Kingdom of the Netherlands

Mission Report DRR team Bolivia

Technical assistance on drought information and early warning systems

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Mission report DRR-team Bolivia

Otto de Keizer, Deltares

Johannes Hunink, FutureWater

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Executive summary

Responding to an official request of the Plurinational State of Bolivia, the Dutch government organized a DRR mission in May 2017 that aimed at providing technical and intuitional advice following the severe drought in 2016 that suffered the country. The mission was executed by an expert team consisting of Otto de Keizer (Deltares), and Johannes Hunink (FutureWater), and was supported by local expert Has Willet (advisor to the Bolivian Ministry).

To maximize outcomes, the mission was partly co-organized with three experts hired by the World Bank (WB) for an assignment with a similar scope. The DRR team and the WB experts aim at identifying bottlenecks and possible plans of action for the Bolivian government in how to address these drought challenges in the future. This report presents the results of the Dutch DRR mission; the WB team carries out a detailed reconstruction of the drought event, specifically analysed the situation in the La Paz/El Alto metropolitan area and is elaborating a separate report of their work in the following months.

The advice summarized in this report is based on intensive stakeholder consultations during the DRR mission. The principal stakeholders that were interviewed and with which discussions were held on possible future medium-term and long-term actions, are: the Ministry of Environment and Water, SENAMHI, the Water Supply Company of La Paz/El Alto, the municipality of La Paz, the Water Supply company of Potosí, among others. Also two field visits were organized to main water providing watersheds of respectively La Paz and Potosí.

The drought event was briefly characterized based on the information received during the mission and available reports. It became evident that response to the drought event was different across the country as was shown by comparing La Paz/El Alto with Potosí. Lack of communication and of a pro-active attitude caused a slow response in La Paz/El Alto and all stakeholders agree that impacts could have been considerably less severe if action was taken in an earlier phase (rationalization, infrastructural measures, awareness raising). Indeed in Potosí this was the case, and in spite of also have suffered severe consequences of the drought, the impacts have been minimized regardless of scarce available economic resources.

From the interviews, several lessons were taken – some of these based on conclusions from the involved parties themselves, others from discussions among the experts, including the WB team. A first recommendation is to start developing an in-depth drought risk and impact assessment, nation-wide and cross-sectoral, taking lessons from the 2016 drought event as a unique opportunity. Based on the observed impacts (post-drought evaluation) but also taking into account future changes (population, climate change, land use change) this risk-based drought impact assessment should allow to draft drought-focused policies, identify the most adequate indicators, and develop better preparedness for future similar droughts.

Secondly, drought information availability should be strengthened on different levels of administration and across different sectors. Tailored drought impact indicators (based on the drought risk assessment) should be monitored and included in a national drought monitoring system. This report provides concrete advice on how to set-up a national drought early warning system, to the extent possible using existing tools and capacities available in the relevant institutes. Such a drought information and early warning system may include a wide variety of information sources (precipitation anomalies, soil moisture, vegetation impacts, reservoir status, etc) based on different sources (weather and flow gauges, satellite information and local reports). A detailed

diagnosis of the services needed, will have to be carried out based on the experience of the recent drought event, responding to the needs of the different users.

We recommend that SENAMHI, as the national hydro-meteorological institute, maintains responsibility for the validation and also the integration of historical and real-time hydro-meteorological data on a national level. We recommend strengthening the professional capacities of SENAMHI as well as its financial basis. The institute should become more attractive to high-level professionals, a clear future vision should be defined, and the institute needs better oversight.

It is important however to differentiate between hydro-meteorological information and water management information, which includes impacts and vulnerabilities. For this reason, we recommend the creation of an (inter-sectorial) monitoring and early warning committee that advices the water authority (Minister of Water) before and during extreme events, and facilitates the availability of relevant hydro-meteorological and water management information. This Committee will be responsible for advising the Minister on drought and flood risk management, the upgrading of monitoring programmes, guiding the development of the drought information system. It will also be responsible for the identification of drought impact indicators, based on consultations with administrative bodies, different users and sectors, and facilitating the development of a national-level drought impact assessment.

On the other hand we recommend the creation of a National Water Centre (name to be defined). This National Water Centre needs to develop and provide relevant information in relation to drought risks and other water related risks, to all relevant regional and national authorities. It needs to have capacities for the development of strategic models as well as to maintain operational systems including a national drought monitor. The recently created 'Unidad de Estudios' within the Ministry may form a basis for the Centre, though close coordination with other ministries including Rural Development, Energy and Civil Defence is crucial. The Centre will also be the technical arm of the Monitoring/Early Warning Committee and give follow-up to decisions taken within this Committee.

Another important recommendation to the Bolivian government is to integrate Drought Management Plans in their current efforts to build organizational frameworks at the basin scale. An Integrated Water Resources Management approach is fundamental and more emphasis should be put on policies that promote full protection of watersheds and recovering measures in the mining areas. The Drought Management Plans should include the strengthening of water management capacities within the local and regional water users and managers. Water management decisions need to be taken on the lowest possible scale according to the subsidiarity principle, as long as the necessary capacities are available.

