International expert symposium
"Coping with Droughts"

'Building a Community of Practice on Drought Management Tools'

19th – 21st November 2014, Santiago, Chile

Final Meeting Report

Access the Symposium webpage

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Introduction

The occurrence of droughts in Latin America and the Caribbean has a large impact on societies and local economies, causing long-term consequences for countries and their population. Climate change scenarios indicate further decrease in precipitation in those regions already prone to droughts, such as northeast Brazil and central-northern Chile, but also threatens to affect regions that have less developed drought response and mitigation strategies. This drives the need to count with effective management of drought risk, covering vulnerability assessment, drought monitoring and early warning, as well as institutional and policy components.

Recognizing the importance of international collaboration to the development of effective drought information tools and the critical need for these tools in an increasingly water-stressed world, this expert meeting aimed at creating a Community of Practice to support the development and use of drought information tools for effective drought management. This community is now embedded in international and regional networks, such as Áridas-LAC, the Center for Natural Resources and Development (CNRD) and the UNESCO Global Network for Water and Development Information for Arid Lands (G-WADI), in close collaboration with the Columbia University Global Centers and the Food and Agricultural Organization (FAO).

The Community of Practice (CoP) on Drought Management Tools encourages dialogue and collaboration as a means to inform and accelerate the development and use of effective drought information tools. The CoP allows all members of the group to share information and experiences with each other, providing members with an opportunity to exchange knowledge. It also creates an agenda to support students and researchers to identify new topics of research, connecting individuals from around the world and allowing them to work together on topics of similar interest.

This first meeting of the Community of Practice was organized around an expert symposium on 19 to 21 November. A broad call for abstracts was launched for experts and scientists on topics related to droughts in semi arid regions (presentations and posters), with the aim to bring different networks together (G-WADI, U. Columbia Global Centers, Aridas-LAC, CNRD network). The symposium was divided into 5 sessions:

i. Drought monitoring, remote sensing and drought indices;
ii. Drought Early Warning and Seasonal Forecasting;
iii. Decision Support Systems for Drought Management;
iv. Drought Assessment and Management in River Basins;
v. Drought Policy.

Furthermore, three working groups were established. They met each afternoon to discuss research and action demand in more detail:

i. Drought Monitoring, Remote Sensing, Drought Indicators and Seasonal Forecasting
ii. Drought Management in Catchments and
iii. Drought Mitigation and Policy

A short summary of each section is presented below. For more detailed information on the content, the abstracts and presentations can be accessed directly on the symposium website.

The key messages and outcomes of the meeting are presented in the Santiago Declaration, which can be accessed here.

Session 1: Drought Monitoring, Remote Sensing and Drought Indices

General Overview Presentations

During this first session, the main focus was placed on the different indicators available to measure and classify droughts, mounting to over 100 currently identified indicators. As Henny van Lanen stated in his presentation, there are a lot of indicators available but not all of them are suitable for each type of drought, while there is a relatively low correlation between them. In this sense, it is important to distinguish the different types of drought (meteorological, hydrological, agricultural and socioeconomical) and to implement complementary indicators per drought type and/or region. Furthermore, Amir AghaKouchak supported this message by presenting the PERSIANN and GIDMaPS systems that provides a composite index for meteo-agricultural drought as well as the Multivariate Standardized Drought Index (MSDI). Here again it can be seen that combining complementary indicators creates a stronger tool for assessing and improving early drought detection.

Nevertheless, Vincente-Serrano outlined the fact that the specific data for complex indices are often not available especially in South America, which leads to the fact that SPI is up to now the most used index. He indicates that evaporation should also be considered and included, creating the SPEI index (Standardized Precipitation Evaporation Index).

The newly launched International Drought Initiative (IDI) was also presented during this first session, and further discussed by Ali Chavoshian. He also made the case that drought exposure should be related to socio-economic factors, to effectively identify drought vulnerabilities and support policy and decision making to address all factors that are related to drought.

Case studies on drought monitoring in LAC

Different case studies were presented during the second part of this first session. Key messages include:

- **Mountainous areas/ Areas with scarce data**

Because of the lack of data in mountainous area (short or incomplete time series), the monitoring uncertainties can be quite high. A first step to deal with this problem besides high elevation climate, snow cover and discharge monitoring should be using rainfall satellite data (which are free and public) to reduce this uncertainty and to monitor and identify droughts.

