Establishing Drought Early Warning Systems in West Asia and North Africa

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Summary

Drought, as one of the natural disasters, can cause adverse social impacts, such as the deficit of drinking water, famine, and conflicts. In order to reduce the costs caused by drought, early warning and monitoring of drought is very important and implementing effective drought monitoring and early warning systems is one important component in a national drought management policy.[1] This study is part of the "Strengthening National Capacities to Manage Water Scarcity and Drought in West Asia and North Africa" project initiated by UN-DESA, and the purpose is to help enhancing national capacities adapting and combating drought in the West Asia and North Africa area. In terms of capacity building, the most obvious aspect is actual training of staff on how to access and use the available static and dynamic geospatial information, and it is also important that that the executive management and political levels decision makers will be aware of the tools and information that are available. This study focuses on the methodologies about establishing the drought early warning systems in the target area by giving a general picture of the drought monitoring and early warning systems operated by various organizations to keep the national policy makers in the target area informed of what are available for them to use and help them be well prepared for the drought.

Some recommendations are presented: for the partners, understanding the needs of these countries and facilitating more cooperation in terms of sharing data and geospatial technologies are important; and for the target countries, more research on the forecasting of drought, more education and training for water professionals, and establishing a free flow of information are highly encouraged to achieve a more drought resilient society.

Acknowledgements

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[1] Science Document: Best Practices on National Drought Management Policy, for High Level Meeting on National Drought Policy (HMNDP), held in Geneva on 11-15 March 2013

Contents

1 Introduction

1.1 Definition of drought

The definition of drought in Oxford Dictionary is "a prolonged period of abnormally low rainfall; a shortage of water resulting from this". Compared with the other natural hazards, drought is more difficult to identify, monitor and manage, due to its long-term development and duration, the progressive character of its impacts and diffuse spatial extent.[2]

1.2 Classification of drought

Drought can be classified into different contexts. Meteorological drought can be defined as "a reduction in rainfall supply compared with a specified average condition over some specified period" (Hulme 1995). Agricultural drought is defined as a reduction in moisture availability below the optimum level required by a crop during different stages of its growth cycle, leading to reduced yields. Hydrological drought refers to the impact of a reduction in precipitation on natural and artificial surface and subsurface water storage systems, and possibly lagging behind periods of agricultural or meteorological drought.[2] Finally, social drought relates to the impact of drought on human activities, both indirect and direct impacts.

1.3 Impacts of droughts in West Asia and North Africa

Drought is a devastating factor for livestock. Half of the Moroccan sheep flock died due to drought in 1945, and in the 1981–82 drought, 25% of the cattle and 39% of the sheep either died or were sold prematurely on a glutted market. In Syria, 3 million sheep (about 25 percent of the flocks) had to be slaughtered during the 1983–84 drought because of a shortage of feed; 4 severe droughts from 2000 to 2011 brought 2-3 million people in extreme poverty, and wiping out 80-85% of herd stock. In a major drought between 1958 and 1962 in Jordan, at least 70 percent of the camel herd died, leading to a virtual demise of camels as an economic element in livestock production.[3]

Drought can lead to food shortage if the crops in the growth season do not get enough water for their growth, and this might lead to series of severe social problems. For example, in 2008, the food crisis in Jordan, Morocco,

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[2] Wilhite, D. A. 1993: Drought Assessment, Management, and Planning: Theory and Case Studies. Boston: Kluwer Academic Publishers.
[3] Information is from the presentation "Drought Policy and Food Security in Jordan"by Anwar Battikhi, for High Level Meeting on National Drought Policy (HMNDP), on 13 March 2013, http://www.hmndp.org/presentations/12.03-HMNDP-Parallel6-Battikhi.pdf

and Yemen lead to social unrest and riots which adversely impact political and economic stability and affect the investment and economic growth.

1.4 Climate change in West Asia and North Africa

Current situation

Millennium Ecosystem Assessment (2005)[4] shows an overlap map of urban areas with the different dryland categories (Figure 1). In the West Asia and North Africa region, most areas are classified into arid or hyper-arid zones. Jordan, for example, has seen drop of 1 meter/year in ground water level during the last 30 years; and its main dams store half of its capacity in the last 20 years.[5]

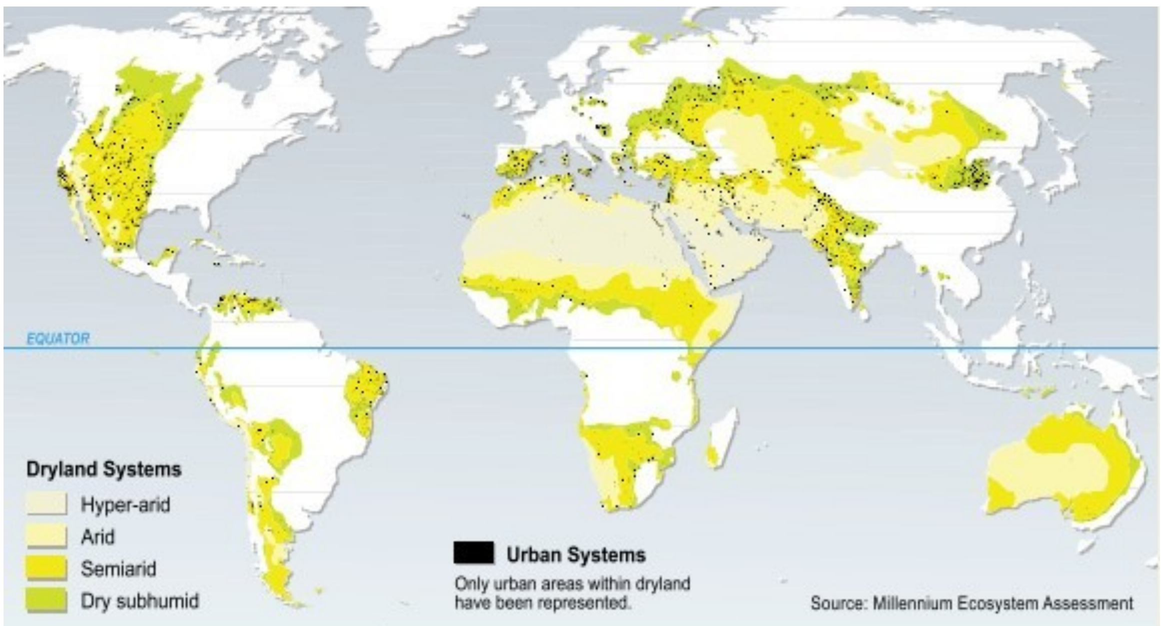

Fig. 1. Overlap of urban areas with the four dryland categories

[4] Ecosystems and Human Well-being: Desertification Synthesis, World Resources Institute, Washington, DC.
[5] Information is from the presentation "Drought Policy and Food Security in Jordan"by Anwar Battikhi, for High Level Meeting on National Drought Policy (HMNDP), on 13 March 2013, http://www.hmndp.org/presentations/12.03-HMNDP-Parallel6-Battikhi.pdf