Abbreviations

AAPS	Autoridad de Fiscalizacion y Control Social de Agua Potable y Saneamiento Básico (regulator drinking water sector)
AAPOS	Administración Autónoma para Obras Sanitarias (Potosí)
DEWS	Drought Early Warning System
ENSO	The El Niño-Southern Oscillation
EPSAS	Empresa Publica Social Del Agua y Saneamiento S.A. (La Paz)
GAM	Gobierno Autónomo Municipal (municipality)
MDRyT	Ministerio de Desarrollo Rural y Tierras
MMAyA	Ministerio de Medio Ambiente y Agua
VIDECI	Viceministerio de Defensa Civil
SENAMHI	Servicio Nacional de Meteorología e Hidrología
SINAGER	Sistema Integrado de Información y Alerta para la Gestión del Riesgo de Desastres
SENASBA	Servicio Nacional para la Sostenibilidad de Servicios en Saneamiento Básico
SPEI	Standardized Precipitation Evapotranspiration Index
VAPSB	Viceministerio de Agua Potable y Saneamiento Básico
VRHR	Viceministerio de Recursos Hídricos y Riego (MMAyA)

1 Introduction

In April 2017 the Dutch government received an official request for support from a DRR-team from the Ministry of Environment and Water of the Plurinational State of Bolivia. From May 7th to 12th an expert team consisting of Otto de Keizer, Deltares, and Johannes Hunink, FutureWater, visited Bolivia. The Dutch team was supported by local expert Has Willet (Dutch advisor to the Ministry) and Ricardo Galindo (Trade Office of the Dutch Embassy), and was joined by a team from the World Bank consisting of Chris Fischer, Angela Salinas and Carlos Olmos. Both the World Bank and DRR Team share an interest in the drought conditions in Bolivia and in identifying possible plans of action for the Bolivian government in how to address these drought challenges in the future. Throughout the mission, they closely coordinated their work and constantly exchanged information. This report presents the results of the Dutch mission; the World Bank team focused on the reconstruction of the drought event and specifically analysed the situation in the La Paz/El Alto metropolitan area and is elaborating a separate report of their mission with slightly different objectives. Annex A provides the executive summary of the World Bank report[1].

A drought period of 11 months – continuously and ongoing - related to El Niño conditions struck the El Alto-La Paz metropolitan area with an acute water shortage in November 2016. The increasing demand for urban water and growing difficulties to provide future water needs are a common feature of the quickly growing population centers. While these issues have been a technical and political concern for several decades, water companies were faced with empty reservoirs by the end of 2016 – also as a result of ENSO conditions last year - and were forced to cut water delivery, affecting La Paz, El Alto, Potosi and other urban centers in an acute manner. Immediate consequences were a deregulation of urban functioning, health threats, organizational disorder, loss of trust in government institutions, social protest, and dismissal of authorities, among others.

[1] Fischer, C, García Ágreda, C.O. y Salinas Villafañe, Á. LA SEQUIA 2016 EN BOLIVIA Y SU REPERCUSIÓN EN LAS CIUDADES DE LA PAZ Y EL ALTO; Reconstrucción del evento, evaluación de capacidades de gestión y recomendaciones hacia el futuro. Junio, 2017.

Figure 1 Hampaturi reservoir, in La Paz during the drought period[2]

As the 2016 events have demonstrated, improving drought forecasting and monitoring demands urgent attention in order to provide water managers, authorities and the urban and rural population with the necessary information and early warning to be better prepared in the case of future drought events. While some progress has been made in the past with the development of flood early warning systems, the technical, infrastructural and institutional adaptation of these systems to provide drought early warning is an urgent issue today.

This is in line with the 7th global target of the SENDAI Framework for Disaster Risk Reduction: to substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

This report prepared by the DRR technical mission provides the Government of Bolivia (GOB) with advice on technical, institutional and financial conditions to be regarded for the short and long term water security through the setup of an effective drought early warning system.

Chapter 2 summarizes the conducted activities, chapter 3 presents the lessons learned based on the 2016 event, and chapter 4 provides an outline for a national drought information and early warning system. The event resulted in many multilateral and bilateral initiatives to support Bolivia on drought management, which are presented in chapter 5. Chapter 6 gives the final recommendations for the Bolivian government and suggests next steps.

[2] http://www.infobae.com/america/fotos/2016/11/22/fotos-emergencia-nacional-en-bolivia-sufre-la-peor-sequia-en-cuatro-decadas/

2 Conducted activities

As explained previously in the Introduction section, this DRR mission (purposely) coincided with a WB mission with a similar goal. Most the activities of this DRR mission were organized and carried out together with the WB team, to ensure meaningful results for both parties and to possibly align DRR-recommendations with potential WB-funding for follow-up activities. A difference with the mission of the WB team is that the focus of the WB was the reconstruction of the drought 2016 with a specific focus on the La Paz/El Alto region, an inventory of ongoing and planned government activities to increase drought resilience and the elaboration of general recommendation to improve drought management, while the DRR mission targeted specifically drought monitoring and early warning at the national scale.

The following sections contains a short day-by-day description of the activities carried out.

2.1 Sunday 07-May

The WB team and the DRR team met in a preparatory meeting on Sunday 07-May to learn about the goals and expectations of the respective missions. The WB team had started their analysis in the previous week and were able to present to the DRR team with an extensive overview of the information collected so far, with useful background information and some first insights. The planning of the week was finalized and coordinated among the teams.

2.2 Monday 08-May

Monday started with a visit to the Achachicala WTP of the La Paz/El Alto water supply system. A meeting took place with management staff and the technical director of the drinking water company EPSAS. The visit was accommodated by Maria Luisa Padilla of VAPSB.

The technical director (Ing. Tomas Quisbert Guarachi) explained how the drought of 2016 evolved and affected their operations, what information they had access to, and what difficulties they found on the institutional level to manage the drought situation. He indicated that a positive outcome of the severe drought that the city experienced is that planned investments in the Master Plan that were delayed are now finally being implemented: the drought situation triggered the authorities to take the necessary steps, and took away certain social obstacles in the intervention areas. He explained that according to their records, 2016 was the driest in at least 16 years. Furthermore, he indicated that the city experienced a less severe drought event in 2010. He found that in 2010 the authorities were more responsive in taking water saving measures. A second important factor that explained the slow responsiveness in their view was the large uncertainty in the drought forecasts provided by SENAMHI.