- **Mexico**

After the severe drought in 2011, the Streamflow Drought Index (SDI) was used to include anthropogenic influence (e.g. reservoir management) in drought assessment. A complementary approach was used to consider the most important features of the region and to allow optimal climate informed decisions.

- **Chile**

There is a high influence of inter-decadal and inter-annual climate variability on drought. Indicators can help translate the impacts of extra-tropical forcings (e.g. ENSO, PDO, AOI) on the precipitation patterns for easier visualization and decision making. This work is currently ongoing for Chile.

- **Brazil**

LAPISMET in Brazil uses the advantages of remote sensing through the EUMETCAST system to assess droughts in the country where the relationship between meteorological and ecological scale is challenging. Remote sensing can also support the decentralization of decision-making.

- **Altiplano**

Queñoa, a long living tree present in the Altiplano, can be used to explore past climate (up to 1,000 years in the past), making this approach suitable to create a climatic archive. It explains ENSO retroactively and drought events in the past. A next step will be to include glacier mass balance reconstruction.

- **Honduras**

A combination of indicators was specifically developed for the country in order to generate local products and compare them to global sets. As a result, vulnerable regions to droughts in Honduras could be identified, based on objective, verifiable metrics.

Conclusions of Session 1

As a conclusion to this session, two observations can be highlighted. First of all, there are plenty of indicators available but not all of them are suitable for each type of drought, and there is a relatively low correlation between them. In this sense, it is important to distinguish between the different types of drought and to implement complementary indicators for each drought type and for different climatic regions. Secondly, if a clear relation is made between the drought and the socioeconomic problems that are a result of drought, effective tools can be developed for drought management that aim at reducing vulnerabilities and improving resilience to drought events.

Session 2: Drought Early Warning and Seasonal Forecasting

General Overview Presentations

The second session of this international symposium started with the presentation of Walter Baethgen focusing on the challenge of translating scientific advances in climate research into knowledge that is relevant for drought management, and in the institutional arrangements and the policy context in which climate knowledge needs to be embedded. This presentation highlighted the importance of communication between science and policy and decision makers, making the case that results from research should be communicated through already existing communication networks and that these should be further strengthened.

Eric Wood presented advances on how dynamical models can be used to provide seasonal forecasts of drought recovery in the coming months, which is very relevant for (agricultural) decision making. Using Ensemble Streamflow Prediction (ESP) the historical record was used to provide a joint distribution (or 'copula') of precipitation and soil moisture, which can then be used to evaluate seasonal forecasts of precipitation and provide a probability to the recovery of soil moisture. Another implementation of Drought Early Warning and Seasonal Forecasting was presented by Pilar Ycaza describing the role of CIIFEN and its partners. CIIFEN works with national meteorological services of Western South-America to deliver operational forecasts for max/min temperatures and precipitation every 3 months, as well as engages in the development of vulnerability assessments to drought and climate change.

Case studies on drought early warning in LAC

Meiry Sakamoto presented the work of FUNCEME in Brazil that provides drought monitoring and forecasting, highlighting how the network of hydro-meteorological monitoring and numerical weather modeling can provide an estimate of water inflow in reservoirs for improved decision making. The three pillars of drought, as identified by the World Bank, have also been used to frame the development of the Northeastern Drought Monitor in a broader drought management context.

Another interesting improvement was presented by Joel Rojas, who implemented a model using NDVI, from in-situ and ENSO data sources that could predict drought up to 1 month in advance. Although only validated for the northern coast of Peru, it shows potential for expansion to other regions in the country or abroad.

Conclusions of Session 2

What was presented during this session shows that significant work has been done to improve drought early warning and seasonal forecasting, but that challenges remain to standardize the different approaches and to provide effective information for decision making. Advances have been made to translate precipitation and temperature forecasts into more actionable information, such as soil moisture recovery or anticipated reservoir levels. Given that this information is highly relevant to migrate from reactive to pro-active drought management and to support the decision making process of multiple stakeholders, further efforts are needed to implement tailored local early warning solutions in the region, drawing upon these successful examples.