Future projection

IPCC Fourth Assessment Report (2007)[6] synthesized the simulation results from 21 models and indicate that West Asia and North Africa is likely to see a 3.5-7 centigrade temperature increase in the last 20 years of this century compared with the temperature of the last 20 years of the 20th century (Fig. 2, top row). For precipitation, most of this area probably has less rain (up to 50% less) in the last 20 years of this century compared with that of 1980-1999. For Jordan and Yemen, in June-July-August (JJA), more precipitation is possible for this comparison (Fig. 2, bottom row).

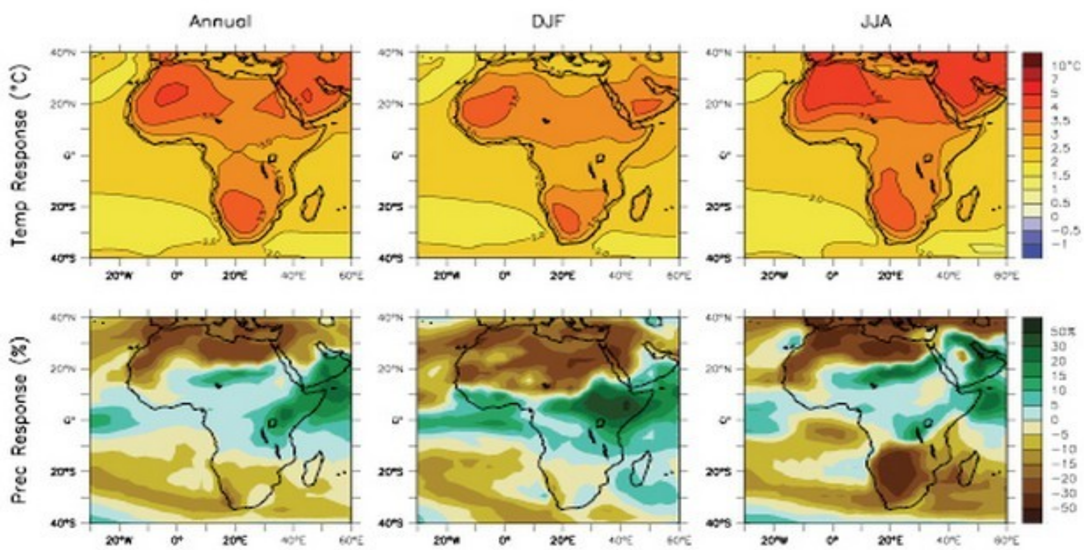

Fig. 2. Temperature and precipitation changes over Africa from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Bottom row: same as top, but for fractional change in precipitation.

[6] Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2012)[7] also depicts the global drought scenarios for 2046-2065 and 2081-2100, as shown in Figure 3. Standard deviation is used for the comparison, and it is likely to see more Consecutive Dry Days (CDD) and higher negative soil moisture anomalies (i.e. soil moisture deficit) in West Asia and North Africa in the latter half of the 21st century. These results indicate that the region might experience more severe droughts in the future.