In the afternoon one of the main watersheds providing water to the La Paz/El Alto system was visited: the Milluni watershed. This watershed is under pressure due to mining activities, causing severe contamination issues (heavy metals). To reduce negative impacts on water quality, a bypass was made around the contaminated sites. However, from the visit it was evident that this only solved the problem partially and that the mining activities are currently causing a severe threat to water quality and water security in the city.

Figure 2 A mining waste pond (on the right), just upstream of the reservoir (on the left) used for water supply La Paz/El Alto

In the evening a meeting was organized at the Ministry of Water and Environment (MMAyA), to inform the Minister Ing. Ortuño and other high-level representatives of the Ministry on the mission and receive first feedback and suggestions. The Minister confirmed the need for better drought monitoring and early warning. He suggested to focus on three levels for DEWS: (1) national level providing a global overview of the drought situation to the decision makers in the Ministry, (2) river basin level, for the larger basins that have some kind of river basin partnership in place, (3) water users as drinking water, hydropower, etc. Also other institutional aspects of drought management were discussed. It was agreed to have a meeting on Thursday to brief the Minister and his team on preliminary outcomes of the mission.

2.3 Tuesday 09-May

A meeting at the VRHR took place, with as main representative the director of reservoirs and of the department of studies (Ing. Oscar Meave). Ing. Meave updated the DRR and WB team on the various related units within the Ministry. He explained on current developments taking place related to drought monitoring (for example SPEI calculation based on about 100 weather station data). The intention is to integrate these developments in the Delft-FEWS system they have in place since a few years. This confirms that the Ministry is very much aware of the need to improve drought forecasting and build capacity within their own departments. They explained how the drought was monitored based on the emergency declarations of the many municipalities in the country (mostly related to impacts on crops and livestock). They stressed however that these declarations are generally not contrasted with observations by the Ministry. The DRR team indicates that remote sensing information can be very useful for this, allowing semi-real-time monitoring of drought impact on biomass (crops and fodder).

Later a meeting took place in the SENAMHI office. Luis Noriega (General Director), Leo Pereira (Director Risk Management) and a few technical staff were present. SENAMHI presented the different activities they carry out and new developments related to drought monitoring. Several products are being prepared in collaboration with the Ministry of Agriculture. SENAMHI stressed they are under-staffed and that it is difficult to preserve their capacity in-house: people tend to leave the organization soon due to poor salary conditions. They expect that a new project, though not approved yet, that extends the station network considerably and includes some staff extension, will improve the situation. The DRR and WB team agreed that this is positive but that a more structural change is desirable for SENAMHI to bring it to the level required by the different institutions that depend on their services. Contracting highly-educated experts (MSc, PhD) should be part of this change. WB stressed that the WB-financed SNICA project is particularly aiming at strengthening capacity in the water resources monitoring aspects of SENAMHI.

Figure 3 Meeting at SENAMHI

In the afternoon, there was a meeting with AAPS (Ing. Victor Hugo Rico and technical staff). Institutional aspects were discussed that negatively impacted the decision making during the drought event, and how these can be improved, specifically the relationship between ESPAS and AAPS. AAPS regulates 70 drinking water operators; drinking water companies inform AAPS on their contingency plans and AAPS can provide observations. Each semester drinking water companies must provide a technical and financial report. AAPS provides support when capacities are lacking. AAPS criticized the management of EPSAS that they did not provide information on the contingency until a very late stage.

The final meeting was with the Municipality of La Paz, with Martín Fabbri, director of municipal companies and public services, Ruben Ledezma, Director of Prevention and Environmental Control, and with Jorge Sotez, Advisor to the Municipal Water Program). They emphasized the importance of the issue for the municipality and the total lack of communication and transparency from EPSAS. The municipality even did its own monitoring, including the use of a drone to monitor the water levels in the reservoirs used for drinking water. The municipality observes an 'absolute' need to transfer the responsibilities from EPSAS to a metropolitan water authority. Apparently this was always the plan since the de-privatization of the drinking water company, but the national government needs to take a decision in this respect.

2.4 Wednesday 10-May

The DRR team travelled to Potosí: a town (200k inhabitants) that experienced severe problems during the drought 2016 but that managed the situation differently as in La Paz/El Alto. DRR team is accompanied by a representative of VAPSB and of SENASBA. In the morning, a meeting took place with the director and technical staff of the municipal drinking water company AAPOS. Raising awareness amongst the inhabitants, already in an early stage of the drought was crucial in Potosí. Rationing water provision started already in an early phase, based on the water availability expected over the next months. Drought forecasts by SENAMHI were consulted but not used as in their experience they often cannot be trusted. In spite of these anticipatory measures, the severity level of the drought finally lead to drastic rationing of water with considerable social impacts.

Figure 4 Meeting with the drinking water Company of Potosí

Several immediate infrastructural measures were taken, but also several long-term projects have been initiated or proposed. The short-term measures have already improved the situation considerably (groundwater pumping, tanks, additional water transfers, improved connections in the network). For some other medium- and long-term measures, e.g. the construction of a new channel section and additional pumping capacities within the city, financing is still being pursued.

The economy of Potosí relies principally on the mining sector. Before the drought 2016, AAPOS sold water to the mining sector, which accounted for approximately half of annual revenues. During the drought, priority was given to urban water supply and the mining sector has started to look for other water sources (groundwater, etc.). As these sources are generally cheaper, AAPOS has lost this client and a significant part of their income. During the meeting, VAPSB provides some suggestions on financing options of the necessary investments.

In the afternoon, a visit of the upstream water-providing watersheds takes place. The watersheds include 29 small reservoirs for water storage. No mining activities take place within these watersheds today, however the DRR team considers it desirable to formalize the protection of the watersheds to prevent future increasing pressures from the mining sector and new communities.

