rwanda Meteorological Service.

Figure 2 shows the variation of annual rainfall compared to the mean value. High peaks in the positive, show years with high rainfall intensity and the peaks in negative show rainfall deficiency often associated to drought events and associated calamities.

In Rwanda the drought early warning system is still to be improved because drought is not well managed and drought is not considered as a major disaster. Meteorological data are not sufficient to ensure an accurate early warning system for drought and desertification management. Indeed, drought events are not well documented in the history and further research is to be encouraged since threats of droughts and dry spells are sometimes experienced especially the eastern and south-eastern parts of the country. This has led to crop failure and sometimes to lowering of hydroelectric capacity of dams. A good example is the thermal power plant which was rented out since 2004 after the hydroelectricity crisis associated with drought which occured at that time (GOR, 2011). Displacement of population in search of fodder and food is also another consequence of drought in drought (REMA, 2004).

Drought warning from historical drought in Rwanda was mainly indigenous, where people used their observations and knowledge. For example, when there was too much rain, a drought was likely to follow for the next seasons or years and this could help in planning agriculture production.

Table 1: List of events announcement attempts to drought by the various early warning systems in Rwanda

Drought year / season	Type of drought	Type warning issued		Information / supporting data/ available knowledge (indigenous and local)	Lead time for warning
		Historical	**Currently available**		
1943-1944	Meteorological /Agricultural and Hydrological	Not documented	-	Generalized famine known as "Ruzagayura"	Since the 1960s
1982-1983	Idem	idem	RMS	Low agricultural production	
1991-1992	Idem	idem	RMS, FEWSNET	-	
1997-1998	Idem	Idem	RMS, FEWSNET	-	
1999-2000	Idem	Idem	RMS, FEWSNET	Famine	
2003-2004	Mainly hydrological drought (in Rugezi marshland)		REMA	Water level was dropped down	
2005-2006	Meteorological/Agricultural and Hydrological	Idem	RMS, FEWSNET	Famine; water sources drying; tendency of desertification	

3.2.2 Burundi

In Burundi, drought warning is supposed to be done by Burundi National Meteorological and Hydrological Service (NMHS) through data publication to stakeholders, researchers, public through, meetings, radios, and Internet. FAO project initiated also a Famine Early Warning System which contributes to early warning particularly for food security with a seasonal bulletin published on food security. Drought Early warning in history is not well documented.

Figure 3 shows the variation of annual rainfall compared to the mean value. High peaks in the positive, show years with high rainfall intensity and the peaks in negative show rainfall deficiency often associated to drought events and associated calamities.

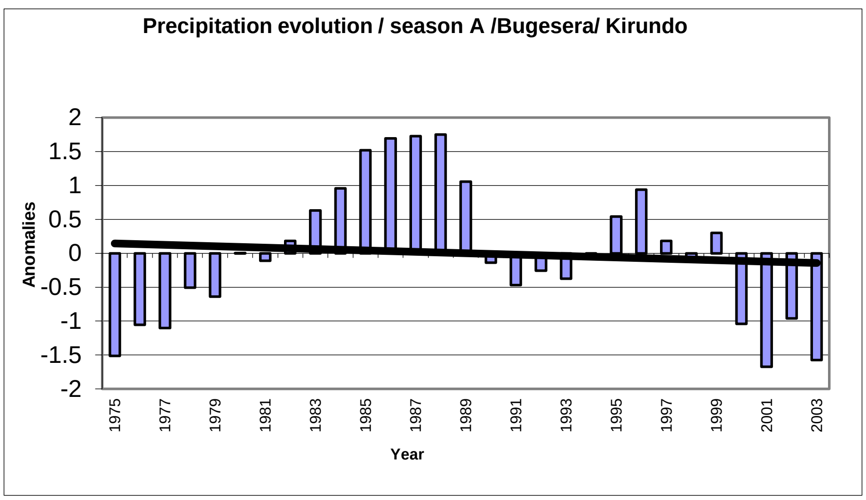

Figure 3: Rainfall anomalies in Burundi for the period 1975 to 2003.

Source: Burundi National Meteorological and Hydrological Service

In Burundi, the Geographic Institute of Burundi (IGEBU) through the National Meteorological and Hydrological Service under the Ministry of Water, Environment, Land Management and Urban is charged of severe weather forecasting (drought or precipitation forecasting).Nowadays, NMHS is making a very short and short range weather forecasting (from 24 hours to 3 days). Equipping Burundi NMHS staff with media equipment such as media studio and skills and presentation techniques to allow effective and timely dissemination and presentation of forecasts, warnings and information is required. A regional seasonal precipitation forecasting is done two times a year (in February and August).

An early warning system is a prerequisite for disaster preparedness which is not well done in Burundi. And the intervention is the responsibility of Disaster Management and Civil Protection Authority of the Ministry of Public Security. This Disaster Management and Civil Protection Authority are newly established, so that the drought early warning system in combination with the intervention still not well developed in Burundi and some improvements are required.

In Burundi, Drought historical drought warning was not well developed, where people used their own observations and knowledge. There is a need to improve coordination and communication between NMHS and disaster Management and Civil Protection Authority for more efficacy regarding challenges related to warnings of severe weather hazards.

3.3 EQUATORIAL LAKES REGION

3.3.1 Tanzania

Based on Tanzania warning system, in every warning, the national level is involved even if the drought will have effect on small area as shown in **Table 2**. This information could not be obtained.

Table 2: History of Drought Disasters in Tanzania

Disaster	Date	level
Drought	2006	National and local
Drought	1996	National and local
Drought	1984	National and local
Drought	2003	National and local
Drought	1991	National and local
Drought	2004	National and local
Drought	1988	National and local

3.4 EASTERN NILE REGION (ETHIOPIAN PLATEAU)

The National Early Warning System (EWS) has been in place in Ethiopia since 1976.It is supported by a National Committee for Early Warning (NC EW), whose members, as stipulated in 'Directives for Disaster Prevention and Management,' include senior staff members of EWRD, Ministry of Agriculture and Rural Development, Ministry of Health, Central Statistical Authority, Ethiopian Mapping Authority, and NMA as shown in **Table 3**. In 1996 the multi-agency Early Warning Working Group (EWWG) was established to coordinate early warning activities related to food-insecurity among government agencies, donors, UN agencies, and NGOs. Early warning committees at all levels, including woredas, gather information and report to higher-level committees as shown in **Table 4**.

Currently, in the pastoral regions of Afar and Somali, EWS are remotely managed by very few professional staff from regional headquarters, while local entities (districts and communities) that owned the information and its management are bypassed and considered as response recipients. Thus, the mainstream EWS is still focusing on hazards management instead of emphasizing vulnerability and socioeconomic factors in risk management.

More frequent droughts in recent years have led to the establishment of generic pastoral EWS that monitors performances of seasonal rainfalls and its impacts on livelihoods and food security situations. However, linking such systems to pastoral communities has being and is still a challenge for system developers, implementers and funding agencies and as a result, pastoralists have often been the major victims of the effect of preventable events such as water scarcity, lack of pasture and diseases outbreaks (SCUK CAMELIS Report, 2007). Lack of linking EW information to responses through community participation was identified to be the missing link in EWS.

Thus, Capacity Added by Mending Early and Livelihoods Information Systems (CAMELIS) projects and PILLAR I and II were formulated to address some of these gaps on a pilot bases so that lessons learnt would be used for future EW improvements. The former was implemented from October 2006 with specific objectives to harmonize the use of livelihoods approaches between different stakeholders that involved EWS in pastoral areas of Afar and Somali. It is also these projects that initiated CBEWS and contingency planning activities in SCUK's early warning works. The later, was implemented between April 2008 to June 2009 with objective of improving drought preparedness through increased capacities of stakeholders in order to enhance, prevent, promote, respond to emergencies and diversify livelihoods assets. These projects however, continued implementing CBEWS and CP approaches without further improving the monitoring tools and scenarios developed for responding drought related crisis.

For the past few decades, application of communication and information technologies to early warning has been expanding which continually improved the technical monitoring of early warning indicators, modelling and forecasting of livelihoods and food security threats globally. However, advances in the application of these technologies in early warning systems continue to be weak and localized at institutional levels in Ethiopia particularly pastoral areas of Somali and afar.

Different pilot projects have been implemented to test new methods of involving communities in EWS process and disseminating early warning information. For example, the use of Community Information Centres (CICs) that used World Space radio technologies under Pastoralist Livelihoods Initiatives (PLI); CAMELIS project which initiated methods of linking community based early warning data collection to Community Animal Health Workers (CAHWS) and disseminated quantitative CBEW information through CICs; Enhanced Livelihoods in Southern Ethiopia (ELSE) /Enhanced Livelihoods in the Mandera Triangle (ELMT) that had components of indigenous early warning knowledge building; short text message on mobile phones in reporting livestock market price information of LINKS GLCRSP projects and other similar projects. However, most of these initiatives were limited by their heavy dependency on technological hardware and software instead of balancing their entire processes of collecting information, analysis and dissemination with social components that could have provided the flavor of stakeholders' sustained acceptance.

Lessons learnt from such past projects facilitated new approach that integrate traditional ways of getting information (*Daguin Afar and Sahanin* Somali) and scientific ways of collecting early warning data through monitoring indicators and systematic analysis. The appropriate approach to involve communities in jointly collecting early warning information and deciding actions based on the analysis outcomes was designed and implemented on pilot bases in CBEWS as the data collection sheet and analysis sheet.

Hazard scenarios were developed in consultations with stakeholders' such as communities and other local and regional partners. The developed participatory contingency plans for pilot districts facilitated responses though late during project years. For example, in Shinile district of Somali region, the contingency plans developed for supplementary feeding, provision of Animal Health Services and Emergency Water Supply were used during 2009/10 (December – February) drought by PILLAR project and a local NGO partners like Aged and Children Pastoralist Association (ACPA) in responding to feed water shortages respectively. In *Chifra* of *Afar* region, the existing contingency plans were used by FAO in developing livestock feed cooperatives. Such cooperative commercially avails the required amount of feed to its clienteles in more cost effective and timely.

Decision making on threats of hazards at community level was considered as an integrative process that requires interaction between information sources, expert analysis, consensus building, development of contingency plans, mobilization of resources and then responses to the crisis at CBEWS designing stage.

Participation, partnerships and community involvement were crucial aspects for proper implementation of CBEWS and Contingency planning for responses at PILLAR project level. In line with this approach, initial phase of implementing CBEWS and Contingency planning activities, SCUK strategy included involvement of all stakeholders at district level including communities in the development and implementation of CBEWS and contingency response plans so as to institutionalize emergency response structures at the community level.

Active participation of different segments of the communities (elders, women groups and community animal health workers), full cooperation of civil society, partnerships among various interest groups, including the private sectors, and training at district levels were done for the effectiveness and sustainability of the CBEWS and CP activities. For example, about 20% and 25% of the interviewees such as districts early warning experts, community elders, CAHWS and NGO partners operating in *Shinile* and *Chifra* conferred their participation in trainings aimed to build partnership and local networks for CBEWS during the early (2007 and 2008) phase of the initiative.

However, in the later phases of the project, the established partnership and network between the project's CBEWS component and its stakeholders such as government (district), communities and civil society partners (NGOs) started to loosen due to intertwined multiple challenges that would be explained in the later sections. **Figure 4**, indicates the relationship between different stockholders that were initially proposed in order to implement community based early warning system in PILLAR project areas.

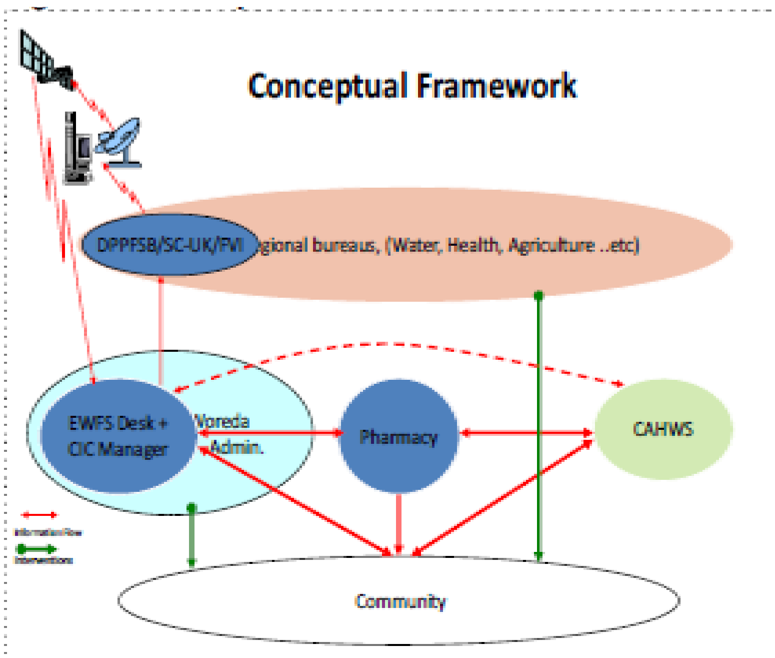

Figure 4: Conceptual framework for drought early warning

Source**:** SCUK-CAMELIS project report, 20th December 2009.

CAHWS to collect EWI data from the community on monthly bases and kept it with district pharmacists. The DEWE takes the data for analysis and output share with Woreda administration. Then warnings summarized and submitted to DPPFSB for dissemination either through World Space radio or other means.

CBEWS initiative aimed to create local partnership and sustainable network for the CBEWS processes. This piloted framework was aimed to empower local stakeholders including communities, CAHWs, EW Experts, community information centre manager, woreda administration and other interested actors. It also aims to expose community potential in responding to crisis with credible primary data to rely on for analysis that facilitates targeting intervention and decision making at local (Woreda) and regional levels. This exercise was also a primary condition towards designing a contingency plans and funds at woreda level.

In Somali Region, community animal health workers (CAHWs) that were used as an entry point to community participation and tasked in collecting early warning information, demanded incentive for their contribution while in Afar region, the partnership still loosely existed. In response to the CAHWS discontinuation in collecting CBEW information, Save the Children office in Somali Region tasked the project staff and districts early warning experts in *Shinile* and *Dambel* to collect both quantitative and standard EW data by interviewing communities during their visits at the district towns. However, although the project maintained partnership with the community, government and others non-governmental partners, important parts of the network for the continuation of quantitative EW information and CBEWS implementation were lost after the end of PILLAR I as indicated **Figure 5**.

Each of the above stakeholders (communities, districts, civil society and donors) as a separate entity have a virtual and courtesy kind of relationship with each other in general (as indicted by the outer blind arrowed lines) but in practical implementation of specific project activities, these partnerships gets loosened and commitment to contribute to the objectives of a project gets nothing more than a leap services (as indicted by the inner dotted arrowed lines).

Practically, there was lack of understanding among stakeholders and even with the project staff on the implementation mechanisms of CBEWS and contingency response plans particularly at Woreda level. Knowledge gaps emerged after the first PILLAR project phase out. Experienced project staff were not fully retained but only partially seconded to CBEWS activities that required full commitments and engagements with different partners.

The mechanism in which CBEWS information was collected and processed further side-lined government partners at Woreda and community level. For instance, project staff in *Shinile* zone of Somali region unlike the staff in *Chifra* of *Afar*, practically abandoned collecting information on quantitative indicators used by CBEWS during PILLAR II due to lack of dedicated early warning staff at project level. These discouraged the continuity of Woreda EW expert partnership in collecting, computing data into the ACCESS database, analyzing and disseminating CBEW information at district level.

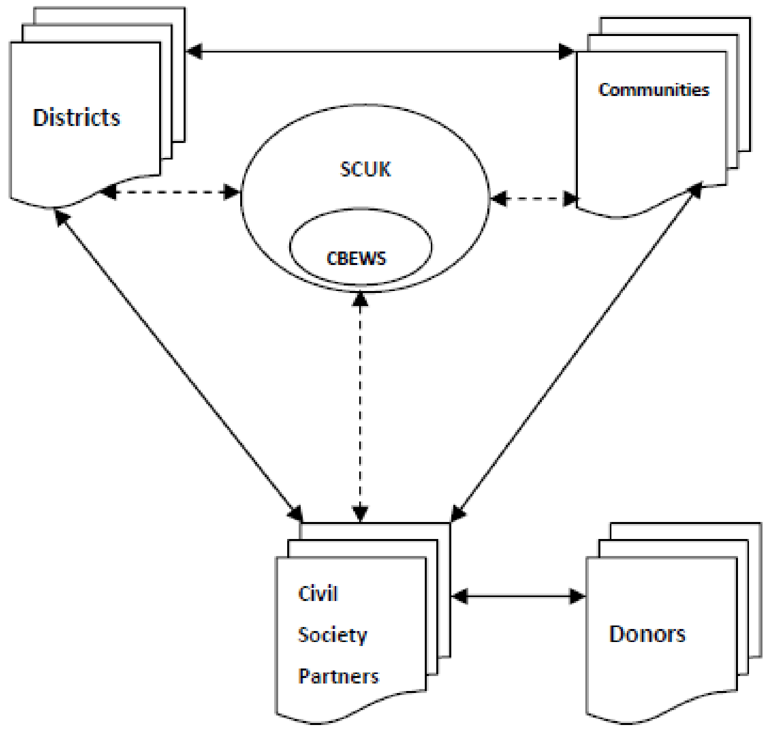

Figure 5: CBEWS and CP network and partners

Nonetheless, early warning experts in *Shinile* zone continued filling and submitting early warning data sheets for the national early warning system to zonal early officer for decision making. The information collected and analyzed for the Woredas were not shared with government partners and communities at districts levels but directly channelled to zonal headquarters and regions including Save the Children UK regional office.

Disseminated early warning information simply created more distrust and disputes between stakeholders at district, zonal and regional levels. Most stakeholders at each level rarely share sectoral information among themselves and any information individually shared without consensus to each level creates competition for recognition and thus undermines timely interventions. Stakeholders that lack part of the information are asked to make decisions on an output of process they do not understand its contexts, the way the information was gathered and analyzed. Therefore, early warning information from zonal and regional systems needs to be interpreted within local contexts and utilized in conjunction with district level information to be effective, adapt to local circumstances and to prevent misinterpretation, and negative impacts.

The list of warnings issued for historical droughts available from literature is shown in **Table 3** and the policy changes implemented are shown in **Table 4**.

Table 3: List of warnings issued in past droughts in Ethiopia

Year	Types of drought	Type warning issued	Information/Supporting Data available knowledge (indigenous and local)	Lead time for warning (months/days)/drought phase
1973/1974	Metrological	The food needs of the country and to mobilize resources. It advises the government and international donors about Ethiopia's food balance, the number of people at risk, and identifies vulnerable regions.	Factors affect food security at household, woreda, regional and national levels. Bulletin contains detailed information on rainfall patterns, crop and livestock conditions, terms of trade (shoat to maize), food prices, water availability, nutrition survey data, nutrition programme coverage and relief pledges (food and non-food items) by region. It also includes information on funding shortfalls by sector (food, nutrition, water and sanitation, education etc) and contains a summary of the key findings from the EWS data.	Monthly
1993	Metrological	Regionalization policy and bottom-up planning approach. Early warning systems and some drought contingency planning, but this has not been coordinated.	Capacity building and Training in data collection for early warning and analysis has been given to functionaries at regional and lower levels.	In times of emergencies
1996	Metrological	Food-insecurity among government agencies, donors, UN agencies, and NGOs.	Gather information and report to higher-level committees.	
2005/2006	Metrological	The default emergency intervention was food relief, and livelihoods protection and emergency livelihoods interventions were limited.	Cattle were the preferred species and two breeding animals were selected from each vulnerable household and were fed on concentrate Feeds acquired from factories in Addis Ababa.	The first signs of a drought emergency appeared as early as July 2005 in parts of Borena zone, yet substantial interventions did not start until February 2006. the drought response in most pastoral areas was largely late and less effective than it might have been. The main problem appears to be the lack of

Year	Types of drought	Type warning issued	Information/Supporting Data available knowledge (indigenous and local)	Lead time for warning (months/days)/drought phase
				systematic application of best practice and the absence of effective policy, institutional and legislative mechanisms to support timely livelihood support interventions.
2008/2009	Metrological drought	SCUK's early warning works. through increased capacities of stakeholders in order to enhance, prevent, promote, respond to emergencies and diversify livelihoods assets. contingency planning activities		
2009/10	Metrological	Contingency plans developed for supplementary feeding, provision of Animal Health Services and Emergency Water Supply	Involvement of all stakeholders at district level including communities in the development and implementation of CBEWS and contingency response plans so as to institutionalize emergency response structures at the community level.	emergency

Table 4: Policy regimes and development programs in agricultural input systems and markets, 1957–2007

Period	Intervention/Event	Focus/Objectives	Remarks
1957 1967	First and Second five year development plan	Develop large scale commercial farms and coffee exports	Subsistence farming was neglected
1968 – 1973	Third five year development plan	Transport infrastructure development, dissemination of high input technologies, credit and extension, formation of cooperative societies.	Implementation revolved around three comprehensive extension programs that focused on high-potential areas only
1971 – 1979	Minimum Package Program I	Expand geographic coverage of the comprehensive extension programs, provide fertilizer, credit and extension to minimum package areas	Fertilizer procurement managed by Agriculture and Industrial Development Bank, fertilizer distribution managed by Ministry of Agriculture
1978	Agricultural Marketing Cooperation	Improve management of agricultural input importation storage and transport by handling	MoA maintains the role of distributing to farmers to about 18000 associations
1980 – 85	Minimum Package Program II	Expand input supply and extension service coverage in three folds	Actual provision of inputs and extension was limited due to lack of financial support, fertilizer overstocking due to inaccurate demand estimate
1991 – 1995	Partial liberalization of the fertilizer market	Open the importation, wholesaling and retailing of fertilizers to private companies	Undertaken by the Transitional Government of Ethiopia. Fertilizer prices remained pan-territorial and subsidized
1993 - 1999	Participatory Demonstration and Training Extension System (PADETES)	Promote improved seed-fertilizer credit packages through a training and visit approach piloted by Sasakwa Global 2000	PADETES demonstrated on a pilot basis that yields could be doubled with the application of modern inputs in Ethiopia
1995 – present	National Agricultural Extension Intervention Program	Scale up the PADETES approach to the national level as a means of boosting cereal yields and output	Efforts to scale up the PADETES approach were less successful than the piloting demonstrated Sasakawa Global 2000
1997 – 98	Fertilizer price liberalization	Eliminate subsidies and deregulate the price of fertilizer at wholesale and retailer level	Liberal prices have not resulted in competitive market due to the government continued

Period	Intervention/Event	Focus/Objectives	Remarks
			control over marketing and credit
2000 – 07	Shifting industry structure	Private companies withdraw from the fertilizer market in 2000 succeeded by holding companies cooperative unions enter the market in 2005 followed by the withdrawal of holding companies in 2007	The Agricultural input Supply Enterprise and cooperative unions emerge as the only actors engaged in fertilizer importation.

Source: Stepanek 1999; Demeke 1995; Gebremedhin et al. 2006; Abate 2008; and authors.

3.4.1 ENSO Information and Early Warning in Ethiopia

An institutionalized famine early warning system in Ethiopia is a relatively recent phenomenon. The reporting system is illustrated in **Figure 6**. In the past, accounts of famine were passed to the central government through rumours and informal reports by the local police and administrators. Previous Ethiopian governments were also sluggish in their responses to disasters due to lack of adequate information, resources, and political will. A formal famine early warning system was established following the 1973/74 famine that killed upwards of two hundred thousand Ethiopian peasants (Kaplan 1988, 24).

In 1976, the military government (which ruled from 1974 to 1991) established the Relief and Rehabilitation Commission or RRC (it was renamed as the Commission for Disaster Prevention and Preparedness or DPPC in 1995). Its task is to assess the food needs of the country and to mobilize resources. It advises the government and international donors about Ethiopia's food balance, the number of people at risk, and identifies vulnerable regions. The DPPC receives information from the Ministry of Agriculture, the NMSA, the Ethiopian Nutrition Institute, and the Central Statistics Authority. Some NGOs operating in Ethiopia have their own early warning systems (Glantz, 1996a).

The Ethiopian NMSA collects and distributes agro-climatic information such as rainfall, temperature, water balance, and sunshine of the country. NMSA disseminates "flash reports" and seasonal forecasts. It also releases crop situation reports and four annual seasonal output reports, two at the beginning and two at the end of the *meher* (main cropping season; begins in September) and *belg* seasons. One problem of the early warning system in Ethiopia is the lack of competence at the lower level of the government hierarchy (DPPC 1996).

Table 5 indicates the association between ENSO and drought in Ethiopia. Recently, the NMSA has begun to use ENSO information to supplement its meteorological early warning system. According to the NMSA, a cool event (*La Niña*) leads to decreased rainfall in the *belg* season (February-May) and heavy rainfall during the main (*kiremt*) rainy season (June-September) (Bekele 1993). A warm event is associated with an above-normal rainfall during the *belg* season. According to previous droughts, a positive SST anomaly that lasts at least a year is always associated with severe *kiremt* (June/September) drought in Ethiopia (ibid.). Thus, during ENSO years, *belg* rains are heavy and the main summer (*kiremt*) rains are reduced. In normal seasons, *belg* rains are variable and the main rains are stable (Glantz 1996b). The abnormally heavy rainfall in the 1996 summer (*meher*) season in Ethiopia (when NMSA had issued an early warning) might have been linked to a *La Niña* (eg, cold event). According to the National Drought Mitigation Center (1996), ENSO information helps for agricultural planning and for mitigating the societal impacts of droughts and floods. ENSO-based forecasts can help in determining land-use policies, and for conservation and humanitarian assistance. For example, when policymakers have advance information of low rainfall, they can prepare plans to assure an adequate food supply.

Table 5: Chronology of El Niño and Drought/Famine in Ethiopia

El Niño Years	Drought/Famine	Regions
1539-41	1543-1562	Hararghe
1618-19	1618	Northern Ethiopia
1828	1828-29	Shewa
1864	1864-66	Tigray and Gondar
1874	1876-78	Tigray and Afar
1880	1880	Tigray and Gondar
1887-89	1888-1892*	Ethiopia
1899-1900	1899-1900	Ethiopia
1911-1912	1913-1914	Northern Ethiopia
1918-19	1920-22	Ethiopia
1930-32	1932-1934	Ethiopia
1953	1953	Tigray and Wollo
1957-1958	1957-1958	Tigray and Wollo
1965	1964-66	Tigray and Wollo
1972-1973	1973-1974	Tigray and Wollo
1982-1983	1983-1984	Ethiopia
1986-87**	1987-1988**	Ethiopia
1991-92	1990-92	Ethiopia
1993	1993-94	Tigray, Wollo, Addis

Sources: Quinn and Neal (1987, 14451); Degefu (1987, 30-31); *Nicholls 1993; Webb and Braun; **Ayalew 1996.

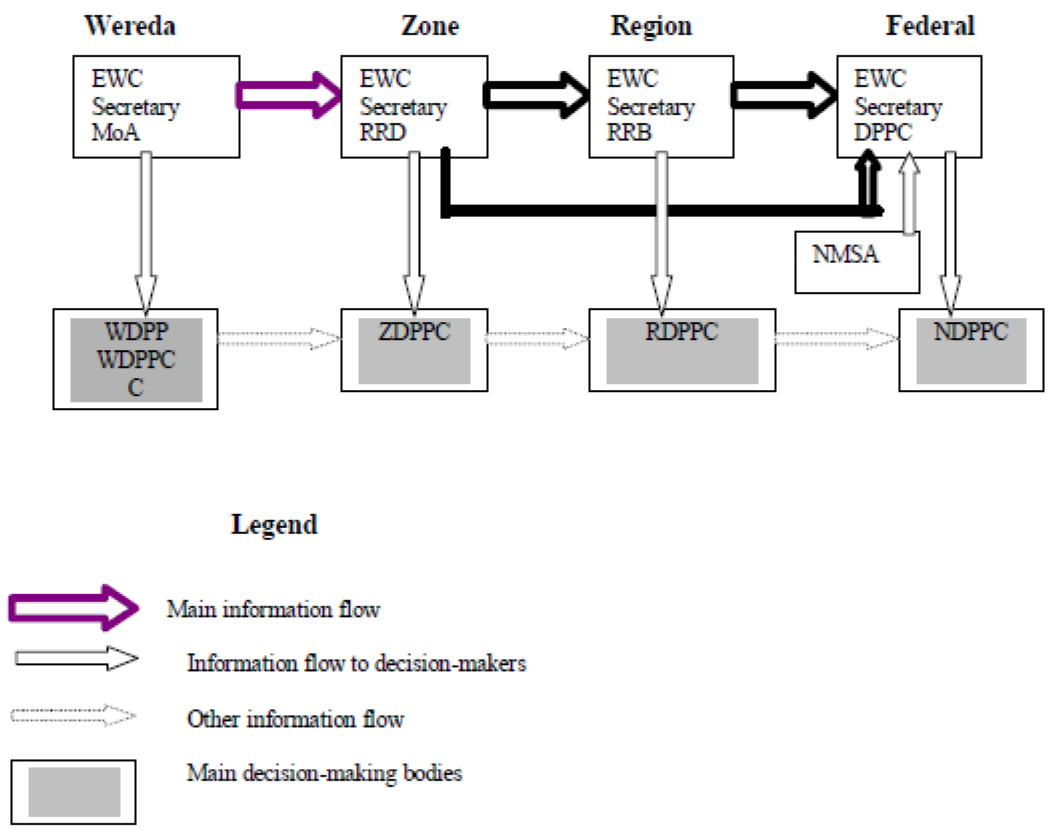

Figure 6: Reporting system of the Ethiopian EWS

3.5 EASTERN NILE REGION (DOWN STREAM COUNTRIES)

3.5.1 Experiences in Egypt

The Nile Forecast System (NFS) is a near real-time distributed hydro-meteorological forecast system designed for forecasting Nile flows at designated key points along the Nile; of major interest is the inflow of the Nile into the High Aswan Dam, Egypt. The core of the NFS is a conceptual distributed hydrological model of the Nile system including soil moisture accounting, hillslope and river routing, lakes, wetlands, and man-made reservoirs within the basin. The information that can be obtained from this system is listed **Table 6**.

Table 6: Types of information obtained from the Nile Forecast System in Egypt

Type of flood/ drought	Information / supporting data/ available knowledge
Meteorological	Temperature
Hydrological	Forecast data from mathematical models.

3.5.2 Sudan

There are historical droughts during 1973, 1984, 1991, 2000, 2005 and 2006, but during these events there is no formal drought warning. In Recent years (2000's) the Sudan Meteorology Authority started drought warning for only large scale rainfed agriculture region before the rainy season by making rainfall forecasting at April and May (rainy season start at the end of May).

Interviews with village leaders and large scale farmers were carried out as group discussions at *Gedaref* region and west White Nile area. An additional number of individual communications were also done with a number of the village leaders and local administrative officers; most of them 30-75 years old, capable of reconstructing the history of the area.

The information collected by questionnaires showed that people in the two regions depend mainly on the local knowledge which can summarize as follows:

- Birds migration to the region (e.g *Quelea quelea; Quelea aethiopica; Egret*)
- Death of birds during the summer due to extreme heat (Low wind speed during the end of the summer months (measured by SMA to be less than 4 m/sec)
- Large number of insects and pests before rainy season and after first rainfall event (e.g. *Microterms sp.; Macrotermes sp*.)The presence of water from previous rainy season at the beginning of the coming season (low land and water ponding digging by local authorities and government
- Length of the winter season with low temperature (when winter start at November and end by February or beginning of March and low temperature special during the night))
- All the above consider as the sign for good or above average rainfall for the forthcoming season
- Forecast of rainy season by SMA and local Farmers start by end of March and beginning of April.

3.6 EXPERIENCES FROM THE LIMPOPO BASIN

The inventory of institutions involved in drought early warning identified that at the regional level the SADC Climate Services Centre (formerly the SADC Drought Monitoring Centre) provides early warning with respect to the drought emergency. In 1992 the message went out not only from the SADC early warning system (which comprises national early warning unit and a regional early warning unit, but also through the US Government's Famine Early Warning System. Responses to those alerts, however, varied considerably at the national, regional, and international levels.

The inventory also identified the Southern Africa Regional Climate Outlook Forum (SARCOF) which provides seasonal climate forecasts or outlooks. In December 1997, SARCOF issued a midseason forecast update covering January through March 1998 as shown in **Figure 7**. It was now possible to evaluate this forecast to determine its accuracy. The forum's consensus forecast was for normal to below-normal rainfall for much of the area. Rainfall was expected to be below normal over much of South Africa, Botswana, and southern Namibia; normal to below normal over northern Namibia, north eastern South Africa, Zimbabwe, southern Zambia, and southern and central Mozambique; normal to above normal over far southern South Africa; and above normal over northern Tanzania. Rainfall over other areas was expected to be near normal.

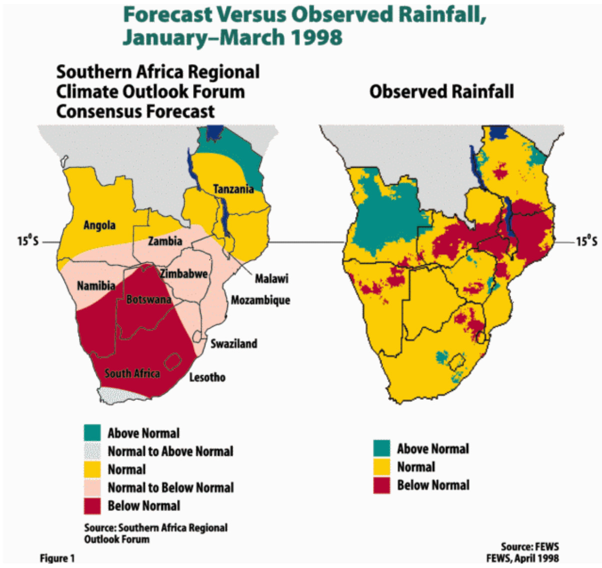

Figure 7: Forecast versus observed rainfall January to March 1998

According to inventory governments are responsible for provision of early warning at national level however these are mainly to detect food deficits in order to inform famine relief efforts. For example the government of Zimbabwe undertakes many activities aimed at providing "hard evidence" that a drought has occurred (Stack 1998). A system to forecast crops has been in existence before 1980.

3.6.1 South Africa

The list of warnings issued for historical droughts in South Africa, obtained from available from literature is shown in **Table 7**.

Table 7: List of warnings obtained from available literature

Drought Period		Type of Drought	Type of Warning	Lead time for Warning and Reference
From	To			
1964	1970	Meteorological and Agricultural	Seasonal Forecasting using Precipitation	Drought And Famine In Africa, 1981-1986: The US Response
1981	1984	Meteorological and Agricultural	Seasonal Forecasting using Precipitation	Drought And Famine In Africa, 1981-1986: The US Response
1987	1988	Meteorological and Agricultural	Seasonal Forecasting using Precipitation	Drought and Famine In Africa, 1981-1986: The US Response
1991	1995	Meteorological, Hydrological and Agricultural	Seasonal Forecasting using Precipitation	The SADC Regional Early Warning System: Experience Gained and Lessons Learnt from the 1991-95 Southern Africa Drought
2002	2005	Meteorological and Agricultural	Standardised Precipitation Index, Seasonal Forecasting using Precipitation	Identifies the slow onset of drought. South African Weather Services

3.6.2 Zimbabwe

The list of warnings issued for historical droughts in Zimbabwe, obtained available from literature is shown in **Table 8**.