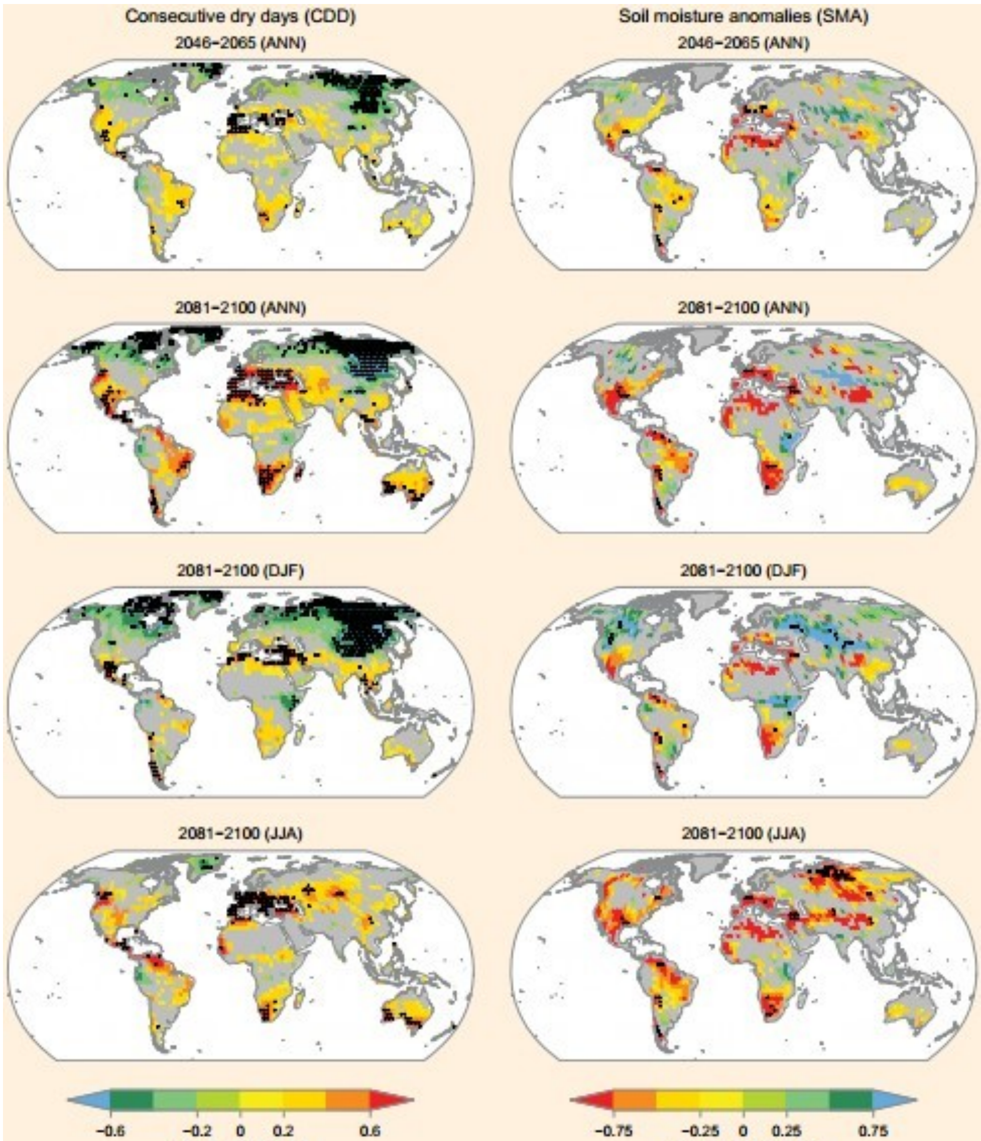

Fig. 3. Projected annual and seasonal changes in dryness assessed from two indices for 2081-2100 and 2046-2065 (top, annual time scale) with respect to 1980-1999.

[7] Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.). Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU ENGLAND, 582 pp.

2 Monitoring of drought and drought early warning systems

Drought indicators based on climate data and remote sensing products are at present the best available tools to monitor drought over large regions and time periods (Vicente-Serrano et al., 2012)[8]. The two most widely used indicators are the Standardized Precipitation Index (SPI) and the Palmer Drought Severity Index (PDSI). There are a lot of studies on the comparisons of different indicators and discuss about their advantages and disadvantages. For example, Zargar et al. (2011)[9] reviewed 74 of the 150 available drought indices, and further information can be found in their study.

Meteorological data is very essential for analytical tools to transform it into relevant drought indicators. In most countries of the region, meteorological networks are adequate, being well equipped and well sited. However, meteorological departments of the region (West Asia and North Africa) are poorly prepared for drought early warning systems. The reasons result from inadequate analytical tools for drought monitoring, unsuitable information products and insufficient data sharing. Most services still define drought as a negative anomaly from normal precipitation, in absolute or percentile deviations. Well-established drought indicators such as the Standardized Precipitation Index (SPI) or the Palmer Drought Severity Index (PDSI) are not used. Besides, there are no regular bulletins that target the agricultural user community or other stakeholders in drought mitigation.[10]

Considering the current trend and future projections for drought situation in West Asia and North Africa, drought early warning systems in global, regional and national levels are necessary because these systems provide the timely and reliable information necessary to make decisions regarding the management of water and other natural resources. Early warning systems can help not only in terms of decision making, but also in saving large amounts of economic costs. In Europe, it is estimated that hydro-meteorological information and early warning systems save several hundreds of lives per year, avoid between 460 million and 2.7 billion Euros of disaster asset losses per year, and create 3.4-34 billion of additional benefits per year through the optimization of economic production in weather-sensitive sectors (agriculture, energy etc.).[11] It can be imagined how much money the countries in West Asia and North

[8] Vicente-Serrano S. M. et al. 2012: Challenges for drought mitigation in Africa : The potential use of geospatial data and drought information systems. Applied Geography, 34, 471-486.
[9] Amin Zargar, Rehan Sadiq, Bahman Naser and Faisal I. Khan 2011: A review of drought indices. Environ. Rev. 19, 333-349.
[10] Source: Drought Early Warning Systems in West Asia and North Africa, DePauw E., 2000.
[11] World Bank policy research working paper, A Cost Effective Solution to Reduce Disaster Losses in Developing Countries, http://www.climateinvestmentfunds.org/cifnet/sites/default/files/WPS6058.pdf

Africa would save after establishing a robust drought early warning system.

Therefore, in this section, the drought monitoring and early warning systems in the United States and other countries, which have provided new early warning and decision-support tools and methodologies in support of drought preparedness planning and policy development will be introduced first, followed by the existing drought monitoring systems and early warning (forecasting) methods available to use in the West Asia and North Africa region, and the ongoing efforts of various organizations.

2.1 Drought monitoring and early warning systems in the United States, Europe and China

Monitoring

United States:

A partnership emerged in 1999 between the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln with the goal of improving the coordination and development of new drought monitoring tools. The U.S. Drought Monitor (USDM) became an operational product on August 18, 1999. The USDM is maintained on the website of the NDMC(http://droughtmonitor.unl.edu/) and this website has evolved into a web-based portal for drought and water supply monitoring. Figure 4 shows a drought monitoring map for US released on Mar 28, 2013.

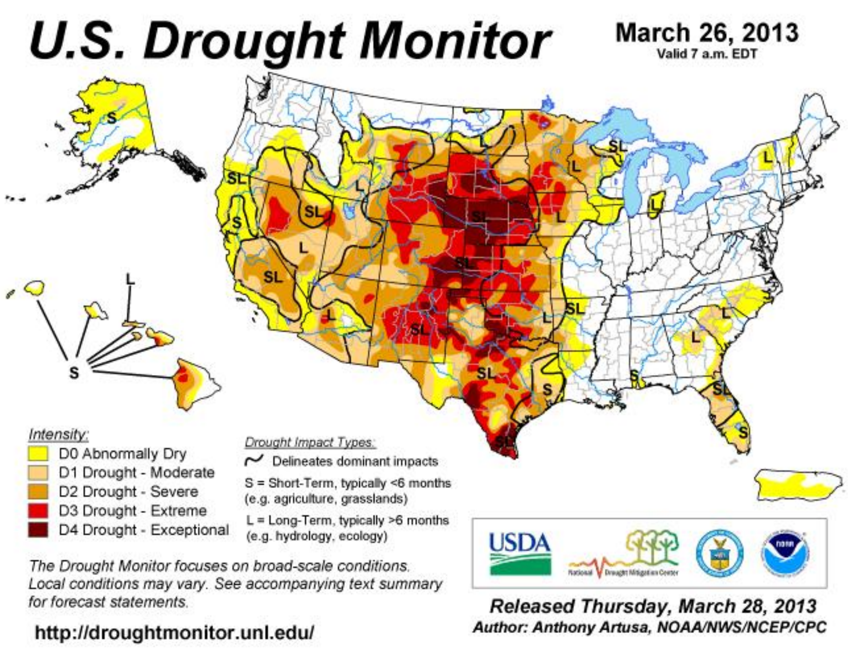

Fig. 4. The U.S. Drought Monitor map

Europe:

The drought monitor developed by the Drought Management Centre for South-eastern Europe (DMCSEE) and the European Drought Observatory (EDO) by European Commission Joint Research Centre uses a combine drought indicator, which is based on SPI, soil moisture and fAPAR. A map of droughts in Europe for 2nd ten-day period of March 2013 is presented in Figure 5. The color scales represents different drought scenarios: Watch means a relevant precipitation shortage is observed; warning means this precipitation translates into a soil moisture anomaly; and Alert means when these two conditions are accompanied by an anomaly in the vegetation condition.