Several of the dams were built during the Spanish colonial period and experience issues: leakage and ceding. The representatives express an urgent need for specialized expertise and advice on how to strengthen these historic earthen-built dams. The main challenge with this is that the dams are historical heritage which means that the original structure needs to be respected. The DRR team indicated that possibly the Dutch water and engineering sector can support and indicate they will follow-up.

Figure 5. One of the reservoirs (on left side of photo) used for the water supply system of Potosí

2.5 Thursday 11-May

The DRR team travelled back to La Paz and met with the WB team. Both teams update each other and a joint plan is made for the final meeting at the Ministry in the evening. A large group of high-level representatives of the Ministry and related institutes participate in the meeting. The WB team presented the preliminary conclusions from the analysis of the drought 2016 event (see summary in next section in this report), institutional analysis, and current initiatives. Based on the inputs received during the mission, the DRR team shows a preliminary framework and design of a DEWS at different decision levels (see section 4.2 of this report)

2.6 Friday 12-May

A final meeting at the WB took place to discuss the main messages, next steps and the initiatives of the WB in relation to drought early warning.

3 Lessons learned based on the drought of 2016

To address water scarcity and drought in Bolivia with adequate policies, investments and decision-support tools, lessons need to be taken from past drought events. In general, drought management is a dynamic and iterative process that needs to be regularly revised and updated according to the current conditions in the country, and identifying or improving the policy indicators. Post-drought evaluation is critical therefore, and outcomes of such an evaluation process should be incorporated in the national water resources planning process. Post-drought evaluations establish a baseline for the revision of drought policy and allow to update and improve existing drought management instruments that are in place.

This chapter can be considered a first quick-scan of the severe drought that suffered Bolivia in 2016. More in-depth analysis should follow including an analysis of climate, social, and environmental aspects, and an evaluation of the effectiveness and weaknesses of the drought policy and implemented mitigating measures. A first notable report in that direction was published recently by VIDECI/UNICEF that performed an evaluation of the emergency measures carried out during the drought[3].

3.1 Characterization of the 2016 drought event

Based on the information received from the interviews during the DRR mission and the available reports and studies, we summarize the key moments and decisions that determined the course and evolution of the 2016 drought event affecting the La Paz/El Alto metropolitan area and other areas and cities of Bolivia like Oruro, Potosí, Cochabamba and Sucre. A more detailed reconstruction of the drought event is currently being prepared by the World Bank mission.

- By the **end of 2015**, SENAMHI publishes a seasonal climate forecast based on The El Niño-Southern Oscillation (ENSO) cycle that shows where in Bolivia water excess and water deficits are more probable to occur during the following season(s). For some regions, a higher probability for flood events is predicted (mainly in the plains, and in the La Paz/El Alto region), for other areas anomalous dry conditions (Los Valles and Altiplano).
- This drought forecast is followed by an Action Plan ("Plan de Acciones inmediatas ante el fenómeno EL Niño 2015-2016"). In Dec-2015 this plan is approved by Supreme Decree 2618 and assigns resources to implement the actions in the health, nutrition, production and water sector.
- **Feb-2016:** SENAMHI carries out another forecast that indicates a higher probability and extension of the drought hazard. Because of this, a new Supreme Decree (No. 2675) modifies budgetary assignments to drought mitigation measures across the country, extending to 65 municipalities more than originally planned in the Department of Beni, La Paz and Tarija, according to data from the Vice Ministry of Civil Defence.
- **May-2016**: The drought further intensifies and starts affecting even more municipalities than foreseen in the Action Plan. The Ministry of Environment and Water delivers a number of tanks to municipalities of Potosí, Oruro, La Paz and Cochabamba. However, many municipalities like for example Potosí (visited during the DRR mission) do not receive sufficient means to allow proper water distribution among the inhabitants and are starting to face social impacts.

[3] UNICEF/VIDECO, 2017: "Evaluación/sistematización de la preparación y respuesta en el marco del plan de acciones inmediatas ante el fenómeno el Niño 2015-2016" Informe final de evaluación

- The reservoirs that supply La Paz/El Alto start to reach considerably lower levels than normal and EPSAS reports this to AAPS. Their calculations indicate in May 2016 that there might be problems with water availability by the end of the year. In **August 2016**, a contingency plan was made but no decisions were taken until November 2016.
- **Nov-16**: EPSAS communicates that it will start rationing water as the two reservoirs Incachaca y Hampaturi, that provide water to about 350.000 persons and 94 zones of La Paz have minimum water levels of 6% and 1% respectively. Authorities inform they will start transport drinking water from surrounding areas and supply it to the inhabitants by large emergency tanks installed in the various neighbourhoods. The operations were supported by the army. According to statistics, about 6.5 million litres of water were distributed each week during the emergency period. Also, several emergency works were carried out, with support of the army, that connect the city with the Hampaturi reservoir.
- By this time, in the rural areas, official records of the "Viceministerio de Defensa Social" say that more than 600.000 hectares of agricultural areas and 550.000 animals were affected by the drought, in 8 of total 9 departments of the country.
- On November 21, 2016, State of National Emergency is declared because of the drought situation, urging the State, Departmental Autonomous Governments and Municipal Autonomous Governments to mobilize resources for all type of emergency measures to guarantee water supply to the population.
- The government creates a Ministerial Water Cabinet, consisting of representatives of all the main ministries, and responsible for coordinating all emergency actions at the national level.
- In **Jan-17**, moderate rainfall partially alleviates the situation but the emergency situation continues several months further in 2017.