Session 3: Decision Support Systems for Drought Management

General Overview Presentations

In this session, several tools for decision support were presented. The Latin American Drought Monitor was recently inaugurated by Justin Sheffield and his team. This tool aims at providing an overview of current drought conditions, as well as future short term (7 days) and longer term, seasonal outlooks, and is especially relevant for data scarce regions. Currently, efforts are underway to calibrate and validate the drought monitor for improved accuracy and forecast skills.

Paulo Barbosa and Hugo Carrao presented the EUROCLIMA Desertification Land Degradation and Drought Observatory. The Observatory provides a web-based platform for detection and monitoring of drought in the region, with the objective to facilitate the integration of climate change mitigation and adaptation strategies into public policies. Through a large set of online tools, drought hazards can be visualized and compared for a comprehensive set of drought indicators. It also provides interactivity with national drought monitoring and mapping systems.

Oscar Rojas presented the "Agricultural Stress Index System" (ASIS) developed by the FAO GIEWS and the Climate, Energy and Tenure Division (NRC). This index was designed to detect agricultural areas with a high likelihood of water stress (drought) on a global scale using remote sensing data, and is based on the Vegetation Health Index. As it includes crop growth information, it allows monitoring of intensity, duration and spatial extent of agricultural drought. Currently, the system is going through testing and pilot case studies for further implementation in countries.

Case studies on drought decision support systems in LAC

In Latin America, national drought observatories are being developed. Liliana Villanueva presented The Chilean Agroclimatic Observatory, which is currently used by the Chilean Ministry of Agriculture. Providing historical drought frequencies, current drought monitoring tools of multiple indicators and early warning of future droughts, the Observatory is serving as a tool for local decision making. Ongoing efforts are focused on embedding the observatory as part of an integrated drought management strategy.

Following the same strategy, a drought observatory is currently being implemented in Peru. Fernando Chiock and Waldo Lavado presented the high vulnerability of the country's agricultural areas to droughts. The purpose of the drought observatory is to provide information and build resilience to drought vulnerability, by coordinating and combining the various sources of information in one operational drought observatory. Efforts are already ongoing to provide a set of drought indicators derived from remote sensing information and in-situ measurements.

Andres Ravelo presented how the terrestrial and satellite information can be used to determine the level of vulnerability and risks of droughts in Mexico and Argentina. The vulnerability can take structural and dynamic factors into account, providing tools to identify the areas that require additional support to improve their drought resilience.

Luis Samaniego presented the Multiscale Hydrologic Model (mHM) as a decision support tool for Drought Management, specifically focusing on soil moisture anomalies. Specific effort was put on evaluating different calibration and validation strategies, using a multiple model (ensemble) approach.

The SiGReRiD (Sistemas para la Gestion de la Reduccion de Riesgos de Desastres) was presented by Roberto Aroche as an example of monitoring system that could include intra-seasonal drought hazards, that are often observed in Central America and the Caribbean. As these short droughts can have significant social and economic impact, the need was identified to proceed with effective monitoring and early warning capacities of this drought phenomenon.

Maria Fernandez presented a methodology to estimate the water balance based on remote sensing dataset 'CMORPH'. The BHOA-CMORPH model captures spatial variability and allows to obtain information for locations where no direct observations are available. The Water Satisfaction Index (ISHi or 'Índice de Satisfaccion Hídrica') could be estimated from the BHOA model and proved a good yield estimator for maize up to two months before the harvest.

Eric Sproles presented two cases study that showed improved scientific and community-based understanding of water resources in data poor regions (the Elqui River and San Pedro watersheds). In the drought-plagued Elqui River watershed, remote sensing data and statistical models were combined to provide seasonal hydrological predictions using novel techniques. In the San Pedro watershed the first calculations of the water balance were developed using station and gridded climatological data, allowing to separate the climatic and management influences of the current water scarcity.

Franziska Zander presented the River Basin Information System (RBIS), a web-based data management platform, that allows analysis and visualization of real-time observational data. A case study in northern Chile was presented for the Limari Watershed (limariRBIS).

Conclusions of Session 3

As a conclusion of this third session, it can be seen that several tools are available to help support the decision making process in the region. Those tools range from regional drought observatories to national integrated drought management portals, while also more local-scale support systems are under development in pilot watersheds. Integration of these information flows remains a challenge, but efforts are on the way to link the information sources at these different temporal and spatial scales.

Session 4: Drought Assessment and Management in River Basins

In this section several case studies on drought assessment and management were presented, focusing on the River Basin Level, involving examples from Italy, Spain, Argentina, Costa Rica and Chile.