Table 8: List of Drought warnings from historical experiences

Drought Year/Event	Drought type	Warning(s)	Lead time for warning and Reference
1981/82	Meteorological, Agricultural & Hydrological	Food security, Rainfall forecast & Warm Enso phase	
1991/92	Meteorological, Agricultural & Hydrological	Food security Rainfall forecast & Warm Enso phase	March 1991(REWS). December 1991 2nd warning(REWS) **Declared a disaster on 6 March 1992**
1993/94	Meteorological & Agricultural	Food security, Rainfall forecast & Warm Enso phase	October 1993(Warm Enso Phase)
1997/98	Meteorological & Agricultural	FAO/WFP Crop and Food Supply Assessment Missions (CFSAMs), Rainfall forecast & Warm ENSO phase	April 1997 & June 1997(RRSP)
2002/03	Meteorological & Agricultural	CFSAMs & Rainfall forecast	April/May 2002(FAO)
2006/07	Meteorological & Agricultural	CFSAMs	**Declared a disaster in March 2007**

3.7 EXPERIENCES FROM WEST AFRICA - NIGER BASIN

There have been attempts to announce events generated from drought by early warning systems as shown in **Table 9**, but the latter have yielded predictions that have not met to the expectations of stakeholders. Some of the prediction systems gave the opposite of the event, others have attempted to describe and assess the movement of the monsoon, but none of these systems have been able to describe the events in the basin.

Table 9: List of events announcement attempts to drought by the various early warning systems exist in Mali

Drought year / season	Type of drought	Type warning issued		Information / supporting data/ available knowledge (indigenous and local)	Lead time for warning (months/days)
		Historically	currently available		
1984	Meteorological / Hydrological / Agricultural	AGRHYMET	**AGRHYMET/CILSS**	High temperatures, degradation of natural resources, water deficit, decrease of biodiversity	3 month
1984-1985	Meteorological	France-meteo	Did not give any forecast in the basin	It was forecasted by France- Meteo that 2004 would be a year of good rainfall, the year was negative.	1 month
1993	Hydrologic / Agricultural	CILSS/SAP	CILSS/SAP	Lower agricultural production and productivity, increased incidence of a disease	1 month
1999	Hydrologic / Agricultural	CILSS/SAP	CILSS/SAP	Increase in warm winds, temperatures, loss of animals, frequency of conflicts, deterioration of living conditions, lower water tables, etc.	1 month
2004-2005	Early Warning System-Mali (Agricultural drought: culture invaded by locusts)	SAP/Mali	SAP/Mali	The year of locusts (the forecast was made in May 2004 by the Office of Plant Protection Mali)	1 month
2004-2005	Hydrologic	SPIAC	SPIAC	SPIAC forecasts were followed with many reserves	1 Week
2011	Meteorological / Hydrological	AGRHYMET/ PRESAO	AGRHYMETC/ PRESAO	AGRYMET / PRESAO have made credible forecasts over the past two years (2009 and 2010), but the 2011 forecast is far from the reality on the ground.	1 month

In addition to these forecasting systems there are traditional knowledge of Climate Reading. The traditional knowledge of weather forecasting and analysis of climatic phenomena are many and varied and occur in all cultural areas of Mali, but we must recognize that they are in the field of "old people" and look set to lose meaning in the face of a generation driven by modernity and Cartesian science.The physical elements, the key to the reading of the climate are in the process that result in damage or loss.

There are four (4) traditional types of analysis:

(a) Analysis of the atmosphere

- Since the advent of agriculture, farmers predict the weather of day or night from the visual sensations and movement of the wind.
- The types of wind are well known namely, the north wind or wind from the Sahel (hot and dry) corresponding to the Harmattan, and the south wind, which gives strong signals (direction, intensity, temperature) enabling people to make a traditional preparation for the rainy season.
- ***QUELS SONT LES*** *délais pour chacune de ces ALERTES*

(b) The air intake :

- The stifling heat with a heavy time imply the possibility of changing times.
- If the wind is blowing from west to east, it announces the start of the rainy season;
- If it is blowing in the opposite direction, it indicates the end of the rainy season;
- If its direction is south-north, the rainy season arrives so early;
- If it blows a lot, it means a lot of rain would there;
- If the cold continues, then the rainy season will be long;
- If the thunder is heard loud and does damage, it means the rainy season will see a significant rain deficit ;
- If the first rain falls at night, we are facing a harbinger of good rainfall and good crop;

(c) Observations of the stars (stars and moon) Ex: Zone *Bandiagara*

- If the last moon before the rainy season is bowing to the right, it announces a good rainfall, and if it tilts to the left, while the rainy season looks bad.
- If the star called "*Ali Badara*" appears at the beginning of the rainy season and found that the rivers do not flow, there will be plenty of rain.

(d) Observations of the behavior of the vegetation

- *Acacia albida* (called locally *Balazan*), begins to turn green in the first months of the dry season (November-December), and loses its leaves at the approach of the rainy season (May-June).
- In the area of *Bandiagara*, when *Euphorbia sudanica*, or *Ceide pentadra* gives many fruits, it is interpreted as a good sign change (good rainfall), while the early yellowing leaves of the *Borassus acthiopium* announces the opposite
- The fruiting and ripening of fruits of tree species such as *Lannea sp, Ladolphia senegalensis* and *Toutartia bivrea* symbolizing the start of the rainy season.
- In the *Bougoun*i zone (*Sikasso* region), the opening of the buds of leaves of *Terminalia sp* coincides with the beginning of the rainy season ;

(e) Observations of animal behavior

- Over the generations, farmers have managed to get an idea of the passage of time through observation of animal behavior
- The arrival of the population of storks (*Ciconia abdimii*) is a sign of the start of the rainy season. Their early arrival (early May) is a sign of good rainfall years. Their arrival in large numbers in record time brings the farmers not to doubt of any rainfall deficit. When the population reaches the very small number, the farmers of the band Sudanese and Sahelian fear a rainfall deficit and adjust their strategic decisions (choice of early varieties, millet, sorghum, corn, or rustic, sesame, groundnuts, *dah, fonio*) to minimize the risk of failed season.
- In the *Bougouni* zone in the southern Mali, it is observed that the cattle egret made its migration in the opposite direction of the stork and the rainy season, leaving the area announces the end of the rainy season.

- Other species of birds are characterized especially by the change in their songs, well sung by the people of the area *Zantiébougou (Bougouni)* to read the climate;
- In several municipalities in the *Bougouni* zone, the species of bird called *Tachus sp* is well known as a bird that nests in the dry season and migrates in the rainy season;

4. CHARACTERISATION OF DROUGHT WARNINGS AT DIFFERENT LEVELS FROM HISTORICAL EXPERIENCES

4.1 MOROCCO AND THE OUM ER-RBIA BASIN

4.1.1 The Royal Center of Remote Sensing (CRTS)

The Royal Centre for Remote Sensing (CRTS) is fully equipped with hardware, software and staff to produce tools for drought early warning and monitoring. Presently, the Centre develops monthly maps that describe evolving agricultural drought situations in different regions of Morocco on the basis of satellite imagery decadal analysis using NDVI (Normalized Difference Vegetation Index). These bulletins (from 2003 to 2011) are available on the CRTS website:

(http://www.crts.gov.ma/modules.php?name=Sections&op=viewarticle&artid=38).

From 2006 to 2009, the CRTS was a partner to the SMAS project

4.1.2 The Secretariat of State in charge of Water and the Environment (*Secrétariat d'Etat chargé de l'Eau et de l'Environnement, SEEE*),

The SEEE through the General directorate of Hydraulics (DGH) and the river basin agencies (ABH) monitors stream flows, water levels fluctuations, underground and in the reservoirs, that reflect the hydrological situation of the country and thus the potential drought situations.

The RBAs work with water sector "partners" or stakeholders in the basin area such as ORMVAs, the National Authority of Potable Water (Office National *de l'Eau Potable* (ONEP)), the representatives from environment, health and provincial officials and, the Water User Associations (WUAs) (Doukkali, 2005). Demands by sectors are estimated and resources for the forthcoming hydrological year (starting in September) are allocated according to resources availability at the end of the raining season (April-May) during joint meetings occurring generally during summer time.

River basin agencies which represent the main water resources management institution at the regional level, do not issue formal drought warnings: they regulate water allocations by sectors, giving the priority to drinking water in case of low reservoir levels.

For example, in 2001-2002, only 27% of what was initially designed (710 Mm^3) was delivered to the Beni-Moussa scheme (Tadla irrigated perimeter, Oum er-Rbia-basin). In 2003, only 150 Mm^3 were available for *Beni- Amir* and 350 Mm^3 *for Beni-Moussa* (36% and 49% of the original allocation, respectively (Hellegers et al., 2007).

4.1.3 The National Direction of Meteorology (DMN)

The National Direction of Meteorology (DMN) has full modern capabilities for daily weather forecasts and modeling tools for seasonal forecasts using meteorological data (precipitation, temperature and other conventional parameters).

In the area of drought warning, the DMN has implemented since 1994 a program aiming to develop the seasonal long-term forecast of precipitation using large scale climate patterns such as the SST, NAO and ENSO2. The main objective of the program is to help the decision-makers to foresee the periods of drought in order to mobilize the necessary means to face it. The project is supported by international cooperation and has two main components: ALMOUBARAK (based on statistical models) which is being carried out in association with the University of Oklahoma (USA) and co-financed by the USAID, and AL MASIFA (based on both dynamical and statistical models) implemented in association with the research centres of the MET services of France, Algeria and Tunisia 4 and co-financed by the European Commission. These studies have led to the adoption of a statistical model which uses SST anomalies over the tropical Pacific Ocean in October-November-December to make predictions of precipitation for February-March-April over Morocco. Also, the skill of the *Arpège-Climat* dynamical model from *Météo*-France has been evaluated, and this model is now running on the DMN supercomputer (an IBM) to make seasonal predictions every month using SST anomalies (Bellow et al., 2007).

In 1999, an experimental bulletin based on the models outputs, titled "Long Term Prediction Bulletin was implemented. (Bellow et al., 2007, Jalil, 2003). Subsequent to El Masifa bulletin, a number of prediction products from various modeling centres have been used to compile the current experimental prediction products in a seasonal weather forecast bulletin. These include the El Masifa dynamical forecast from ARPEGE-Climat and the statistical forecast of SST anomalies, the NAO forecasts from CIMMS, and model predictions from ECMWF, the UK Met Office, the ECHAM3 dynamical model, the IRI and NCEP products. According to the DMN, the key sectors and decision makers that could benefit from seasonal forecasts in their management processes are high ministerial authorities, hydrological services and agriculture services. As a result, it has been decided from discussions between DMN and Moroccan Hydrological and Agricultural Services to provide predicted regional rainfall indices in terciles representing dry, normal and wet cases on a monthly basis. As a result, the Bulletin as illustrated in **Figure 8** and **Figure 9** is now issued to end users and sent mainly by mail at the beginning of each month (Bellow et al., 2007). From 2006 to 2009, the DMN was a partner to the SMAS project

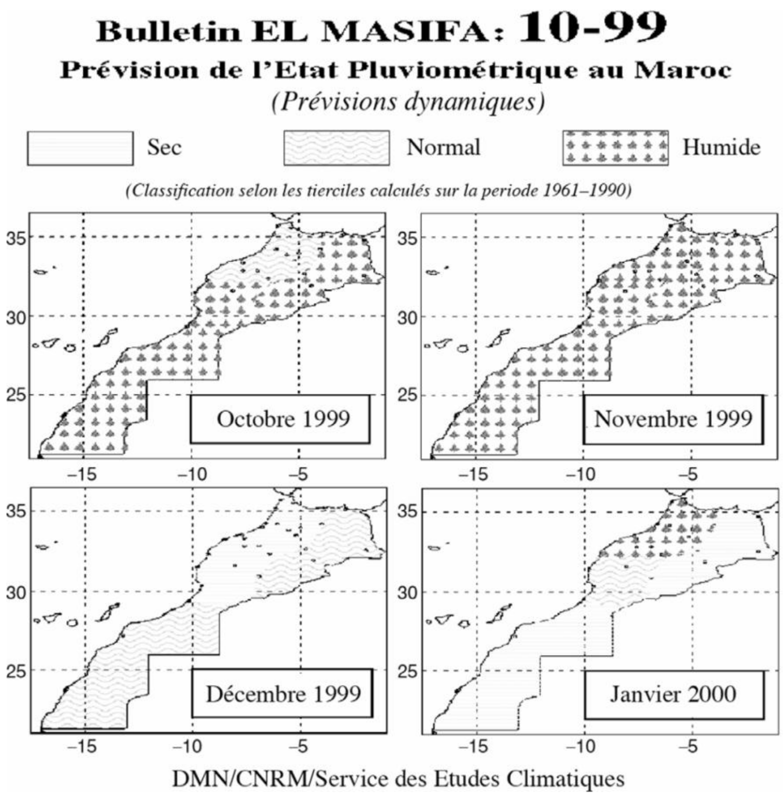

Figure 8: An example of a prediction from the El Masifa Project distributed during the winter of 1999 to 2000.

Predicted precipitation anomalies are categorized as "Above Normal" (Humide), "Near Normal" (Normal),and "Below Normal" (Sec) (from Bellow et al., 2007)

Direction de la Météorologie Nationale

Centre National de Recherches Météorologique

Programme El Moubarak

Bulletin de prévision saisonnière des précipitations au Maroc

Echéance : Octobre à Décembre 1999 et Janvier 2000 Issue le : 4/10/99

Introduction :

Nous présentons ci-après un ensemble de prévisions saisonnières issues de centres Météorologique mondiaux différents et qui concerne le Maroc. Elles sont toutes à titre expérimental. La DMN n'assume aucune responsabilité sur les décisions prises sur la base de ces prévisions.

Prévision issue du CIMMS (Université d'Oklahoma-USA- :

Les prévisions du CIMMS sont élaborées à partir du mois de Novembre et portent sur le mois de décembre, janvier, Février et la saison Mars-Avril.

Prévisions dynamique issue d'El Masifa (base : Septembre99)

Le modèle ARPEGE-Climat prévoit pour la moitié nord du Maroc (Régions Sahariennes exclues) ce qui suit :

Oct 99	Nov 99	Déc 99	Jan 2000
Normal	Humide	sec	Normal

Oct-Nov-Déc (OND 99)	Nov-Déc-99 –Jan 2000
Humide	Normal

Prévision issue de l'U.K Met-Office: (base: Septembre 99)

Pour OND : Précipitation autour de la normale sur tout le Maroc légèrement au dessus de la normale sur les provinces du sud. La prévision issue de ce modèle pour cette saison n'est pas assez fiable.

Prévision issue du CEPMMT (i.e. ECMWF in Frensh) : (base : Septembre 99)

Pour OND : Le modèle ne présente pas de signal significatif sur le Royaume.

Prévision issue d'autres modèles climatiques : (base : Septembre 99)

Pour OND : Dans l'ensemble les deux modèles ECHAM3 et CCM3 prévoient de conditions au dessus de la normale sur les côtes atlantiques et des conditions normales partout ailleurs.

Conclusion :

L'analyse de sorties de l'ensemble de modèles, à part le modèle ARPEGE-Climat, montre que la saison Oct-Nov-Déc sera en général normale à sèche sur le Maroc. Le modèle ARPEGE-Climat prévoit quand à lui un état légèrement humide sur la moitié du nord du Royaume.

Figure 9: Example of the seasonal forecast bulletin published by the DMN

Source Bellow et al., 2007

4.1.4 The Ministry of Agriculture and Maritime Fisheries (MAMF)

The Ministry of Agriculture has full capacity of trained human resources to survey emerging drought impacts in the field – which is an important facet of drought early warning: assessing drought intensity through its impacts on crop development and yield, pasture and livestock feeding systems, crop pests and diseases associated with the drought situations, impacts on water resources for human and watering points for livestock (Ameziane, 2010).

During the agricultural campaign, the Ministry of Agriculture publishes on its website (http://www.agriculture.gov.ma/node/439) an assessment of the agricultural situation though the evaluation of agricultural indicators such as the ploughed fields and cereal seedling situations, the use of entrants (fertilizers, pesticides). The site provides also an overview of the rainfall situation by comparison to the normal year. But according to the different services engaged during our survey, no concrete early or even late drought warning actions are undertaken towards farmers in the case of an emerging drought. Results from our survey revealed a different drought approach between agricultural services in charge of rainfed areas and irrigated perimeters.

a) Regional Directorates of Agriculture (DPA)

The regional directorates of Agriculture (DPA) are in charge of rainfed areas. According to the extension agents and staff from the different DPA visited during our survey, no drought warning actions are conducted in the case of an emerging drought and only relief actions are implemented.

b) Regional Offices of Agriculture (ORMVAs)

The main responsibilities of the ORMVAS are as follows:

- Assess agricultural development schemes in irrigated perimeters, within the framework of the large hydraulic infrastructure management.
- Monitor and provide assistance for the exploitation of irrigated perimeters, through irrigation scheduling, experiments in agricultural production, monitoring of irrigation and soil and drainage water quality, maintenance of irrigation networks and collection of the corresponding water charges.
- Organize the agricultural production

Thus, since the ORMVAs are in charge of the irrigated areas, they have to manage water resources allocated by the basin agency for irrigation. The amount to be released is calculated according to the projected inflows and available reserves in the dams. This provisional allocation is established at the beginning of the irrigation season (September) and farmers are informed about it. Thus, the ORMVA management issues clear 'guidance' on feasible cropping plans prior to each season, based on the anticipated water availability per hectare, and the demand of individual crops. In case of low reservoir levels due to a succession of dry years, the provisional allocation is low and farmers are informed about priority crops. The amount released may be adjusted during the year depending on the actual rainfall. In the case of unexpected water scarcity during the season, priority of water delivery is given to specific crops.

For example, during the severe drought of 1991-93, Morocco experienced severe water shortage. Thus restrictive management programs were implemented and the priority was to ensure drinking water needs. Restrictions on water supply for irrigation had reached an average of 50% in large areas. If measures taken to address this situation have varied during the first dry year from one area to another; they were generalized in the second year due to the worsening of water scarcity. Measures adopted by the ORMVAs can be summarized as follows:

- The reduction of wheat planting areas.
- During the second dry year, spring and summer crops, very consuming in water, were forbidden and restricted to farmers using underground water.
- The reduction of irrigation: Priority was given to perennial crops (alfalfa, orchards) but safe volumes were applied to other crops.
- The promotion of underground water irrigation.
- The constitution of vigilance committees whose tasks were to conduct awareness campaigns for users of irrigation water, to monitor water distribution and the proper functioning of irrigation networks.

From 2006 to 2009, the MAPM was a partner to the SMAS project.

4.1.5 The HCEFLCD (*Haut Commissariat aux Eaux et Forêts et à la lutte contre la désertification*): The High Commissariat of Water, Forest and Fight Against Desertification

The HCEFLCD is in charge of developing and preserving forest resources by fighting against the desertification. The drought is especially managed in a proactive way and concerns sylvo-pastoral actions, rangelands, water sources and social actions. But, the HCEFLCD also leads indirectly to a drought warning through the warning of forest fires which the risk increases with increasing drought levels. This program is generally made in partnership with the DMN. The system so finalized is presented as an internal manual for the provincial actors. It follows the actions of intervention and awareness campaigns.

From 2006 to 2009, the HCEFLCD was partner of the SMAS project

4.1.6 INRA (*Institut national de la Recherche Agronomique*) : National Institute of Agronomical Research

According to the responsible persons which was surveyed in the INRA of Rabat, and which is one of the seven drought studies responsible persons in the institution, the bases of drought warning are the following 3 parameters:

- The rain levels during November and December months
- The NDVI
- The crops water requirements

But this is only for internal use and no regular results are published in this way, except sporadically during some projects or studies.

In Morocco, many studies use the yield of cereals as an indicator of drought warning at any time of the season in a given province. Indeed, approximately 95 to 98 percent of rainfall occurs in the country during the period from October to May and this coincides with cereal production cycle. There are three important phases for cereal production in Morocco:

- October-December: seeding phase
- January-February: vegetation growth
- March-May: flowering, reproduction, and spiking

By comparing the predicted yield with the statistical yield series, drought severity can be assessed and an early drought warning can be issued when the predicted yield falls in the moderate or severe drought classes. This can be done at the early stages of cereals season.

The Crop Growth Monitoring System (CGMS), which was produced by the MARS project, was cited by the surveyed persons as the current drought warning system used by the INRA. Actually, The CGMS monitors crops development within UE countries and also beyond European boundaries (Turkey, Ukraine, Morocco, Algeria and Tunisia) and specific bulletins are produced.

The system is driven by meteorological data modified by soil characteristics and crop parameters. This mechanistic approach describes the crop development in terms of biomass, storage organs etc. along the combination with the phenological development, from sowing to maturity, on a daily time scale. The main characteristic of CGMS lies in its spatial structure which integrates interpolated meteorological data with soil features and crops parameters, through elementary mapping units for the simulation in the crop model. The core of the system is based on 2 deterministic crop models, WOFOST and LINGRA. GIS tools are used to prepare data and to produce results maps. Input and output are stored in a data base. Statistical procedures are used to forecast quantitative crops yield. In summary, CGMS consists of three main parts (levels 1, 2 and 3) as shown in **Figure 10**.

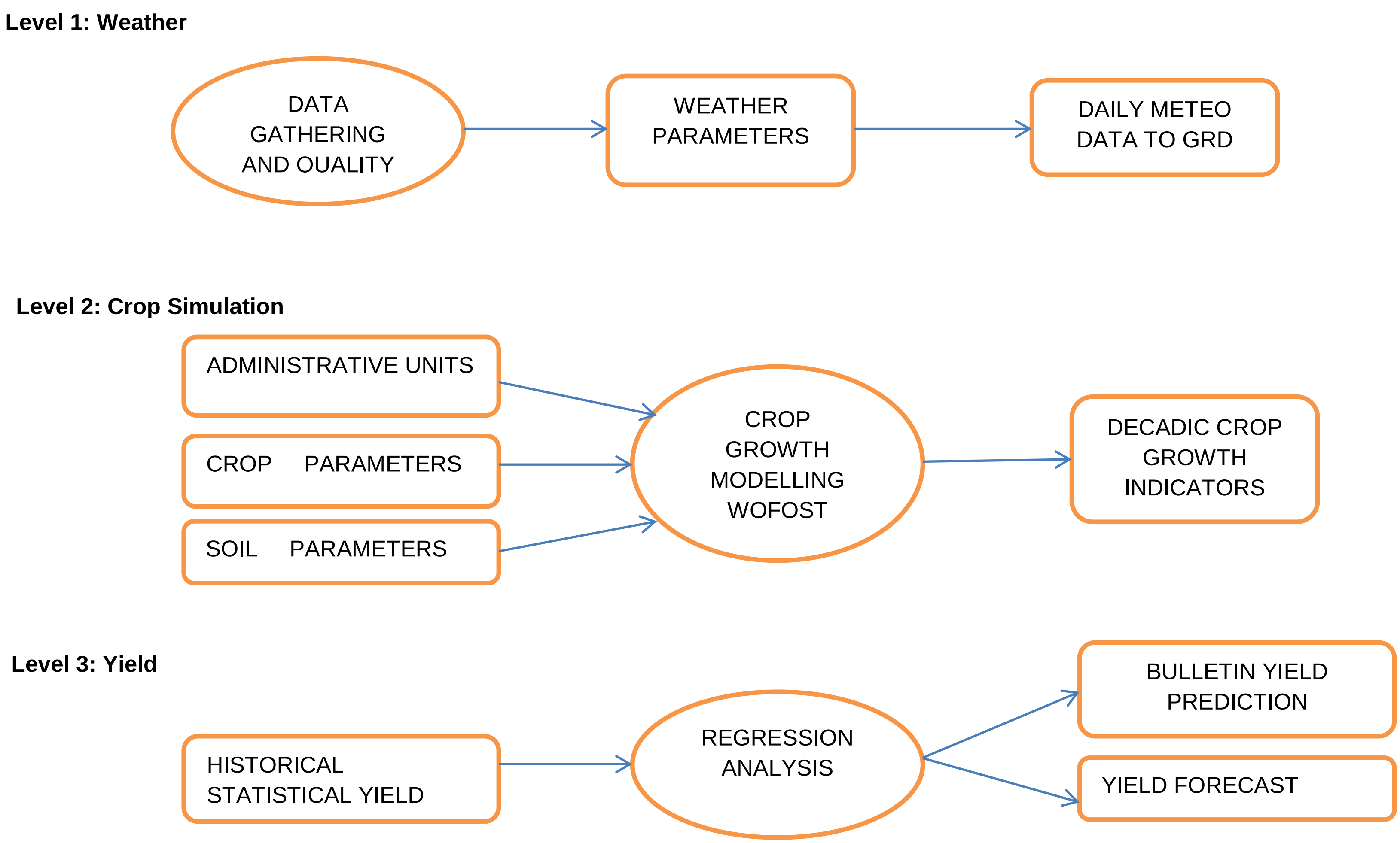

Figure 10: Main parts of the CGMS

Source: INRA-JRC-IPSC-AGRI4CAST, 2009

Yacoubi et al (1998) also found the following interesting results for the Settat region in Morocco:

- There is only 12 percent chance of having a drought year when none of the first three months of production (October, November, and December) is deficient in rainfall.
- There is 43 percent chance of having a drought year when the month of October is deficient in rainfall.
- When both the months of October and November are deficient in rainfall, the probability of having a drought year is 55 percent. In this case, drought is specifically defined in agronomic terms. These results allow an early prediction (and/or warning) in terms of probabilities.

4.1.7 The SMAS project

The SMAS project (Système maghrébin d'alerte précoce à la sécheresse) aiming to establish a Maghreb-wide system for early warning to drought was coordinated by OSS and implemented in Algeria, Morocco and Tunisia from 2006 to 2009 in the framework of the LIFE-Pays-Tiers Program, financed by the European Union.

At the Moroccan level, the DMN, the CRTS, the MAPM and the HCEFLCD were involved in the project. Each institution contributed by the production of drought indicators:

- CRTS : Drought monitoring indicators from satellite data
    - Standardized Vegetation Index (SVI),
    - Vegetation Condition Index (VCI),
    - Temperature Condition Index (TCI)
    - Vegetation Health (VH)
- DMN: Meteorological drought Indices from rainfall data
    - Standardised Precipitation index (SPI)
    - Ran index

- MAPM: Agronomic indicators
    - Ploughed fields situation compared to the last ten years mean

- Cereals (wheat and barley) seedling situation compared to the last ten years mean

- HCEFLCD: Forest indicators
    - Soil preparation for reforestation
    - Progress of planting for reforestation

These indicators were compiled in drought early warning bulletins that were produced on a monthly basis from November to April in 2008 and 2009 and available on the CRTS website (http://www.crts.gov.ma/modules.php?name=Sections&op=viewarticle&artid=73)

Unfortunately, the production of these bulletins ended with the end of the SMAS project in 2009.

4.2 EAST AFRICA- NILE BASIN EQUATORIAL LAKES REGION (BURUNDI, KENYA, TANZANIA, RWANDA AND UGANDA)

RMS is providing an early warning system service for meteorological and hydrological droughts which are the major types of drought in Rwanda, while FEWSNET (funded by USAID), FAO Global Information and Early Warning System (GIEWS) and WFP Vulnerability Analysis and Mapping (VAM) are especially focusing on food security in collaboration with the Ministry of Agriculture.

Burundi National Meteorology and Hydrological Service (NMHS) is the main responsible to provide an early warning system service for meteorological and hydrological droughts which are the major types of drought in Burundi, and FAO project is especially focusing on food security in collaboration with the Ministry of Agriculture.

Burundi and Rwanda share a common region prone to drought events (Eastern and southern region of Rwanda and the north-east of Burundi also having the same name in both countries "Bugesera". Early warning and preparedness is to be strengthened in close collaboration between the two countries neighboring as impacts are also shared (USAID, 2010).

4.2.1 Tanzania

The main sources of early warning information at the national level are the early warning /food security bulletins produced by the National Food Security Department (NFSD) Ministry of Agriculture and Food Security (MAFS) and FEWS-NET. The Government national early warning system in Tanzania is primarily based on analysis of data and information provided by Tanzania Meteorological Agency (TMA), Ministry of Cooperative and Marketing (MCM) and Crop Monitoring and Early Warning Unit (CMEWU) NFSD. Predictions and warnings are primarily focused on food availability indicators, the system providing information on the potential balance between preliminary crop production estimates and food requirements. Regular information on health and nutrition; livestock prices, condition, and terms of trade; and the monitoring of specific coping mechanisms are currently not included in the system. Agro-meteorological and remote sensing data are provided by the TMA, which provides weather forecasts and outlooks, including pre-season climate outlooks developed in collaboration with the East African Zone and the Horn of Africa drought monitoring centre. FEWS-NET supplements data available from the national system through: the use of its own analytical products (remote sensing: rainfall estimates; NDVI data etc); undertaking additional analysis on available data (e.g. market data); the further development of available data on crop production, livestock condition, and food prices via direct contact with data providers at the local and national levels; analysis of data collected during vulnerability assessments; and through the implementation of specific studies (Amani and Standen, 2004).

In 2002/3 Tanzania faced a serious food shortage resulting from poor performance of the rains in different parts of the country. Compared to a normal year, food and cash crop production in the affected areas fell by between 30% and 50%, this having serious implications on household food security and income levels. During 2003/4 the early warning system would appear to have been effective in assessing the probability of drought and in predicting, warning and communicating16 information as to its potential impact at both the national and regional levels. The system can therefore be considered to have fulfilled key elements of its disaster prevention and preparedness objectives. The poor food crop situation was predicted as early as February 2003, based on the poor performance of the Vuli rains. Rainfall forecasts released by the TMA, and reported by FEWS-NET17, also indicated that rains were likely to be below normal in most locations, this reportedly triggering market speculation, and the hoarding of stocks by traders. In March, the information produced by the early warning systems prompted the President to announce that the Government would be implementing a number of measures to lessen the impact of the drought. Finally in April the MAFS Food Situation Outlook' reported that Tanzania was likely to meet approximately 92 percent of its food requirements, in May MAFS subsequently identifying a number of districts where food shortages were likely to emerge (Amani and Standen, 2004).

For the above warning, CFO uses statistical and dynamical methods (mean average) and meteorological/climatic data. Other data used include SSTs, Cloud imagery, NWP products and NDVI data.

a) TMA/CFO with roles of weather and drought forecasting
b) MoAFSwith roles of contingency planning, food situation assessment, stockpiling of food and seeds, and early warning in collaboration with TMA. FEWS with the role of early warning and teaming in matters relating to food security.

The models being applied on the input data are as follows:

- Statistical models, which uses correlation analysis by Climlab program and regression analysis by SYSTAT or Climate Prediction Tool (CPT)
- Dynamic methods, which are used to compare and verify statistical methods

The drought indicators that are produced (outputs) are as follows:

- Statistical method drought indicators are normal (climatology), above normal (flood) and below normal (drought) as values of seasonal rainfall amounts, which can indicate the occurrence of rainfall, flood and drought events respectively.
- Dynamic method drought indicators are normal (climatology), above normal (flood) and below normal (drought) in percentage of occurrence of rainfall, flood and drought events respectively.

The CFO system provides: Seasonal rainfall amount availability; occurrence and forecasts of droughts; drought prone areas; severity of droughts; types of crops depending on rainfall amount availability; weather transmitted diseases; famine forecasts.

4.2.2 Rwanda

Table 10: Data methods and equipment used to collect data for the alert in Rwanda

Data input	Source	Method	Equipment	Frequency of data collection
Rainfall, wind, temperature, pressure, sunshine, humidity in Rwanda	RMS MOH MINAGRI	Field measurements of meteorological data	Meteorological station networks Hydrological stations	Hourly
Groundwater monitoring and water discharge in Migina catchment	UNESCO-IHE/NBCBN/NUR	Automatic and manual measurements	Piezometers Mini diver, van essen and vertical staff gauges	Daily
Forecasting and prediction of weather	RMS	Media	TV, Radio, printed media	Daily
Famine Early Warning System Network	FEWSNET	Publication	FEWSNET Bulletin Conference	Monthly Seasonally
Early warning system on Food and Agriculture	FAO-GIEWS	Idem	Report on food security	
Vulnerability Analysis and Mapping	WFP-VAM	Idem	Report on food security	

In the past, before 1994 war and Genocide, Hydrological Bulletins were regularly published under the Ministry in Charge of Water as shown in table **Table 10** but, these publications are no longer published and need to be resumed. It is also the case of the Rwanda Agricultural Research Institute which was publishing Climatological Bulletins in the past but; such publications are no longer available. Rwanda Meteorological Service (RMS), was operating under the Ministry in charge of airports (MINITRANSCO in the past) is now under the Ministry of Infrastructure and is the main provider of meteorological information disseminated through the following routes:

- Conference with journalists: sometimes, journalists are at RMS where they can receive important information on seasonal weather (three months ahead) to disseminate. This campaign insists on the two rainy seasons: September to December (SNOD) and March to Mai (MAM).

- Radio (public and private) and Rwanda Television: Weather forecast is daily broadcast through these channels
- Printed media: (news papers, and meteorological bulletin).

Other collaborators of the Ministry of Agriculture are contributing to the forecasting and early warning regarding food security like Famine Early Warning System Network (FEWSNET-USAID) and Food and Nutrition Security Monitoring System (World Food Programme, World Vision, UNICEF, etc), Global Information and Early Warning System on Food and Agriculture (United Nations, Food and Agriculture Organization), Publications from National Institute of Statistics of Rwanda etc.

4.2.3 Burundi

Table 11: Data methods and equipment used to collect data for the alert in Burundi

Data input	Source	Method	Equipment	Frequency of data collection
Temperature, Wind velocity, humidity, precipitation, pressure rainfall	IGEBU-NMHS	Field data collection	Meteorological station network	Hourly and Daily
Forecast and Prediction of Weather	IGEBU-NMHS	Publication	Printed media Internet Meteorological bulletin Workshops	Daily and 3 days
Famine Early Warning System Network	FEWSNET	Publication	FEWSNET Bulletin Conference	Monthly Seasonally
Early warning system on Food and Agriculture	FAO-GIEWS	Idem	Report on food security	
Vulnerability Analysis and Mapping	WFP-VAM	Idem	Report on food security	

Until now, Annual Hydrological bulletin is regularly published under the Geographic Institute of Burundi. Also, the decadal and monthly Climatological Bulletins as shown in **Table 11** are published and are sent to the users. Burundi National Meteorological Service (NMS) was operating under the Presidency authority (in the past) and is now under the Ministry of Water, Environment, Land Management and Urban and is the main provider of meteorological information disseminated through the following routes:

- Interview with journalists during workshops: sometimes, journalists are at NMHS where they can receive important information on seasonal weather to disseminate.
- Internet (public and private): Weather forecast is daily disseminated through that channel
- Printed media: (meteorological bulletin).

Other collaborators of the Ministry of Agriculture are contributing to the forecasting and early warning regarding food security through FAO Project newsletters publication etc.

4.3 EASTERN NILE REGION (ETHIOPIAN PLATEAU)

NGOs such as Save the Children UK and CARE in Somali and Afar regions, and Save the Children US and CARE in Oromiya and Somali regions as shown **Figure 11** and **Figure 12** respectively , have supported the development of early warning systems and some drought contingency planning, but this has not been coordinated. Development and disaster response mechanisms in many woredas are still weak, and investment in development and disaster management is minimal.