Overall, based on the information received during the DRR mission, we conclude that the 2016 drought event caused the following principal negative impacts across the country:

- Economic:
    - Decreased production in agriculture, hydroelectric energy, industry, and financial activities that depend on these sectors. Unemployment caused by decreased production
    - Income reduction for water firms due to reduced water delivery (this was especially evident for the Potosí water supply company due to reduced income from the mining sector)
    - Costs in emergency measures to improve resources and decrease demand (additional costs for water transport and removal, costs for advertising to reduce water use)
- Environmental
    - Decreases in water supply and the quality of surface water and groundwater
    - Increased salt concentrations and pollutants coming from past or current mining activities (e.g. in streams, underground layers, irrigated areas)
    - Damage to ecosystems, wetlands, and biodiversity (e.g. soil erosion, dust, reduced vegetation coverage)
    - Lack of feed and drinking water
- Social
    - Inconveniences due to water rationing
    - Damage to public health and safety, by affecting air and water quality
    - Increase in social inequality, through larger impacts on specific socio- economic groups, specifically also children[4]
    - Tensions between public administrations and affected groups

[4] UNICEF/VIDECO, 2017: "Evaluación/sistematización de la preparación y respuesta en el marco del plan de acciones inmediatas ante el fenómeno el Niño 2015-2016" Informe final de evaluación

To take lessons from 2016 drought event, and allowing better preparedness for such events in the future, these different impacts should be further quantified using a set of appropriate indicators. The following section provides first insights obtained during the DRR mission related to current bottlenecks in terms of knowledge on drought impacts, indicators and data.

3.2 Bottlenecks in knowledge and data

Risk-based drought impact assessments
A major difficulty in managing the 2016 drought situation in Bolivia by the national and departmental administrations was to oversee the actual drought impacts across the country, affecting different critical services, users, groups and sectors. Such an overview can be obtained from a comprehensive set of drought impact indicators, and should follow from a cross-sectoral drought risk assessment. During the drought, reports and ad-hoc impact assessments were carried but authorities had no access to the complete picture, based on thorough analysis of all risk factors in the different areas.

In rural areas, Bolivia experiences moderate drought events with more frequency than in urban areas. Therefore, institutions and management instruments are prepared more or less for these moderate rural droughts, but the extent and severity of the 2016 was unprecedented. Consequently, institutions involved in managing the drought situation in 2016, lacked the adequate indicators and management instruments that would have been outcomes of a cross-sectoral drought impact assessment. The basic information on the extent and severity of the drought and the associated risks in the different sectors were not sufficiently clear and transparent to the managing bodies of Bolivia.

The 2016 drought event is thus an opportunity carry out a drought risk and impact assessment, as it provided lots of useful data. Based on the observed impacts (post-drought evaluation) but also taking into account future changes (population, climate change, land use change) this risk-based drought impact assessment should allow to draft drought-focused policies, identify the most adequate indicators, and develop better preparedness for future similar droughts.

Up-to-date drought information
Drought impacts affect many sectors differently. Some sectors have no responsibility to monitor and record drought impact data. As a result, in contrast to hydro-meteorological records, which are stored by SENAMHI, the records of sectoral drought impacts are scattered across many institutions with limited access for other users.

SENAMHI publishes hydro-meteorological bulletins on a regular basis, but they seem not to be well adopted by the relevant institutions that should make use of this type of information (Ministries, etc.), with the exception of the Ministry of Rural Development and Land (MDRyT), which prepares agrometeorological bulletins, and SINAGER, which provide warnings based on this information. The indicators used can be better tailored to the needs of the different institutions that require regular updates on the drought situation.

On the other hand, SENAMHI also publishes drought warnings based on the El Niño oscillation. This information seems to be adopted well by the authorities (Action Plans, etc.), although as became clear also from the 2016 event, the accuracy of this type of forecasts is an issue (probably due to a mix of factors: the inherent uncertainties with this type of forecasts, the particular climatic system of Bolivia, lack of capacity at SENAMHI, etc.).

The need to improve the current water and climate information system at SENAMHI, collecting cross-sectoral information and providing relevant indicators on water resources has been identified previously by different studies and is acknowledged by the institution itself. Several projects are being prepared in that direction; some of these have already been approved (see Chapter 5). However, the majority of these projects do not focus on strengthening drought information availability and the monitoring of drought impact indicators.

As the 2016 drought event in the La Paz/El Alto area made clear: there was in fact data available that could have been used to take action in an earlier phase (E.g. extremely low water levels in the reservoirs). However, these data, critical for water security of Bolivia, was not exchanged between entities nor integrated in a national drought monitoring system. Data on critical infrastructure, even if managed by local authorities, should thus be integrated in such a system, and become fully transparent to authorities at the national scale, and possibly to the general public.

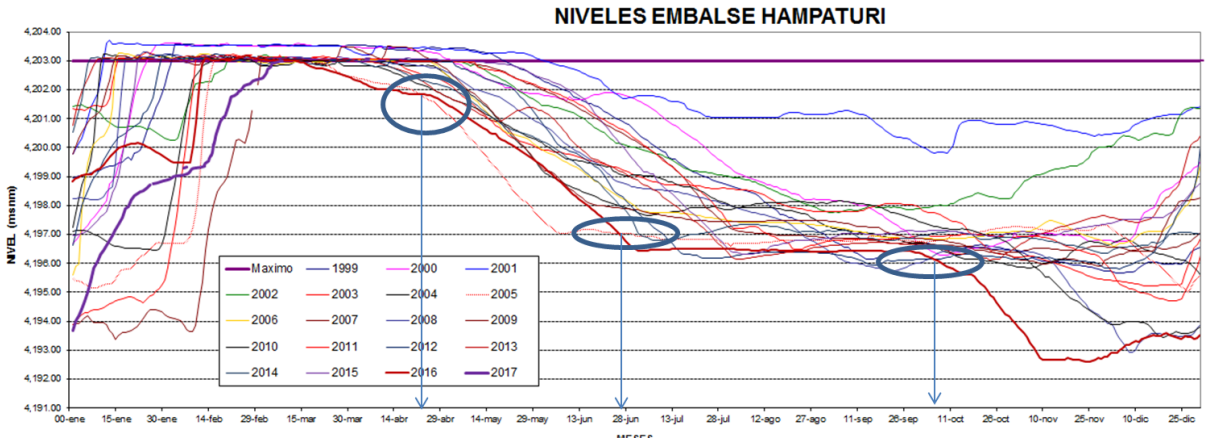

Figure 6. Historic water levels of the Hampaturi reservoir, one of principal reservoirs of the La Paz/El Alto system; demonstrated for calendar years between 1999 en 2017