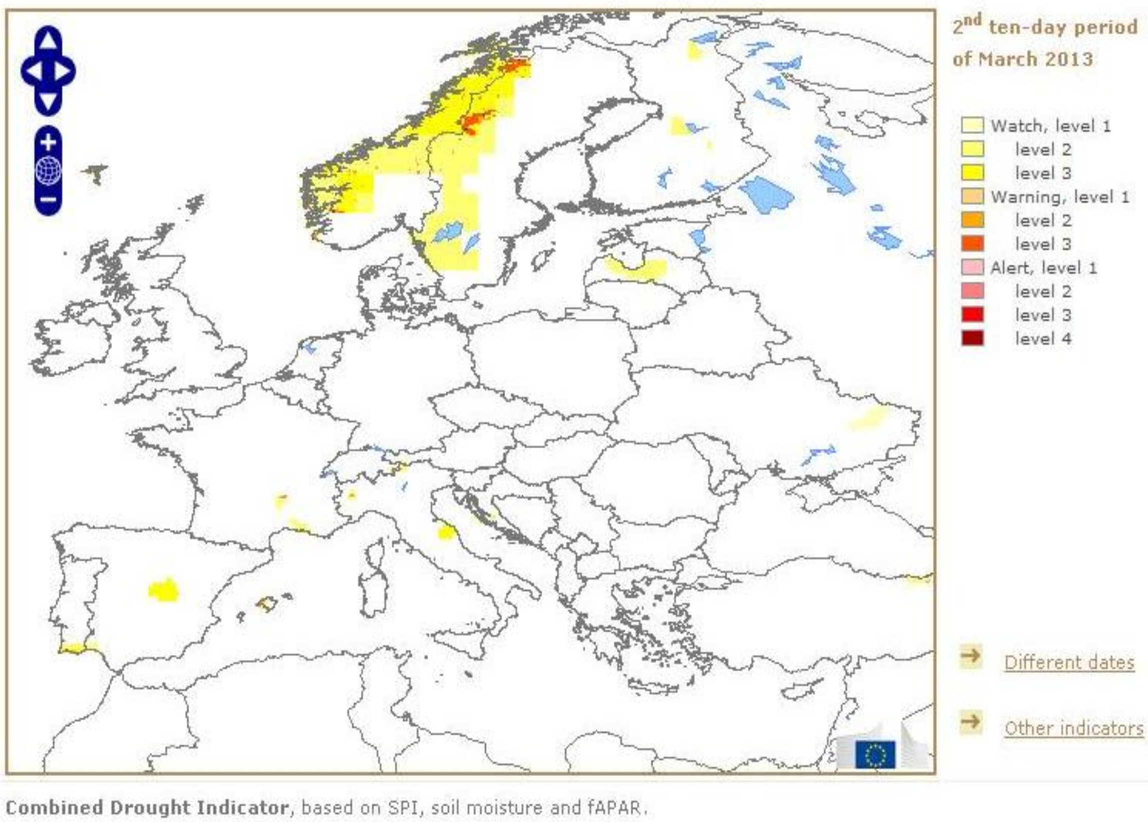

Fig. 5. The European drought monitor map.

China:

In China, the National Climate Center is in charge of the monitoring, diagnosing and predicting the droughts. Figure 6 shows a map on the website[12], which depicts the precipitation anomalies percentage national map on Apr 2nd, 2013. For the widely used indicators such as SPI and PDSI, there is no related information found on the website.

As we know, a single variable is not enough for monitoring drought. It is suggested that drought indicators should be introduced for better monitoring.

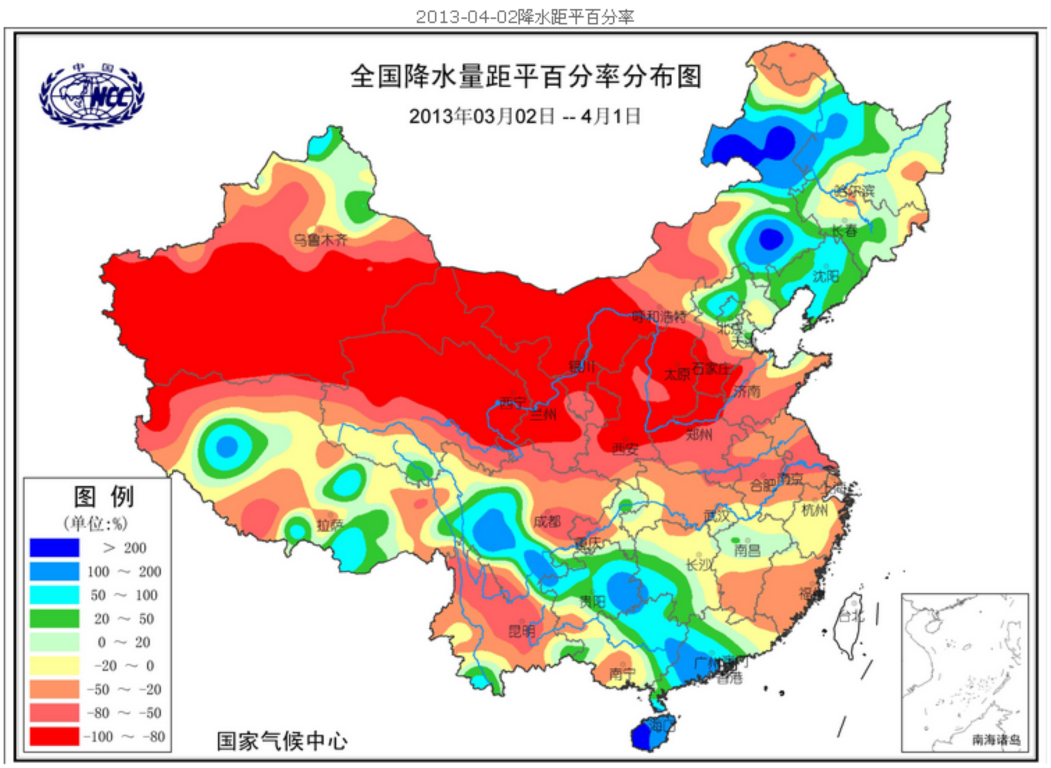

Fig. 6. China's drought monitor map.