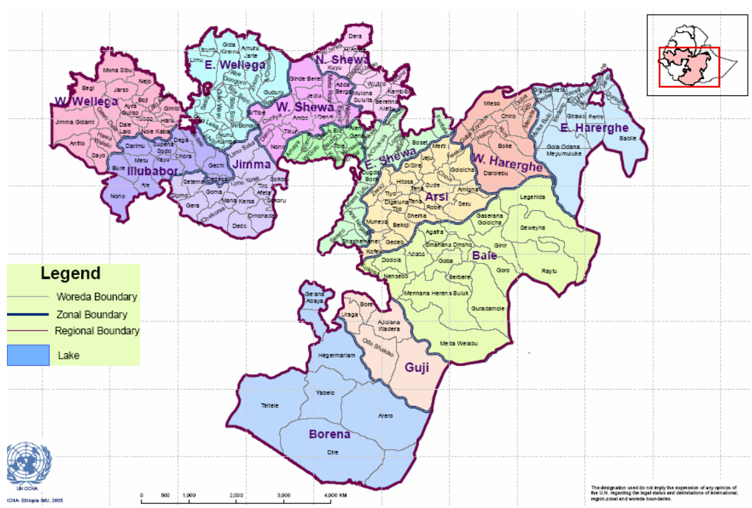

Figure 11: Map of Oromiya Region

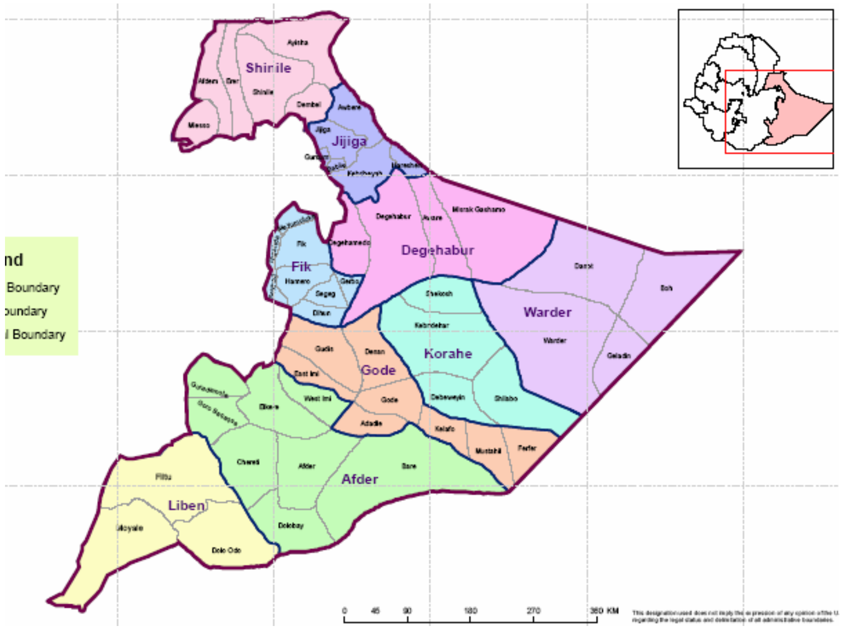

Figure 12: Map of Somali Region

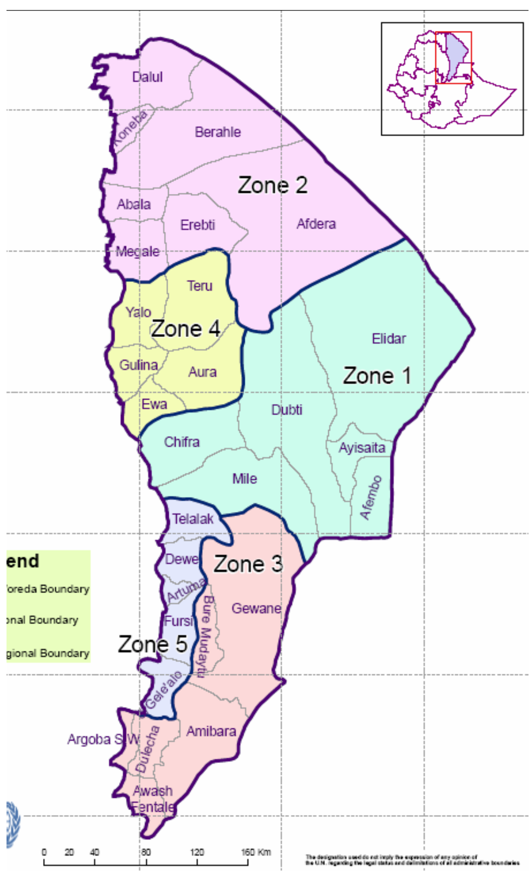

Figure 13: Map of Afar Region

The Early Warning Department (EWD) in DPPA is responsible at the national level for early warning activities. It is supported by the Early Warning Working Group (EWWG), with members from line ministries, UN agencies and NGOs. The Ethiopian government has its own early warning system. But the difficulty has always been tracking and gaining an insight into the lives of the pastoralists... You have to have an early warning system that is focused on conditions in the Somali and similar other regions, which are pastoral conditions and insecurity. The key to any effective EWS are accurate baselines - statistics that reveal how people live and can be used as a starting point for any assessments. For instance, if the price of livestock drops and grain prices rise, it is an indication that people are selling their livestock - an asset - in order to meet their immediate hunger needs through grain. Other examples are communities selling milk - a sign that they may be facing shortages. An EWS was set up by Save the Children UK (SCUK) after the 2000 famine. This system provides accurate details of potential famines in the harsh, arid climate of southeastern Ethiopia shown in **Figure 13**. It will save lives and will prevent famines as long as there is a donor response. Lautze (2003) observes that most EW systems are failing to generate a 'meta-analysis' out of the copious volume of data being generated.

There is a wide proliferation of food early warning systems using different assessment mechanisms and methodologies. The following is the list of the main types of trigger mechanisms identified.

a) Biannual multi-agency assessments: The government carries out two multi-agency, multi-sectoral assessments each year to guide it in declaring an emergency and making an international appeal.
b) The rainfall/stocking ratio mechanism: This trigger mechanism is specific to the Borena plateau, where PARIMA and ILRI have found a strong correlation between rainfall and stocking rates of cattle.
c) The EWS trigger mechanism: Run by the DPPA, with SCUK support. EWS run by NGOs: CARE and other NGOs run localized drought early warning systems.
d) Community's own traditional early warning system: Based on experience and observation of seasonal rainfall levels, bird behavior and the condition of pasture, water and livestock, pastoralists are able to detect risk.

e) Nutritional assessments: Nutritional assessments measure the nutritional status of vulnerable groups, particularly under-fives. Malnutrition rates determine whether further action is necessary.

f) Agency staff on the ground: Agency staff usually monitor the situation and carry out situational analysis of drought status, enabling agencies to start discussing a changing situation and take action. CRS staff working in Borena undertook water provision interventions on the basis of staff observation, making this a form of trigger mechanism for response.

g) Declaration of emergency by the federal government: An emergency and appeal for international support is issued; usually this is done after extensive consultations and field-based assessments, and may at times be politicized. It typically takes between eight and 12 weeks after the onset of an emergency for a declaration to be issued.

The DPPA early warning, Metrological drought, and surveillance system is based on regular monthly monitoring of key indicators at woreda level. These feed into bi-annual joint assessments with relevant line ministries and humanitarian agencies following the *meher* and *belgrains* (*deyr* and *guu* rains in Somali Region and **ganna** and *hagaya* rains in *Borena* zone). The assessed parameters include training in data collection for early warning and analysis, all relevant indicators of food security are monitored on a monthly basis culminating in an annual nation-wide pre and post harvest crop assessments. Pastoral assessments are also carried out in the livestock dependent regions. Early warning reports are regularly issued to Government, donors and the international community. There are also ad hoc assessments following the onset of a crisis. The monthly monitoring is conducted by local government officials against a set of indicators, including food production, prices, human and animal health and the onset and distribution of rains. The system is responsible for monitoring the food situation in the country and for taking appropriate measures to mitigate these shortages. The collected information is distributed in the form of Bulletin contains detailed information on rainfall patterns, crop and livestock conditions, terms of trade (shoat to maize), food prices, water availability, nutrition survey data, nutrition programme coverage and relief pledges (food and non-food items) by region. It also includes information on funding shortfalls by sector (food, nutrition, water and sanitation, education etc) and contains a summary of the key findings from the EWS data. There is however a lack of trust in this information at the federal level, as it is felt that woreda officials tend to exaggerate needs in order to receive more relief resources, very largely food. The seasonal assessments are said to involve protracted negotiations between assessment teams and woreda officials to agree on beneficiary numbers, despite a centrally agreed methodology to conduct the assessments (Sandford, quoted in Haan et al.,2006; interviews at DPPA, June 2007). The lack of confidence in grassroots data collection is due to the utilization of local knowledge and information at the grass roots level which resulted in additional seasonal assessment exercises for verification purposes (Grunewald et al., 2006). In the presence of an impending emergency, the need to repeat the assessments prevents timely responses .This was the case in the 2005/2006 drought. The development of a woreda-net internet infrastructure will increase the speed and transmission of EW information from the grass roots. In addition, the early warning and response directorate(EWRD)should work to include satellite information in the EWS to monitor the food production condition in all areas and to predict the likely occurrence of disasters ahead of time more effectively. **Table 12** indicates timeline of action in response to the drought in *Borena* and *Leban* zones.

Table 12: Timeline of action in response to the drought in Borena and Leban zones

Timeframe	Activity
Week 1	CARE monthly drought monitoring report triggers the convening of the Emergency Coordination Meeting
Week 2	A rapid assessment is undertaken led by government zonal authorities
Week 3	Assessment report discussed at the Emergency Coordination Meeting
Week 4	Report forwarded to Oromiya Regional Government for discussion
Week 5	Oromiya regional government discusses report and forwards to the federal government
Week 1 - 5	CARE and others undertake a nutritional survey in affected areas
Week 6	CARE presents the nutritional survey report to the Emergency Coordination Meeting. Federal and the regional authorities hold consultations with zonal team
Week 7	The federal and regional governments assemble an assessment team to visit the field. This assessment team is joined by the zonal team
Week 8	The Federal and Regional assessment teams provides feedback to the zonal coordination
Week 9	Assessment report submitted to the federal government and discussed
Week 10	The Federal Government issues an appeal and allows response by zonal, regional and federal agencies. CARE had begun water trucking for domestic use before government appeal and declaration on emergency

Source : CARE, 2005/2006

It can be concluded that the limitations of the official early warning and assessment system include the following:

- sampling bias and geographic coverage;
- inadequate baseline information;
- overemphasis on cereal production;
- imbalance between quantitative and qualitative information;
- delays in the conversion of data into beneficiary numbers and food aid needs; and
- lack of distinction between chronic and transitory food insecurity (Haan et al., 2006).

Modeled as it is on highland agricultural areas, Ethiopian early warning system is ill-suited to pastoral areas as indicated previously. Various organizations, including Save the Children UK, are involved in strengthening the early warning system and response components at the federal, regional and zonal levels. Meanwhile, DPPA is reviewing the system with a view to developing livelihoods baseline information disaggregated at zonal level. The new system is based on the Household Economy Approach (HEA) developed by SC-UK, which is set to become the official food security assessment methodology. The HEA approach investigates how different groups of households adapt to economic stress. Households are used as the unit of analysis, and their economic activities at different periods in the year are examined to model the sum of ways they make ends meet from year to year, and how they survive (or fail to) through various economic shocks. HEA is implemented in two stages as follows:

a) Baseline analysis is used to understand how households categorized according to different levels of wealth have survived during a 12-month period or 'reference year' in the recent past. This analysis, based on key informant interviews, secondary data and community interviews, includes how households obtain food, generate income and organize expenditure. The baseline is the starting point for investigating how access to food changes as a result of hazards (e.g. drought, conflict or market dislocation).
b) Scenario analysis uses information on hazards and households' documented coping strategies to forecast likely future access to food and other items at household level. This helps identify which areas and what types of households are likely to cope should a hazard strike, and which will need assistance; what

types of interventions will be most appropriate; and when and for how long they should be implemented.

HEA is currently used in the SNNPR Region, where baselines have been completed for all 40 livelihoods zones and 100 woredas. This work is supported by USAID, which has funded the establishment of the Livelihoods Integration Unit (LIU) within DPPA and the PLI-EW project, implemented by SC-UK in pastoral areas. The LIU has conducted training for DPPA and local woreda officials in the use of HEA and livelihood zoning, and is planning to extend the development of baselines to Tigray, Amhara, Oromiya, Harar, Benishangul and Gambella. In 2007, the methodology was applied during a seasonal needs assessment (June) to identify expected emergency requirements in SNNPR and Somali Region, using the livelihood baselines available.

In December 2007 the methodology was also to be applied in Afar, Tigray and Amhara Regions, supported by LIU and SC-UK. However, some in the EWWG feel that the HEA methodology is too complicated and too time- and labour-intensive (Haan et al., 2006). DPPA shares some of these concerns. There is also disagreement over the appropriate response when groups reach the ‘Livelihood Protection Threshold’, as opposed to the ‘Survival Threshold’ identified by the HEA.WFP has been working on an index for triggering contingency planning when an emergency is detected. This is the Livelihood Protection Cost Index (LPCI), a weather-based index aimed at providing an objective, independently verifiable and replicable indicator of livelihood loss.

The index is developed by evaluating historical weather data and determining its correlation to crop yields and revenues (Hess, 2007). One possible application of the LPCI to pastoral areas is being discussed, whereby weather data could be correlated to grass cover and forage conditions using the Livestock Early Warning System (LEWS) methodology. However, to date the LEWS has not been able to develop an effective link between the information generated and pre-planned response (Lautze, 2003).The LPCI is being developed within the context of contingency planning for the Productive Safety Nets. Efforts are ongoing to link the WFP LPCI with the HEA database. The HEA approach identifies when and where people have inadequate access to food, quantifies the shortfall in access and suggests possible interventions. Most importantly, it is predictive; it makes it possible to model the impact of events such as drought or rising food prices on households' ability to access food and income.

Figure 14 shows the HEA analytical approach. Food and income obtained from different activities (e.g. crop production, labor) are determined for a baseline year; the impact of a hazard (e.g. drought) on the food/income profile, and the degree to which households can redress these impacts through coping strategies, are then determined through primary data collection. Food and income access are quantified, converted into calories and compared with thresholds for livelihoods protection and human survival, to quantify the food gap in the event of a hazard (or for the chronically food-insecure, in a normal year).

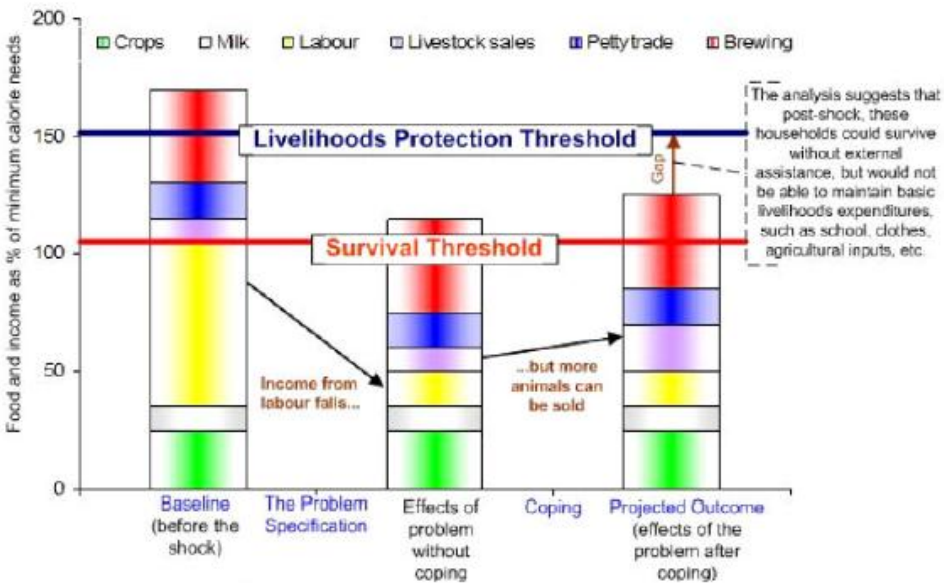

Figure 14: HEA analytical approach

Once these relationships are understood, analysts can model the effect of changes in production, food prices, labor opportunities or other drivers. The effects of planned interventions can be modelled in a similar way. An HEA analysis is carried out in pre-identified livelihood zones, and for locally-classified wealth groups in each zone, as both geography and wealth place constraints on the livelihood options and coping strategies available to people.

The Livestock Early Warning System (LEWS) subproject in the USAID Global Livestock CRSP aims to provide information in a timely manner to allow pastoralists and national and international agencies to respond to emerging drought conditions. The LEWS technology suite utilizes weather satellite sites to acquire temperature and precipitation data. This is linked to a forage production model to create a detailed map showing plant species, soil conditions, livestock levels and movement. The system can generate data for a 30-year period (see http://cnrit.tamu.edu/lews).

The Integrated Food Security and Humanitarian Phase Classification (IFSHPC) was developed by the Somalia Food Security Analysis Unit (FSAU) run by FAO. It combines food security, nutrition and livelihoods information to assess the relative severity of a food crisis and the implications for humanitarian response. Crises are classified into five ‘phases’, from generally food secure to famine/humanitarian crisis.

The IPC is not in itself a methodology, but uses existing data and information drawn from various studies and assessments to classify food security according to reference indicators (e.g. on nutrition, livelihoods, coping strategies). From this a risk map is created showing actual and predicted ‘hot spots’. FAO is working with donors and partners to refine and roll out the IPC in a number of pilot countries. Critics contend that the IPC is too dependent on available indicators fitting the key reference table; is too subjective; its single classification for chronic food insecurity is too limited; and thresholds from one phase to another can potentially be difficult to apply. The IPC has nonetheless generally been seen in the Horn of Africa as a useful instrument to attract attention to impending crisis using existing information and analysis.

Early warning system is a very critical component of post-disaster preparedness. Not only does DPPC have a separate department devoted to EWS, but also it serves as a secretariat of National Committee for Early Warning (NCEW). Operating under the auspices of the national disaster management agency (DPPC), NCEW is a multi-agency establishment whose members include Ministry of Health, Ministry of Agriculture, Central Statistical Authority, Ethiopian Mapping Authority, National Meteorological Services Agency, Ethiopian Nutrition Institute. The Ethiopian early warning system is one of the oldest in Africa (Teshome, 2005) that was set up following the 1973/74 famine and the methods of data collection are shown in **Table 13**, although early warning information and indicators are entirely geared to drought hazard. In other words, organized primarily to address the problems stemming from climatic abnormalities that have direct influence on food production, food availability and pastures for livestock grazing, the principal purpose of EWS in Ethiopia has often been geared towards predicting food situation in the country and offers predictions about the likelihood of emergency situation.

In any case, most of the early warning indicators pertaining to drought in use in the other parts of the world where similar hazards are endemic have originally been developed and tested in Ethiopia (Teshome, 2005). Lautze wrote: The DPPC has developed a fairly credible EW system for crop producing areas and has predicted, on a number of occasions, disaster well advance (e.g., 1984/85, 1992, 1994/95, 1999/2000, and 2002/2003). In recent years, its information has induced government, donor, UN and NGO humanitarian responses on an adequate scale to prevent the mass migration of vulnerable people to famine shelters, thereby avoiding the worst of the famine images that were once synonymous with Ethiopia (2003).

Early warning committees for collating, organizing and disseminating early warning data/information have also been established in all regions down to woreda and kebele levels. The establishments at all levels have been very effective in terms of generating Up-to-date pre-harvest and post-harvest data, information in the pastoral lowland regions and predicting impending drought induced famine disasters.

Table 13: Corresponding methods and equipment used to collect data for the alert

Data input	Source	Method	Equipment	Frequency of data collection
Agricultural production monitoring, of crops and sometimes livestock products	Vulnerability assessments provide a baseline of information on how people access food in a normal year	Food balance estimates are usually based on a combination of rainfall data, satellite imagery and field assessments of crop growth.	Improved systems for data collection, analysis, and dissemination to end users, as well as strengthening of the communication channels from the community to national levels.	Periodically to reflect on the effectiveness of the system as a whole.
Market information systems, for domestic and sometimes international trade	vulnerable groups	Need assessments take place in affected areas once a current or potential problem has been identified through an EWS, and aim to determine requirements for food aid and other interventions in detail.	Hydro-meteorological stations	Periodically and daily
Social monitoring of the most vulnerable groups	Monitoring social, economic, cultural and physical indicators.			
Nutritional surveillance				
occurrence of drought, rainfall, pests, and the outbreak of human and livestock diseases				
climate information at the local level		"Mali model"	through climate downscaling, expansion of hydro-meteorological stations, and support for new technologies.	
other data (e.g., on vegetation, crops and livestock status, human and animal health and nutrition, water resource availability and quality, environmental indicators, etc) are collected at the community level to help in forecasting and early warning, and also to better understand local conditions.				

Additionally, following the recommendation of FAO in 1990, a food reserve of 205,000 tons intending to provide food, in case of emergency, for an estimated drought vulnerable population of 4.2 million for nearly four months has since 1992 been established (DPPC, 1993, 1998). As integral part of post-disaster preparedness scheme, the EFSRA managed to stockpile food reserve to the level of 307, 000 metric tones (MT) in 1998 that appeared to have arrested what would become a major human catastrophe in 1999/2000. Administered by government appointed national board and drawn from earnings of government, NGO and donor fund sources, NPPF chiefly offers a reservoir of financial outlay for both pre-disaster prevention and post-disaster emergency and response measures. Furthermore, DPPC operates a fleet of transport tracks that are able to provide relief cargo from port of origin to main warehouses and from the latter to different distribution sites. NGO and UN transport fleets have also been supplementing transport deficits that occur between ports, warehouses and distribution centers (DPPC, 1998). All in all, warehouses, transport, procurement, inventory, information networks and related logistical facilities are put in place, although these are often found to be insufficient compared to an estimated 4.5 to 5 million people facing the risk of drought disaster annually in Ethiopia (FDRE, 2006).

Over the past half a century, there have been legions of factors that contribute to recurrent drought disaster in Ethiopia. Deficit rainfall, prolonged high temperatures, strong winds, high rates of evaporation and relatively low humidity characterize drought (Workeneh, 1989). Drought can also be explained in terms of phenomena/events that might characterize it; namely, hydrological or agricultural drought. While the former demonstrates phenomena where a prolonged absence of rainfall results in the lowering of stream flow, depleting soil moisture and fall in ground water that disrupts water supply, agricultural drought stems from seasonal rain failure and thus unable to furnish the soil with moisture causing substantial reduction in crop yields or total loss (Melaku et al, 1997). Ethiopia has for many years suffered from both. Increasing population pressure on land, coupled with associated overgrazing, soil erosion and removal of vegetation cover and other forms of poor land use have caused the vulnerabilities of Ethiopian communities to drought hazard.

More recently, EWS have shifted towards a broader understanding of food security which includes (i)food availability, (ii) the stability of food supplies, (iii) access to food (physical, financial and social), and (iv) biological utilization of food (which depends on health). Reflecting these four dimensions of food security, more effective EWS are organized around four main pillars (FAO, 2000):

- • Agricultural production monitoring, of crops and sometimes livestock products
- • Market information systems, for domestic and sometimes international trade
- • Social monitoring of the most vulnerable groups
- • Nutritional surveillance

However the main focus of many EWS is still crop production and food market trends, with much more limited attention to social monitoring and nutritional surveillance. Food balance estimates are now usually based on a combination of rainfall data, satellite imagery and field assessments of crop growth.

Effectively responding to a food security emergency requires more than just an early warning system to raise the alarm and indicate that a problem is emerging. Baseline vulnerability assessment, early warning, needs assessments and programme monitoring and evaluation are all recognized as important stages of an effective food security (or broader humanitarian). Vulnerability assessments provide a baseline of information on how people access food in a normal year, their sources of vulnerability and the coping strategies available to them, which helps to identify vulnerable groups and develop appropriate responses. Need assessments take place in affected areas once a current or potential problem has been identified through an EWS, and aim to determine requirements for food aid and other interventions in detail. Monitoring and evaluation are important both during emergency responses, in order to check the effectiveness of interventions and make any necessary adjustments, and periodically to reflect on the effectiveness of the system as a whole.

The EWS conducts hazard assessments periodically and yearly by monitoring social, economic, cultural and physical indicators. The EWS was established to “monitor and warn the threat of disasters ahead of time to trigger timely, appropriate, and preventive measures.” However the primary focus of the EWS has been to monitor causal factors of food insecurity. Thus it monitors the occurrence of drought, rainfall, pests, and the outbreak of human and livestock diseases that affect the availability of, and access to food. The existing EWS is not well-suited to fast-onset natural disasters such as floods, and certain rapidly spreading diseases and pests, and conflicts.

Communication among the *kebele* (community), woreda, regional, and federal levels is at the core of the early warning system and must be strengthened for effective functioning of the system. This includes improved systems for data collection, analysis, and dissemination to end users, as well as strengthening of the communication channels from the community to national levels.

There is widespread recognition, among Government and development partners, of the need to develop a more unified, transparent, coordinated, and objective early warning system, that has a system of “checks and balances.” Although more than 30 early warning systems, methodologies, and approaches exist in the country, there is no coordinating framework that brings together the different streams of information into a multi-sectoral early warning system that assesses hazards in, e.g., agriculture, health, nutrition, and natural resources management. There should be one major unified early warning system that assesses multi-sectoral hazards across the country, including monitoring of drought risk, food insecurity, health epidemics, malaria outbreaks, livestock diseases, and market information. This requires the coordination of early warning activities from the community level up to the federal levels, across line Ministries at the federal level, and among the many actors and donors working on early warning issues at the community, regional, and national levels.

There has been some progress toward the development of unified early warning systems. In recent months the US AID-funded FEWS NET and the WFP-funded Vulnerability Analysis Mapping (VAM) have joined forces to generate a unified monthly Early Warning Bulletin. This is a major stride toward streamlining and integrating existing monitoring and early warning systems in Ethiopia. In addition, DMFSS has requested technical assistance from FEWS NET and VAM to help in preparation of monthly reports by Government.

The Government has made a strategic decision to decentralize the early warning system to the woreda level, particularly with regards to slow-onset risks such as drought and food insecurity. Given the importance of data captured and used at the woreda level, DMFSS needs to focus on woreda-level capacity building for monitoring and early warning, along with contingency planning and financing. In the existing system, the key information gathered and potential decision-making is at the woreda level. This allows information gathered at the community level to be used by those at the community level. One potential mechanism for the transfer of information between the community, regional, and national levels is through the Woreda Net system, an initiative to connect the woredas through a network. This system is largely nonfunctional at present but has the potential to be an important mechanism for information dissemination.

Improved data collection at the local level and a strengthened multi-hazard early warning system require reliable information on climate monitoring. The National Meteorological Agency (NMA) currently has about 1,000 hydro-meteorological stations of various classes located throughout the country. However, information at the local level is seen as unreliable, and not captured in a way that would allow the community itself to use the data for early warning and forecasting, and for planning of crop-livestock systems. There is a need to provide capacity building for better and more reliable climate information at the local level through climate downscaling, expansion of hydro-meteorological stations, and support for new technologies. The NMA is promoting the “Mali model” for community-based climate monitoring whereby climatic data, along with other data (e.g., on vegetation, crops and livestock status, human and animal health and nutrition, water resource availability and quality, environmental indicators, etc) are collected at the community level to help in forecasting and early warning, and also to better understand local conditions.

In turn, this information can be used together with agriculture and heath extension agents for planning farming systems and livelihoods that have higher returns, are more resilient to hazards, and are environmentally sustainable.

4.4 EASTERN NILE REGION (DOWN STREAM COUNTRIES)

4.4.1 Experiences in Egypt

The Nile River in **Figure 15** has two main tributaries; the White Nile and Blue Nile River with their confluence at Khartoum. Downstream the Main Nile is also fed by the Atbara River which is dry most of the year and drains the northern part of the Ethiopian Plateau during the rainy season. After it passes the famous Great Bend the river enters Lake Nasser, which is formed after the construction of the High Aswan Dam, completed in 1902.

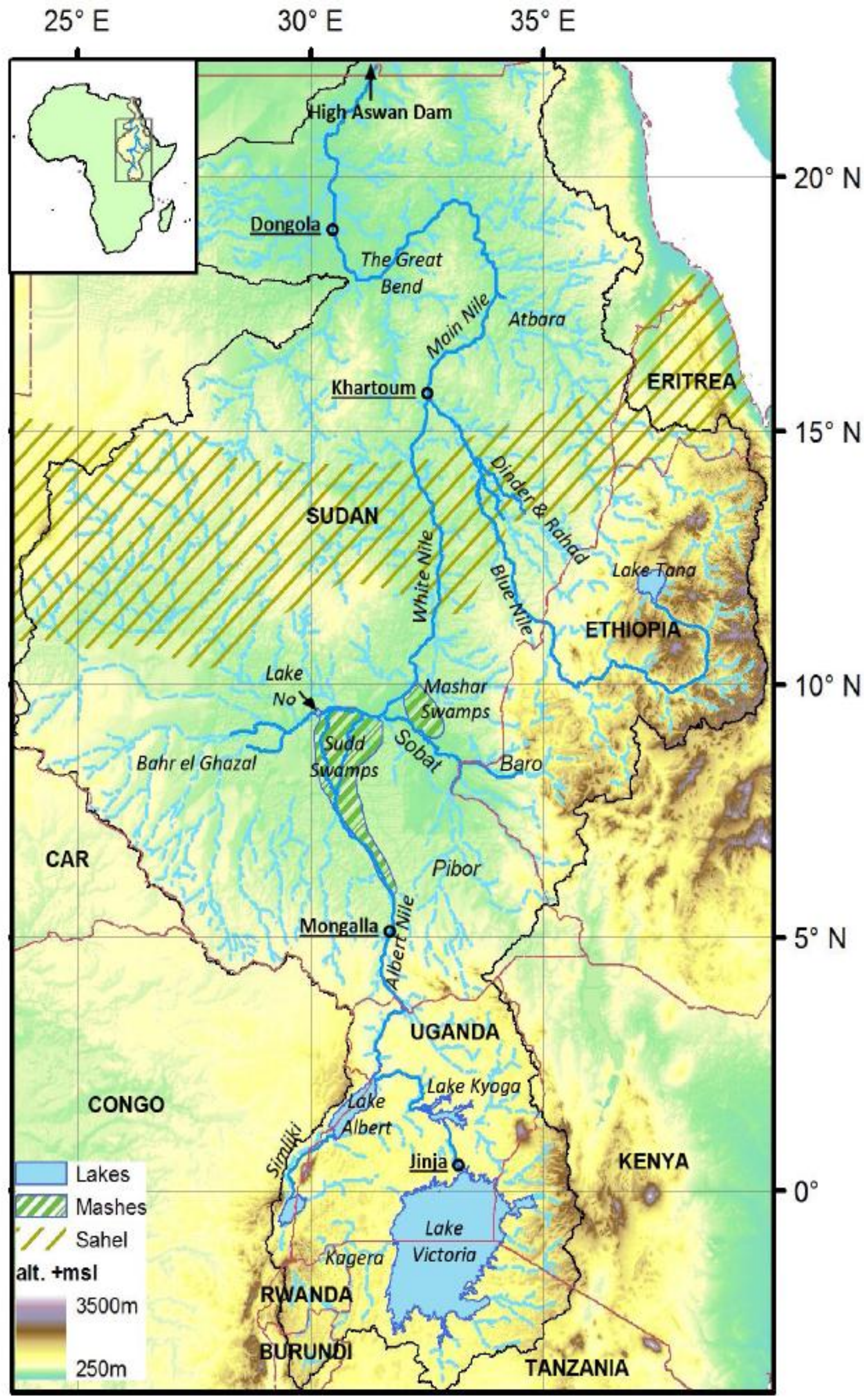

Figure 15: The Nile River Basin (elevation according to GTOPO30 (USGS, 2009b)

In the Nile Basin two interrelated problems are observed in relation to water resources. First of all, most Nile countries are under severe water stress, using most of their long term renewable water resources. These stresses urge the need for improved efficiency under current water availability. Since the socio-economic system highly depends on the current amount of inflow, minor changes on this water budget will have great consequences. The RIBASIM-NILE model provides a tool to assess impacts of upstream developments on available water resources along the Nile River. The second problem is to cope with the effects of climate change on water resources. Many studies quantify the sensitivity of parts of the Nile Basin to climate change (e.g. Conway & Hulme, 1993, 1996; Gleick, 1989, 1991).

The spatial division of water supply and demand in the Nile River is high. While the majority of supply is accounted for by rainfall upstream in the Blue and White Nile tributaries, demands are highest downstream, in Sudan and Egypt. The latter two countries experience high water stress, whereby Sudan and Egypt use more than 50% and 90% of their long term renewable water resources (Arnell, 1999). At high water stress, only small changes in water supply have enormous consequences for the socio-economic system in the demanding countries. Basin sensitivity studies indicate the degree of perturbation of water resources in changing climatic conditions. Studies in climate simulation and projections of climate change, give insight to which extend the future climate can be modelled.

Climates across the Nile Basin have to be classified in more than one type. **Figure 16** shows the annual amount of rainfall is highest in the tropical regions at the Great Lakes and the Ethiopian Plateau with annual maxima up to 2,100mm and 1,900mm respectively. Where the climate at the Great Lakes is characterized by a bimodal distribution with two rainy seasons, at the Ethiopian Plateau a clear wet and dry season is distinguished. In a transition zone downstream the Great Lakes, rainfall is gradually concentrated to a single rainy season. Between 6° and 13° north the climate is characterized as semi-arid with less than 500mm rainfall per year. North of 13th latitude, the climate is considered arid, with annual rainfall less than 100mm. In Figure (9), the annual variation of reference evapotranspiration is given. It must be noted that these amounts do not exactly represent potential evapotranspiration, as vegetation influences are neglected. **Figure 17** shows the lowest values for reference evapotranspiration at the Great Lakes region and the Ethiopian Plateau, due to the high humidity and surface elevation of these regions. Values increase further north as the temperature rises and humidity decreases. At Dongola, reference evapotranspiration is around 2,500 mm/year, indicating high open water evaporation over the river, lakes and reservoirs.