3.3 Bottlenecks in governance

The 2016 drought event has made evident several weaknesses in the inter-institutional arrangement and procedures. Based on the interviews and information available, we identify the following key bottlenecks:

- The Master Plan for the Metropolitan Area of La Paz/El Alto[5] included several critical investments aimed at increasing water security for the area, with a recommended time-schedule for implementation. Financial issues and social opposition have caused several delays in the implementation of these interventions – aggravating the situation in 2016.
- The scattered information on drought impacts among the different institutions has made it difficult to manage the drought situation effectively. A national drought management plan is also missing.
- No basin-level Drought Management Plans (DMP) are in place in Bolivia, among others due to the lack of institutional structures at the basin-level. Drought Management Plans include drought indicators and thresholds for drought classification and the drought early warning system, specific to the area or basin of interest and define measures to achieve specific objectives in each drought stage. The DRR mission recommends the Bolivian government to integrate DMPs in their current efforts to build organizational frameworks at the basin-scale.

[5] MMAyA, 2013, "Plan Maestro - Plan Maestro Metropolitano de Agua Potable y Saneamiento La Paz - El Alto, Bolivia"

- Related to the previous, the lack of an integrated water resources management approach at the basin-scale causes serious threats to water security: past and current mining activities are nowadays affecting water quality in the La Paz/El Alto area, in spite of several mitigating measures that have been taken previously. More emphasis on policies that promote full protection of the watersheds, and recovering measures in the mining areas is recommended.
- In the La Paz/El Alto area, the drought made clear that there are serious issues with the competences in water resources management in general, among EPSAS, AAPS and the municipalities principally. It is our recommendation to study this further and restructure.
- SENAMHI is under-budgeted and suffers a serious lack of capacity (number of staff and educational/professional level) as well as lack of vision on the future of the organization and embedment with the other related institutions.

4 Outline for a national drought early warning system

This chapter provides an outline for a national drought early warning system in Bolivia, based on the needs and requirements from the main users. In the following subchapters respectively Technical and Institutional Requirements (4.1), an outline of the system (4.2), as well as a proposed approach for implementation (4.3) are provided.

A critical component of planning for drought is the provision of timely and reliable climate information, including seasonal forecasts, that aids decision makers at all levels in making critical management decisions[6]. As the recent drought event in Bolivia demonstrates, timely, transparant drought information and early warnings to specific users and decision-makers could have helped reduce the impacts significantly.

UNISDR defines an Early Warning System as "The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss"[7]. This warning information is used by different users, including regional and national water authorities. It also may include inter-sectorial drought task committee which coordinates actions and advices the national responsible water manager (in Bolivia likely the Minister of Environment and Water).

UNISIDR differentiates four key elements of an early warning system:

1. Knowledge of the risks (disaster risk information and assessments);
2. Monitoring, analysis and forecasting of the hazards;
3. Communication or dissemination of alerts and warnings;
4. Local capabilities to respond to the warnings received.

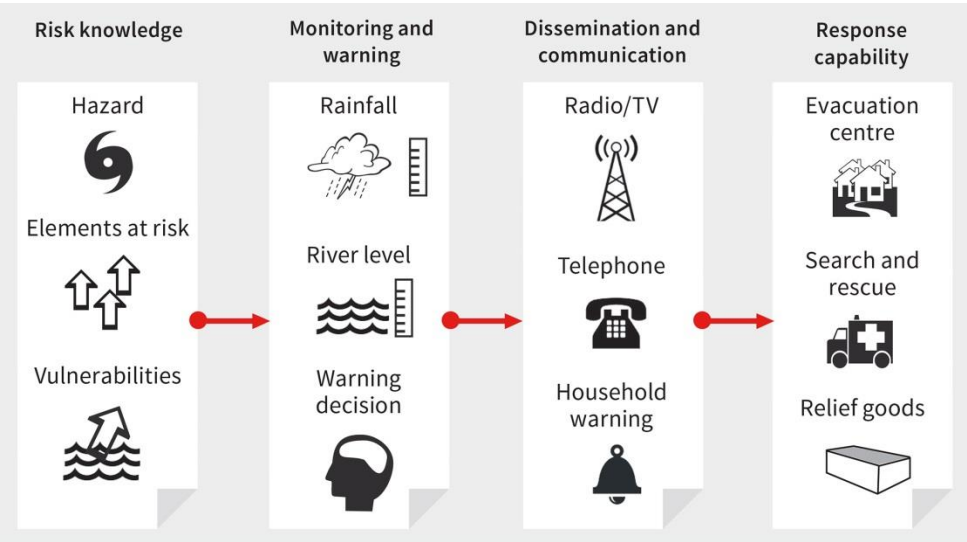

Figure 7 The four key elements of an early warning system by UNISIDR[8] ,

[6] Wilhite, D.A., Svoboda, M.D., 2000. Drought early warning systems in the context of drought preparedness and mitigation. Early Warn. Syst. Drought Prep. Drought Manage., 1–21.

[7] 2009 UNISDR Terminology on Disaster Risk Reduction. Geneva. http://www.unisdr.org/we/inform/publications/7817.

[8] John Twigg, 2015. Disaster Risk Reduction, Good Practice Review 9.

All these elements are relevant; here we will focus on first 2 elements, so the necessary (drought risk) knowledge and information to empower people and authorities to take the right decisions. The links with other information and early warning systems, including a flood early warning, will be explored as the technical design and implementation is rather similar, which makes it logical to approach it as a multi-hazard monitoring and forecasting system.