Claudia Vezzani presented the drought management and early warning approach in the Po River Basin, **Italy**. The development of the Early Warning System for the Po River (DEWS Po) provides the capacity for monitoring, but also for early-warning and 'what-if' scenarios. Also climate change impacts are evaluated by the DEWS model to identify long-term actions needed.

Another example of Drought Assessment and Management in River Basins was presented by Joaquin Andreu giving insight into the management of the Jucar river basin in **Spain.** He showed that drought management strategies have evolved significantly throughout the decades, forcing more and more integration of different institutional stakeholders, but at the same time also increasing the political power to create pro-active responses to drought hazards. This also gave way to joint modeling and monitoring of the basin, considering conjunctive uses of water, water rights and priorities, but also environmental requirements, sustaining an Integrated Participative Approach. Drought Monitoring and Early Waning is embedded in the watershed and triggers action from the different agencies involved. They stressed the importance of Customized Operational Drought Indicators and to have the capacity to evaluate specific real-time risk assessment and the efficiency of measures to be taken, to allow effective drought decision support.

Alexandra Nauditt presented a drought and water allocation management system for the case study of the Limari river basin, **Chile**. Based on a combination of hydrological and water allocation models, seasonal water availability can be predicted on basin scale and fed into a water allocation model on irrigation scheme level. A major restriction for the implementation (besides the current lack of water to manage) are the missing hydro-meteorological data in the Cordillera on the one hand and information transparency in the irrigation schemes (missing data on daily discharges in the channels, land use). During the discussion, somebody observed that even though this basin belongs to the most investigated ones in Chile, it is the most affected by the current drought as well as it was affected by the past drought events. A possible explanation is the continuous unsustainable expansion of cultivated area since the 70s until today and a missing connection between the researchers and the stakeholders.

A study case over the **Argentinean Andes** (Cuyo Basin) was presented by Juan Rivera. With the objective of investigating the inter-seasonal and inter-decadal climate variation, two methods were used: analysis of low flows and hydrological drought assessment through the Standardized Runoff Index (SRI). Three main results were highlighted: First, there is a presence of inter-annual and inter-decadal fluctuations. Second, the seasonal deficiencies in the Cuyo basins are linked to climatic variations in the 20 - 60 days band. And third, intra-seasonal variations are evident in temperature at different atmospheric levels, with short warm and cold pulses that acts as streamflow regulators during the months of November to February (temperature variations influence the snowmelt changes, snowmelt and precipitation determine drought events).

Oscar Melo and his team presented a survey about the perception of climate change and drought impacts in three basins of **Chile**. The background and motivation of this study was that a possible way to cope with drought would be the users adjusting their resources consumption to the current conditions and/or to the water availability. Because the adjusting of behavior depends on the perception of the water users, this perceptions and action taken by farmers and urban households needed to be investigated. The results showed that there was a difference between rural and urban area (flooding is a higher concern for urban zone), most of the people (>60%) declared being very vulnerable to drought, a large majority (>87%) declared perceiving climate change and expected future climate change conditions.

The objective of the presentation by Christian Birkel was to characterize temporal and spatial patterns as well as climatic and physiographic drivers of droughts in **Costa Rica**. As a result, two types of streamflow drought were detected; severe droughts of long duration but low volume deficit during the dry season and minor droughts of short duration but high volume deficit in the wet season. A method was also proposed involving climatic and physical catchment characteristics to predict streamflow drought indices.

Maisa Rojas presented a case study from **central-southern Chile**, using 28 CMIP5 coupled models in connection with the Variable Infiltration Capacity model (VIC), identifying the climate change impact on streamflows. As a result it was found that there is a significant change in the annual runoff amounts and shifts in runoff timing. Using the RCP8.5 scenario, Central/Southern Chile is projected to become warmer and drier (up to 30% by the end of the century), while in some areas (Maule River Basin) winter runoff is projected to increase because of the zero isotherm moving upward, although the streamflow in the annual cycle is expected to decrease.

Eduardo Salgado presented improvements of technological character as well as institutional organization governance in order to increase productivity of small farms in **Chile (Petorca)**. Involving farmers from the start, cultivation methods were evaluated and adjustments proposed, as well as intensive training courses were offered to the farmers and professionals. As a result, 40% of farmers increased their annual profits, while 44% achieved a positive change (higher selling prices and lower production cost).