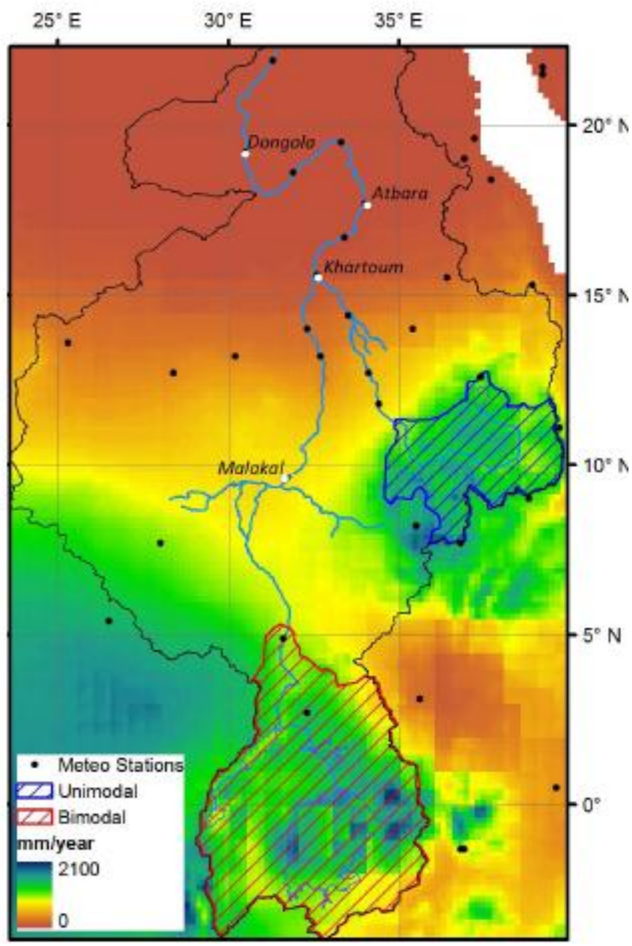

Figure 16: Rainfall (New, Lister, Hulme, & Makin, 2002)

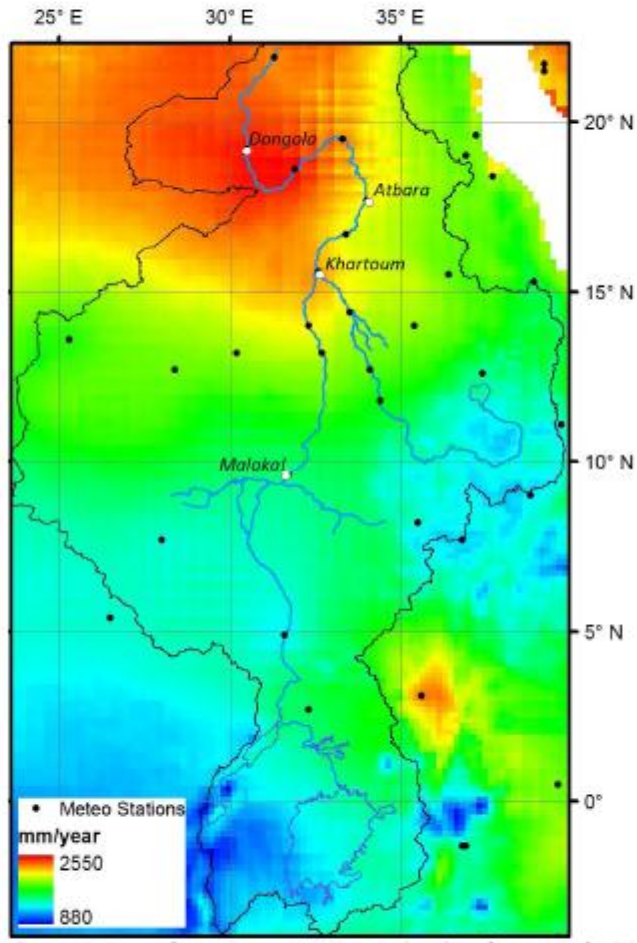

Figure 17: Reference evapotranspiration (van Beek, 2008)

Egypt is situated in the arid belt in Northeast Africa and is extremely dependent on the Nile for its water needs and security. There are increasing indications worldwide about possible climate change with wide ranging effects on the environment, societies and economy and to which human activities have contributed considerably (CO2, greenhouse effect). One of its implications is that rising sea levels could directly threaten the Nile Delta in Egypt, a situation that is exacerbated by great uncertainty about the effects of changing inflows (quantity and quality) from the Nile. **Figure 18** exhibits the variations in the natural annual inflow at Aswan during the period 1871 – 2000. The figure demonstrates the decreasing trend in the annual inflow average from 106.7 BCM during the period 1871-1900 to 87.0 BCM from the beginning of the century till the start of operation of HAD when the average annual flow was determined by 84.4 BCM The vital element for Egypt's Nile water security is provided by the water supply and adequate management of the storage of HAD reservoir (Lake Nasser).

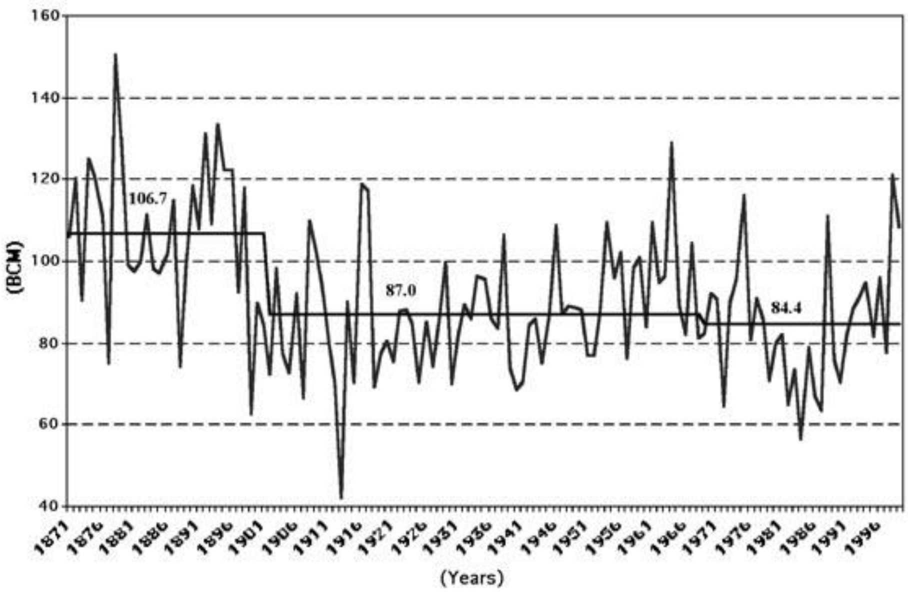

Figure 18: Annual inflow average during the period 1871-1900

Source: The Planning Sector, MWRI

There is no clear records explain in details what of type of droughts or flood that methods related to. The predicted of Nile flood is estimated by statistical methods or by mathematical models to predict the river Nile flow reached to HAD. Based on these information the HAS operational strategy is valid and water distribution policy has been established.

The main inputs to this model are the rainfall and potential evapotranspiration. From the outset of NFS development shown in **Figure 19**, it was decided to utilize satellite remote sensing technology in estimating rainfall over the basin. This was motivated by the scarcity and discontinuity of rainfall records within the basin in addition to the lack of direct monitoring control over rain gauges, as all basin rainfall occurs outside the borders of Egypt where the system is hosted. Therefore, the system grid was designed to match that of the satellite rainfall. In addition, the system includes a large database of rain gauge data, as part of the NileBasin Hydro meteorological Information System (NBHIS) which also holds flow records at all key river gauges.

Geostationary satellite imagery is received using a dish antenna on the roof of the ministry building. This imagery is used to generate daily high resolution (20km) girded estimates of rainfall over the basin, that is then blended with gauge-only rainfall analyses. The combined daily rainfall product is used to drive a girded distributed hydrological model of the basin.

When used for forecasting as intended, a short NFS simulation (a few weeks) is performed using observed rainfall (merged satellite and gauge estimates) to define the model status (soil moisture storage, reach storage) on the current date. Subsequently, an ensemble of historical rainfall (for as many years as available) for the 3 months following the current date is applied to the model to simulate possible inflow series to Lake Nasser, called Extended (and more recently Ensemble) Streamflow Predictions (ESP). Once a week observed flows at some key points (e.g. Diem) are assimilated to update the model states. It implies that the rainfall estimates are adjusted for the last 4 weeks to minimize the difference between the simulated and the observed flows. When input data are missing or felt unreliable the deterministic model can be replaced by a first order Markov model for three locations (Malakal, Roseires and Khartoum). This model produces possible monthly runoff traces, which are subsequently disaggregated to daily data. The stochastic model is often applied to replace the deterministic forecast for the White Nile at Malakal, as the quality of the latter is considered less reliable. The system relies on a GIS database to represent the connectivity of the different pixels as well the different streams, rivers, and sub-basins associated with the designated forecast points. In summary the NFS is composed of 6 main components that perform the following functions:

- Rainfall Estimation
- Hydrological Simulation
- River Flow Forecasting
- Assimilation
- Data Collection and Management (NBHIS)
- GIS Functions

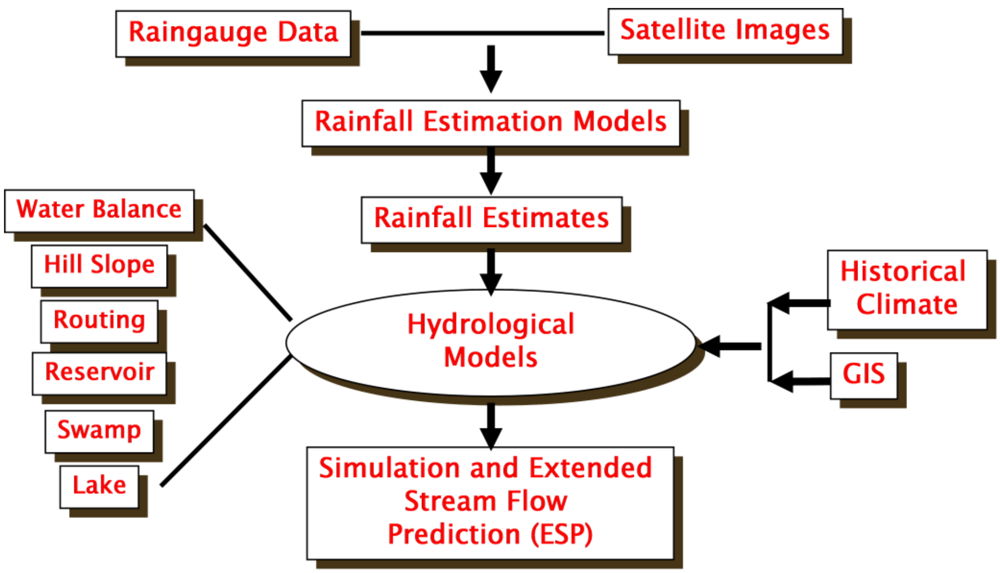

Figure 19: Schematic of the Nile Forecast System

The NFS requires rainfall and potential evapotranspiration data for the whole Nile basin as inputs. These are required as gridded rainfall and potential evapotranspiration data (i.e. maps) with a daily time step although monthly data can be also used as the system contains routines for disaggregating these to the daily time step. NFS also requires discharge data at key stations for assimilation, calibration, and performance evaluation. Discharge is usually obtained from stage measurements using rating curves that are updated annually based on concurrent stage and discharge measurements.

Since its development started in 1992, the NFS has been enhanced several times. The latest enhancement of the NFS was undertaken in 2009 by the Hull University under the remit of the Nile Basin Initiative Flood Preparedness and Early Warning (FPEW) project.

The enhancement focused, amongst other things, on the rainfall estimation methodology through developing a multi-spectral technique that takes advantage of the new generation of the European METEOSAT satellite (METEOSAT Second Generation – MSG). The NFC obtained a new reception system from VCS Engineering, Germany in 2007 to replace the old Primary Data User System (PDUS) unit that was in operation since 1992. The MSG spacecraft provide considerably enhanced datasets over their predecessors, both in the spatial and temporal resolutions of available imagery and in the number of separate wavebands for which images are available. The following **Table 14** describes the methods and equipment used to collect data for the alert.

Table 14: Data Entry of NFS methods and equipment used to collect data for the alert

Data input	Source	Method	Equipment	Frequency of data collection
Rainfall, rain gauge data	WMO/ METEOSAT satellite rainfall /data base rain gauge data	Daily/Monthly	Satellite /Scales of flood and Data Collection Platform (Server) linked to satellite	Daily /Real time data
Estimated Potential Evapo-transpiration	WMO/ METEOSAT satellite rainfall /data base rain gauge data	Daily/Monthly		Daily

4.4.2 Sudan

In D2.1 report we are focused on the Sudan as whole country. For these deliverable (D2.3) central part of the country were selected as case studies; because these part represent important productive agricultural regions under rain-fed for main staple crops (sorghum, millet, wheat), cash crops (sesame, Arabic gum) and irrigated sugar cane schemes. The main factors determine the growing season in this area is rainfall (in term of amount, duration, and distribution). **Figure 20** shows the rainfed agriculture and the rainfall isohytes.

Drought warning in Sudan depends mainly on the local and indigenous knowledge by using information and experiences of elder's. The information collected from survey showed that the farmers used the information about the length of the winter season, temperature during summer months, cold wind during May and June and migration of some kind of the birds as tools to derive the warning. While Sudan Meteorological Authority (SMA) are responsible for rainfall forecasting for two to three month before the rainy season by using Cold Cloud Duration images, Sea Surface Temperature and other available information for early warning during recent years.

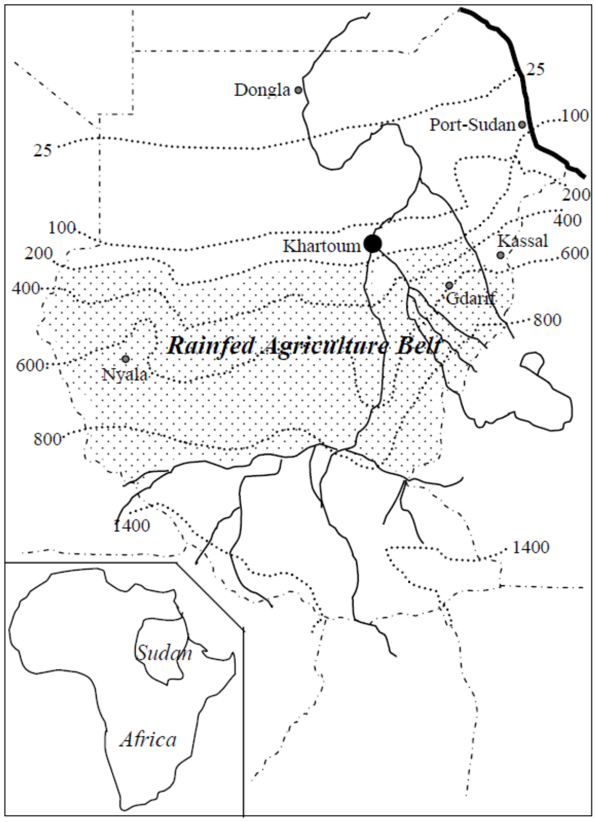

Figure 20: Map of the Sudan showing the rainfall and rainfed agriculture belt.

There are historical drought events at the early to mid-1970s, mid-1980s, early 1990s and early 2000s (these years were determined as common drought years by Elagib, 2009. During these years there are no clear warning systems.

Sudan Meteorological Authority (SMA) produces drought warning according to type of drought as follows

a) Meteorological Drought produce rainfall forecast reports every:
   - Dekadal (10 Days).
   - Seasonal (Four Months). (see **Figure 21**)

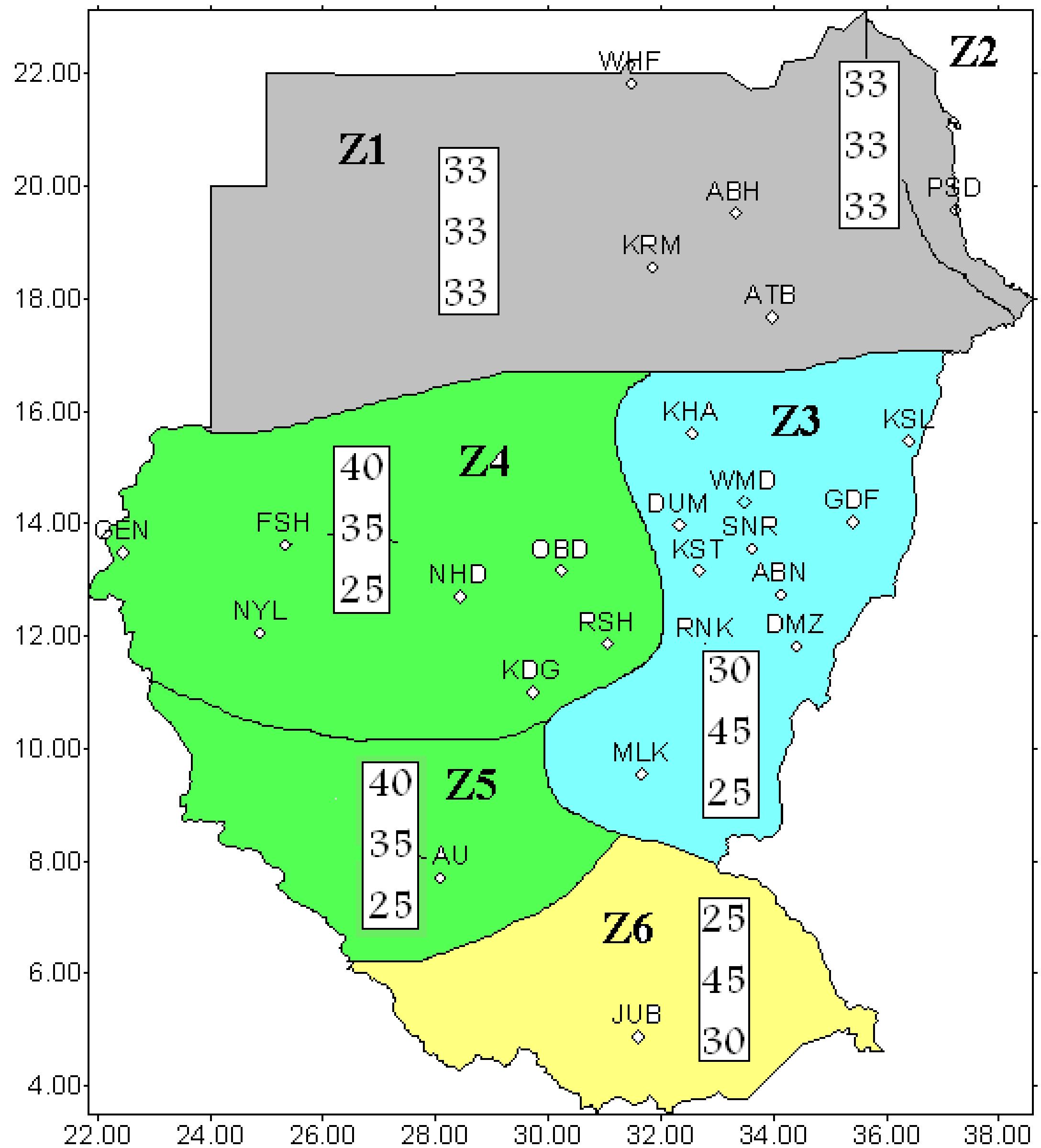

Figure 21: Sudan Seasonal Rainfall Forecast from June to September 2010 (SMA)

(The upper percent for above normal, middle ones for normals, and below for below long term average rainfall)

b) Agricultural Drought:

- Before the rainy season (April- May)
- During the Growing Season (June – November).

c) Hydrological Drought:
   - Start of the rainy season.
   - Mid of the rainy season during August for Nile river flood (Peak of the rainfall) End of the rainy season (late October).

For meteorological drought the Sudan Meteorological Authority and IGAD Climate Prediction and Applications Center (ICPAC) are responsible for rainfall forecasting for two to three month before the rainy season by using Cold Cloud Duration images, SST during April and May and other available information. The SMA uses a number of models and techniques to analysis the input data, this includes: Regional climate change index, Sudan Agricultural monitoring information System (SAMIS), PRECIS model, numerical and statistical packages (EAT, MM5, WFR and other seasonal model). Also CCD data calibrate with rain gauge data to estimate the rainfall amounts in the remote areas of Sudan as shown in **Figure 22.**

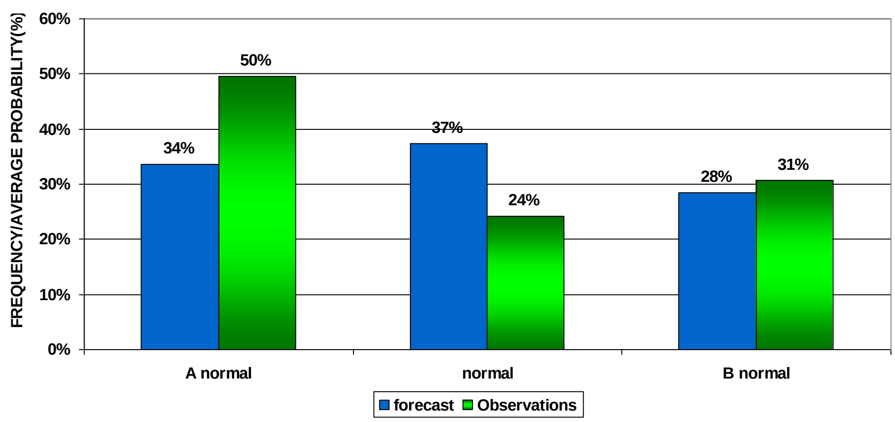

Figure 22: JJAS rainfall forecast for period 1999-2009

(Source; SMA)

For Agriculture drought the warning system in remote areas depend mainly on the indigenous and local knowledge systems by using stars, the length of winter month and appearance of some types of insects and birds. **Figure 23** shows the drought episodes in Gedaref region (about 1/3 of the rainfed sorghum cultivated in this area)

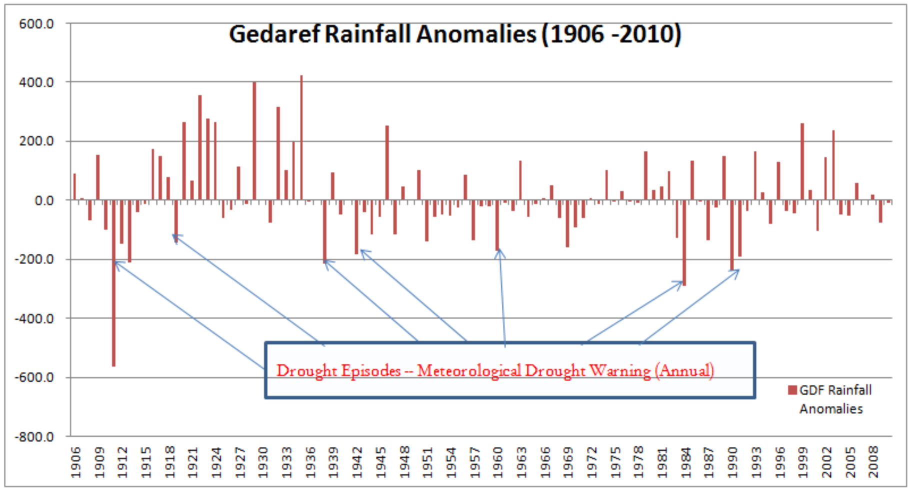

Figure 23: Gedaref Rainfall Anomalies (1906-2010)

4.5 SOUTHERN AFRICA DEVELOPMENT COMMUNITY (SADC)

Short-term weather forecasts and seasonal forecasts have been produced by the SADC Climate Services Centre (Drought Monitoring Centre). Weather reports and predictions for the region were posted in a "10 Day Drought Watch Bulletin". The last bulletin is dated 1-10 May 2002 shown in **Figure 24**. Although this is somewhat out of date, the report for rainfall in the region indicates severe shortages, which is indicative of the season as a whole.

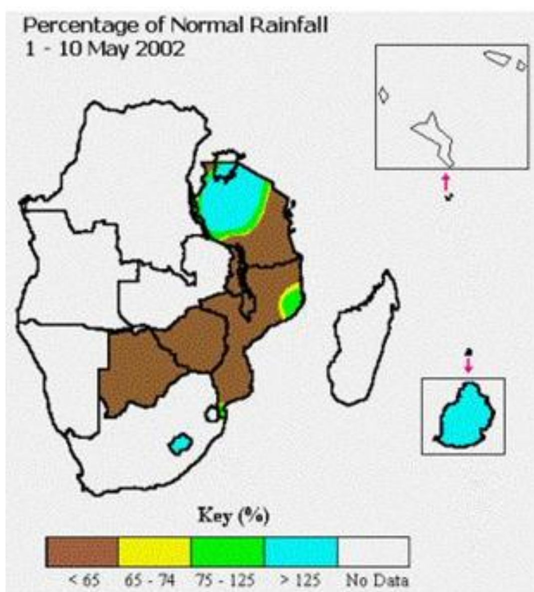

Figure 24: Percentage of normal rainfall for the period 1-10 May 2002

The scientists also take into account the El Nino-Southern Oscillation (ENSO) forecast. A typical ENSO forecast is shown in **Figure 25.**

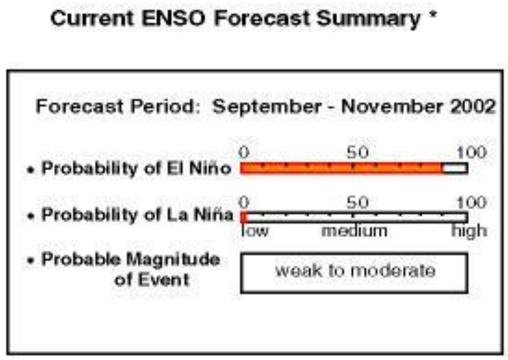

Figure 25: El Niño & Southern Oscillation (ENSO) Update - July 2002

The Southern Africa Regional Climate Outlook Forum meeting (SARCOF) brings together national, regional, and international weather experts to build a consensus seasonal forecast for the region. The process uses statistical and other climate prediction schemes to determined likelihoods of above-normal, normal and below-normal rainfall for each area. Above-normal rainfall is defined as lying within the wettest third of recorded (30- year, that is, 1971 -2000 mean) rainfall amounts; below-normal is defined as within the driest third of rainfall amounts and normal is the middle third, centred on the climatological median. The scientists also take into account the El Nino-Southern Oscillation (ENSO). The forecast is provided to users in a map form as shown on **Figure 26.**

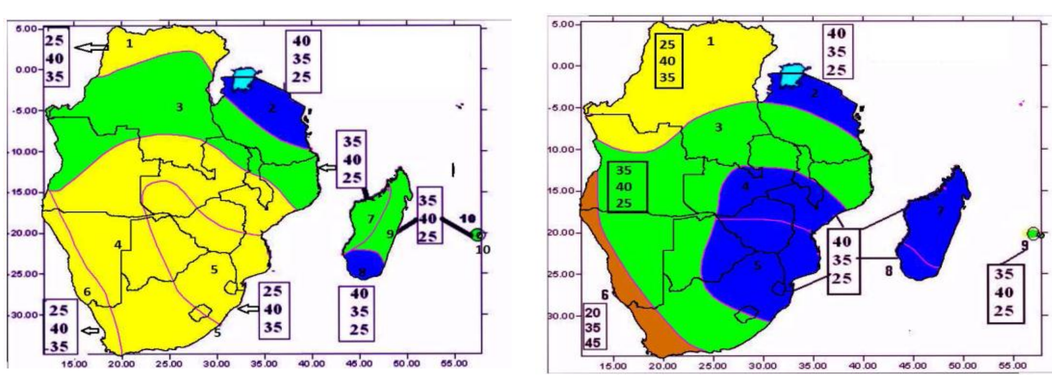

Figure 26: Rainfall forecast for October-November-December 2011 and January-February – March 2012

Source: SARCOF 15 statement

A six-month ahead forecast is issued and the season is split into two parts namely October-November-December and January-February-March. Individual governments used this forecast as the basis for contingency planning and for the formulation of advice to water users such as farmers and industry. The experience of drought early warning in SADC is described in the following section.

(a) The 1991/92 Drought:

In1991 climatologists, predicted the meteorological drought based on their El Niño modelling (Cane et al. 1994). As early as March 1991, the SADC Regional Early Warning System (SADC REWS) had predicted a substantial, region-wide grain shortfall (around 3 million tonnes) for the marketing year (1991-92) preceding the drought. The SADC Food Security Bulletin for December 1991 alerted governments and the donor community of this adverse change in growing conditions and issued tentative assessments of the likely impact on the forthcoming grain harvest in a number of countries.

(b) The 1993/94 Drought:

As early as October 1993, the DMC issued a forecast for the season based mainly on the observed and expected trend in the El Niño Southern Oscillation, normal rainfall was predicted across most of the SADC region for the period October to December 1993; some deficits were forecast for the latter half of the season (January to April 1994). Unlike the situation during the 1991–92 drought, when drought warnings were either not received or not taken seriously, warnings about potential rainfall shortages during the 1993–94 season were disseminated to most key users and the media (Unganai 1994).

(c) The 1997/98 Drought

Starting in April 1997, IRI climatologists communicated directly with scientists at the RRSP in Harare, expressing concern over the warming of the Pacific Ocean. The second-quarter REWU bulletin (SADC 1997a), published in May1997, did not report on the ENSO anomaly, and it was the June 1997 FEWS bulletin (FEWS 1997a) that first sounded the alarm to the early warning organizations. The bulletin devoted a page to describing ENSO and its tele-connections, and concluded by noting that “NOAA has now issued an ENSO advisory that a warm event is developing. Having started in the April–May period and having developed quite rapidly, this may be one of the stronger episodes FEWS and other groups are monitoring this event carefully to track its development and determine its likely effect on weather and crops”. By their July 1997 Bulletin (FEWS 1997b), FEWS had begun to include a monthly “El Niño Update,” and advised that countries in southern Africa “should be sure that structures are in place to anticipate and handle problems”. By mid-June 1997, SADC had formed an ad hoc committee to monitor ENSO, made up of representatives from the REWU, FEWS, and DMC. That same month the REWU issued a statement addressed to the SADC Ministers of Agriculture, advising them to prepare for a likely ENSO related drought. The June 1997 REWU quarterly food security bulletin (SADC 1997b) also warned of the developing ENSO warm event.

(d) The 2002/2003 Drought

In late 2000 FEWS NET began to publish monthly reports on the food security situation in the SADC region, using the internet as the primary means of dissemination. By drawing on the work of the national Vulnerability Assessment Committees (VACs), collaborating closely with the Regional VAC (RVAC) and posting these reports on the web every month during the crisis, FEWS NET complemented these monthly reports with twice monthly and also produced “Executive Overviews” to summarize information in an actionable form for decision makers. The July 2002 assessment was published by FEWS NET as a Position Paper; assessments in September and December 2002 were published by SADC RVAC as Regional Food Security Assessment Reports. Warnings were first made public in April 2002, before the harvest had even begun in some areas.

A summary of the warnings is given in **Table 15**.

Table 15: Monthly drought reports or warnings for 2002/03 drought.

Month, Year	Title of Monthly Report/Warning	Key Content of Monthly Report
April 2002	*FEWS NET Monthly Report*: "Production Shortfalls Imminent"	Maize production by country in 2001 and 2002 compared to five year average; special focus on problems in Zimbabwe; assessment of South Africa's ability to cover the regional deficit
May 2002	*FEWS NET Monthly Report*: "Food Security Crisis Deepens"	Graph of regional production plus stocks (total availability) vs. consumption over past eight years, showing largest deficit since 1995; discussion of how to fill the gap, including mention of U.S. white maize availability; assessment of transport corridor capacity to handle imports.
June 2002	*FEWS NET Monthly Report*: "Shortages, Higher Prices in Region"	Report on FAO/WFP CFSAM. First quantitative estimate of import needs (3.18m MT), embedded in text of report; discussion of price rises in some markets of Malawi and Zimbabwe.
July 2002	*FEWS NET Monthly Report*: "Regional Cereal Shortage, Import Challenge" *FEWS NET Position Paper*: "Is a Famine Developing in Southern Africa?"	Maps and table of estimated import requirements for 11 countries in region. Report on WFP Regional Emergency Operation (EMOP) for six most affected countries (Mozambique, Malawi, Swaziland, Lesotho, Zambia, Zimbabwe), SADC FANR monitoring and response plans, and UN Consolidated Appeal. First use of regional map on front page with (qualitative) summaries of food security situation for key countries
September 2002	*FEWS NET Monthly Report*: "Imports Lag, International Response Inadequate" *First SADC RVAC Regional Food Security Assessment Report*:	Updated import requirements, and progress towards meeting them; statement on GM maize controversy in region. Regional map for six most affected countries on front page, with number affected and import requirements; report on results of first rolling food security assessment, including information on wasting, coping mechanisms; prospective information through end of current season; section for decision makers.
October 2002	*FEWS NET Monthly Report*: "Assessments Point to Rising Needs"	Updated import needs and "slow progress" in filling them; Child wasting estimates from national VACs; climate forecasts for current growing season.
December 2002	*FEWS NET Monthly Report*: "Food Security Prospects Worrisome" *Second SADC RVAC Regional Food Security Assessment Report*	Update on "poor rainfall performance" for current growing season and likely impact on continuing crisis; Update on "large remaining cereals gap" that will be "difficult to fill". Updated regional map with number affected and import needs; food aid progress and plans; review of market prices; HIV/AIDS impacts on food security; statement that "in general wasting levels are still not a cause for concern" but noting "scanty data".
February 2003	*FEWS NET Monthly Report*: "Signs of Improving Food Security Conditions"	Report on anticipated 2003 harvest and likely import needs; report on most recent vulnerability assessments

4.5.1 South Africa

The South Africa Weather Services (SAWS) has moved from using a downscaling a global system to the region (atmospheric modelling) to the ECHAM 4.5 Ensemble prediction system for climate forecasting. Enhanced Probabilities is considered to be more than 45% probability for a specific category. If there are areas that do not show an indication of more than 45% probability, then the forecasts for that area is considered to be uncertain. The forecast is provided to users in a map form as shown on **Figure 27**

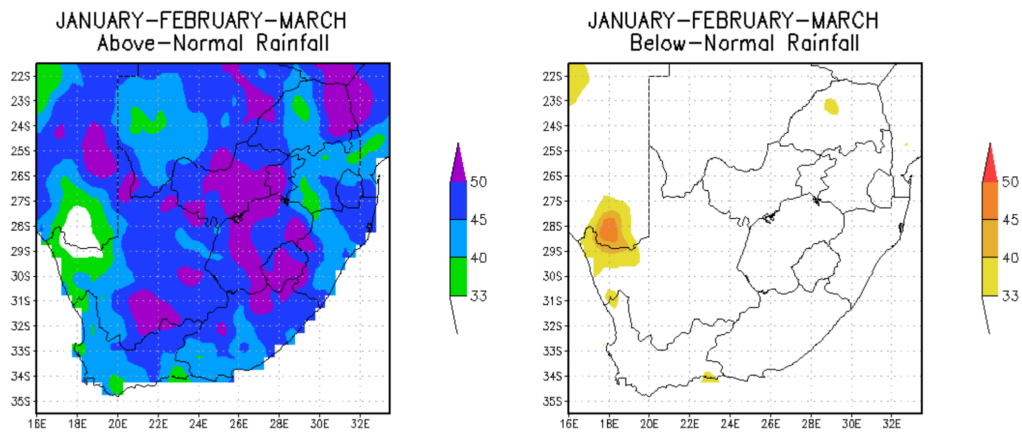

Figure 27: Rainfall forecast for January –March 2012

Source: SAWS

These long range forecast are for 5 months in advance. This forecast can be used as an early warning tool for the season to come. **Table 16** and **Figure 28** show that if a forecast is issued in July, it is possible to assess the outlook of the start of rainy season especially the expectation of early or late rains.

Table 16: Application of SAWS 5months ahead forecasts for drought early warning.

Month Issued	Nov	Dec	Jan	Feb	Mar	Apr
Period Covered	Dec-Jan-Feb Jan-Feb-Mar Feb-Mar-Apr	Jan-Feb-Mar Feb-Mar-Apr Mar-Apr-May	Feb-Mar-Apr Mar-Apr-May Apr-May-Jun	Mar-Apr-May Apr-May-Jun May-Jun-Jul	Apr-May-Jun May-Jun-Jul Jun-Jul-Aug	May-Jun-Jul Jun-Jul-Aug Jul-Aug-Sept
Surface Water Management – Limpopo	Season outlook		Review water availability			

Month Issued	May	Jun	Jul	Aug	Sep	Oct
Period Covered	Jun-Jul-Aug Jul-Aug-Sept Aug-Sept-Oct	Jul-Aug-Sept Aug-Sept-Oct Sept-Oct-Nov	Aug-Sept-Oct Sept-Oct-Nov Oct-Nov-Dec	Sept-Oct-Nov Oct-Nov-Dec Nov-Dec-Jan	Oct-Nov-Dec Nov-Dec-Jan Dec-Jan-Feb	Nov-Dec-Jan Dec-Jan-Feb Jan-Feb-Mar
Surface Water Management – Limpopo			Early Warning		Review	

The expectation of runoff and storage status can be assessed in November an as early as January a review of surface water availability can be made.