However, it is important to stress two significant differences between drought and flood events. First-of-all, the spatially affected area is in general much larger in the case of droughts, and likewise the structural and economic impacts are harder to measure. Secondly, the actual impacts of drought events are dependent on how *water demand and use* are managed in preparation or during the drought event, requiring the coordination of different sectors including agriculture, energy and drinking water.

Drought information and early warning in The Netherlands

In The Netherlands the Water Management Centre (WMCN), a part of Rijkswaterstaat, provides current knowledge and information about the Dutch water system, and elaborates daily forecasts and early warnings relevant for water users and authorities. During extreme situations, the Water Management Centre in coordination with national coordination committees including one on droughts, coordinates news coverage and arranges reliable and useful information about the expected conditions. It advises national and regional water authorities about the measures to take and arranges the coordination with the parties involved.

It provides up-to-date information based on 7 operational systems including one for drought management and early warning. The so-called 'FEWS Water Management' system is developed based on Delft-FEWS and provides insight in future developments of water availability and demand. Calculations are based on different weather scenarios and consider different management alternatives. FEWS Water Management also produces drought bulletins that include the current and expected drought situation, which are published on a weekly or less frequent basis dependent on the severity of the drought event.

The figure below shows the general process of the WMCN. Data are used from the National Water Monitoring Network, the national meteorological institute KNMI (meteorological observations and forecasts), as well from regional water authorities and neighboring countries.

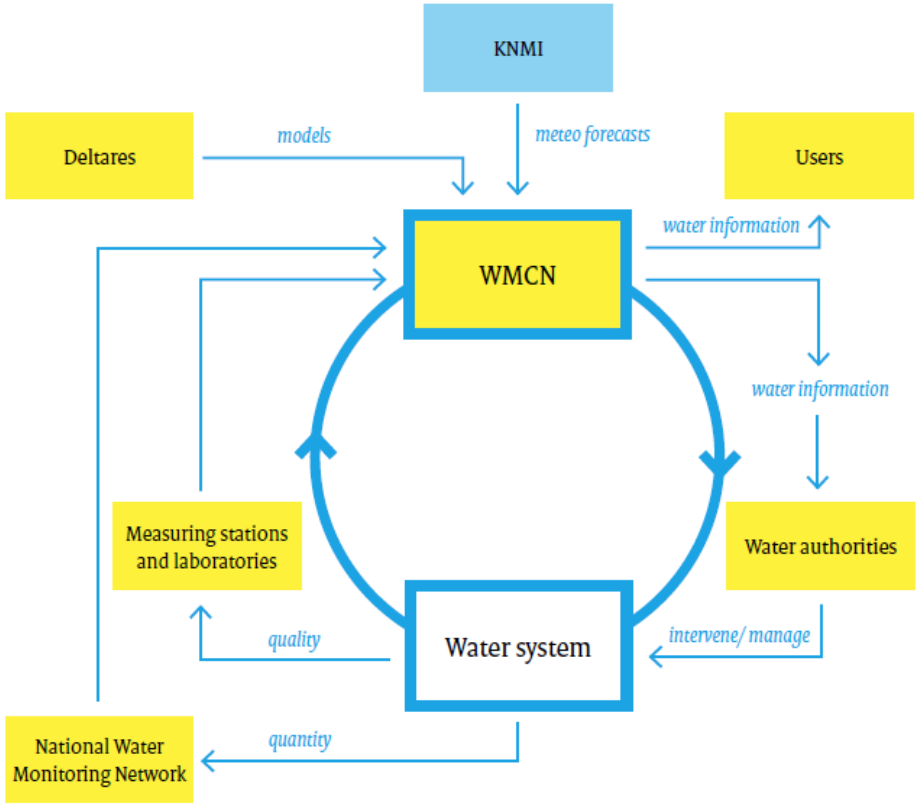

Figure 8 *The Water Management Centre in the Netherlands*

4.1 Technical and institutional requirements

The needs for drought information and early warning in Bolivia exist on different scales: the national level, including the ministries of Environment and Water, Agriculture, Civil Defense, Health and Education; the river basin level[9], including departments, and interdepartmental river basin committees; and the municipal level. Additionally to the water users and authorities, national universities are relevant as their research needs to contribute to the improvement of drought management in Bolivia.

Each user needs different types of information and with different levels of detail, which are dependent on its responsibility. Users include for example farmers, households, energy companies but also local, regional and national institutes. For most users the meteorological and hydrological forecasts are sufficient to take their daily decisions. Other users, e.g. drinking water companies, some ministries and the energy sector, will need the original and validated data, and possibly national forecast data and results, to develop their own analysis, forecasts and optimize their decision process. This last group will have high level professionals that are capable of elaborating their own analysis and run additional models when necessary.

A drought early warning system must provide timely data and information for each of these user types. And the users should be able to take their own decisions based on these data and information.

From an institutional perspective it is important to develop a coordinated effort to manage drought risks. Currently, a lack of coordination exists between the different ministries and a weak hydro-meteorological institute is hampering the provision of good quality information to inter-sectorial decision-making processes. Improving these aspects is fundamental is key in improving drought risk management and early warning.

Figure 9 shows an organizational structure proposed by National Drought Mitigation Center of the University of Nebraska-Lincoln, as adapted by WMO and GWP[10]. The committees will have their own tasks and goals, but well-established communication and information flow between committees and the task force is a necessity to ensure effective planning.

The Drought Task Force is an institutionalized version of the 'Gabinete del Agua' created during the drought crisis in Bolivia. Its responsibility is to coordinate actions, implement mitigation and response programs, and make policy recommendations to the responsible stakeholders in government (likely the Minister of Environment and Water in Bolivia).