Conclusions of Session 4

To conclude this session 4, two facts can be highlighted. First, spatial variability, topography, local climate conditions and hydro-geological characteristics demonstrate strong control on hydrological drought. Hence, drought management on river basin scale requires more local tailoring than global and regional drought management tools currently provide. Secondly, the connection between local stakeholders and researchers is crucial in order to translate the data and knowledge into practice on one side as well as to identify problems and research demands on the other side. Strong climate change signals have also been identified for some basins, requiring adequate adaptation strategies to be implemented, which remains a significant challenge. The basin approach also allows to assess hydrological and agricultural droughts impacted by unsustainable overexploitation of water resources.

Session 5: Drought Policy

General Overview Presentations

Mark Stafford opened the debate with the observation from his experience that 80% of our time is spent trying to understand the droughts, while only about 20% is spent on political incentives to adapt to drought. In fact, drought policies may perhaps be even more important than understanding the mechanisms. For example, the very fact that drought has a particular definition inhibits the initiative and increases inequities because the people are waiting for drought to be declared, previously to any kind of action against drought.

Chileans Presidential Delegate on water resources, Reinaldo Ruiz, explained the policies under development to manage droughts in **Chile**. The country has undergone major changes that affect water resources, as economic growth and development have doubled water demand but water availability has not changed significantly, while the water supply has also decreased due to climate change. In order to cope with this change in the future, some policy changes must be made to ensure universal access to water. Furthermore, the legal framework should be updated to take into account the new variables (water rights, climate change, etc.). Also desalination and national rainwater collection plans should be implemented in the future.

Francisco Espejo presented advances on the implementation of national drought policies in **South America**. The key elements are pro-activeness in the planning (assess and if needed, adapt policies), publicly oriented (the local population should be aware of the policies and educational material should be provided), including a resource management focus and improvement of observational network (observation and information systems should be tailored to the size of each country and existing networks such as universities, governments, private sectors, etc should be integrated).

Laura Meza presented new support to agriculture and drought management in the LAC countries. First, she introduced the holistic approach of agroclimatic risk management for Central America (risk management taking into account the community of producers, the market and the state). Secondly, the FAO support on drought management was presented. The FAO helps in knowledge management (tools and methods), in advocacy (high level meeting on drought) and in policy developments. Finally, Laura Meza presented the new approach, focusing on the cross sectorial dialogue (water-food-energy Nexus). An important point made during this presentation is that the stakeholder dialogue is central. Also it was made clear that politics and institutional arrangements actually decide if a drought management will be a success or a failure. In that sense it is crucial to have people to translate science into decision making.

Israel Velasco pointed out the inequality regarding drought policy and impacts. Indeed the administrative limits do not always fit the river basins limits nor the socials aspects. In this sense, different solution can be applied in the same basin, leading to different results. Furthermore, the vulnerability is analyzed based on the basin but the human vulnerability is not assessed. Vulnerability to drought is very subjective and drought does not affect everyone in the same way. Nevertheless, there is no standard solution, but it is clear the local expertise needs to be involved, giving a particular role for those who manage and operate the basins. This goes back to the conclusion of session 4, where it was made clear that drought management and hence policy should be made at a regional or basin scale level.

Anahi Urquiza presented a complementary study concerning the hydrological vulnerability from a social point of view. The vulnerability is associated with the social inequality (concentrated ownership, different vulnerability between the agricultures, increased migration countryside-city). There is also a limited amount of collective action (deterioration of the traditional collaboration and different organizations are duplicating the same work). Finally, the drought impact is often self-inflicted by absence of preoccupation for sustainable management and by exacerbation of the hydraulic stress. Taking into account the social aspect of vulnerability, a model of resilience must be provided based on the learning capacity of the different communities and their background (cultural and economical).

Ilka Roose presented her proposal of PhD about the social dynamics in water conflicts, **Chile** and two expected cases studies were presented (Chile and Mexico).

Rene Garreaud concluded that the multi-annual drought in **Chile** during the 2009-2014 period is a non-frequent phenomenon, with a connection to climate change. He also indicated impacts on the environment that could trigger effects downstream, such as on natural vegetation, forest fires and fisheries. Climatic forecasts based on numerical models suggest an increase in multi-annual drought in the future, doubling its probabilities.