[12] http://cmdp.ncc.cma.gov.cn/extreme/dust.php?product=dust_moni

Early warning

In terms of early warning, no information is found in the EDO or China's climate center's websites. The Climate Prediction Center of National Weather Service in the United States has done a great job. The U.S. Seasonal Drought Outlook[13] shown in Figure 7 depicts the drought tendency valid for about a 3-month period, which gives the decision makers enough time to prepare for the drought relief. It is also very user-friendly in terms of the easiness to understand the severity of drought in each region.

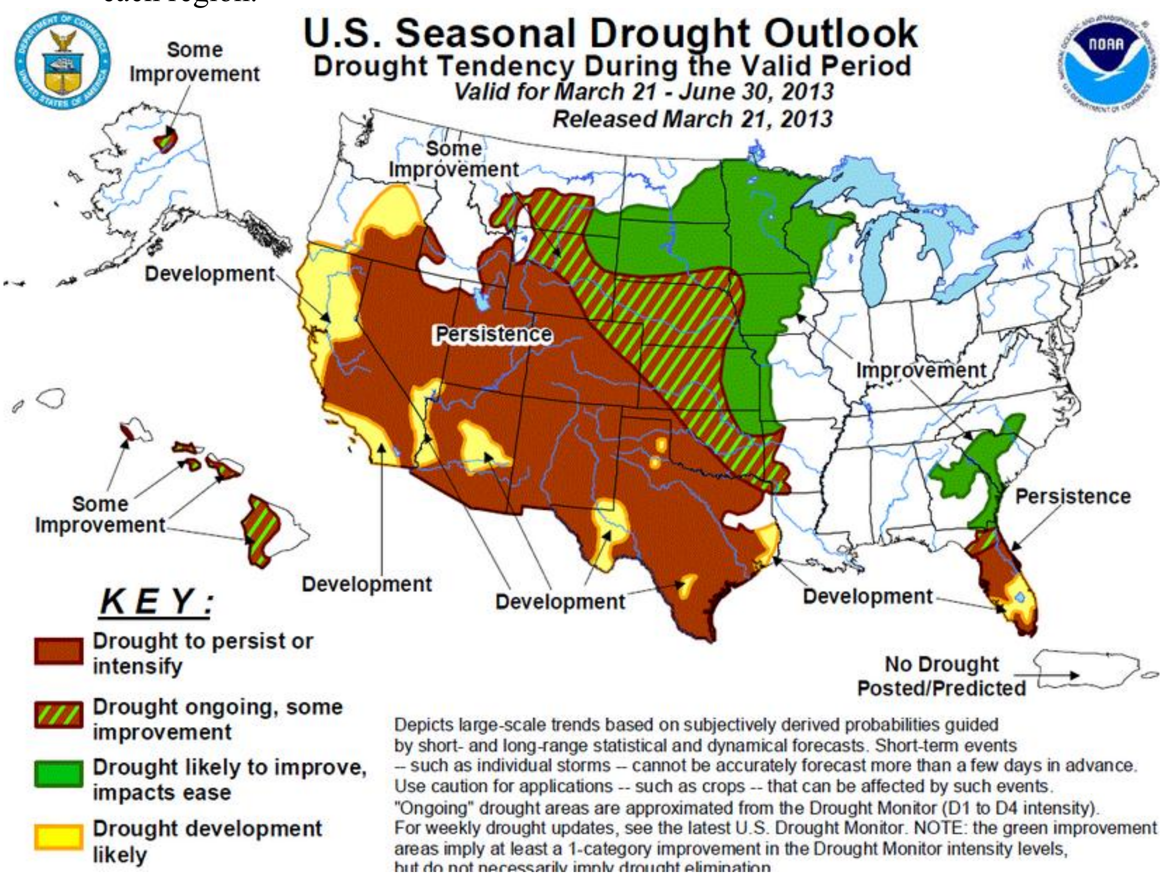

Fig. 7. The U.S. Seasonal Drought Outlook map.

13 http://www.cpc.ncep.noaa.gov/products/expert_assessment/season_drought.gif

2.2 Drought monitoring and early warning systems for West Asia and North Africa

Monitoring

The available drought monitoring systems for countries in West Asia and North America to use include: the experimental African Drought Monitor operated by the Land Surface Hydrology Group at Princeton University with support from the UNESCO International Hydrology Program [14] (Figure 8); the Global Drought Monitor, developed by the Department of Space and Climate physics of the University College London[15] (Figure 9); and the US Geological Survey (USGS) Famine Early Warning Systems Network (FEWS NET) Data Portal [16] and probably the most comprehensive one available. This portal is provided by the USGS FEWS NET Project, part of the Early Warning and Environmental Monitoring Program at the USGS Earth Resources Observation and Science (EROS) Center, and it provides access to geo-spatial data, satellite image products, and derived data products in support of FEWS NET monitoring needs throughout the world. 20 indices including SPI, Daily 10-day Moisture Index etc. are mapped and easily accessed. Figure 10 shows an Africa SPI map as an example.