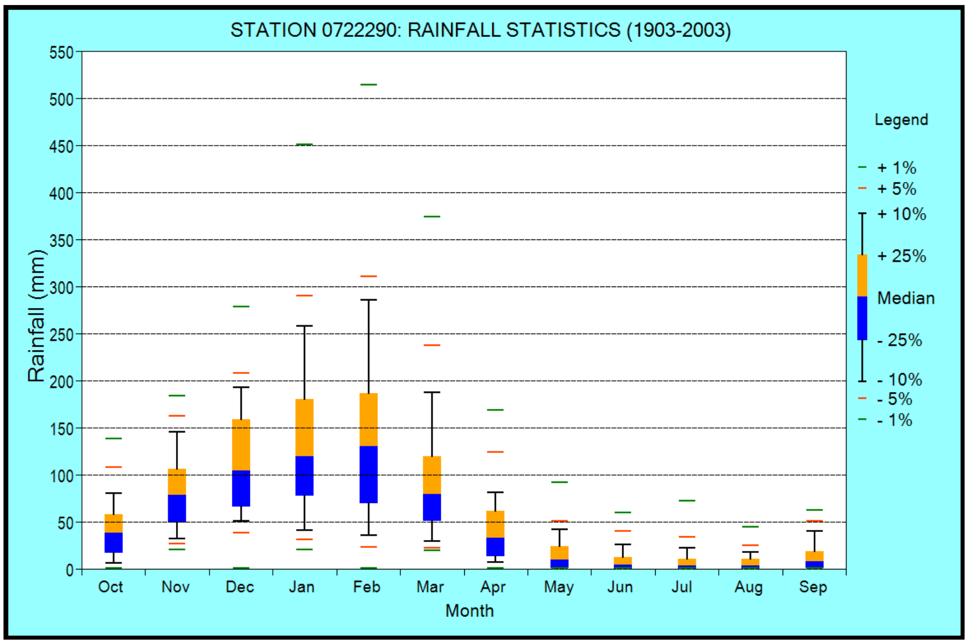

Figure 28: Distribution of total monthly precipitation

Source: HDAM Graphs, 2012

The SAWS also generates Standard Precipitation Indices (SPI) and provides them in map form as shown in **Figure 29**.

The interpretation of the maps is as follows:

- From September to November 2005, there was some alleviation of the dry conditions in the northern provinces as well as the far south, However, some dryness remained in the northernmost province, Limpopo.
- The rainfall for the six-month period, as shown by the SPI map for June to November 2005, shows near normal conditions over the largest part of South Africa, but moderate to very dry conditions in several areas, most notably in the Southern Cape, southern parts of the Northern Cape and the far north, Even though some parts of Limpopo received good rains during November 2005, there was still a strain on water resources.

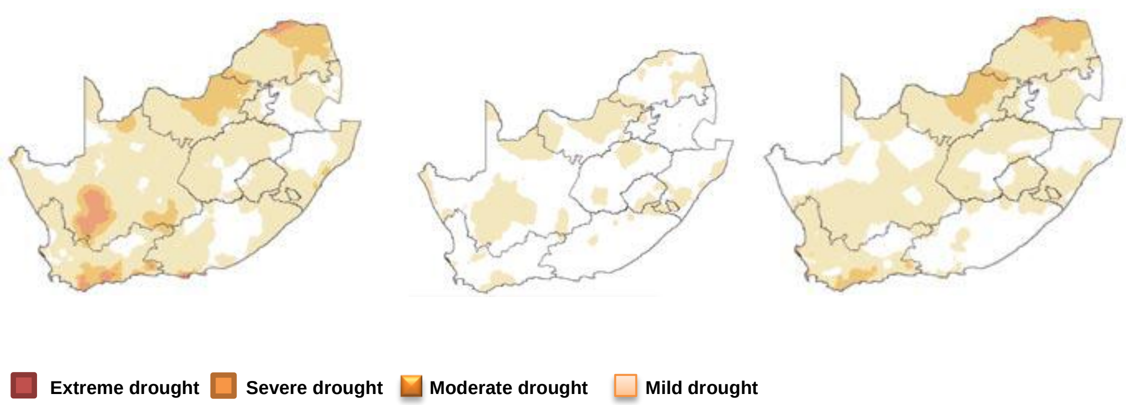

Figure 29: Standardized Precipitation Index (SPI) for South Africa, November 2005 (left); September to November 2005 (middle); June to November 2005 (right)

Source: South African Weather Service

4.5.2 Zimbabwe

This section describes drought warnings and responses during some drought events namely 1991/92; 1993/94; 1997/98; 2002/03; and 2006/07.

a) The 1991/92 , 1992/93 Droughts:

Zimbabwe was included in the warning provided by the SADC DMC. The DMC worked closely with the Meteorology Department. *Describe the specific warnings provided for Zimbabwe.*

b) The 1997/98 Drought

Zimbabwe was included in the warning provided by the SADC DMC. The DMC worked closely with the Meteorology Department. **Figure 30** shows the drought early warning in terms of precipitation issued for the 1997/98 droughts issued by the SARCOF and the Meteorological Services in Zimbabwe.

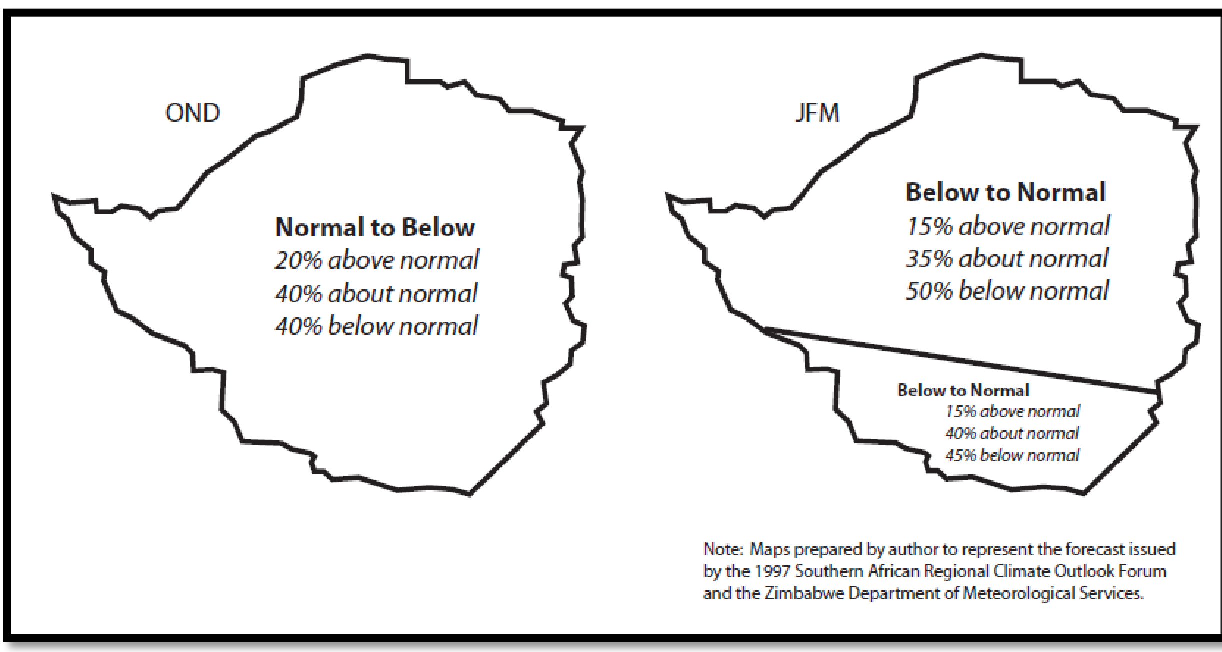

Figure 30: Zimbabwe early- and late-season forecasts for 1997–1998.

Source: FEWS 1997c

c) 2006/07 Drought

Zimbabwe was included in the warning provided by the SADC DMC. The DMC worked closely with the Meteorology Department. *Describe the specific warnings provided for Zimbabwe.*

5. CHARACTERISATION OF WARNINGS FROM INDIGENOUS AND LOCAL KNOWLEDGE SYSTEMS

5.1 MOROCCO AND THE OUM ER-RBIA BASIN

In order to get information about drought warnings from the farmers point of view and perceptions, a questionnaire was proposed to farmers of the Oumer-rbia basin. The survey covered rainfed and irrigated areas and the large variety of bioclimatic areas as shown in **Figure 31** by sampling the provinces of *Khenifra, Azilal*, (mountainous areas) *Beni-Mellal*, and *Settat* Plain areas) and *El Jadida* (coastal area).

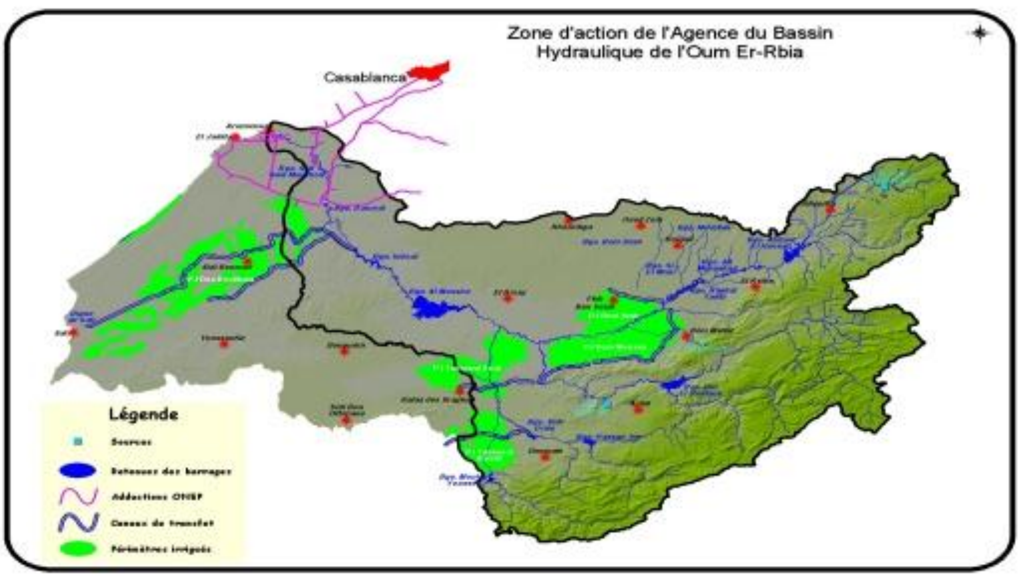

Figure 31: Location of the irrigated areas (in green)of Tadla and Doukkala in the Oum er-Rbia basin

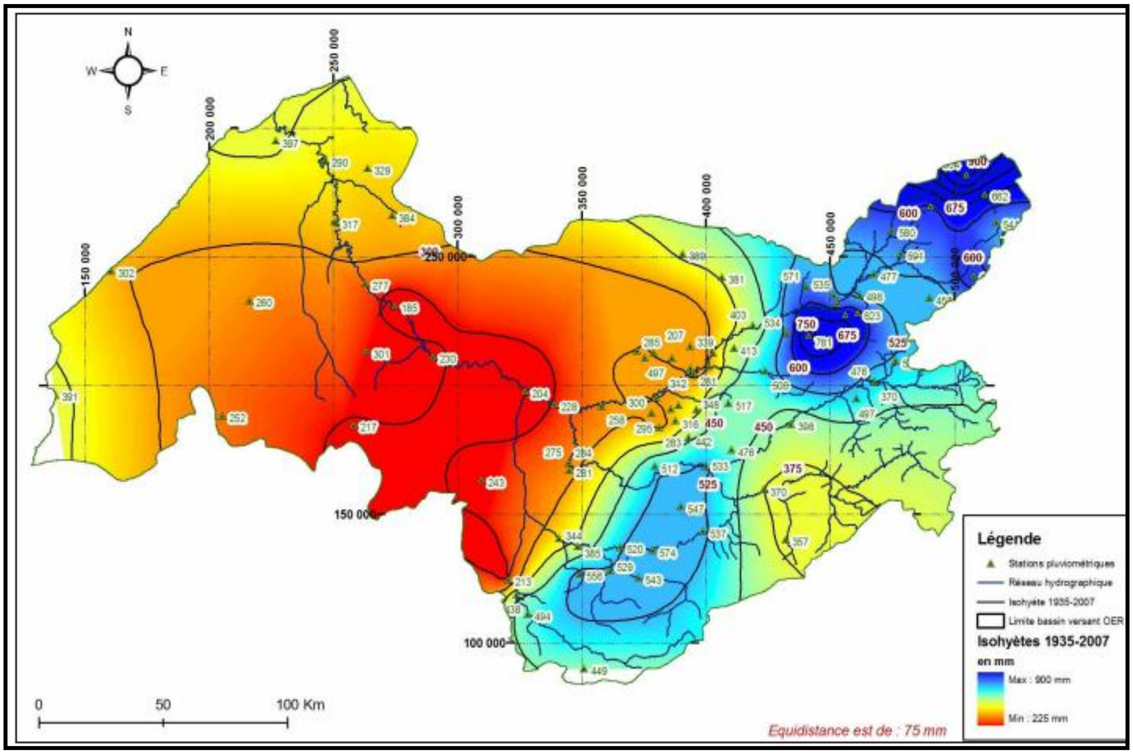

Figure 32: Distribution of isohyets in the Oumer-rbia basin

(red=dry, dark blue=very wet)

In the provinces with irrigated areas (Beni-Mellal, El Jadida), **Figure 32** shows the distribution of the isohyets and the objectives of the sampling were to cover both rainfed and irrigated areas as well as small, medium and big size farms knowing that in Morocco 71% of farms have less than 5 ha with an average of 2.1 ha/farm while in other provinces sampling were only based on farm dimensions. **Table 17** summarizes the number of farmers, and communes surveyed in each province. The provinces covered in the survey are shown in **Figure 33** which also includes 2 of the 9 Moroccan irrigated perimeters: the Tadla and Doukkala.

Table 17: Total of farmers, communes and provinces surveyed

Province	Number of rural communes	Number of farmers
Khénifra	3	20
Azilal	5	9
Beni-Mellal	8	39
Settat	5	20
El Jadida	5	16

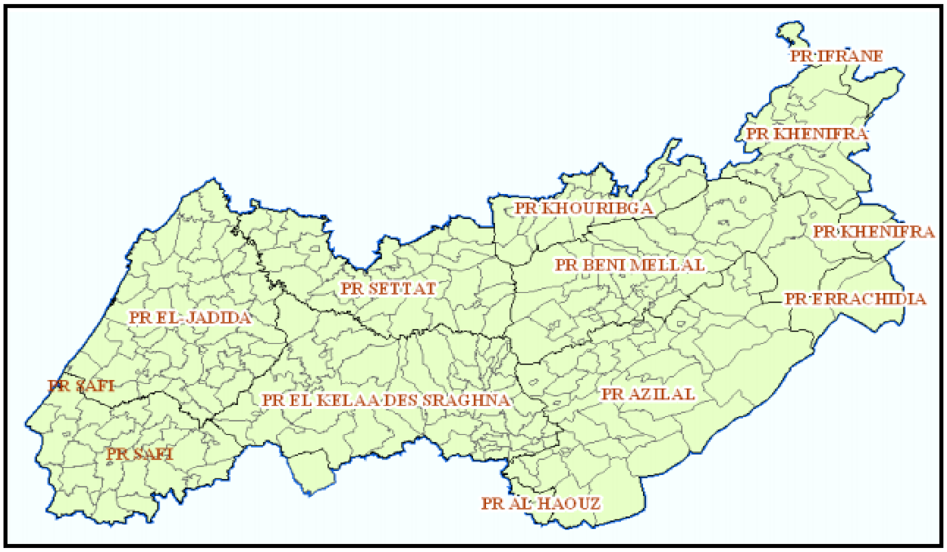

Figure 33: Surveyed provinces of the Oumer-rbia basin

The questionnaire proposed to farmers aimed to address the main following issues:

- Their knowledge of historical droughts events and how they characterize and recognize the emergence of dry periods.
- The existence of indigenous or local knowledge on drought emergence.
- Drought mitigation and adaptation practices.
- Drought relief aid they get from agricultural services during drought events.
- The existence and characterization of drought warnings before the implementation of drought relief actions.
- Assess the existence of different behaviors between "rainfed" and "irrigated" farmers.

Regarding historical drought events, nearly all the farmers surveyed (in all the provinces and whether they are "rainfed" or "irrigated" farmers) still keep in mind the drought event of 1980-1985 and consider it as the worst and most severe drought episode of the century. The drought episodes of the 90's (1991-93 and 1994-95) and of 1999-2000 and 2006-2008 are also cited as severe drought events. These information confirm data from literature search that count the dry periods of 1981-84, 1991-93, 1994-95, 1999-2003 and 2006-2008 among the main dry periods spread across major parts of Morocco since 1896 (Bouignane, 2010).

Rainfed farmers generally characterize and recognize droughts periods and are thus warned of their emergence by the following indicators:

- The lack of rainfall: From the farmers point view, the lack of rainfall is the major indicator of drought. Moreover, they do only not consider the total amount of rainfall but do also pay a special attention to its spread throughout the agricultural season. Indeed, results from our survey show two main periods of concern for the farmers which are first October, November and December and then the month of March. Since rainfed farmers are mainly cereal growers, the first one corresponds to the ploughing, sowing period while the second one is the grain filling period.
- The increase of the price of intrants and of goods of primary necessity
- The decrease of livestock prices

The situation is different for irrigated farmers who do not rely as much and as directly on rainfall like rainfed farmers. Indeed, each year, the river basin agencies and the basin's stakeholders agree on a programme for water allocation and although farmers are represented on the agency board which sets up the annual programme, their influence is negligible (2 members out of 35 on the board) and only the ORMVA may interact with significant power to negotiate agricultural allocation. This provisional allocation is established at the beginning of the irrigation season (September) and farmers are informed about it.

The ORMVA also issues "guidance"' on feasible cropping plans prior to each season, based on the anticipated water availability per hectare, and the demand of individual crops. Thus, in case of water shortage, priority is generally given to industrial and perennial fodder crops and orchards. In addition, summer crops and spring crops are dismissed from the irrigation provisional irrigation plan in case of initial severe water shortage.

According to results from our survey, farmer's strategies to cope with drought include:

- stockpiling grain and fodder from good years
- liquidating animals to a minimum reproductive herd that requires less fodder and to ensure some income
- digging new and deeper wells
- the resort to bank credits
- the emigration to urban areas
- the resort to other activities that may ensure some income to the household.

In addition, when the lack of rainfall persists until the end of February and the beginning of march, farmers use the sowed cereal fields as pastures.

They rely also on the drought relief actions implemented by the agriculture services and that consist mainly on:

- ensuring drinking water to rural population
- protecting livestock (subsidies toward the costs and distribution of concentrates and other feeds, development of water points)
- jobs creation
- drought insurance

These actions are typically crisis management strategies that are implemented after the onset of the drought while our main objective through this survey was to assess either there was any early or late drought warning action addressed to farmers and undertaken by state services prior to the implementation of these relief actions.

Thus, according to the large majority of farmers they do not get any drought warning from agricultural services. Irrigated farmers added that since the ORMVA informs them at the beginning of the agricultural campaign about the provisional water allocation, they somehow consider it as a drought warning in case of a reduced allocation.

In addition, all the farmers surveyed mentioned the rain prayer as the only drought official drought warning they get. Indeed, when rainfall situation at the end of December presents a significant shortage and weather forecasts do not expect any forthcoming rainfall, a join meeting is set between all the institutions involved in water governance and the information is forwarded from the Ministry of Interior to the Ministry of Islamic Affairs, which calls for a rain prayer (salat al Istisqa). This was recently the case in Morocco, Friday, January 6, 2012, where the faithful gathered in the various mosques of the country to call for rain. It is through this action that the drought is declared to the people. However, it concerns the agricultural drought which can be coupled or not with other kind of drought. The tradition of praying for rain is older than Islam: Jews and Christians were already practicing, and even the American Indians had their "rain dance".

Before the invention of the printing press, popular knowledge was passed on through proverbs, sayings, quotes-phrases easy to remember, in direct contact with everyday reality.

Farmers in Morocco refer to popular sayings that punctuate their activities over the year. Season after season, they use proverbs as reminders. Berber know how was accumulated for a period of more than three thousand years. This knowledge is still used nowadays by Moroccan farmers. The Berber calendar is divided in four seasons of three months each. The corresponding Gregorian months are mentioned in parenthesis as shown in **Table 18**.

Table 18: Correspondence between Berber and International years

Seasons and months in the Berber calendar	Corresponding season & months in the Gregorian calendar
Amewan	**Autumn**
Ctember (September)	From 14 September to 13 October
Tuber (October)	From 14 October to 13 November
Wamber (November)	From 14 November to 13 December
Tagrest	**Winter**
Jember (December**)**	From 14 December to 11 january
Yennayer (January)	From 12 January to 13 February
Furar (February)	From 14 February to 13 March
Tafsut	**Spring**
Meɣres (March)	From 14 March to 13 April
Ibrir (April)	From 14 April to 13 May

Seasons and months in the Berber calendar	Corresponding season & months in the Gregorian calendar
Mayyu (May)	From 14 May to13 June
Iwilen/Anebdu	**Summer**
Yunyu (June) : du	From 14 June to 13 July
Yulyu (July)	From 14 July to 13 August
Yust ou Awussu (August)	From 14 August to 13 September

Beyond the months in the traditional agricultural calendar, there are other markers that are the seasons, or important periods, which are marked by special occasions and celebrations. For these crucial moments, J. Servier uses the evocative name of the door of the year (tibbora usegwass).

(a) The main stations of the year

An interesting aspect of the Berber tradition before the Muslim era is the contrast between the two periods of 40 days each, considered to be the coldest in winter ("Nights", Lyalli), and the hottest in the summer ("The heat wave", Ssmaym, Awussu). The following events are characterized and have impacts on agriculture:

- 1st *yenayer*, celebration of the Berber year;
- 21 *yenayer*, azara or the beginning of early return of warmer climate;
- 31 *yenayer*, days of the loan, *Amerdil* or days of the goat;
- 15 *furar*, 1st day of the spring;
- 27 *furar*, beginning of the period *lhussum* to *imγaren*, period of bitter cold;
- 23 *meγres, ahaggan*, negative rainfall;
- 27 *yebrir, mi-nissan*, beneficial rainfall;
- 24 *yunyu, laïnsara* bonfire and fumigation of fruit trees;
- 12 *yulyu, 1er awusu*, entrance of the heat wave, the period when the rite is performed as a preventive measure against diseases by spraying, ablutions and bathing;
- 17 *tuber*, 1st day for tillage also called *Adam* ploughing.

(b) Climate and agricultural activities

Table 19 and **Table 20** present the proverbs and adages related to climate and agricultural activities and to crops' requirements in irrigation or rainfall.

Table 19: Proverbs and adages related to climate and agricultural activities.

Period or season		Description/Interpretation
International year	**Moroccan/ Arabo-Berber, agricultural year**	
From 14 September to 13 October	*Ctember*	Increase in water level in wells.
		If gets cold in autumn, both strong and weak could perish.
		Autumn rainfall won't bring any guest.
		If fig's leaf size become like that of the mouse, the length of the day equals that of the night.
From 14 October to 13 November	*Tuber*	-
From 14 November to 13 December	*Wamber*	Who wants to store wheat grain for the next year should sow it in November.
		If three bright stars rise up in the evening in a vertical line, speed up cereal seeding and say the growing season is over.
		Tillage without manure is like the missed without news.
		At this time, only barley could be seeded as wheat could be eaten by birds.
From 14 december to 11 january	*Jember*	The cold of December can reach liver.
		The cold of December makes bride looks like a monkey and the elderly like a skin.
		If the sun rises red, attach your donkeys and rest, and when the sky looks red, prepare your donkeys for a walk.
From 12 January to 13 February	*Yennayer*	"Saad Akl Boulaa", the sky is raining and the soil is absorbing.
		In "Saad Al Boulaa", feed a person he won't be satiated, and call him he won't hear you. This means that the cold is causing appetite increase and makes a person less reactive.
From 14 February to 13 March	*Furar*	Rain in February is a cure to all ills (of agriculture).
		In February, rain is generally pouring in large amounts.
		In February (the laugher), one sometime it is sunny & sometime it raining.
		The leave of "*Layalli*" (period of extreme cold) is a grace, and the leave of Smaym (period of extreme heat) is an indignation.
		During the period of "Lyalli", early sowing (Bakri) is like late sowing (Mazouzi).
From 14 March to 13 April	*Meγres*	If it rains in March, fields blossom even it they were growing poorly.
		The rain in March has the same impact as that of the rest of the year.

Period or season		Description/Interpretation
International year	**Moroccan/ Arabo-Berber, agricultural year**	
		March, talking to the other months: if I am present (if March is rainy), you can all disappear, but if I am absent (no rain in March), you have to be all present (it should rain in all the other months to compensate March's rain).
		If it is raining in March, if April isn't too sunny, and the skies are clear in May, the third of harvest could be saved for the next year even for the servile farmer who doesn't have land.
		Every tree should be planted before March, and all seeds should be seeded before *Hayan (Ayyam alhoussoum*)
		Don't count your baby's goat among other baby's goat until Hayyan days are over (*Ayyam alhoussoum*). This means that the cool weather and the scarcity of feed can kill baby goat.
		Ears always develop after *Lyalli Hayyan* had elapsed.
		In *Batn Al Hout*, it should rain or we die.
From 14 April to 13 May	*Ibrir*	Rainy and sunny days alternate in April until ears come up from the cereal flag leaf.
		April's cold makes the boar shaking. This means that the temperature may rise in April, but it can drop suddenly.
		If it doesn't rain in April, my teethes become like the axes, and my eyes as big as the cup. This means that the people are afraid to have a low harvest.
From 14 May to13 June	*Mayyu*	When May arrives, the orphans become independent. This means that with the warm temperature, the food becomes abundant and finding a shelter isn't a problem.
		In May, bring your sickle and get prepared for cereal grain harvest.
		If the sky is clear the third of harvest will be stored in the next near.
		In May, you can harvest cereals even if they are still green.
		If it rains in May, you can seed maize and be sure that the yield will be good.
		Leave the letter R (months not comprising the letter R in Arabic) and you can sleep outside under the sky.
		Summer cold is sharper than the sword.
From 14 August to 13 September	*Yust ou Awussu*	Figs become rape from the inside.
		The beginning and the end of August are *mudd.*
		If thunder, which is the sound made by lightning takes place in August, use all your capital to buy livestock.
		If there is thunder in *Smaim*, the illness strikes either women or livestock.
		When figs are ripe, the *mudd* is close.

Table 20: Crop's requirements in irrigation water or rainfall

Proverb	Description/Interpretation
Barley says: this is *Ntah*, irrigate me or I will fall.	The lack of water during *Ntah* period is detrimental to barley crop.
Cereal says: this is "*Btan Lhout*", irrigate me or I will die.	During *Batn Lhoute* period, cereals should get enough rain or should be irrigated to avoid yield loss.
If it rains in *Btan Alhoute*, no grain will die (all seeds will germinate).	If rain is abundant during *Batn Lhoute* period, no seed will die.
In *Al Btine*, irrigate muddy soil.	During *Labtine* period, irrigate abundantly.
In *Alkahka*, the field owner dies from distress.	During Alkahka period, the owner
If it rains in February, agriculture will cure for all illness.	Crop harvest can be secured if it rains abundantly in February.
The lack of rain in February, will add harm on harm in agriculture.	The lack of rain in February will makes things worse.
Abundant rain in February, adds good on existing good for agriculture.	Abundant rain in February, will improve crop yield.
Abundant rain in February, farmers will use all their storage capacity at its maximum.	Abundant rain in February will make harvest more abundant.
If March is rainy, and April with abundant dew, my kids will be happy, as food will abundant.	Abundant rain in March, and clement temperatures in April are favorable to high yields.
Rain in April, is more beneficial than torrent from the Nile.	Rain in April is more beneficial than abundant irrigation.
Cereal killed by sun can be revived by rain, but cereal killed by rain can't be revived by sun.	The impact of heat can be reversed by rain, but that of excess water can't be reversed by the sun.
Wounds from water stress can be healed, but wounds from excess water can't.	The negative impact of water stress is reversible, but the impact of excess water.
If agriculture is flooded it can't be healed.	The negative impact of excess water is irreversible.

Moroccan farmers are aware of the critical periods for different crops, especially cereals. To achieve high yields, it is necessary that the rain falls in sufficient quantity during these periods. Thus, we find that the cereal is highly dependent on rainfall for the period from January to April. This is consistent with the conclusion of Ouattar and Ameziane (1989) that the phase most sensitive to water deficit of cereals is bolting-heading, followed by the ripening of grain as shown in **Table 21**.

Table 21: The impact of climate on crops

Proverb	Description/Interpretation
Rain brings everything good.	Rain water is the main production factor in agriculture.
If rain is abundant in *Lafrouaa season*, all grains can mature.	If rain is abundant during *Lafrouaa* season (from February 25 to March 22), crop yields will be abundant.
If rain is abundant in *Lafrouaa season*,, one would forget its concerns.	
If rain is abundant during *Batn alhout* period, no grain will die.	If rain is abundant during *Batn alhout* period, flowering, fecondation and maturity will take place under favorable conditions.

Proverb	Description/Interpretation
If rain is abundant during *Batn alhout* period, if you have some barley grains in your house, store it safely using a padlock otherwise you will regret it.	………….
If rain is abundant during *Batn alhout* period, the field which is well drained gives half of its potential yield, but the waterlogged field gives only a quarter of its potential yield.	Excess rain during *Batn alhout* season can be harmful in soils which aren't well drained.
If rain is abundant during *Attouraya* season, both early sown and late sown cereals show high yields.	If rain is abundant during *Attouraya* season crop production is abundant even for late seeding.
If rain is abundant during *Al shoula, Antah* and *Annissane* seasons, crop yield will be at its maximum.	Cop production is at its maximum if rain is abundant during *Al shoula, Antah* and *Annissane* seasons.
If rain is abundant during *Al Lyali,* prepare yourself for good harvest.	If rain is abundant during *Al Lyali,* prepare yourself for good harvest.
If rain is abundant during *Al Lyali,* cultivate your land without any delay.	If rain is abundant in Lyalli season, don't stop cultivating your land, as you may note access your land to do it later.
In February, water is needed in large amounts.	Rainfall during February has big impact on crop production.
If rain is abundant in February farmers will use their storage capacity at its maximum.	Abundant rainfall during February maximizes crop yields.
If rain in January allows good crop growth in February, and rain in March allows good growth in April, good harvest is secured.	Good rain in January, and March allows to secure good crop yields.
If it rains during *Anntah* season, one should grow wheat and maize.	Rainy during *Anntah* season, allows good yields for wheat (autumn cereal), and maize (spring cereal).
January is a female camel in the making, February shows it is really full and March guarantees' that it will give birth.	Rain in the months of January, February, and March is what guarantees good crop yields.
Lyalli season guarantees straw, March guarantees grains, and April fruits.	The production of straw is maximized by rain during Lyalli season, grain production is maximized by rain during March, and fruit production is maximized by rain in April.
If April is misty, don't bother yourself with paying hand labor salaries.	Misty April is a good sign for abundant crop production.
If rain is abundant during Saad Saoud season, water move up in trees, the snack get out from its hiding, and milk is produced abundantly.	If rain is abundant during Saad Saoud season, fruit and animal production will be abundant, and animal wild life will be favored.
During a good year, it rains with every wind.	Good agricultural year is due to well distributed rain.
God may protect us from locusts in March, thunder storms in April and fog in May.	All the three enemies have a devastating impact on crops.
Everything that come from the East is good, except humans and wind.	*Chergui* wind destroys everything, like the guest to whom we aren't prepared for.
Rain during *Achina* period is detrimental to crops and livestock	Rain during *Achina* period is detrimental to crops and livestock.
In a year with abundance of *Chergui* wind (warm wind coming from the east of Morocco), there is nothing to see, nothing to milk, and nothing to harvest.	*Chergui* wind destroy everything. It destroys pastures, livestock, and crops.

Proverb	Description/Interpretation
If it rains in September, water level increases in wells and barley semolina becomes tasty.	Early rain have beneficial effect on underground water and crop yields and quality, and the crops starts the growing season with a good soil water holding capacity.
If it rains during *Anasser* period, nothing would be left for you to press (grapes).	Late rains can damage grapes production.
If the rain is abundant in September, the farmer could make his plans.	Abundant rain in September helps farmers decide what crops to grow and at when to plant his crops.
The fate of the growing season is decided during fall.	The outcome of the growing season is conditioned by weather during fall.
Winter is dark, spring is a dream, summer is a guest and fall is the year.	The outcome of the growing season is conditioned by weather during fall.
If you are a real farmer, you should follow thunder storms.	Farmers should valorize every drop of water from the rain even it s a storm.
All plants are just fodder until grains are stored.	The uncertainty of rainfall during the growing season can compromise harvest.
Don’t trust the agricultural campaign which starts green.	Very early rains could be a sign of a bad year, because of early droughts at the beginning of the growing season, just after plant emergence.
To spread risks and to have no surprises at the end of the growing season, because of late rains at the beginning of the campaign or the lack of rain at the end of the campaign, it is recommended to perform both fall and spring crops.	Given the uncertainty of rainfall both in autumn and spring, it wise to diversify cropping systems, and practice both fall and spring crops.

(c) Weather forecast

Lack of scientific capacity to make reliable weather forecasts, farmers and breeders have relied on natural events. Given the importance of meteorology in agriculture and traditional farming, this area has been largely treated as the weather allows the farmer to plan his farming activities and to choose the right moment to achieve them. Some of these forecasting methods are valid in the short term, others are applicable to long term as shown in **Table 22**.

Table 22: Proverbs and adages related to weather forecast.

Proverb/Adage	Description/Interpretation
Thin clouds are a premise for rain.	Thin clouds are a premise for rain.
Warm sun is expelled.	Warm sun is followed by rain.
If it gets warm during summer, it will get cold in winter.	Warm summer is followed by cool winter.
If you notice fog, cereal will mature.	Fog will hasten cereal maturity.
If there is fog, take your kids to the forest.	Early fog during the day means the day will be warm.
As wind is strong, rain will be abundant.	Strong wind will bring abundant rain.
Don’t trust fire if it is extinct, and don’t trust blue	It may rain, even if the skies are blue in *Lyalli*

Proverb/Adage	Description/Interpretation
skies during *Lyalli* season.	season.
Don't take for granted guest's words and stars during *Lyalli* season.	Even if the sky is clear, rain may fall during *Lyalli* season.
Clouds are better than clear skies during *Lyalli* season.	Clouds help keep warmth while clear skies are responsible for cold nights as heat will be lost to the sky.
If you eat figs, buy yourself a burnous.	When figs are mature, it is time to get prepared to the cold season.
If fig is mature, be prepared to the rainy season.	When fig is mature, the rainy season is getting close.
If you see ripe figs, wait for the mud.	When fig is mature, the rainy season is getting close.
If the Heron shows up, the rain is close.	The arrivals of herons, means that rainy season is close.
If *Lyalli* season arrives, ask the vine tree, and if it is out, ask the vine tree.	Cold weather during *Lyalli* season makes vine tree to stop growing, and when it leaves, vine starts to re-grow.
When vine leaves have the size of mouse's ears, the length of the day is equal to that's of the night.	Equinox corresponds to the time when vine leaves have the size of mouse's ears.

Table 23 shows other saying related to meteorology known to farmers

Table 23: Other sayings related to meteorology are known to farmers/herders. They are intended for advice, comments or wishes.