Arreguin Cortés and López Pérez presented the new water policy of CONAGUA, **Mexico:** PRONACOSE. This policy was implemented to address drought risk and consists of three main pillars. The first one is about the drought monitoring and early warning system using indexes (SPI, SDI, etc.). The second pillar is about drought evolution at the basin scale (general agreements for the beginning and end of the drought and law enforcement to guarantee human water consumption). The last pillar is about the programs to prevent and mitigate drought (PMPMS). This integrated drought management effectively addresses all aspects of drought and allows moving from crisis management to drought risk management.

Conclusions of Session 5

As a conclusion for this session about drought policy, different aspects were highlighted. First, there is a need to move beyond drought monitoring and early warning, but to engage in drought policy and link this with monitoring efforts, specifically at the local scale. Also it was made clear that policy and institutional arrangements actually decide if drought management will be a success or a failure. In that sense it is important to translate and intermediate between science and decision making. Secondly, there are three keys element for an effective drought policy: pro-activeness in the planning (assess and if needed, adapt policies), closely involve the general public (the local population should be aware of the policies and educational material should be provide, while the stakeholder dialogue is central), include a resource management focus and improvement of observational network (observation and information systems should be tailored to the size of each country/basin and existing networks such as universities, governments, private sectors, etc. should be integrated). Finally, the social aspect should not be neglected. Indeed there is inequality regarding drought policy and impacts (on social, administrative and geographical level). The inequality resides in the fact that the vulnerability is associated with the social inequality (concentrated ownership, different vulnerability between the agricultures, increased migration countryside-city). Taking into account the social aspect of vulnerability, a model of resilience must be provided based on the learning capacity of the different communities and their background (cultural and economical).

Partners Funding Drought Management

A set of short overview presentations were given by the partners currently engaged in funding drought management in countries of the Latin American and Caribbean region. Francisco Espejo presented the efforts by the Spanish Cooperation (AECID) and the Meteorology Office (AEMET) with support from the WMO to streamline national drought management plans in the different countries of the region. Richard Escadafal presented the activities of the 'Institut de recherché pour le développement' (IRD) related to investigation, capacity building and innovation with respect to environment and natural resources, with specific mention of the Aridas-LAC programme for development in arid lands. Noosha Tayebi presented the ongoing activities of the World Bank, and especially its Water Partnership Programme (WPP) related to building drought preparedness and climate change resilience, with a special focus on supporting countries implementing effective drought management tools. Koen Verbist finalized the presentations with an overview of the projects and activities funded through the UNESCO Science Trust Fund with respect to drought management and water resources management, and more specifically the MWAR-LAC project and its follow-up activities.

Working Group Sessions

During the three days, each afternoon was dedicated to each of the three working groups:

iv. Drought Monitoring, Remote Sensing, Drought Indicators and Seasonal Forecasting
v. Drought Management in Catchments and
vi. Drought Mitigation and Policy

A short summary of the group work results are presented here:

Working group 1: Drought Monitoring and Early Warning, Remote Sensing and Drought Indicators

After introductory presentations of Humberto Barbosa on Remote Sensing for Drought Applications, Jorge Nuñez on the Latin American and Caribbean Drought Atlas and Andres Ravelo on Drought Indicators in use in the region, a brainstorming session was held to define a roadmap for effective drought management in the LAC region around four different topics:

1) What is the current funding basis available for drought management
2) What is the current capacity in the region
3) What are the current constraints and limits identified in the region
4) What are the current needs identified in the region

1) A clear lack of funding was identified, specifically to obtain meteorological data, the lack of an inadequate number of monitoring stations in many countries, and the lack of scholarships for graduate students to work on topics of drought management. The PEER programme was highlighted as a partnership between researchers in the US and international institutions, which could help with bringing some funding to the region.

2) Concerning the current capacity, the EUROCLIMA and G-WADI programmes were mentioned as supporting regional capacity building, but what is truly missing is to bridge the gap between scientific advances and awareness raising and uptake by national governments and local decision makers.

3) The major current constraints are limits for funding, the lack of interaction between countries and organizations and the lack of integration/understanding of how drought indices are related to/forced by different climatic oscillations.