[14] http://hydrology.princeton.edu/~nchaney/Africa_Drought_Monitor_Webpage/GMinterface.php

[15] http://drought.mssl.ucl.ac.uk/drought.html?map=%2Fwww%2Fdrought%2Fweb_pages%2Fdrought.map&program=%2Fcgi-bin%2Fmapserv&root=%2Fwww%2Fdrought2%2F&map_web_imagepath=%2Ftmp%2F&map_web_imageurl=%2Ftmp%2F&map_web_template=%2Fdrought.html

[16] http://earlywarning.usgs.gov/fews/africa/index.php

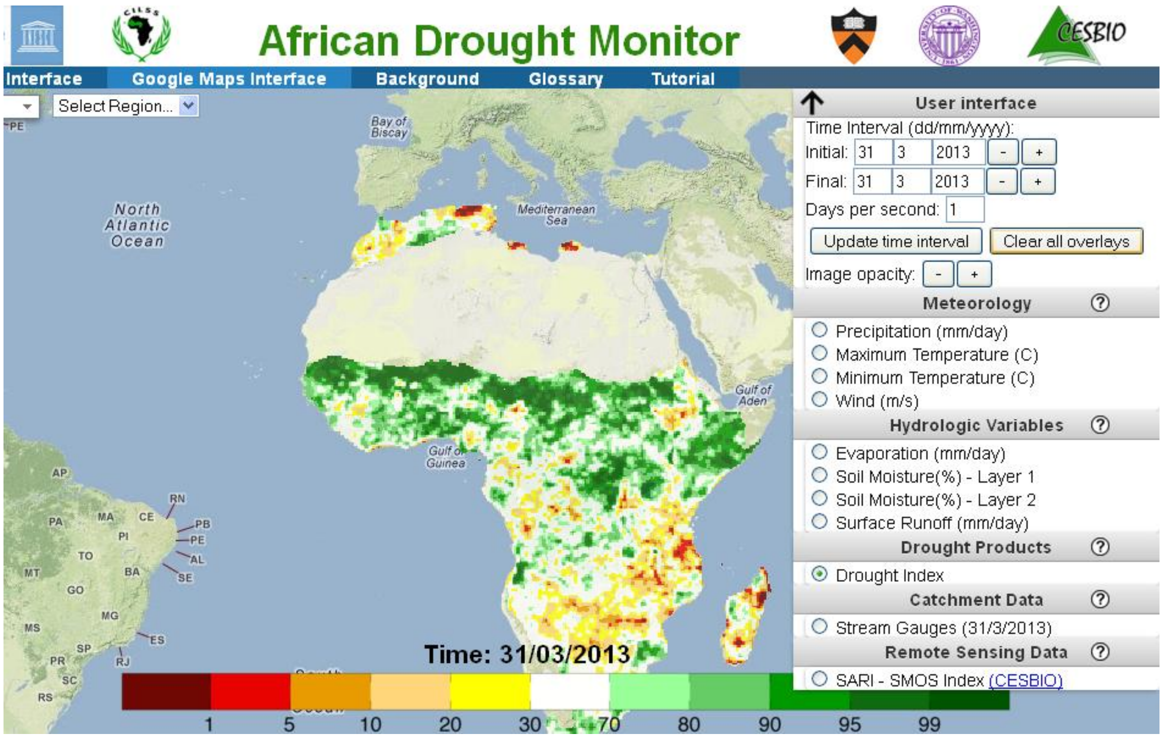

Fig. 8. The African Drought Monitor.

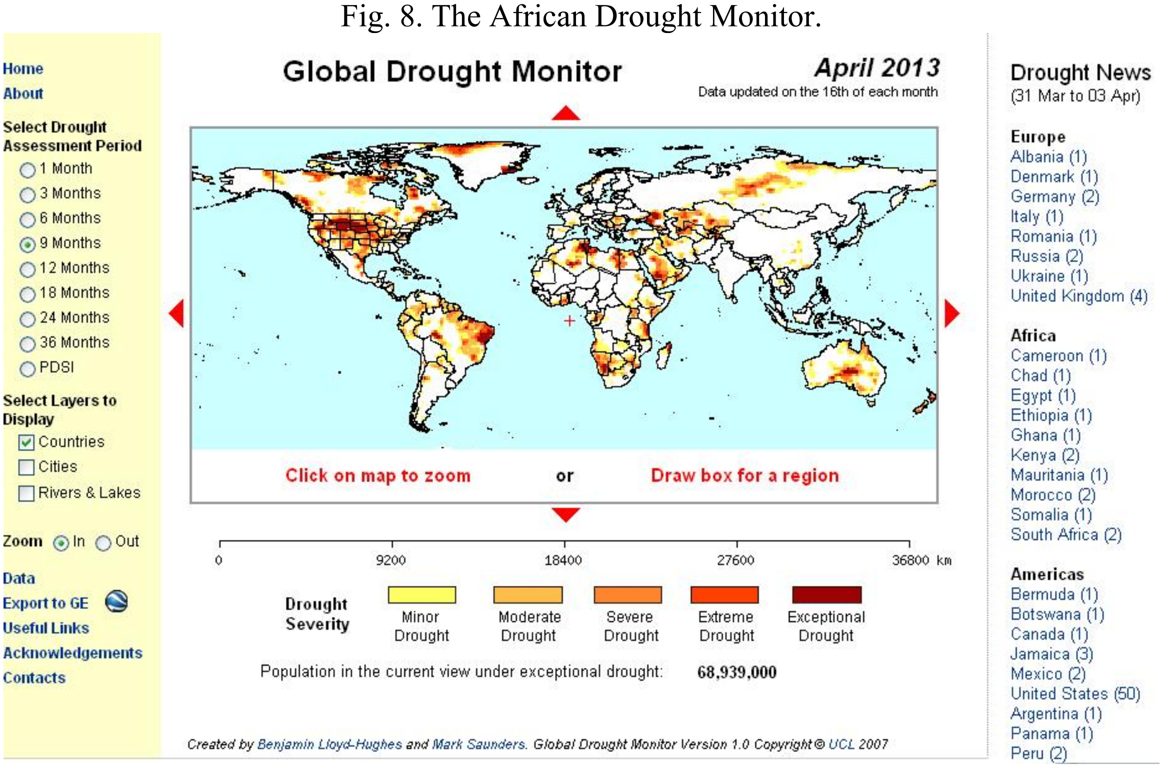

Fig. 9. The Global Drought Monitor.