Saying	Description/Interpretation
May God give us rain but not too much.	Enough rain is good but too much can harm crops, livestock and humans.
May God make *Smaim* season not too warm and *Lyalli* season not too cold.	Farmers fear both warm weather in *Smaim* season and cold weather in *Lyalli* season.
Summer is just summer and winter is the home owner.	It is winter which makes the difference through the amount of rain, and by its cold.
Sun in April fires fish and cold hurts.	Both sun and cold are harmful in April.
Sun in April fires fish in water.	Sun in April is harmful to both humans and animals.
Sunny weather after rain is equivalent to abundance.	Warm weather after abundant rain will boost agricultural production.

5.2 SOUTH AFRICA

Lovedu territory is situated in Limpopo Province between the Oliphants River to the south and Klein Letaba in the north. The Lovedu nation is under the rule of Queen **Modjadji** – the renowned rainmaker in Southern African region. The queen's ancestors control rain and its distribution as the intermediary to God. The Lovedu rainmaking practice is a complex institution that goes beyond the confines of merely seeking rain in times of drought. In this very important practice, the chief actor Queen Modjadji is primarily the sole rainmaker who provides security to her people and may withhold rain to punish their enemies. In life the queen is the transformer of the clouds and in death she changes the seasons and guarantees their regular cycle. The queen is not directly responsible for individual rain episodes, but rather she exercises some general control which ensures good rainy seasons. Her rainmaking rites continue throughout the year, for example as part of the agricultural ceremonies the Lovedu ritualise the first green produce. At this ceremony all new crops maturing in the fields are collected, ground together with medicines and put into the rain pot. Thereafter, the queen tests the new produce before anyone is allowed to collect or consume them. The queen works with a rain “doctor” or a team of rain doctors. In bad times, the doctor divines the cause and seeks explanations why the queen is unable to create rain clouds. As part of the remedial action, the doctor may use his special medicines. The rain doctors are also consulted independently outside their areas. Tsonga and Venda chiefs are on record for hiring Lovedu rain doctors. Even Tswana across the Limpopo used to call upon some of these specialists (Schapera 1971).

The manner in which the queen transforms the clouds and the details of the act are closely guarded secrets bound up with the royal title and succession to the throne.

Queen Modjadji controls rain only in agreement with her ancestors, and they are capable of holding her abilities back, just as she is able to stay the hands of the rain doctors. Hence, the queen always prays to ancestors not to hold her hands so she can work her charms productively. Since the queen’s ancestors can cause drought by not helping, further steps to appease them will sometimes be taken. The height of the appeasement process is the sacrifice of black livestock and this typically takes place in times of serious drought. (*Sacred Powers and Rituals of Transformation : McEdward Murimbika*)

Table 24 illustrates the available indigenous and local knowledge system known to farmers.

Table 24: Characterization of Warnings from Indigenous and Local Knowledge Systems

Predictor/ signal	Description/Interpretation	Implications
Cry of Cuculus solitarius bird	The cry of Cuculus solitarius bird between August and November is a sign of the beginning of the wet season	Farmers prepare farming inputs upon the cry of the bird.
Abundance of some wild fruits	The abundance of some wild fruits that include Vanguer birrea during the period of December to February is taken as a sign of imminent famine	Harvest from previous season is preserved Wild fruits and vegetables are also collected and preserved
Cry of frogs	The cry of frogs during the summer season (September to March) is taken as a sign of approaching rainfall.	Farmers prepare their farming inputs in readiness to plough
The position of the moon	When the moon is slightly tilted to the west and the crescent is facing down during the periods of August to December it is taken as imminent sign of rainfall within a week.	Farmers prepare their farming inputs in readiness to plough and plant
Abundance of certain insects	The abundance of butterflies, locusts and grasshoppers during the farming season is taken as a sign of imminent drought and famine	Harvest from previous season is preserved and preserved

6. METHODS, TOOLS AND DATA USED TO DERIVE DROUGT EARLY WARNINGS

6.1 SADC REGIONAL DROUGHT EARLY WARNINGS

6.1.1 South Africa

Table 25 shows methods and equipment used to collect data for the early warnings

Table 25: Methods and equipment used to collect data for the early warnings

Data input	Source	Method	Equipment/Tools	Frequency of data collection
Temperatures(air, min, max, soil), Precipitations, Atmospheric pressures, Wind direction and speed, Evaporation, Humidity	SARCOF	Use of surface sea temperature which is compared with observed rainfall. A statistical relationship is then derived between the two	Radar, thermometers, rain gauges	Daily
Global data assimilation systems and various GCM raw model output.	South African Weather Services	Daily measurement of water levels and the slope of the river	Radar, thermometers, rain gauges	Daily
Climate variability (wind speed, direction, temperature and insulation)	Meteorological Departments	Observations of clouds and their movement	Radar, thermometers, rain gauges	Daily
Historial Inflow data	Department of Water Affairs (Tzaneen)	Data entry input is performed by the Tzaneen Area Manager of Department of water affairs. The historical inflow data is plotted on the graph and patterns are observed and used to predict the future availability of water	Gauge stations	Daily

6.1.2 Zimbabwe

Table 26 shows the methods used to derive drought warnings in Zimbabwe. El Niño modelling is one of the most used method to derive warnings for drought. A warm El Niño phase is associated with droughts over southern Africa. Food security monitoring is also another method that is used in Zimbabwe to predict drought. This involves crop assessments, and household food security. Crop assessments are also done through the use of GIS modeling to monitor crop stress, (NDVI). Climate data in the form of mainly probabilistic rainfall forecasts are also done and drought early warnings can be derived from these.

Table 26: Methods, tools and data used in deriving warnings

Drought event	Method, tools or data used	Frequency of data collection
1991/92	El Niño modeling Crop assessments reports Grain availability assessments reports Meteorological data (rainfall, runoff). GIS data	FAO crop assessments done annually. ZIMVAC crop assessments are done yearly NEWU crop assessments are done monthly Ten day forecasts are issued every week and 24 hour forecast everyday with agromet bulletins issued monthly. Seasonal forecasts are also done.
1993/94	Trend in El Niño/ Southern Oscillation. Food security assessment reports Climate data GIS data	FAO crop assessments done annually. ZIMVAC crop assessments are done yearly NEWU crop assessments are done monthly. Met data is collected daily
2002/03	FAO/WFP Crop and Food Supply Assessments. Climate data	FAO crop assessments done annually. ZIMVAC crop assessments are done yearly NEWU crop assessments are done monthly. Met data is collected daily
1997/98	Trend in El Niño/ Southern Oscillation. Probabilistic rainfall forecasts. Climate data GIS data	FAO crop assessments done annually. ZIMVAC crop assessments are done yearly NEWU crop assessments are done monthly. Met data is collected daily
2006/07	Trend in El Niño/ Southern Oscillation Probabilistic Rainfall forecasts. Climate data GIS data	FAO crop assessments done annually. ZIMVAC crop assessments are done yearly NEWU crop assessments are done monthly. Met data is collected daily

6.2 WEST AFRICA - NIGER BASIN

The input data in all existing warning systems in Mali are in general climate data (hydrological data, (water level, elevation, precipitation) and climate data (wind speed, wind direction, temperature and insulation). The frequency of data collection is in general daily as shown in **Table 27**.

Table 27: Corresponding methods and equipment used to collect data for the alert

Data input	Source	Method	Equipment	Frequency of data collection
Climate variability (wind speed, direction, temperature and insulation)	Meteo France	-	Radar	Daily
Water height, time of flood wave propagation from upstream to downstream (Mopti and Koulikoro)	AGRHYMET/ PRESAO Nationale Directorate of Hydrology	Daily measurement of water levels and the slope of the river	Scales of flood and Data Collection Platform (PC) on satellite	Daily
Climate variability (wind speed, direction, temperature and insulation)	Meteo Mali	Observations of clouds and their movement	Radar, thermometers, rain gauges	Daily
Early Warning System (SAP)	National Directorate of hydrology, National Directorate of Meteorology, National Directorate of Agricultural Engineering, National Department of Agriculture, Institute of Geography of Mali, National Directorate of Environment and NGOs	Data entry input is performed by Early Warning System (SAP) in the software CSPro and the consolidated file is then transferred to an SPSS database. Purification of socio-economic data is performed on the software SPSS.16. The anthropometric data is performed on Epinut/Epi6fr.4.0, Anthro2005/OMS for data standardization (NCHS, WHO) and SPSS data, Excel for output frequency tables, crosstabs, charts, and Word for report writing.	The information is collected from administrative and technical services of the government, local politicians and civil society from the urban and rural districts to the Prefectures, the regions and finally to capital city of Bamako through questionnaires.	The frequency is quarterly and biannual
Prediction System of Information and Early Warning on flood of the Niger Delta (SPIAC)	The information comes from AGRHYMET and the National Directorate of Hydrology.	The transmission of information and their interpretation and use will be different. Level where they are issued (hydro-meteorological stations located upstream of the Delta) at where they will be used, the information can undergo a	Scales of flood and satellite data come from AGRHYMET LANDSAT and other sources	Daily and yearly

Data input	Source	Method	Equipment	Frequency of data collection
		series of transformations and interpretations without losing their essence and their effect. The recovery of information from its source of emission can help to strengthen the methods and tools used for transmission, but also its nature, according to the needs and emergencies of the main applicants (users).		

7. ASSESSMENT OF WARNINGS IN TERMS OF CHANCE OF DROUGHT OCCURING, MAGNITUDE AND DURATION

In this section we answer the question: What does each warning mean in terms of the chance of drought occurring, its magnitude and duration? We want to relate a warning to these parameters.

7.1 EQUATORIAL LAKES REGION

7.1.1 Tanzania

Table 28 shows chance of drought and its magnitude in Tanzania

More detailed information could not be obtained.

Table 28: Chance of Drought and its magnitude in Tanzania

Disaster	Date	Chance of occurrence	magnitude	duration
Drought	1984	high	severe	More than 2 years
Drought	1988	high	Not severe	Less than and to 2 years
Drought	1991	high	Not severe	Less than and to 2 years
Drought	1996	low	severe	More than 2 years
Drought	2003	high	severe	2 years
Drought	2004	low	Not severe	Less than and to 2 years
Drought	2006	high	severe	More than 2 years

7.1.2 Rwanda

Drought occurrence in Rwanda tends to be Cyclic and mostly linked to other events like El Nino/La Nina as shown in **Table 29** and others. A deep study on the frequency of occurrence and magnitude is to be done since available data are scarce and not enough to provide a real picture. Due to lack of adequate techniques, and insufficient research on drought in Rwanda, these events mostly occurred without adequate preparedness. The graph above shows the variation of annual rainfall compared to the mean value. High peaks in the positive, shows years with high rainfall intensity and the peaks in negative shows rainfall deficiency often associated to drought events and associated calamities.

Table 29: El Nino/La Nina Episodes and Droughts in Rwanda

	El Nino /La Nina Episodes and Catastrophe associated	Consequence	Affected Region
1917	Marked dryness	Loss of crops, generalized famine	All country
1923	Marked dryness	Loss of crops, generalized famine	All country
1931	Marked dryness	Loss of crops, generalized famine	All country
1933	Marked dryness	Loss of crops, generalized famine	All country
1943/44	La Nina associated with Drought	"Ruzagayura" Famine	Most parts of the country
1982/83	El Nino Episode associated with drought, and strong heats	Low agricultural production	Most parts of the country
1991/92	El Nino Episode and Drought	-	Eastern part of the country
1997/98	El Nino Episode with drought and high heats	-	-
1999/2000	La Nina with drought and high heats	Famine	Eastern part of country especially Bugesera
2005/2006	La Nina associated with high heat and prolonged drought	Famine; water sources drying; tendency of desertification	Most part of the country but Eastern and Southern parts most affected

Source: NAPA-Rwanda, 2006 (Also reported in the deliverable report 2.2).

7.1.3 Burundi

Table 30 shows historical drought events and their magnitude In Burundi

Table 30: Historical drought events and their magnitude In Burundi

Year	Climatic events	Impacts	Affected Zones
1917	Marked dryness	Loss of crops, generalized famine	All country
1923	Marked dryness	Loss of crops, generalized famine	All country
1931	Marked dryness	Loss of crops, generalized famine	All country
1933	Marked dryness	Loss of crops, generalized famine	All country
1943	Marked dryness	Loss of crops, generalized famine	All country

Year	Climatic events	Impacts	Affected Zones
1950	Marked dryness	Loss of crops, generalized famine, decrease level of the lakes	All country
1958	Dryness	Loss of crops, generalized famine, decrease level of the lake Tanganyika (772.8 m)	All country
1973-1974	Marked dryness	Bad agricultural output without humanitarian aid	All country
1983-1984	Marked dryness	Loss of crops, generalized famine with humanitarian aid	All country
1990	Dryness	Loss of crops	All country
1993	Late rainfall	Bad agricultural yield	All country
1999-2000	Marked dryness	Loss of crops, famine, displacement of populations, humanitarian aid	North-Est. of the country (Kirundo and Muyinga)
2004-2005	Late rainfall	Bad agricultural output in the North-East of the country, decrease levels of the rivers, the level of the lake Tanganyika drops dangerously, Insufficient of hydroelectric Energy	All country

Source: NAPA-Burundi, 2007

7.2 EASTERN NILE REGION (ETHIOPIAN PLATEAU)

There have been notable droughts in Ethiopia throughout human history (Haile 1988; Degefu 1987; Pankhurst 1966; Nicholls 1993; Webb and Braun 1994). Previous droughts and the frequency of rainfall deviation from the average suggest that droughts occur every 3-5 and 6-8 years in northern Ethiopia and every 8-10 years for the whole country (Haile 1988, 90).

Haile (1988, 85) believes that Ethiopian drought is caused by ENSO, along with sea surface temperature (SST) anomalies in the Southern Atlantic and Indian Oceans combined with anthropogenic activities. ENSO events and SST anomalies affect rainfall distribution in Ethiopia by displacing and weakening the rain-producing air masses (1988, 92).

There is a remarkable correspondence between annual rainfall in Ethiopia and ENSO events (Haile 1988). A statistical analysis by Attia and Abulhoda (1992) shows that "ENSO episodes are negatively teleconnected with the floods of the Blue Nile and Atbara" rivers that originate in Ethiopia. Eltahir (1996) also concluded that ENSO events affect flows of the Nile River (indicating drought in highland Ethiopia, which is a source of 85 percent of Nile water) and that knowledge of these events could be used to improve the predictability of its annual flow. Empirical data indicate an association between ENSO events and droughts in Ethiopia. Thus, an ENSO-based early warning system, used effectively by policymakers, could help to reduce the societal impacts of drought in Ethiopia.

According to Nicholls (1993), 1888 was a major ENSO year that damaged the economies of Brazil and Australia, as well as Ethiopia. Drought struck Ethiopia in 1888, leading to the historic deadly famine of 1888/89. About one-third of the population died because of famine, and ninety percent of the animals perished due to rinderpest infestation and the drought (Webb and Braun 1994, 20). In 1957/58 drought and locust invasion led to famine in Tigray. The 1972/73 drought led to the Wollo famine, during which about 200,000 people died. In all these cases, there was little early warning. When past ENSO events are compared with drought and famine periods in Ethiopia, they show a remarkable association. Some drought years have coincided with EN events, while others have followed it.

The 1982-83 ENSO "was the most extreme event in at least a century," with equatorial SSTs in the Pacific Ocean increased by an average of 2 degrees Celsius and exceeding 6 degrees Celsius on the coast of Peru (Cane 1993). In Ethiopia, the 1983-84 drought tooks the lives of an estimated one million people, destroyed crops, contributed to the death of animals, and threatened the lives of millions of people with starvation. Famine was exacerbated, if not caused, by war and failed government policies, but drought was the main catalyst to crop failure. The famine prompted unprecedented (but delayed) humanitarian intervention, in spite of Ethiopia's Marxist government of Mengistu Haile-Mariam.

The association between ENSO and droughts in Ethiopia is due to an atmospheric teleconnection or "the linkages over great distance of seemingly disconnected weather anomalies" (Glantz el. al., 1991). This means that the oceanic and atmospheric processes in another part of the world, such as the equatorial Pacific, could affect

Ethiopian climate. Reliable ENSO information could be useful to forecast drought with longer lead time, enabling policy-makers to introduce early mitigating policies. Mark Cane (1993) believes that "prediction is a possibility . . . especially when the patterns are forced by observable changes in surface conditions such as sea surface temperature (SST)."

A study by Cane et al. (1994) found a correlation between Zimbabwean maize yield and ENSO that, according to the authors, enables prediction of maize production with a lead time of up to a year. These findings show that in the 1970s and 1980s, droughts and low maize yields vacillated nearly in step with El Niño. Thus, a warming of the central and eastern equatorial Pacific surface waters appears to provide a warning for policymakers to take actions in preparation for future drought in their region. Such findings could be used for drought early warning in Ethiopia as well.

Nicholls (1993, 170) believes that ENSO information could have provided an early warning to decision makers about Ethiopia's severe 1888 drought, had such information existed then. The other Ethiopian droughts and famines in the 20th century appear to have followed ENSO events as well. It is thought that the correlation between droughts in the Horn of Africa and El Niño events is coincidental. The current state of knowledge also suggests that monitoring the Southern Oscillation Index (SOI) could predict drought with a longer lead time (ibid.).

Based on the 1986 El Niño information, "NMSA provided a seasonal forecast, and the DPPC (then the RRC) succeeded in averting the 1987 famine" (Ayalew 1996). In 1988 and 1989, the Ethiopian authorities and donors used ENSO data to recommend appropriate policies regarding the amount of land to be cultivated, input supplies (seeds, fertilizers), and conservation of food and water (NMSA, in Glantz 1996b). Following the receipt of the 1992 ENSO information, the Transitional Government of Ethiopia (1991-95) set up the Disaster Prevention and Preparedness Committee in the Prime Minister's Office. The famine conditions of 1994 were averted due to the appropriate use of the 1993 information (Ayalew 1996). In 1996, the summer floods were predicted by the National Meorological Services Agency (Teshome 1997). The NMSA warned of possible flooding in its May 1996 forecast. In June 1996, the DPPC in turn distributed an early warning to its users.

7.3 EASTERN NILE REGION (DOWN STREAM COUNTRIES)

7.3.1 Experiences from Egypt

The NFS satellite rainfall-estimation system is based on the principle of cold cloud duration (CCD). CCD techniques are based on the assumption that high cloud tops (which show cold in infra-red imagery) are frequently associated with strongly precipitating cumulonimbus systems. Thus, there is a statistical relationship between the duration of a probably-precipitating cloud in a given time period and the amount of rainfall within that period. A probably precipitating cloud is identified from thermal infrared (TIR) imagery using a brightness temperature threshold. TIR brightness temperatures correspond closely to cloud-top heights and clouds with high tops may thus be identified by locating image pixels with brightness temperatures less than a given threshold (set to 233°K in the NFS).

As noted above, high tops are commonly associated with vertically extended cumulonimbus clouds that generate the most significant element of tropical precipitation. Unfortunately, high tops are also associated with non-precipitating cirrus clouds, whose presence introduces considerable uncertainty into the statistical relationship. It is also possible for low-topped stratiform clouds to be associated with significant rainfall. An additional cause of uncertainty is that not all precipitating clouds rain at the same rate. However, these uncertainties average out over large space and time scales. In terms of impact on hydrological model outputs, they are therefore more likely to affect flow timings rather than total flow volumes and these uncertainties will average out over larger catchments.

The MSG satellite provides five channels in the thermal infra-red bands. The availability of a 'split IR window' 10.8m and 12.0m is particularly useful since it facilitates screening for thin cirrus clouds which contaminate single-window infra-red based products. A number of multispectral algorithms have been developed (Bellerby et al., 2000; Capacci and Conway, 2005; Turk and Miller, 2005). These algorithms vary in the methodologies used to derive the functions combining the spectral elements, although all show a distinct advantage in using multi-spectral data. The choice of image data to incorporate into an enhanced NFS satellite precipitation estimation system involves a trade-off between the additional precipitation information provided by viewing the Nile Basin in a new wavelength against the substantially increased data archiving requirements presented by the use of each new MSG image band. In addition, it must be noted that the precise utility of multispectral image data for rainfall estimation may only be determined through an extensive study containing many months, or preferably several years of data. Such an extensive run of archived data was not, of course, available at the time of enhancing NFS and as a result a pragmatic decision had to be made as to the additional channels to archive. These channels are thermal infra-red channels (9.7, 10.8, 12.0 and 13.4 m).

It was concluded that through the NFS capabilities it could be predicted the annual River Nile flow which is considering the effect of Hydro/meteorological data input accuracy.

7.3.2 SUDAN

Chance of occurrence of drought events through local knowledge it is prefect in term of magnitude and duration as shown **Table 31**. There is also annual predication of drought from the SMA rainy season.

Table 31: List of Drought event and chance of occurrence in Sudan

Region	Drought period	Chance of Occurrence	Duration
Central Region	1972-1973; 1978-1980; 1983-1988; 2002-2007	Mild to Severe	More than 2 years consecutive drought
Northern Region	1980-1981; 1984-1985; 1990-1991;1995-2002, 2004-2008	Severe	More than 2 years consecutive drought
Coastal Region	1984-1987; 1990-1991; 1995-2008	Mild drought	More than 2 years consecutive drought

7.4 SOUTHERN AFRICA DEVELOPMENT COMMUNITY (SADC)

7.4.1 Regional Drought Early Warnings

Many users of early warning information ask why the 1991-92 drought could not have been foreseen if Regional Early Warning Systems (REWS) are useful. The answer lies in the fact that REWS do not predict weather conditions. The REWS are restricted to the assessment of the impact of weather conditions on crop production prospects and, hence, on the food supply situation (Rook 1998). The REWS generally say very little about harvest prospects until the growing season gets under way. The 1991-92 southern African drought was, in fact, a good example of the practical limitations of early warning systems under the present state of the art. The 1991-92 growing season started well in most parts of southern Africa. It was not until the end of 1991 that indications of a prolonged dry spell began to surface. Although by this stage it was already clear that, because of wilting and delayed plantings, the maize harvest was going to be reduced, there were still prospects for recovery if the rains returned in the following few weeks. In the event, the rains did not return in January or February 1992, which are the critical rainfall months for the southern African maize crop.

The 1992 drought as shown in **Figure 34**, by the end of December 1991, however, dry conditions had set in and had started to spread across southern Africa. The SADC Food Security Bulletin for December 1991 alerted governments and the donor community of this adverse change in growing conditions and issued tentative assessments of the likely impact on the forthcoming grain harvest in a number of countries. During the next three months, dry conditions intensified and, by March 1992, the full impact of the drought on grain production had become apparent.

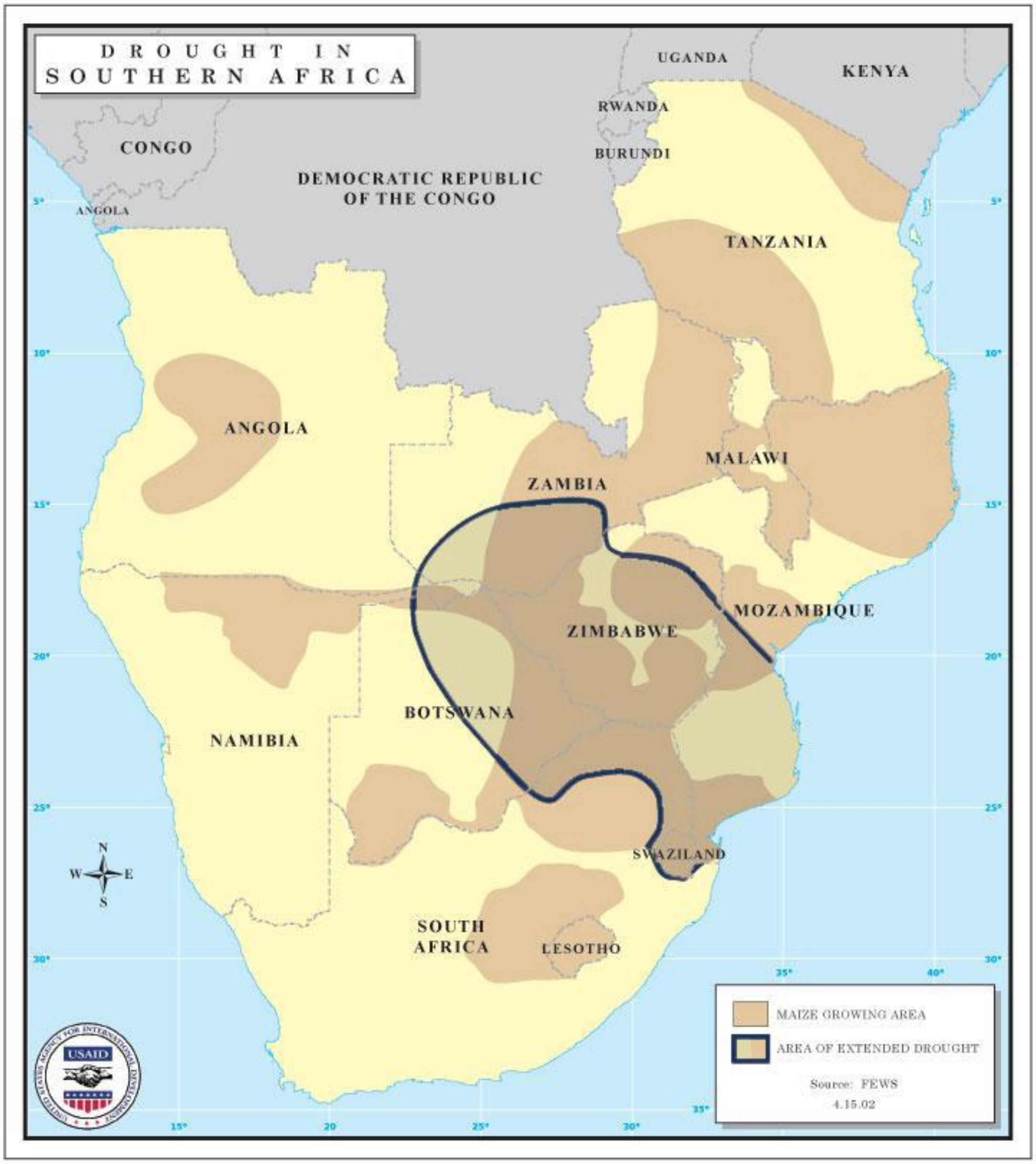

Figure 34: Agricultural Drought Stricken Areas in SADC in 1992

Source: USAID

7.4.2 South Africa

One of the local approaches to predicting whether a hydrological drought cycle is still being experienced or is likely to start, applies historical flow data as shown in **Figure 35**. This approach is for water resource systems with little or no upstream development.

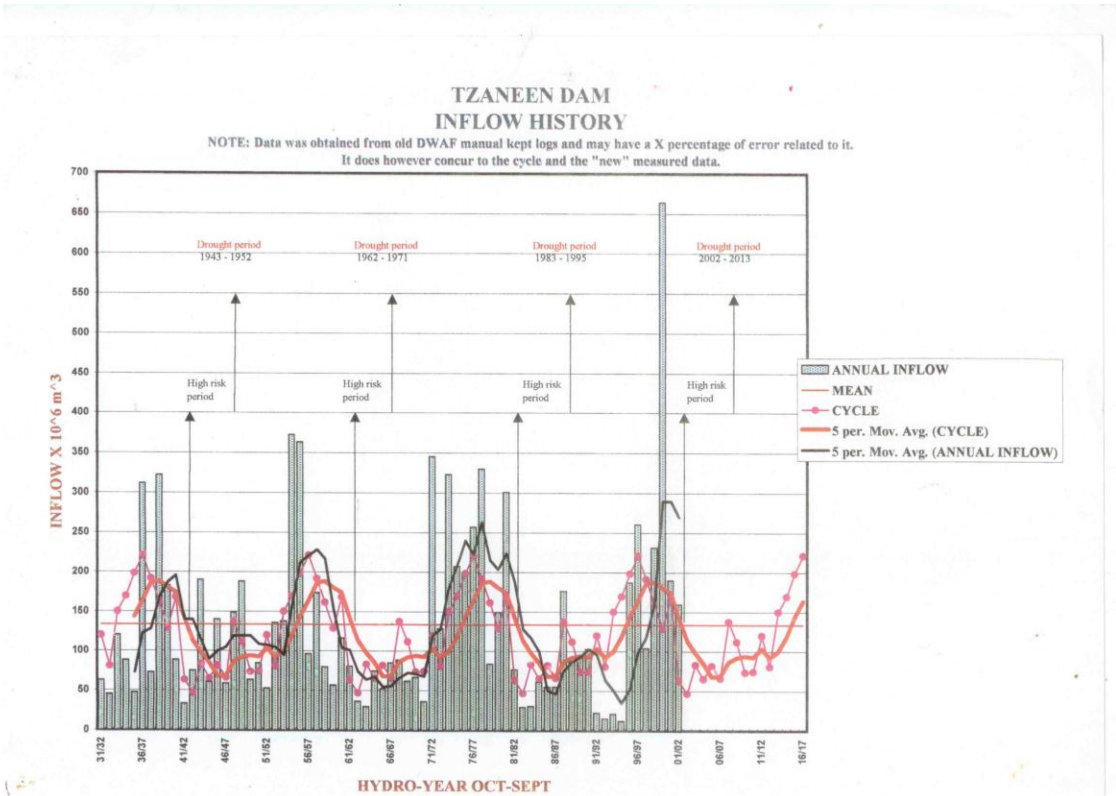

Figure 35: Tzaneen Dam historical inflow

Source: DWA

The Department of Water in South Africa uses storage trajectories to provide a constrained window of possible storage states based on stochastic analysis of inflows and taking into consideration upstream developments. The five year trajectories in **Figure 36** illustrate this approach. Users and water managers determine the water to be released to users when the dam level is following any one trajectory. In this short-term analysis the starting storage condition is important and the situation at the end of the runoff/rainfall season is typically applied.

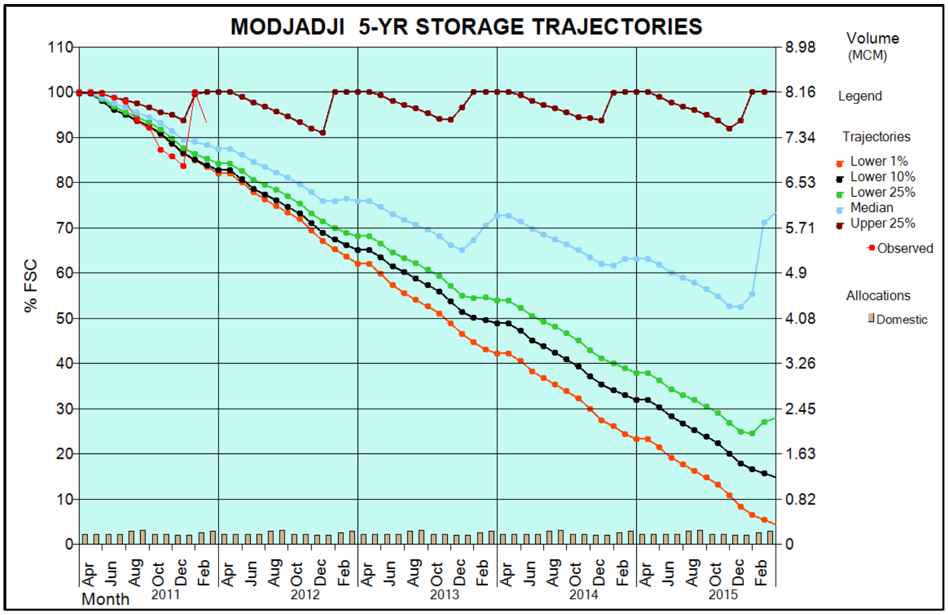

Figure 36: Modjadji Dam storage trajectories

Source: HDAM Graphs, 2012

In general drought warnings are issued after assessing the availability of water on the dams against the total allocations to users.

The same approach for annual water allocation is applied with the lowest historical inflow and different allocations to irrigation farmers. This approach gives an indication of how the dam will perform with different allocation quotas as shown in **Figure 37**

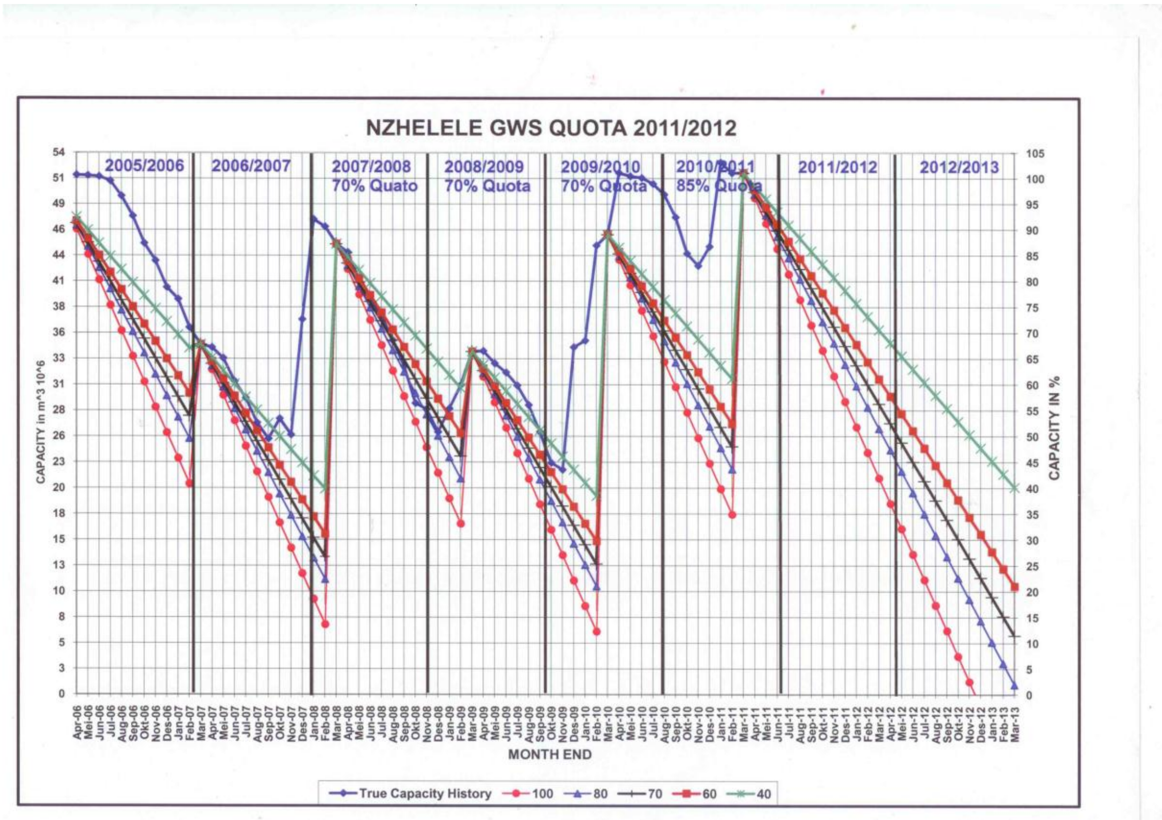

Figure 37: Nzhelele Dam historical inflow and water allocation quotas

Source: DWA

7.4.3 Zimbabwe

Table 32 shows early warnings for 1992 drought

Table 32 :Early warnings for 1992 drought

Time /Period	Warning
Feb 1991	Agro-met bulletin forecasted an 18.5 % less for maize yield compared to the previous year.
March 1991	Crop forecast indicated a crop year lower than the three year average from 1987/88 to 1990/1991
July 1991	Agro met bulletin forecasted an all low maize stock level y Dec 1991
Nov 1991	NEWU issued a warning on critically low food stocks.
Dec 91	Zimbabwe Meteorological Services Department forecasted that below normal precipitation will be expected in most parts of the country.