4) A set of current needs were identified that need to be addressed in the region:

- Data should be made available, free of charge and through easy access;
- Coordinated efforts are needed to evaluate different drought indices or models;
- The need of the users should be identified, instead of assuming them;
- Drought management tools need to be adjusted to bring them in line with the user needs;

- More collaboration between decision makers at the policy level and scientists is required;
- A database of available drought indices should be implemented;
- Other climate hazards should be considered in the Community of Practice, apart from floods and droughts.

Working group 2: Drought Management in Catchments

During the first day, tools for drought management on river basin scale were discussed. In most drought monitoring systems and early warning, meteorological drought indices as SPI or soil moisture indices are used which do not consider topography driven climate variability, storage in reservoirs, groundwater and snow or overexploitation of water resources.

Santiago Penedo (ITT) held an introductory presentation on existing drought monitors worldwide and the applied indices. This reveals the strong demand for more site appropriate drought management tools and indices especially in regions of steep topography (Chile) with relevant storage.

Hydrological models are further tools to assess catchment based hydrological droughts, drought typology (VanLoon and Van Laanen, 2012[1]) to be used in short and long term drought prediction and scenario development. Christian Birkel held and introductory lecture on the role of hydrological models in drought management. Hydrological models can integrate the propagation of drought from meteorological into hydrological systems. Such models can support forecasting as well as to understand drought physical processes taking place. Major challenges for using models include data availability and uncertainties related to measurements and models performance. Models to be used in drought assessment need to be selected carefully. As with the indices, especially in semi-arid regions they need to have a strong ground water and storage component to be able to deal with low flow analyses. In snow melt driven catchments, snow dynamics need to be considered.

Eric Wood raised the question, who are the real users of such systems? Stakeholders, decision-makers, water users? In fact, the end user is still not the local farmer. Such systems should be demand driven according to the needs of users and water agencies not only from the research side. Moreover, the approach should be multi-sectorial including all interests within a basin. Each catchment has a different political and administrative setup which needs to be taken into consideration.

During the second day, the preparation of a Horizon 2020 project dealing with the establishment of a catchment indicator based alert system for semi-arid Southern European and South American catchments was discussed. River basin associations can play a key role for drought management as they are responsible for the water allocation in catchments.

Joaquin Andreu, former technical director of the “Confederación Hidrográfica del Río Jucar” and a renowned hydraulic engineer, introduced to the drought management plans implemented in the Jucar river basin, based on decades of experience with water allocation in dry years. For the Po river basin, Claudia Vezzani highlighted the missing consideration of drought vulnerability in drought management. Especially for the agricultural sector, drought vulnerability should be more thoroughly analysed and addressed in water allocation.

Missing indicators, tools and stakeholder involvement for drought management on catchment scale were discussed during the group work.

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[1] Van Loon, A. F., and H. A. J. Van Lanen (2012), A process-based typology of hydrological drought, Hydrol. Earth Syst. Sci., 16(7), 1915–1946, doi:10.5194/hess-16–1915-2012.

Working group 3: Drought Mitigation and Policy

The third working group began with an introductory presentation from Laura Meza on UN Initiatives focusing on National Drought Management Plans, from Francisco Espejo with a reports of the regional meeting on the Implementation of National Drought Policies in South America, Santa Cruz, Bolivia, 10-14 November 2014, and from Flavio Nascimento: Drought policy in Northeastern Brazil and was then followed by an open conversation with the different participants. The goal of the discussion was to obtain a proposal for the following elements:

- review of effective policies to address drought and mitigation strategies;
- elements needed in drought policies and;
- challenges and recommendations for implementation in the region.

In the following discussion, some points were highlighted. At first, the organization of "regional water discussion groups" seems to be well adopted by the communities, however there is sometimes a lack of organization of the communities, and also the absence of political actors and potential sponsors makes implementation of recommendations difficult. Secondly, even if there is much information, it is not always available for everyone (no internet access, no library, etc.). Also, the convocation of the discussion groups should be more decentralized.

Additionally a clear lack of education and awareness on drought hazards and vulnerability was identified. Indeed, there is no direct translation between the scientist and the final user, and the interpretation and the transmission of the information is still missing. On the other hand, it should not be forgotten that farmers have experiences and knowledge about their land and climatic variability. This should be taken into account and an exchange should be made between scientists and the final user that includes this additional valuable information.

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