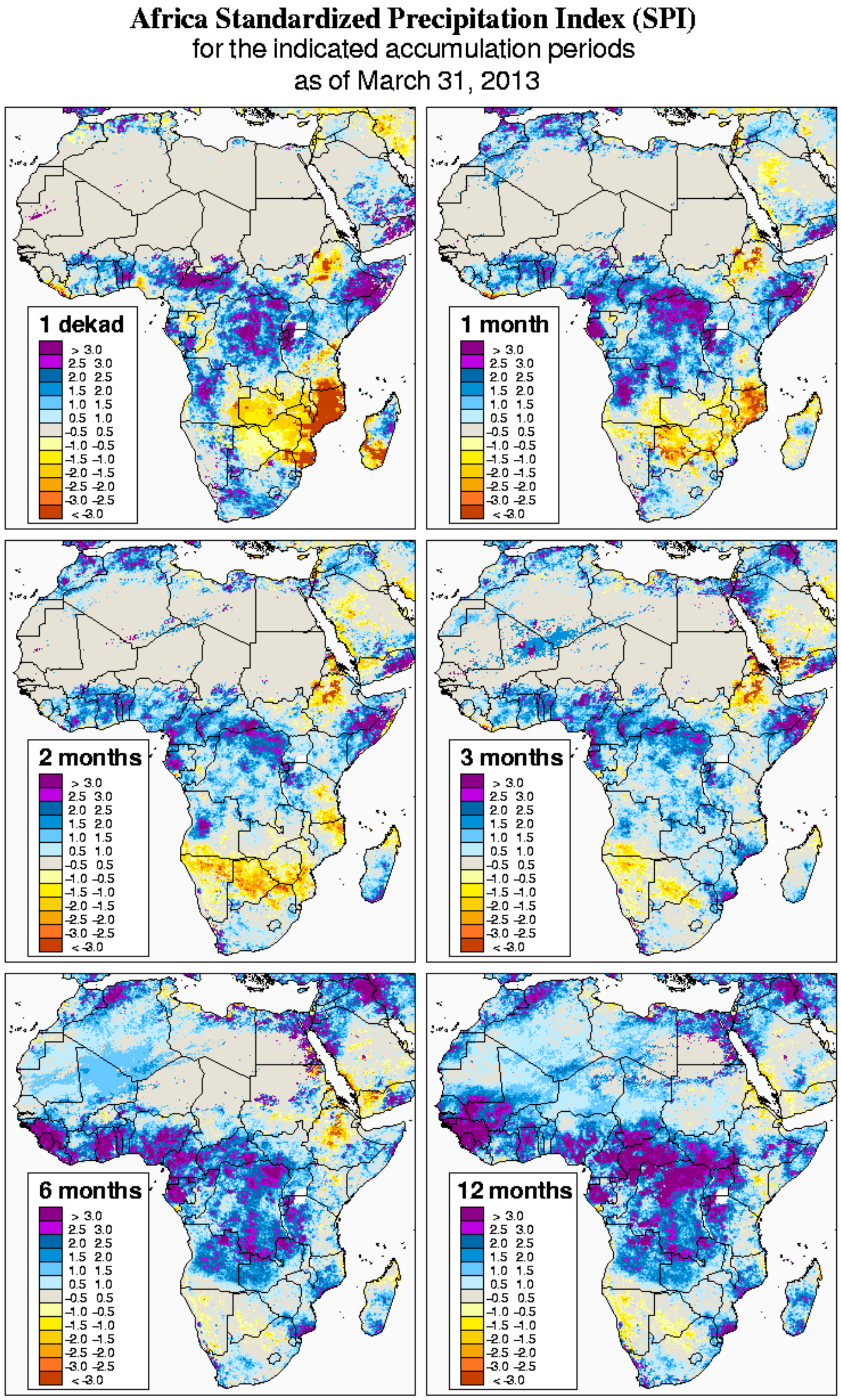

Fig. 10. Example Africa SPI map from FEWS NET Data Portals.

Early warning

Early warning of droughts relies on the drought forecast products in this region. There are a lot of methods to forecast drought. Since the European centre maintains a seasonal forecast up to 4 months lead in time for the entire Africa and National Center for Environmental Prediction (NCEP) in the US also provides long-term meteorological forecasting in Africa,[17] one way to do that is to use these climate dynamic model forecast of the variables such as precipitation to calculate the drought indicators for the future.

Considering the uncertainties existing in the model predictions, for operative purposes it is better to combine the model predictions with other empirically based predictions. Empirically based methods for drought forecasting have been developed based on the drought indicators, the historical frequency of rains and some other factors as predictors, such as sea surface temperatures and teleconnection patterns like North Atlantic Oscillation (NAO) and El Nino Southern Oscillation (ENSO).[17]

There are a lot of studies focusing on the drought forecast. Eshel et al. (1999)[18] developed a dynamically motivated statistical forecasting scheme for eastern Mediterranean winter rainfall with the resulting forecasts robust and statistically significant at about 13 months lead time. Mishra and Singh (2011)[19] reviewed different methods used for drought modeling, including drought forecasting, probability based modeling, spatio-temporal analysis, use of Global Climate Models for drought scenarios, land data assimilation systems for drought modeling and drought planning. More studies can be found in their paper. Figure 11 (their Figure 2) clearly shows the different components of drought forecasting. All of these researches provide a foundation for an operational early-warning system for droughts.

In fact, a lot of the countries in West Asia and North Africa already set up the observation networks retrieving the meteorological variables. However, the processes of turning the meteorological variables to drought indices are not built up yet, let alone the model predictions. Obviously more research is needed in this area, and this is the core for achieving a more drought resilient society.

[17] Challenges for drought mitigation in Africa : The potential use of geospatial data and drought information systems. Applied Geography, 34, 471-486.
[18] Eshel G. et al. 1999: Forecasting Eastern Mediterranean Droughts. Monthly Weather Review, 128, 3618-3630.
[19] Mishra A. K., Singh V. P. 2011: Drought modeling: A review. Journal of Hydrology, 403, 157-175.