The 1992 drought was very severe especially for the southern parts of Zimbabwe as shown in **Figure 38**.The southern parts of Zimbabwe which form parts of *Mzingwane* catchment area was the most affected.

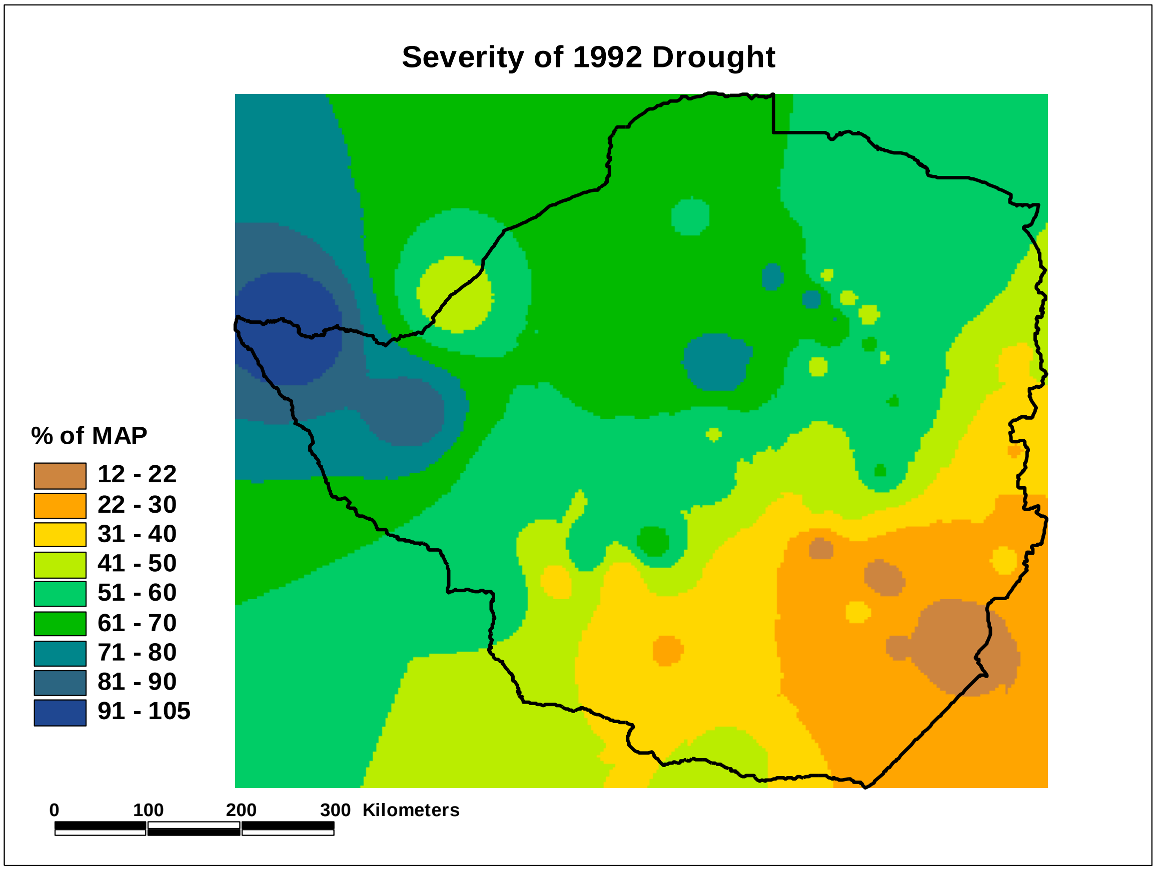

Figure 38: Severity of drought in 1992

8. LIST OF DIRECT USERS OF DROUGHT EARLY WARNINGS AND HOW THEY INTERPRET THE WARNINGS

8.1 EQUATORIAL LAKES REGION

8.1.1 Tanzania

Generally, the response of users on drought warning is very slowly at all levels from local to national. At the local level, due to poverty and lack of education and at national level, the lack of funds and political influence, delays decision making.

8.1.2 Rwanda

Storage of crop yield for future use during shortage is one of the priorities of the Ministry of Agriculture in order to insure food security. In addition, the Ministry of Agriculture and Animal Resources gives necessary information to the farmers related to the weather forecast (period of cultivation, type of crops to be cultivated according to the season, land use consolidation, etc.).

According to a recent survey done by the National Institute of Statistics of Rwanda (NISR) and World Food Programme (WFP) inventoried the following indigenous response measures in regards to droughts.

- Rely on food borrowed from friends
- Reduction of food quantity per day, especially for mature people
- Rely of savings
- Survive on less expensive diet
- Work for money for survival
- Selling livestock

(NISR and WFP, 2009)

8.1.3 Burundi

In Burundi, situation is similar as follows: NAPA-Burundi identified the following measures in response to climate weather events: Rainwater harvesting, afforestation and reforestation, intensive livestock farming, biodiversity protection, establishment of buffer zones on lakes and marshlands, promotion of resistant and short cycle crops, promotion of other renewable energies as alternative to fuel wood, promotion of dry resistant species for afforestation and reforestation, etc.

Responses of people when severely affected by drought are also similar to those in Rwanda. These include reduction in number of meals per day, working for money or for food especially in previous years, sale of livestock even at small amounts and displacement of people in search of food and fodder (MINATTE, 2007).

8.2 EASTERN NILE REGION (ETHIOPIAN PLATEAU)

The first response of the Ethiopian government drought forecast in 1997 was to warn that the Kiremt rainfall would be erratic and start late. The DPPC wrote its early warning report about the possible impacts of the abnormal weather. Immediately, the NDPPC came up with a response plan to avert the disaster. The two-pronged response was designed in the area of agricultural policies and mobilization of resources. Meetings were organized in the regions, zones and weredas to brief every Disaster Prevention and Preparedness Committee member on responses specific to the area. They decided to study the strengths and weaknesses of the most vulnerable weredas.

At the national level, the NDPPC asked the Ministry of Agriculture, which is a member of the committee, to come up with possible responses. The Ministry estimated that food production would be down by 40%, based on the weather forecast issued by the NMSA for the Kiremt season. It recommended the planting of drought-resistant crops, such as chickpea, and the replanting of failed crops with fast-maturing ones, such as teff and lentils. It also recommended the provision of seeds to farmers until the end of August and the protection of crops through the free distribution of pesticides. In addition, it advised the use of all newly constructed micro-dams and ponds by farmers, as well as the building of irrigation canals. Farmers were also advised to plant potatoes and convert lost crops to feed the animals. The mass media was to be used to educate the people on the response actions.

A major response came from the office of the Prime Minister when the issue of El Niño was raised during a meeting of the Prime Minister with high-level national officials and the Regional Presidents on August 25, 1997. They addressed their concern about the impact of El Niño and all responsible officials and departments were given instructions to respond to the crisis. **Table 33** shows the interpretation and use of the information.

Table 33: Interpretation and Use of Information

1. Who uses the information ?	2. How information reaches users	3. How information is interpreted (alerts - indigenous and local)	4. What is the response to the assessed information? (provide all available data)	5. How good were the responses during these drought events?
(ENSO) farmers, herders, and the government.	Bulletin	The information concerning the advent of an ENSO event could warn both cash and food crop producers. Based on such information, farmers could introduce adequate agronomic changes. With reliable drought early warning, farmers could buy fodder or sell their cattle before market prices collapse. At the national level, surplus food could be stored for the next season, and additional food could be imported in anticipation of shortfalls. Herders might also sell off part of their herds before the arrival of drought.	According to Farmer (1993), forecasting needs to be more spatially specific for the analysis to be useful. Farmer (ibid.) also raises the issue of the temporal and spatial distribution of ENSO effects on rainfall. As Farmer (1993) notes, broad statements about the weather, without stating how the information could be used, will make famine early warning ineffective. ENSO-based early warning should be more specific in time and space to be relevant to peasant farmers.	ENSO information is useful, but it has some weaknesses when applied to specific local conditions. For ENSO information to be credible at the local level, it has to respond to unique drought-related problems that arise due to diverse microclimates. ENSO-based weather and climate prediction is general in nature and less effective in providing locally specific drought early warning.
El Niño government-farmers	The mass media was to be used to educate the people on the response actions. media report and TV interviews	The Ministry estimated that food production would be down by 40%, based on the weather forecast issued by the NMSA for the Kiremt season. It recommended the planting of drought-resistant crops, such as chickpea, and the replanting of failed crops with fast-maturing ones, such as teff and lentils. It also recommended the provision of seeds to farmers until the end of August and the protection of crops through the free distribution of pesticides. In addition, it	the Prime Minister addressed their concern about the impact of El Niño and all responsible officials and departments were given instructions to respond to the crisis. The regions also issued evaluation reports on the impact of the erratic rainy season on agriculture. The DPPC issued a special report in October about the impact of El Niño on Ethiopian weather. As the season progressed, the Ministry of Agriculture advised farmers to replant their crops especially when	Resource constraints and the lack of carry-over stock from 1997 contributed to the problem. The timely response to the crisis by the government avoided the death of people due to famine. Despite various constraints, the Disaster Prevention and Preparedness Committees at all levels met every two weeks to exchange information, experience and evaluate the effectiveness of various responses. Local functionaries were also working despite the

		advised the use of all newly constructed micro-dams and ponds by farmers, as well as the building of irrigation canals. Farmers were also advised to plant potatoes and convert lost crops to feed the animals. One of the most important roles of the NMSA during the 1997 abnormal weather was to update the unpredictable weather by providing information, such as about the continuation of the rains beyond the normal end of the season. For example, on Nov. 12, 1997, the NMSA urged farmers to "gather their harvest before an untimely rain expected over the various parts of the country." The Ministry of Agriculture also advised farmers to harvest their matured crops before it was too late. Farmers were also advised to construct drainage in areas where crops had not yet matured. The Ministry of Agriculture continued to advise farmers for the 1998 *Belg* season. In December 1997 and January 1998 one could see unseasonable crops, such as chickpeas, in the field in many parts of northern Ethiopia.	the rains returned to some areas in August. The zone officers provided the seeds on credit in order to take advantage of the rains. The October-November 1997 floods disrupted the normal harvest of crops, and local governments organized popular campaigns to help farmers gather their crops.	disadvantage of having unreliable local weather information about their weredas or villages. Ethiopia has designed a five-year development plan to deal with future disasters. War between Ethiopia and Eretria (conflict) was added to the constrain

The regions also issued evaluation reports on the impact of the erratic rainy season on agriculture. The DPPC issued a special report in October about the impact of El Niño on Ethiopian weather. As the season progressed, the Ministry of Agriculture advised farmers to replant their crops especially when the rains returned to some areas in August. The zone officers provided the seeds on credit in order to take advantage of the rains. The October-November 1997 floods disrupted the normal harvest of crops, and local governments organized popular campaigns to help farmers gather their crops. One of the most important roles of the NMSA during the 1997 abnormal weather was to update the unpredictable weather by providing information, such as about the continuation of the rains beyond the normal end of the season. For example, on November 12, 1997, the NMSA urged farmers to "gather their harvest before an untimely rain expected over the various parts of the country." The Ministry of Agriculture also advised farmers to harvest their matured crops before it was too late. Farmers were also advised to construct drainage in areas where crops had not yet matured.

The Ethiopian government was so concerned about the crisis that it asked the UN FAO/WFP crop production and food needs assessment team to arrive earlier than usual. The DPPC was also mobilizing resources internally and from the donors. The DPPC continued to appeal for aid to donors who were initially reluctant in their generosity. On November 29, 1997, Ethiopia appealed for 572, 835 MT of food aid to be distributed to over 4 million people. The major component of the 1997-98 appeal was emergency relief. Food supply was critical as early as December 1997 in the central highlands. Resource constraints and the lack of carry-over stock from 1997 contributed to the problem. Donors finally pledged for 352, 249 MT and eventually delivered 303, 987 MT.

The timely response to the crisis by the government avoided the death of people due to famine. The Ministry of Agriculture continued to advise farmers for the 1998 *Belg* season. In December 1997 and January 1998 one could see unseasonable crops, such as chickpeas, in the field in many parts of northern Ethiopia.

One of the characteristics of the 1997-98 crisis was the way information was flowing between the various DPP Committees in the center and in the regions. Despite various constraints, the Disaster Prevention and Preparedness Committees at all levels met every two weeks to exchange information, experience and evaluate the effectiveness of various responses. Local functionaries were also working despite the disadvantage of having unreliable local weather information about their weredas or villages. Ethiopia has designed a five-year development plan to deal with future disasters.

As a final note, at the end of the El Niño in the middle of 1998, a war started between Ethiopia and Eritrea. The war began on May 12, at a time when Ethiopians were coping with the adverse impacts of El Niño. The conflict was an added constraint on the El Niño-related responses by the government and the people. About 450,000 Ethiopians who live in the border areas occupied by Eritrea were displaced and became dependent on food aid. They lost their animals, seeds, and harvests. Other farmers in the border areas could not plant, because of the lack of security and occasional shelling. Thousands of Ethiopian farmers were mobilized to defend against the Eritrean threat, and the farms of those who joined the army were cultivated with the help of those who remained in the villages. In July 1998, Eritrea confiscated 45,000 tons of U.S. grain that was in an Eritrean port en route to Ethiopia. It is believed that Eritrea confiscated more than US$300 million worth of goods when the conflict erupted. Ethiopia was forced to import food and other items through Djibouti in order to avoid the Eritrean ports because of the conflict.

The first media report on El Niño appeared on August 5, 1997, when experts from the NMSA gave an interview on Ethiopian TV to explain the role of the El Niño phenomenon in Ethiopian droughts. There was no report in the Ethiopian media about the evolution of the 1997 El Niño. The media reported the NMSA forecast issued by NMSA at the end of May, but there was no follow-up report on the issue.
Media interest in El Niño began to pick up when the impact was felt at the end of August, and when the Prime Minister’s Office instructed federal and regional authorities to monitor the situation of El Niño and its impact on Ethiopia. The Ethiopian News Agency, The Ethiopian Herald and Addis Zemen wrote that El Niño causes drought in Ethiopia. The media also wrote about the impacts of the drought and floods of 1997 for which they blamed El Niño. One of the shortcomings of the Ethiopian media was their inability to clearly inform the public without confusion. There was no expert analysis or editorial specifically focused on El Niño and its

climate-related impact in Ethiopia, which might have contributed to an understanding of the phenomenon by Ethiopians.

8.3 EASTERN NILE REGION (DOWN STREAM COUNTRIES)

8.3.1 Experiences from Egypt

The users needed from drought warning better understanding of climate variability, and improved management of its associated risks, presents a real promise to decision makers seeking to understand how to adapt to climate change. The patterns of registered past climate settings can tell us something about what future climate could be. Climate, by definition, is the mean and variation of weather measured over a period of time, ranging from months to thousands of years in some cases. Changes in mean climate tend to be incremental, thus, small, on a year-to-year basis, compared with natural fluctuations. Because of this, strategies developed to manage and build resilience to year-to-year climate variability go a long way towards managing possible climate change to come. In Egypt, Nile Forecast Center has the ability to simulate the consequences of changes in the River system and in the climatologically and hydro-meteorological regime of the Basin. The NFC is developing and using hydrologic models that simulate the complete water balance for the entire Nile Basin. The simulation ability developed would allow assessing the consequences for Egypt of planned or actual water abstractions and of works across the river in the upstream countries, in order to plan appropriate adjustment measures. (NFC), MWRI had carried out project which is called “Lake Nasser Flood and Drought Control/Integration of Climate Change Uncertainty and Flooding Risk” LNFDC/ICC was amid to enhance of the existing facilities within the NFC of the Planning Sector, to aid the Egyptian MWRI in setting scenarios for risk assessment due to floods, droughts and climate change. The simulation ability developed would allow assessing the consequences for Egypt of planned or actual water abstractions and of works across. Uniqueness of Nile Forecasting Issue depends on producing reliable forecasts of the Nile River in Egypt is not that simple and it is possible to say that this represents an extraordinary task in many respects. Looking from Egypt’s prospective, what makes the Nile catchment unique when hydrological forecasts of inflows into the High Aswan Dam, this could be the question. Forecasting of inflows into the High Aswan Dam reservoir exclusively depends on rainfall-runoff and runoff/runoff stream flow processes occurring outside Egypt, i.e. in the areas which are inaccessible for direct monitoring, measurements, and real data communication to the forecasting center.

There have been several efforts to determine the optimal reservoir release policies in relation to reservoir inflows and storage levels. Many of these efforts dealt with the HAD reservoir only. However, **Figure 39** presents a logical framework for the system operation. The figure shows the three main components of supply, demand and control (operating rules).

Supply	Control	Demand
Main sources	**Aswan Complex**	**Consumption**
Equatorial lakes	Lake Nasser	Agriculture
Ethiopian plateau	High Aswan Dam (HAD)	Municipalities
	Pond of 6 km. bet. HAD and LAD	Industry
	Low Aswan Dam (LAD)	Navigation

Figure 39: Logical framework for the system operation

Planning and forecasting system that integrates future Nile River basin flows and sea level rise for this century on the basis of the state-of-the-art climate based information. Such a system with its scenarios assisted decision-making by the Egyptian Government to sustainable development alternatives for long term. The main project output has determined scenarios, assess risks and identify mitigation measures due to variations in the Nile River regime and climate leading to floods, droughts and land use changes in the Nile Basin (upstream and downstream HAD) and integrated its findings in Egypt's national water strategy, planning and operations. In has also supported the MWRI in setting scenarios for risk assessment due to floods, droughts and climate change.

The early warning system has been developed under the FlaFloM project by a Belgian-Egyptian team. The team consists of the Egyptian Water Resources Research Insititute (WRRI), the Belgian consultancy company SORESMA and the Free University of Brussels. The project has been developed in close collaboration with Prof. Dr. Gamal Salah El-Afandi (Al Azhar University, Cairo), the South Sinai Crisis and Disaster Management Centre and the municipality of Nuweiba City. The contract for the pilot area around Nuweiba City has a value of 800,000 Euro. 70% is financed by the European Commission (LIFE Fund) and 30% by Egypt. . The system was applied in Sinai Peninsula where a number of water level sensors were installed on the major stream flows on the flood plains in Sinai. These sensors were linked via VHF communication system to a central monitoring room in the WRRI. The sensors detect any water flow that may run in the flood plain streams and transfer these data to the central room. The room is equipped with simulation models and GIS systems to simulate the water flow along the catchment's area and predict the expected water hydrographs and calculate the expected volume of water and maximum water velocities at the major bottlenecks along the flood plain. The system also draws a risk map for the vulnerable areas along the flood plain.

8.3.2 SUDAN

For governmental bodies the responses are very high and direct to the warning. But for farmers in most cases their responses are very low. Some time they know the condition but still they believe the season might change at any time. Sometime the farmers to cope with the drought condition use different methods and techniques:

- short and early maturing varieties
- cultivate in other area with high rainfall
- move the animal to the south part of the region where there is high rainfall
- use water harvesting techniques

8.4 SOUTHERN AFRICA DEVELOPMENT COMMUNITY (SADC)

8.4.1 South Africa

Table 34 lists the direct users of drought warnings identified on this study.

Table 34: List of direct users of drought warnings

Stakeholders and Interest Groups	Interpretation of warnings	Particular interest
Department of Water Affairs	Use of El Nino and La Nina, also the historical dam inflow data and water allocation relative to the dam level	Dam Management
Department of Agriculture	Seasonal forecast issued by South African Weather Services for the below normal to above normal rainfall	Drought Management

Municipalities	Warnings are given by the department of water affairs for any availability of water	Water Distribution
Catchment Management Areas	No warnings issued	Water Management
Water Users Association	Some application of self-restrictions is applied by some water users or practice physical observation of stream	Water Availability
Disaster Management Centres	Seasonal forecast issued by South African Weather Services for the below normal to above normal rainfall	Drought Management

8.4.2 Zimbabwe

Table 35 lists the direct users of drought warnings identified on this study. The value chain for users of information from the Meteorological office is illustrated in **Figure 40**

Table 35: List of direct users of drought warnings

Stakeholders and Interest Groups	Interpretation of warnings	Particular interest
Government Ministries		
Lands, Agriculture & Rural Resettlement: AGRITEX, MSD	Communicating the warning to farmers Interpreting the warning to a product that can be useful to farmers. Offering advice on appropriate methods & ways to tackle the impending situation.	Custody of agricultural policy
Finance and Economic Development.	Costing the extent of drought in monetary terms. Lobbying for aid or funding.	Macro-economic growth and stability
Local Government and National Housing.	Mainly use the information to ensure coordination of drought management.	Civil protection, coordinates government social protection programmes, drought relief and emergencies .Coordinates and oversees all local government administration and leadership
Public Service, Labour and Social Welfare	Assessment of community vulnerability levels. Putting in place timely welfare programmes to assist affected communities.	Maintaining welfare and implementation of social safety nets and welfare programmes
Food and Nutrition Council.	nutritional status of infants and other people	Development and monitoring of policies, strategies and programmes for addressing food and nutrition security
Parliamentary Portfolio, Committee on Lands, Agriculture, Water Development, Rural Resources and Resettlement, Presidents Office	Timing of declaration of the drought. Mobilising funding Appealing for funding	The Committee monitors the general performance of the executive (government) and undertakes specific investigations for information of Parliament.
Farmers:		

Stakeholders and Interest Groups	Interpretation of warnings	Particular interest
Small holder farmers	Nature of the season	
Commercial farmers		
Local rural leaders:		
Traditional leaders.	Community governance	
Agribusiness.		
GMB.	Sourcing grain	Acquisition (from local and external sources), storage and distribution of grain to ensure national food security
AGRIBANK.	Funding relief programme	Long-term viability and maximizing dividends
Milling Companies.		
Livestock Feed Processors.		
Seed producers.		
Consumers.		
Both rural and urban communities	Stocking of food reserves	
Media	Ensuring warning is disseminated to the people. Production of progress reports.	Provision of timely and accurate information.
NGO: (Local and International)		
Christian Care, World Vision, Care International, Africare, World Lutheran Federation ORAP, Plan International, Catholic Relief, Save Children UK, Save Children USA	Preparation and provision of relief. Lobbying for relief fund. Reporting. Carrying out vulnerability assessment	Advancing food security and social well being of communities Economically empowering local Communities. Securing and maintaining funding from sponsors
International Donors (Development partners):		
USAID, DFID, GTZ, NORAD, AUSAID, Canada CIDA	Provision of relief fund	Promoting poverty reduction at community levels through efficient and effective use of donor resources

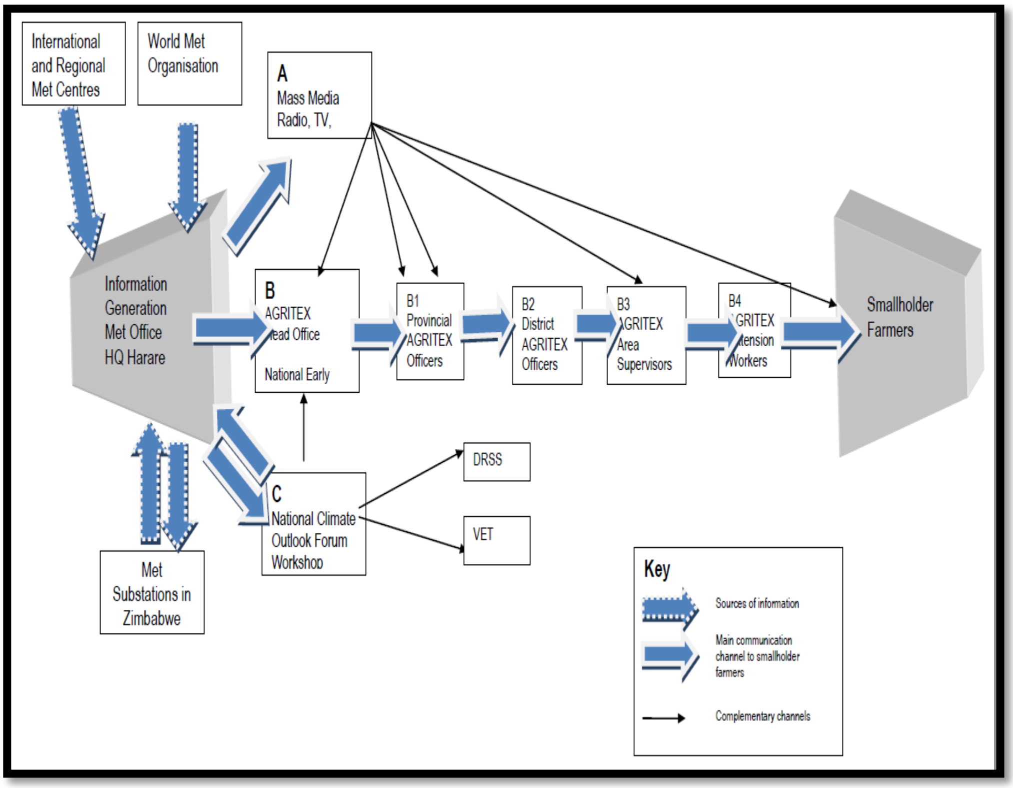

Figure 40: Drought early warning information from Meteorology Office users value chain.

9. ASSESSMENT OF HOW USERS INTERPRET DROUGHT WARNINGS AND DETERMINE HOW TO RESPOND TO THEM

9.1 EQUATORIAL LAKES REGION

9.1.1 Tanzania

The direct users of drought warnings and the way they interpret the warnings could be concluded as below:

- Farmers-means no food since all crops will die
- Pastoral-animals will die due to shortage of food and water
- Disaster management office-relief actions

There is no specific method and tools used. However, in the course of the disaster, the government can use its administrative levels to trace or force the responses. In some cases, other organizations such as FAO, UNICEF, NGOs can commission a study on responses.

9.1.2 Rwanda

Table 36: Interpretation and Use of Information, RWANDA

1. Who uses the information?	2. How information reaches users	3. How information is interpreted (alerts - indigenous and local)	4. What is the response to the assessed information? (provide all available data)	5. How good were the responses during these drought events?
Farmers, local administration/districts; NGOs; water managers, transport industries.	Radio, TV, printed media, reports, archives; .	Usually it is accepted without any deep analysis and seen as a warning information	Planning of agricultural activities especially for cooperatives more linked to the advises from the districts and NGOs operating in rural areas	Cropping periods are adjusted and improvement of land use techniques; An example like KWAMP project in south eastern Rwanda(support project to strategic plan for agricultural transformation/PAPSTA; Kirehe District Community-based Watershed Management/KWAMP)
Ministerial departments; Consultants dealing with projects on environment and natural resources; Students and lecturers at universities; Development projects in agriculture, irrigation, hydropower, construction of roads and infrastructure; International Institutions (WB;USAID;GTZ;UNDP)	Hydrological bulletins (used to be published in the past, currently not published)	Information is analyzed and used of suggesting some recommendations to different stakeholders	Organization of seminars , conferences and workshops; Debates via radio and TV; panels	Improvement of dissemination of information and even exchange of agricultural products from regions less dry to affected regions in the context of EAC (east african community)
Ministerial departments; Consultants dealing with projects on environment and natural resources; Students and lecturers at universities; Aviation service at airports	Climatological bulletins of ISAR (this was published in the past and today, it also needs to be resumed)	Researchers at ISAR and universities produced a number of publications usually increasing the size of archives and by now and then exploited	Databank for some services like REMA and libraries	The services in charge of climate change at REMA and at Primature(ASCAD/ archive system of cabinet documents) are now digitalizing their electronic archives while the RMS and ISAR(now part of RAB) are aiming at resuming the publication of bulletins at large scale
Water and Land Users and policy makers	Maps from the Center of GIS at the national university of Rwanda(UNR) and at the ministry of natural	Maps are key tools in published documents; Tender documents	Maps are tools which are now very used in different projects; Construction of websites; digitalization of electronic archives is a	Land rehabilitated; Projects of land consolidation and agricultural intensification; construction of terraces

1. Who uses the information?	2. How information reaches users	3. How information is interpreted (alerts - indigenous and local)	4. What is the response to the assessed information? (provide all available data)	5. How good were the responses during these drought events?
	resources via Rwanda Natural Resources Authority(RNRA)		starting program by various ministries and national agencies and commissions or taskforces	

9.1.3 Rwanda and Burundi

In both countries, according to National Adaptation Plan of Action to climate change (NAPA-Rwanda, 2006 and NAPA-Burundi, 2007), Major recommended actions and responses to droughts are similar and include mainly the following measures: Promotion of irrigated agricultural techniques, tree planting, radical terraces and erosion control, promotion of improved and adapted crop species, Integrated Water Resources Management, Rainwater harvesting and storage, Rely on other energy sources as alternative to fuel wood, creation of non-agricultural activities as alternative sources of income, Intensive agro-pastoral activities, and improvement of hydrological and agro-meteorological early warning system for timely intervention. **Table 36** shows the interpretation and use of the information.

9.2 EASTERN NILE REGION (ETHIOPIAN PLATEAU)

The potential beneficiaries of ENSO information in Ethiopia are farmers, herders, and the government. The success of an ENSO early warning depends on the actions taken by its users. The information concerning the advent of an ENSO event could warn both cash and food crop producers. Based on such information, farmers could introduce adequate agronomic changes. With reliable drought early warning, farmers could buy fodder or sell their cattle before market prices collapse. At the national level, surplus food could be stored for the next season, and additional food could be imported in anticipation of shortfalls. Herders might also sell off part of their herds before the arrival of drought. ENSO information is useful, but it has some weaknesses when applied to specific local conditions.

ENSO is a regional oceanic and atmospheric phenomena with global consequences. Its study and dissemination is of global importance. ENSO's effectiveness and limitations should be seen as based on its relevance to the various hierarchies of users. The information is important for regional policymakers to plan agricultural trade within and between countries and for relief transfers at a global level. The key issue is how to use ENSO at the village level, where the subsistence farmers need specific local information.

Applying ENSO-based drought early warning to local conditions could reduce the impact of drought on society to its greatest extent. Farmers could be warned before the advent of drought as to when, what, and where to cultivate and when to sell their animals. Such actions require credible and reliable early warning and adequate information flow between government agencies and farmers. Such information helps the government to reorganize its resources before the impact of drought is felt. However, the effectiveness of ENSO information depends on its adequate dissemination to the local level and on the confidence of its users in the information.

Thus, how should ENSO information be treated by the various hierarchies of decision makers and users? ENSO's effective level of prediction capability is global or, at best, regional. Its forecasting precision decreases when the spatial focus is narrowed from global, to regional, to national, to local levels. According to Farmer (1993), forecasting needs to be more spatially specific for the analysis to be useful. Farmer (ibid.) also raises the issue of the temporal and spatial distribution of ENSO effects on rainfall. This issue is relevant to Ethiopia, a country that has many local climates (Gonfa, 1996). For ENSO information to be credible at the local level, it has to respond to unique drought-related problems that arise due to diverse microclimates.

The diversity of climate in Ethiopia has given rise to the presence of several cereal species (English and Hess, 1974). Ethiopian peasants possess and cultivate diverse crops because of the diversity of microclimates. Not only do important crops such as wheat and barley have different planting and harvesting dates, but the multiple species of wheat, barley, and teff also exhibit varied maturation periods due to differences in soils, sunlight, temperature, and rainfall variations.

How does general ENSO information help the success of farmers with no access to irrigation? As noted, ENSO-based weather and climate prediction is general in nature and less effective in providing locally specific drought early warning. In Ethiopia, the NMSA, which is responsible for weather and climate forecasts, does not even have district branch offices.

Peasant farming in Ethiopia is complex. It is difficult to make generalized crop recommendations because farms a few kilometres apart have different natural endowments known only to local farmers. Those who advice farmers need to know the details of local weather, soil types, resources, and farming systems. Mengisteab Haile (1997), an agrometeorologist with the DPPC, stated that it is difficult to take samples of agrometeorological data from various districts. Topography tends to make local microclimates unique. As Farmer (1993) notes broad statements about the weather, without stating how the information can be used, will make famine early warning ineffective. ENSO-based early warning should be more specific in time and space to be relevant to peasant farmers.

9.3 EASTERN NILE REGION (DOWN STREAM COUNTRIES)

9.3.1 Experiences from Egypt

Based on the prediction of the Nile flow the MWRI has been constructed a ministering committee for managing the river flow, it is included all the concerning sectors

- Nile Water Sector
- High Aswan Authority
- Water Management and Distribution Sector
- Irrigation Sector Sectors
- Development Irrigation and Nile protection Sector

Another research institutes have been included in this steering committee.

Table 37 shows the interpretation and use of Information

Table 37: Interpretation and Use of Information

Who uses the information ?	How information reaches users	How information is interpreted (alerts - indigenous and local)	What is the response to the assessed information? (provide all available data)	How good were the responses during these drought events?
Ministerial committee for managing the river flow, MWRI	Official reports	Water distribution management plan	Operational policy of HAD. Prediction of Water availability for each water user sectors (Agriculture, Industry, Domestic use) For research studies.	During these events the users use this information for planning of agricultural activities.

9.3.2 Sudan

Sudan Meteorological Authority (SMA) provides the information below for different users for early warning

- Maps of rainfall estimate and its derivatives (accumulation, difference from average, percentage of average, total amounts on dekadal, monthly & seasonal bases.
- Number of dry & wet days within each dekadal.
- Start of growing season.
- Maps of NDVI and its derivatives (maximum, difference from average, as a percentage of average).

he above information compiled in: Monthly Agromet Bulettien (avilable online and also send to the stakeholders in mail list; Hard copies send to policy makers by mail; Daily rainfall forecasting through the Public media (Radio and T.V.); Climate projection for 50 years.The beneficiaries and the users of the SMA information are as follows:

a) Ministry of The council of Ministers
b) Ministry of Irrigation and Water resources.
c) Ministry of Agriculture.
d) Ministry of Humanitarians Affairs.
e) Ministry of Animal Resources.

- Warnings were associated by adequate details about the level of severity of the drought compared by the annual/ Monthly/ Dekadal average Rainfall and famous historical drought events.
- Direct contact with the decision makers and key institution representatives' through the emergency chamber. Available communications tools will be used to deliver the warnings.
- Users compare the current situation with most similar historical situation for the same geographical area.
- The large and small scale farmers depend on local knowledge

9.4 SOUTHERN AFRICA DEVELOPMENT COMMUNITY (SADC)

9.4.1 Responses at Regional Level

While many users found the accuracy of the main-season consensus seasonal forecast provided from the SARCOF process disappointing, a close correspondence between the forecast and observed events in the earlier part of the season enhanced its credibility as a basis for planning. The responses of governments and their citizens to the forecasts have provided useful lessons for national and regional drought planning, preparation, and mitigation.

It is arguable, therefore, if the REWS could have provided any reliable indication of harvest prospects before February/March 1992. What the REWS was able to do, however, during the period leading up to March 1992, was to raise awareness among decision makers of a deterioration in harvest prospects as the growing season developed, and to alert them that, should the worst happen, quick action would be needed if further food shortages were to be avoided.

In terms of being able to provide earlier, and at the same time reliable, crop forecasts there is need for a major breakthrough in the application of climatological information for early warning. At present, the types of advice issued on such phenomena as ENSO are not sufficiently reliable or dependable to be able to be used in crop harvest forecasts, partly because general global links are frequently overshadowed by localized climatic effects and partly because such advice is not yet sufficiently prognostic.