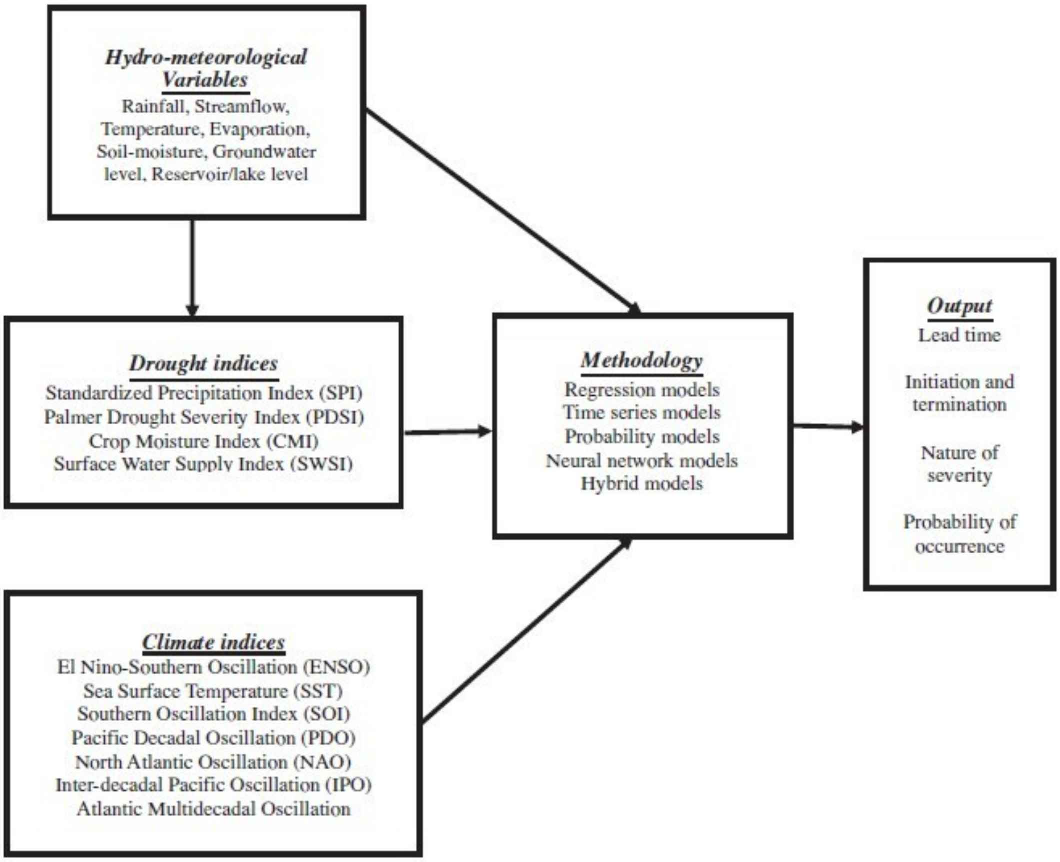

Fig. 11. Different components of drought forecasting (Mishra and Singh, 2011).

2.3 Ongoing efforts

Created in 2002, the Network on Drought Management for the Near East, Mediterranean and Central Asia (NEMEDECA) with the ICARDA, the Food and Agriculture Organization of the United Nations (FAO) and the Centre International de Hautes Etudes Agronomiques Méditerranéennes (CIHEAM), serves to enhance technical cooperation among concerned national, regional and international organizations in the region, which include nations in the Arabian Peninsula; Central Asia; the Mediterranean European region; North Africa, the Nile Valley and the Red Sea; and West Asia. The Network aims to promote risk, vulnerability and impact assessments of drought, prepare and create drought-preparedness and mitigation plans and boost cooperation in planning and implementing drought-mitigation programmes at national and regional levels.

Sahara and Sahel Observatory (OSS) established a network of 25 observatories for long-term ecological monitoring, and in North Africa, Algeria, Egypt, Morocco, Tunisia and Mauritania are involved. OSS also launched the SMAS project, to help establishing the drought early warning systems in Algeria, Morocco and Tunisia.

Starting from 2005, IBIMET-CNR developed an ambitious long-term training programme in cooperation with the United Nation Convention to Combat Desertification (UNCCD) Secretariat: Mediterranean Training Programme for the Harmonization of Early Warning Systems and Operational Instruments for Monitoring Climate Change and Desertification (MTP). MTP aims at improving technical cooperation and information exchange among National Meteorological Services and Institutions of Mediterranean Region facilitating the building-up of a scientific network among institutions for harmonization of methodologies and instruments in climate change and desertification impacts monitoring.[20]

3 Discussions

With some existing structures to use or known methodologies to work on, there are still some points to make clear before achieving a practical drought monitoring and early warning system in the West Asia and North Africa region. The key questions include, but not limited to which indicator(s) are best for monitoring drought, and what the threshold is for taking actions. To answer these questions, some studies should be conducted with the following steps:

1) Gather the data for calculation of the different indicators;
2) Calculate the indicators and look at the previous drought events to see whether the calculated indicators can reflect the real drought severity or coverage;
3) Compare among the different indicators, choose one or more according to their performance in terms of success of reflecting the real situation of the past events, and decide the threshold for taking action (relief measures).

4 Recommendations

For the partners, who are contributing to help the nations in West Asia and North Africa with building the drought management capacities:

Understanding the stakeholder and institutional arrangements, roles, responsibilities and capacity requirements is necessary to involve these stakeholders and institutions in drought initiatives, to develop appropriate products, to underpin the development of capacity as needed and to embed the products and knowledge developed within the drought mitigation plans.[21]

[20] Training programmes for the dissemination of climatological and meteorological applications using GIS technology.http://meetings.copernicus.org/www.cosis.net/abstracts/EGU05/09759/EGU05-J-09759.pdf
[21] Vicente-Serrano S. M. et al. 2012: Challenges for drought mitigation in Africa : The potential use of geospatial data and drought information systems. Applied Geography, 34, 471-486.

Putting more efforts in facilitating the cooperation among the countries in terms of data and technologies sharing is also of great significance.

For the countries in West Asia and North Africa, facing the drought risks currently and possibly expecting more severe drought events in the near future:

Research
More human and financial resources should be invested in the research on the drought forecasting methods and geospatial technologies, to improve drought preparedness and mitigation.

Education and training
The awareness should exist that the capacity of water management depends largely on the educated and trained water professionals. Holding training workshops in the national level and actively participating in the training sessions hosted by the international organizations are encouraged.

Keeping informed
The success of the early warning systems relies on the free flow of information. Drought monitoring unit might be set up to compile and interpret all data sources for monitoring drought extent and impact and report through regular or special bulletins to the central drought management unit.

Drought information should also be delivered to end users in a timely manner and in an understandable format to be effectively used in the decision making process and as part of a drought preparedness plan with the ultimate goal of creating a more drought resilient society. It is advisable to implement a drought monitoring and early warning system in national levels, integrating several sources of climate information, in an automated web server operating in real-time.

Joint responsibility is encouraged to involve more power in face of the battle combating the droughts and can be achieved through cooperation at local, national, regional and global level and through partnerships with a multitude of stakeholders ranging from the citizens to policy makers to the private sector.

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Vicente-Serrano S. M. et al. 2012: Challenges for drought mitigation in Africa : The potential use of geospatial data and drought information systems. *Applied Geography*, **34**, 471-486.

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Amin Zargar, Rehan Sadiq, Bahman Naser and Faisal I. Khan 2011: A review of drought indices. *Environ. Rev.* **19**, 333-349.