Experience in southern Africa has amply illustrated the fact that the credibility of early warning systems needs to be improved before decision makers gain the confidence to utilize their information. Such credibility can only be built up gradually, as the systems prove themselves by providing useful and dependable services. If early climatological indicators are to be incorporated into such a system, they too need to be usable and dependable. In this respect, ENSO bulletins need to be more user-oriented (users, in an early warning context, are not always climatologists or meteorologists), providing assessments of the likely impact (e.g., risk analysis) on rainfall and other weather conditions in particular parts of the world. Until such a stage has been reached, there seems little prospect of significantly improving the timeliness of drought early warnings (Rook 1998).

By December 1991, several individual governments had received information that the upcoming harvest would be below normal due to drought. Rainfall had stopped in many places and plants were experiencing moisture stress. The December 1991 reports from the NEWUs noted failed rains and poor crop conditions. The REWU compiled these reports and published its December 1991 Quarterly Food Security Bulletin in late January 1992. Its release coincided with the SADC Annual Consultative Conference which was being held in Maputo, Mozambique. The report predicted a below-average maize harvest region-wide. Ministers attending the conference were also presented with remote sensing images showing the location of the International Tropical Convergence Zone for October-December 1989, 1990, and 1991. These images clearly showed that the ITCZ was north of the region and that the prospects for rain from January 1992 onwards were very low.

Individual countries responded at different rates to the drought emergency. For a given country, a national declaration of drought is an important part of the drought response. Relief organizations are often unable to respond to a pending problem until the government makes an official request for aid. Individual countries responded at different rates to the drought emergency. The Government of Zambia was the first to declare a national disaster in February 1992 (GRZ, 1992). Zimbabwe, Malawi and Botswana followed in March 1992 (UN FAO, 1992; MSI, 1994). A national declaration of drought is significant because relief organizations are often unable to respond to a pending problem until the government makes an official request for aid (Sheets and Morris, 1976). In 1991/92, two major relief organizations reported their awareness of the potential food problem but were unable to take action until the governments in the countries in which they were operating acknowledged the problem and solicited their assistance.

There has been some complaint that initial reactions by governments and donor agencies to the warnings in April 2002 were sceptical, thus delaying immediate action (Mano et al 2003, Save the Children 2003, SADC Food Security Network 2002e, and SADC Regional Vulnerability Assessment Committee 2002).

By May 2003, the FAO/ World Food Program (WFP) Crop and Food Supply Assessment Missions had estimated that 1.2 million metric tons of food aid would be required to help fill the gap in the SADC Region. These data were reported in the June 2003 report, along with an estimated food gap of nearly 3.2 million metric tons. The WFP launched its Emergency Operation (EMOP) between April and June 2003, stating that “approximately 13 million people are facing a severe food crisis over the next nine months”. By September 2003, RVAC was estimating that 14.4 million people in the SADC Region required an additional 1 million metric tons of food aid to cover a total food gap of 3.3 million metric tons. By December 2003, the estimated number of affected persons had climbed to 15.25 million. Throughout the crisis, the food gap and progress towards meeting it were highlighted, and other relevant information (such as the GM maize controversy) was presented.

During April and May of 2002, FAO and WFP conducted Crop and Food Supply Assessment Missions (CFSAMs) in Lesotho, Malawi, Mozambique, Swaziland, Zimbabwe, and Zambia. These CFSAMs generated initial estimates of the number of households in need of food assistance. In principle, these estimates were to be updated over the course of the crisis by a series of joint “rolling vulnerability assessments” carried out by the national VACs with support from the RVAC, FEWS NET, WFP, and others. The stated purpose of these assessments was to identify who and where the most vulnerable populations where and what level of support they may require” (Save the Children, 2003).

Responses to initial warnings concerning the depletion of grain stocks over the 12-month period leading up to the drought were generally slow and late. It was not until such stocks had dropped to critical levels that reactions were initiated, by which time it was already too late to avoid the maize shortages which hit countries like Zambia and Zimbabwe during the early part of 1992 (Pawadyira and Ndlovu 1993).Perhaps because of the critical stock position at the time, responses to the drought alert were much swifter. First indications of a concerted reaction came as early as January 1992, well before the full impact of the (still ongoing) drought could be assessed, when the SADC Food Security Sector Coordinator was directed by SADC Ministers to consult closely and urgently with member states, with a view to:

- assessing the extent of food shortages;
- evolving a common strategy to address the problem; and
- convening, if necessary, a Donor's Conference.

In the ensuing period up to the end of March 1992, during which time the regional drought intensified, the REWS and its national components, the National Early Warning systems (NEWS) undertook a series of rapid assessments of anticipated food availability and of needs during the forthcoming marketing year. In March/April 1992, a joint FAO/WFP Crop Assessment Mission was launched in the SADC region. Its findings verified the REWS findings. On April 14 1992, SADC convened a special meeting of Ministers of Agriculture and Transport to formalize regional institutional arrangements for drought relief. At about the same time, SADC entered into discussions with the UN Department of Humanitarian Affairs (DHA) in Geneva, Switzerland. These discussions culminated in the issuance of the worldwide Drought Emergency in Southern Africa (DESA) appeal on the 26th of May 1992. This was followed up in early June 1992 by a jointly organized international Donor Pledging Conference(SDD 1993).

In addition, it is important to recognize that, while all these activities were going on, individual countries - notably Zambia and Zimbabwe - had already begun to identify sources for their commercial maize imports. As it turned out, this was to have a significant bearing on the food security situation in these countries during the following months.

The 2006/07 drought was also linked to El Nino conditions. The drought was declared a national disaster by the President of Zimbabwe in March 2007 (Chronicle 2007; IRIN 2007) and this obligated the government to provide relief services to people in need by either using its own resources or appealing to international relief agencies (Chigodora 1997; FAO/WFP 2002)

Before the end of December 1993, Tanzania had declared the drought a national disaster. The period from about January to February 1994 saw a gradual shift in the rainfall pattern. The deficits that were widespread north of the 18th parallel were cleared in a short time as heavy rains battered those areas. In its updated forecasts, the DMC predicted further improvement to the north and diminished rainfall to the south. From about mid-February 1994, a dry spell that extended into the entire month of March 1994 hit most of southern Zambia, southern Malawi, eastern Botswana, most parts of Zimbabwe and Mozambique. **Figure 41** shows actual drought-affected areas for this time period over southern Africa.

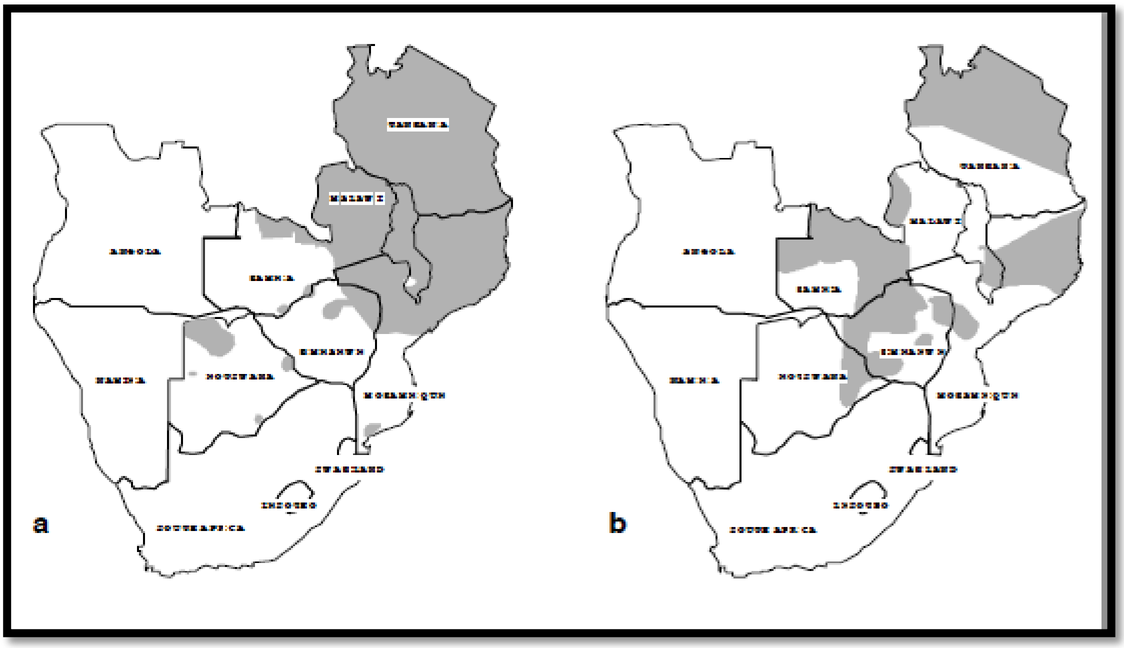

Figure 41: Drought-affected areas of southern Africa for (a) 20 December 1993 and (b) 28 February 1994.

9.4.2 South Africa

Using the seasonal outlook produced by the South African Weather Service (SAWS) the following advisory guidelines are suggested by the Department of Agriculture as shown in **Table 38**.

Table 38: User Responses to Drought Early Warnings

Water Users	Response Area	Response
Rainfed Crop Producers	Soil choice	○ Choose suitable soil type. ○ Roughen the soil surface to minimize evaporation. ○ Minimize compaction by reducing the passing of heavy machinery in the field. Land preparation: ○ Avoid, where possible, soils with pronounced plough pans. ○ Use a ripper to break plough pans and increase access of roots to stored water and nutrients. ○ Do not expand land under crop production unnecessarily. ○ Prioritise fallow land.
	Crop choice and planting	○ Choose drought resistant cultivars or drought tolerant crops as a precautionary measure. ○ Provide flexibility and diversification. ○ Stick to normal planting window if appropriate

		and follow the weather and climate forecast regularly. ○ Consider staggered planting-spreading over weeks. ○ Do not experiment with new and unknown cultivars and also avoid unnecessary capital investments. ○ Always practice crop rotation. ○ Planting in a controlled environment (e.g. green house) is advisable where possible.
	Crop management	○ Adjust planting density accordingly. ○ Consider mulching to minimize evaporation. ○ Control weeds regularly. ○ Consider a conservative fertilizing strategy during dry conditions. ○ Consider organic fertilization. ○ Scout for pests and diseases regularly and control where necessary
Irrigation Farmers		○ Remove all weeds containing seeds, but keep other vegetative rests on the land because that will reduce evaporation. ○ Check and repair all tools and machinery. ○ Irrigate during cool conditions to avoid evapotranspiration. ○ Avoid over irrigation because that can create problems e.g. water logging and diseases. ○ Adhere to the water restrictions when issued.
Domestic and Home Garden Water Users		○ Conserve existing water supplies. ○ Eradicate water weeds. ○ Limit water waste and losses. ○ Repair leaking pipes. ○ Re-use water and retain high quality. ○ Harvest water during rainy days.
Stock Farming		○ Provide lots of drinking points. ○ Provide phosphorous licks freely. ○ If grazing is in danger, herd animals into pens where different animals can be segregated and fed separately. ○ Herd management should be aimed at maximizing animal condition during the growing season as it affects the degree at which animals lose/gain weight and condition during the dry periods. ○ Decide in advance when to switch the animals to different levels of feeding. ○ Sell mature livestock as soon as they reach marketable condition. ○ Treat the rangeland as a valuable asset. ○ Build fodder reserves in years of good rainfall. ○ Always practice rotational grazing. ○ Retain nucleus of best cows aged 4 to 6 years. ○ Diseases- Local veterinary services. ○ Always consider relevant vaccinations and control outbreak of diseases.
Grazing		○ Subdivide your grazing area into camps of homogeneous units (in terms of species. Composition, slope, aspect, rainfall, temperature, soil and other factors) to minimize area selective grazing as well as to provide for the application of animal management and veld management practices such as resting and

		burning. o Determine the carrying capacity of different plant associations. o Calculate the stocking rate of each, and then decide the best ratios of large and small animals, and of grazers or browsers. o Provide periodic full growing-season rests (in certain grazing areas) to allow veld vigor recovery in order to maintain veld productivity at a high level as well as to maintain the vigor of the preferred species. o Rested veld forms an important source of cheap feed during winter for dry stock with appropriate protein supplementation. o Do not overstock at any time. o Eradicate invader plants. o Periodically reassess the grazing and feed available for the next few months, and start planning in advance. o Spread water points evenly. o Cut forage early to stimulate re-growth. o Provide suitable licks to make coarse, dry range grasses more palatable

These advisories issued by Agricultural Department monthly are broad guidelines and should be interpreted considering the local aspects of the region such as soil types, cultural preferences and farming systems. The basic strategy to follow would be to minimize and diversify risk, optimize soil water availability and to manage the renewable resources (rain water and grazing) to uphold sound farming objectives. The districts/ municipalities should further simplify, downscale and package the information according to their language preference and if possible use local radio stations and farmers' days in disseminating the information. **Table 39** shows the interpretation of the drought warning by farmers

Table 39: Interpretation of drought warnings

Predictor/ signal	Description/Interpretation	Implications
Multiple System model	Sea surface temperature	Availabilty or non-availabilty of rainfall
Cry of Cuculus solitarius bird	The cry of Cuculus solitarius bird between August and November is a sign of the beginning of the wet season	Farmers prepare farming inputs upon the cry of the bird.
Abundance of some wild fruits	The abundance of some wild fruits that include Vanguer birrea during the period of December to February is taken as a sign of imminent famine	Harvest from previous season is preserved Wild fruits and vegetables are also collected and preserved
Cry of frogs	The cry of frogs during the summer season (September to March) is taken as a sign of approaching rainfall.	Farmers prepare their farming inputs in readiness to plough
The position of the moon	When the moon is slightly tilted to the west and the crescent is facing down during the periods of August to December it is taken as imminent sign of rainfall within a week.	Farmers prepare their farming inputs in readiness to plough and plant

Abundance of certain insects	The abundance of butterflies, locusts and grasshoppers during the farming season is taken as a sign of imminent drought and famine	Harvest from previous season is preserved and preserved

9.4.3 Zimbabwe

(a) Response by Farmers

The Commercial Farmers' Union (CFU) had been monitoring the media reports of a growing El Niño from the beginning, and so made a special effort to meet with forecasters from the Meteorological Services Department in Harare to discuss implications, and to keep its members knowledgeable. During the winter months of July and August 1997, the CFU incorporated discussions of El Niño into its "field-day" activities in the different regions, reinforcing the probabilistic nature of the prediction. Occurring in July and August 1997, these deliberately coincided with times at which commercial farmers were buying their seed for the upcoming season. The general advice the CFU developed for its farmers, in coordination with the Meteorological Services Department in Harare, was to plant early to take advantage of the predicted good early season rains, and to plant short-season varieties to avoid the likely late season drought. Farmers working with CFU agronomists at the field-day meetings generated location-specific recommendations about what particular varieties to plant. Most farmers incorporated these recommendations into their planting decisions. Using the information was more difficult in the smallholder sector, especially among communal land farmers in drier regions of the country, where "below-normal" rainfall implied a high likelihood of crop failure. Modelling results (Phillips et al 2001), and more recently, field studies (Patt et al 2005), show that the forecasts can be of value to farmers, by allowing them to optimize for the expected rainfall with a different mix of seed varieties and a staggered planting schedule.
But as of 1997, except for a few people within NEWU, most people had little idea what ENSO was, and how to interpret the seasonal forecasts. In July1997, Agritex organized a two-day workshop in Harare to discuss the use of seasonal forecasts with Meteorological Services Department and RRSP personnel. One suggestion was to educate Agritex extension officers about El Niño, so that they could help farmers make better decisions. However, it took several months for this to happen. Even though the workshops were late, Agritex did advise farmers prior to the normal planting time, soon after the release of the Meteorological Services Department seasonal forecast in early October 1997. Agritex instructed field staff to tell farmers that rainfall would be below normal. Agritex advised farmers to plant more drought-tolerant varieties of maize, or extremely drought tolerant crops like sorghum and millet, to plant early (October instead of November), and to sell off draft animals, where possible. The communal farmers received this information in conjunction with the media

reports. Both the media and the Agritex field staff compared the current year with 1991–1992, when there was a massive drought in which even drought-tolerant crops had failed. Agritex deliberately tried to avoid conveying probabilistic forecasts down to the district and local level, out of fear of confusing the farmers. The workshops—planned in July 1997—took place in eight provinces between November 18 and December 5 1997 with representatives from the NEWU, Meteorological Services Department, and DMC. Provincial Agritex staff attended, and some district and local extension workers. This series of training sessions probably came too late to educate people for the 1997–1998 season, since they occurred after the time for early planting (October), and well after the time when communal farmers typically buy their seed (August and September). Furthermore, the vast majority of the local extension officers did not attend training sessions, and never learned about probabilistic forecasts associated with El Niño. Communal farmers reacted in many different ways to the deterministic forecasts. Some, particularly among those in wetter areas of the country did plant varieties of maize more drought tolerant than usual, and did plant early. Most communal land farmers did not change their behaviour in response to the forecast, and very few sold their animals. Some farmers, particularly among those in the driest regions, waited until December or January (i.e., late) to plant their millet, sorghum, or maize, after having seen early season rainfall turn out to be relatively normal. These farmers fared poorly when the rains ended early, as predicted. In total, the area of land the smallholder farmers planted was 21.3 percent lower than the year before, and the total harvest was 43.1 percent lower (Policy and Planning Division 1999). Those farmers who planted late suffered most.

(b) Response by the Media and Government

The media extensively covered the ENSO event and corresponding forecasts of drought, and for many people was the only source of climate-related information. People in the meteorology, food-security, and agricultural sectors were highly critical of the coverage that the media devoted to the ENSO event, accusing them of blowing it out of proportion. The feeling among professionals was that the media hype contributed to a poor understanding of the uncertainties associated with ENSO. Because they felt that the media overplayed El Niño, many saw their own role as trying to downplay the significance of the ENSO warm event, urging people not to panic. As the summer came to a close in March and April 1997, the Meteorological Services Department in Harare organized a post-season review meeting, where they reviewed with stakeholders the results of the forecasting effort during the season. The conclusion of the Meteorological Services Department was that the forecast of normal to below normal had been accurate. What was not accurate, they said, were the stories in the media predicting a major drought from "the mother of all El Niños," reports that most people in the country read and used in making their decisions.

Early warning clearly worked during the 2002/03 crisis. It alerted local governments and the international community to looming food shortages as the harvest was just beginning, provided quantitative estimates of the number of affected households and the need for food aid and commercial imports, regularly updated these numbers through effective communications, and mobilized public opinion and resources to meet enough of those estimated needs to largely avert a humanitarian crisis. The early warning and response process also reflected an exceptional degree of collaboration among governments in the region, the emergency response community, and donor agencies. The way in which the work of national vulnerability assessment committee (VAC) was coordinated by the SADC Regional VAC and fed into donor and relief agency response is especially impressive. Darcy and Hofman (2003, p. 43) consider it a "striking example of a coordinated multi-agency assessment process" and suggest that the assessment methods, driven primarily by the Save the Children (UK) Household Economy Approach (HEA), achieved greater standardization than has been typical in past crises.

Monitoring drought presents some unique challenges because of its distinctive characteristics. Some of the most prominent challenges were 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 a problem because of missing data or an inadequate length of record;
- Data sharing is inadequate between government agencies and research institutions, and the high cost of data limits their application in drought monitoring, preparedness, mitigation and response;
- Information delivered through early warning systems is often too technical and detailed, limiting its use by decision makers;
- Forecasts are often unreliable on the seasonal timescale and lack specificity, reducing their usefulness for agriculture and other sectors;
- Drought indices are sometimes inadequate for detecting the early onset and end of drought;
- Drought monitoring systems should be integrated, coupling multiple climate, water and soil parameters and socio-economic indicators to fully characterize drought magnitude, spatial extent and potential impact;

- Impact assessment methodologies, a critical part of drought monitoring and early warning systems, are not standardized or widely available, hindering impact estimates and the creation of regionally appropriate mitigation and response programmes;
- Delivery systems for disseminating data to users in a timely manner are not well developed, limiting their usefulness for decision support.

Table 40 summarizes the 1991/92 drought response in Zimbabwe.

Table 40: Key events in Zimbabwe's drought response.

Date	Event
March 1991	3 million tonne grain shortfall for SADC region predicted for 1991/92 mkt. year - based on current grain stocks/harvest
April 1, 1991	GMB budgeted for maize to cover pre-harvest gap
July/August 1991	NEWU predicts zero closing stock of maize with GMB (by mkt. year end) due to poor harvest
October 1991	GMB officials went to RSA and arranged contract for 100,000 tonnes of maize
November 1991	NEWU drought forecast issued: warned of less than adequate stocks for Jan./Feb., and impending drought
December 1991	Tentative assessment of upcoming low grain harvest -- based on lack of rains
December/January	Rains failed (preventing maize tassel stage)
1st week of February, 1992	Appeals for emergency maize shipments
March 6, 1992	national drought disaster declared
March 1992	SADC REWS issues detailed forecast of upcoming harvest, having identified drought's magnitude -- regional import needs defined
June 1992	Official regional appeal made for donor assistance at Geneva pledging conference

Source: GMB, 1990, 1991, 1992; SADCC/REWS, 1991, 1992; SADC/FSTAU, 1993.

9.5 EXPERIENCES FROM WEST AFRICA - NIGER BASIN

Communication and dissemination of information are needed for better decision making at the grassroots level. All populations have no access to national television. Local radio stations broadcast information at the grassroot level. There are other communication mechanisms that also disseminate information, such as the Weekly Magazine of the Regional Directorate of Fisheries. In addition to the above mentioned ways, the interventions of the City Council and Administration at the prefecture level contribute to the dissemination of information in the database. **Table 41** shows how the information is interpreted and used in the Niger Basin.

Table 41: Interpretation and Use of Information

1. Who uses the information ?	2. How information reaches users	3. Comment l'information est interprétée (alertes - autochtones et locales)	4. What is the response to the assessed information? (provide all available data)	5. How good were the responses during these drought events?
Farmers, herders, fishermen	Television, Radio	Decision on crop seeding	Prediction of crop calendar	During these events the users use this information for planning of agricultural activities.
All those involved in fish industry	TV, Weekly magazine of the Regional Directorate of Fisheries	Fishing period	Anticipation of the fishing season	
Users are the socio-economic organizations and local communities, NGOs, decentralized services of the state, rural and urban districts	Progress reports, annual reports and a monthly newsletter sent to technical services and they are responsible for transmitting its information to grassroots communities through the extension agents that are on site	The information is interpreted by the technical officers.	This information allows users to take steps to adapt to changes that are planned in their area.	It should be an awareness campaign so that people can take steps to adapt.
Users (farmers, fishermen, farmers)	Radio, television and telephone	Decision for the planning of activities (period of plowing period sown, etc.).	Planning of activities	Users believe that information
Local communities, Technical Services of the State and NGOs	Radio, television and monthly reports are distributed to the Technical Services	The information is interpreted by the technical officers.	Taking measures to prevent natural disasters	

10. LIST OF REFERENCES

1. Cane , M. A., et al. (1994). "Forecasting of Zimbabwe maize using eastern equatorial Pacific sea surface temperature." Nature: 370.
2. ADA, 2008. Plan Maroc Vert. www.ada.gov.ma/Plan_Maroc_Vert/plan-maroc-vert.php
3. Ameziane T.E., (2010). Questionnaire on Needs and Existing Capabilities for a Global Drought Early Warning System.
4. Bellow J., A. Mokssit, J. O'Brien, and R. Sebbari. (2007). Building national and specialized climat services. In A. Troccoli et al. (eds.), Seasonal Climate: Forecasting and Managing Risk, pp 323-360.
5. Bouignane A., 2010. La sécheresse dans le bassin du Sebou, Etat actuel et perspectives. SEMIDE, Mediterranean Joint process. Water scarcity and drought working group meeting. Madrid, 17-20 February 2010.
6. Boujenane I. (2003) L'Agriculture à travers l'Oraliture. Agriculture et Humanisme. Actes Editions. 72 pages.
7. Doukkali M.R. (2005). Water institutional reforms in Morocco. Water Policy (7) 71-88.
8. Hellegers P.J.G.J, C.J. Perry, and Petitguyot T., 2007. Water pricing in Tadla, Morocco. In: Molle & Berckoff (Eds), Irrigation water pricing, CAB International 2007.
9. INRA-JRC-IPSC-AGRI4CAST, 2009. Bulletin commun pour le Maroc, 2009.Rapport N°1 2009, 1/6/2009- Septembre 2008-Mai, 2009.
10. Jalil M. (2003). Integrating Early Warning in Disaster Preparedness and Response in Morocco. Second International Conference on Early Warning (EWC-II). Bonn, 16-18 October, 2003.
11. Ouattar S. et Ameziane T.E. (1989) Les céréales au Maroc. De la recherche à l'amélioration des techniques de production. Les Editions Toubkal., Casablanca.
12. Yacoubi Yacoubi M., El Mourid M., Chbouki N. & Stockle C., (1998). Typologie de la sécheresse et recherche d'indicateur d'alerte en climat semi-aride marocain. Sécheresse 9 : 269-276.1998
13. Chigodora, J. (1997). "Famine and Drought:The question of food security in Zimbabwe." Drought Network News. 1(9): 3-7.
14. Chronicle (2007). 2007 Declared a Disaster. Chronicle.
15. FAO/WFP (2002). Special on Report on Crop and Food Supply Assessment Mission to Zimbabwe, Food and Agricultural Organisation of the United Nations and World Food Programme.
16. HDAM Graphs, 2012, WR Nyabeze and Associates, www.wrnyabeze.com
17. IRIN (2007). "Zimbabew :Govt declares drought, but say no to food aid."Mano, et al. (2002). Identifying Policy Determinants of Food Security Response and Recovery in the SADC Region: The Case of the 2002 Food Emergency. FANRPAN Policy Paper prepared for the FANRPAN Regional Dialogue on Agricultural Recovery, Food Security and Trade Policies in Southern Africa,. Gaborone, Botswana.
18. Pawadyira, M. S. and S. Ndlovu (1993). A review of early warning: The 1992 drought disaster in Zimbabwe Harare, Department of Civil Protection.
19. Rook, J. M. (1998). The SADC Regional Early Warning System:Experience Gained and Lessons Learnt from the1991-92 Southern Africa Drought. Harare, Zimbabwe, UN Food & Agriculture Organization (FAO),SADC Regional Early Warning System.

20. SADC Food Security Network (2002a). “Production Shortfalls Imminent”. MinisterialBrief. 10 April 2002.
21. http://www.fews.net/centers/current/monthlies/report/?f=r3&m= 1000541&l=en.
22. SADC Regional Vulnerability Assessment Committee (2002). “Region Emergency Food
23. Security Assessment Report Covering … Lesotho, Malawi, Mozambique, Swaziland,
24. Zambia and Zimbabwe”. 16 September 2002.
25. Save the Children-UK (2003). “Understanding and Responding to Fragile Livelihoods in Southern Africa”.
26. SCK (2003). "(Save the Children- UK)Understanding and Responding to Fragile Livelihoods in Southern Africa."
27. SDD (1993). Report on the 1992 Drought Disaster. Harare,Secretariat for the Drought Disaster: 49.Stack, J. L. (1998). Drought warning dissemination in Zimbabwe. Harare, Department of Agricultural Economicsand Extension ,University of Zimbabwe
28. Unganai, L. S. (1994). "Drought and Southern Africa: A Note from the Harare Regional Drought Monitoring Centre." Drought Network News.
29. Babiker, A. A. & Mohamed, A. A. W., 2010. Climate Change Current Activities in Sudan, paper in Regional workshop on the status of climate change activities in the Nile Basin Countries
30. Elagib, N. A., 2010. Exploratory analysis of rain days in central Sudan. J. Meteorol. Atmos. Phys. DOI 10.1007/s00703-010-0088-6
31. Sudan Meteorological Authority – Agrometeorology Division
32. Government of Rwanda "GOR" (2011), Green Growth and Climate Resilience National Strategy for Climate Change and Low Carbon Development, Kigali, Rwanda. Available at: http://www.smithschool.ox.ac.uk/wp-content/uploads/2011/03/Rwanda-Green-Growth-Strategy-FINAL.pdf Accessed on 01 December 2011.
33. NBCBN (2010), Integrated Flood and Drought Management for Sustainable Development in the Nile Basin. Egypt, 2010.
34. NISR and WFP (2009). Comprehensive Food Security and Vulnerability Analysis and Nutrition Survey (Data collected in February-March 2009): available at http://www.wfp.org/content/rwanda-comprehensive-food-security-and-vulnerability-analysis-2009 and http://www.wfp.org/content/rwanda-comprehensive-food-security-and-vulnerability-analysis-2009. Accessed on 12 December 2011
35. REMA (2009): Rwanda State of Environment and Outlook Report” Rwanda Environment Management Authority, Kigali, Rwanda.
36. Sandford, J. (2002), Review of Assements Currently Undertaken in Ethiopia, Addis Ababa.
37. Lautze, S., et al. (2003) Risk and Vulnerability in Ethiopia: Learning from the Past, esponding to the Present, Preparing for the Future. A report for USAID. Feinstein International Famine Centre, Tufts University, Medford.
38. Save the Children UK experiences on piloting Community Based Early Warning Systems in 3 districts of Somali and Afar Regions of Ethiopia, What worked and what didn’t, by, Abdurrahman Ali Issack and Ahmed Yusuf, Consultants, Study commissioned under Preparedness Improves Livelihoods and Resilience (PILLARII) PROJECT, Addis Ababa, Ethiopia, 5th July, 2010

39. Attia, B.B., and A.B. Abulhoda, 1992: The ENSO Phenomenon and Its Impact on the Nile's Hydrology. In M.A. Abu-Zeid and A.K. Biswas (Eds.), Climate Fluctuations and Water Management. Butterworth Heinemann. 71-79.
40. Ayalew, M. (Former Head of The Early Warning and Planning Department, The Relief and Rehabilitation Commission), 1996: Addis Ababa, Ethiopia. Letter, August 26.
41. Bekele, F., 1993: Ethiopian Use of ENSO Information in Its Seasonal Forecasts. In M. H. Glantz (Ed.), Workshop on Usable Science: Food Security, Early Warning and El Niño. 25-28 October, 1993. Budapest, Hungary, Boulder: National Center for Atmospheric Research, 117-121.
42. Cane, M.A., 1993: ENSO and Its Prediction: How Well Can We Forecast It? Usable Science: Food Security, Early Warning and El Niño. 25-28 October 1993, Budapest, Hungary, Boulder: National Center for Atmospheric Research.
43. Cane, M.A., E. Gideon, and R.W. Buckland, 1994: Forecasting Zimbabwean maize yield using eastern equatorial Pacific seas surface temperature. Nature, 370:21, July, 204-5.
44. Degefu, W., 1987: Some aspects of meteorological drought in Ethiopia. In M. H. Glantz (Ed.), Drought and Hunger in Africa. Cambridge: Cambridge University Press.
45. DPPC (Disaster Preparedness and Prevention Commission), 1996: DPPC News. 6:3, April.
46. Eltahir, E.A., 1966: El Niño and the natural variability in the flow of the Nile River. Water Resources Research. 32:1, 131-137.
47. Farmer, G., 1993: What does the famine early warning community need from the ENSO research community? Workshop on Usable Science: Food Security, Early Warning and El Niño. 25-28 October, Budapest, Hungary, Boulder: National Center for Atmospheric Research, 163-168.
48. Glantz, M.H., 1996a: Are Famines so Difficult to Predict? Internet Journal of African Studies. http://www.brad.ac.uk/research/ijas/,.
49. Glantz, M.H., 1996b: Currents of Change: El Niño's Impact on Climate and Society. Cambridge UK: Cambridge University Press.
50. Glantz, M.H., 1993: Introduction. Forecasting El Niño: Science's Gift to the 21st Century. In M.H. Glantz (Ed.), Workshop on Usable Science: Food Security, Early Warning and El Niño. 25-28 October, Budapest, Hungary, Boulder: National Center for Atmospheric Research, 3-11.
51. Glantz, M. H., R. W. Katz, and N. Nicholls, 1991: Teleconnections Linking Worldwide Climate Anomalies. Cambridge: Cambridge University Press.
52. Haile, T., 1988: Causes and Characters of Drought in Ethiopia. Ethiopian Journal of Agricultural Sciences. 10:1-2, 85-97.
53. Kaplan, R. D., 1988: Surrender or Starve, the wars behind the famine. Boulder and London: Westview Press.
54. Gonfa, L., 1996: Climate Classifications of Ethiopia. Meteorological Research Reports Series, No. 3, May. Addis Ababa, Ethiopia, National Meteorological Services Agency.
55. Mengisteab, H., 1997: Disaster Preparedness and Prevention Commission. Interview. Addis Ababa, Ethiopia, January 23.

56. National Drought Mitigation Center, 1996: Understanding ENSO and Forecasting Drought. March 1 enso.unl.edu/ndmc/enigma/elnino.htm
57. NMSA (National Meorological Services Agency), 1996: Climatic &Agroclimatic Resources of Ethiopia. Meteorological Research Report Series, 1:1, January. Addis Ababa, Ethiopia.
58. Nicholls, N., 1993: What are the potential contributions of El Niño - Southern Oscillation Research to Early Warning of Potential Acute Food-deficit Situations. in M. H. Glantz (Ed.), Workshop on Usable Science: Food Security, Early Warning and El Niño, 25-28 October, Budapest, Hungary, Boulder: National Center for Atmospheric Research, 169-177.
59. Pankhurst, R., 1966: The great Ethiopian famine of 1888-92. Journal of History of Medicine and Allied Sciences, 21, 95-124 and 271-94.
60. Quinn, W. H. and V. T. Neal, 1987: El Niño Occurrences Over the Past Four and Half Centuries. Journal of Physical Research, 92:C13, December 15, 14,449-14,461.
61. Teshome, E. (Head of the Department of Early Warning, Disaster Preparedness and Prevention Commission [DPPC]), 1997: Interview, Addis Ababa, Ethiopia, January 17.
62. Trenberth, K. E., 1991: General Characteristics of El Niño-Southern Oscillation." In M. H. Glantz, R. Katz and N. Nicholls (Eds.), Teleconnections linking worldwide climate anomalies. Cambridge: Cambridge University Press, 13-42.
63. Webb, P. and J. von Braun, 1994: Famine and Food Security in Ethiopia: Lessons for Africa. Chichester: John Wiley & Sons.
64. Arnell, N. W. (1999). Climate change and global water resources. Global Environmental Change, 9, 31-49.
65. Conway, D., & Hulme, M. (1993). Recent fluctuations in precipitation and runoff over the Nile subbasins and their impact on main Nile discharge. Climatic Change, 25(2), 127-151.
66. Conway, D., & Hulme, M. (1996). The impacts of climate variability and future climate change in the Nile Basin on water resources in Egypt. International Journal of Water ResourcesDevelopment, 12(3), 277-296.
67. Gleick, P. H. (1991). The vulnerability of runoff in the Nile Basin to climatic changes. Environmental Professional, 13(1), 66-73.
68. Ministry of Water Resources and Irrigation, Egypt, 2003. “Adopted measures to face major challenges in the Egyptian Water Sector” From Kyoto 3rd World Water Forum 2003.
69. MINATTE (2007), National Adaptation Plan of Action to Climate Change (NAPA), Bujumbura, Burundi.
70. Cited from: http://preventionweb.net/english/professional/news/v.php?id=12519

Websites

www.minela.gov.rw

www.mininfra.gov.rw

www.meteorwanda.gov.rw

www.statistics.gov.rw

www.wfp.org

www.minagri.gov.rw

www.fews.net

www.crts.gov.ma/modules.php?name=Sections&op=viewarticle&artid=38.