[9] We assume river basins of a scale of 10.000 km^2 and larger

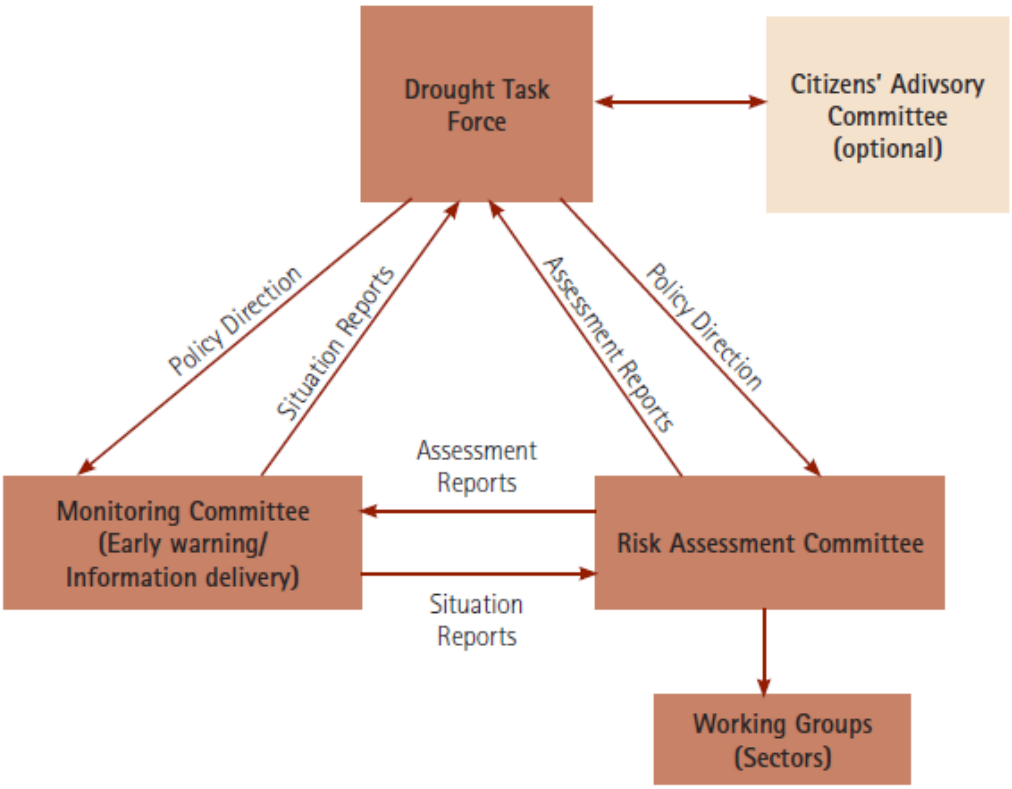

Figure 9 Drought preparedness and mitigation plan organizational structure[10]

For a drought monitoring and information system the proposed Monitoring/Early Warning Committee is most relevant here. This coincides with the recommendation made during the DRR mission to create a 'technical - scientific' committee that includes the data users and generators, strengthens the exchange, and improves quality of drought information services. In the WMO/GWP policy guidelines it is proposed to create these committees on the provincial level or aggregated based on similar climatic conditions, however we recommend to create the Monitoring/Early Warning Committee, at least initially, on a national level only (due to current capacities and size of the country).

The makeup of the Monitoring/Early Warning Committee should include representatives from all agencies with responsibilities for monitoring climate and water supply. It is recommended that data and information on each of the applicable indicators (e.g. precipitation, temperature, evapotranspiration, seasonal climate forecasts, soil moisture, streamflow, ground water levels, reservoir and lake levels and snowpack) are considered in the committee's evaluation of the water situation and outlook.

We recommend that the Monitoring/Early Warning Committee be preceded by a senior delegate from the Ministry of Environment and Water, with background in water management. For the establishment of the committee and to support the functioning during the first months, technical assistance through a specialized external consultant may be useful. The committee needs to include representatives from monitoring agencies, e.g. SENAMHI, AASANA, SEARPI, as well as

[10] World Meteorological Organization (WMO) and Global Water Partnership (GWP) (2014) National Drought Management Policy Guidelines: A Template for Action (D.A. Wilhite). Integrated Drought Management Programme (IDMP) Tools and Guidelines Series 1. WMO, Geneva, Switzerland and GWP, Stockholm, Sweden.

representatives from the water users, including representatives from the agricultural, drinking water (AAPS) and energy sectors.

SENAMHI has a key role regarding meteorological and hydrological forecasting. This role needs to be complemented by drought impact monitoring and early warning. One of the objectives of the Monitoring/Early Warning Committee should be to strengthen both types of services.

SENAMHI, as the national hydro-meteorological institute, is on a national level the main party responsible for monitoring and elaboration of information on historical, current and future weather and hydrology. The division between the role of SENAMHI and ministries is in practice not always clearly divided.

SENAMHI is responsible for developing knowledge and information on meteorological and hydrological threats of national relevance. The Ministries (representing the different sectors) assume the responsibility for developing risk analyses based on the information SENAMHI provides. Water managers on local and river basin level (e.g. drinking water companies) need to take responsibilities regarding the management of their resources, and where necessary complement hydro-meteorological monitoring and information.

It is fundamental to base the development of a national drought and early warning system on already existing systems within SENAMHI and other institutions. Focus needs to be on developing technical and institutional capacities within Bolivia, and preventing distraction from (international) cooperation with particular interests. Though it may seem attractive to replace everything with a big new system, if it is not accompanied with large improvements in capacities (e.g. number of professionals with MSc and PhD) within SENAMHI it is a significant sustainability risk.

Technological developments must go hand in hand with the development of capacities within SENAMHI and other relevant institutions. The presence of professionals within SENAMHI with an MSc and PhD level will need to increase.

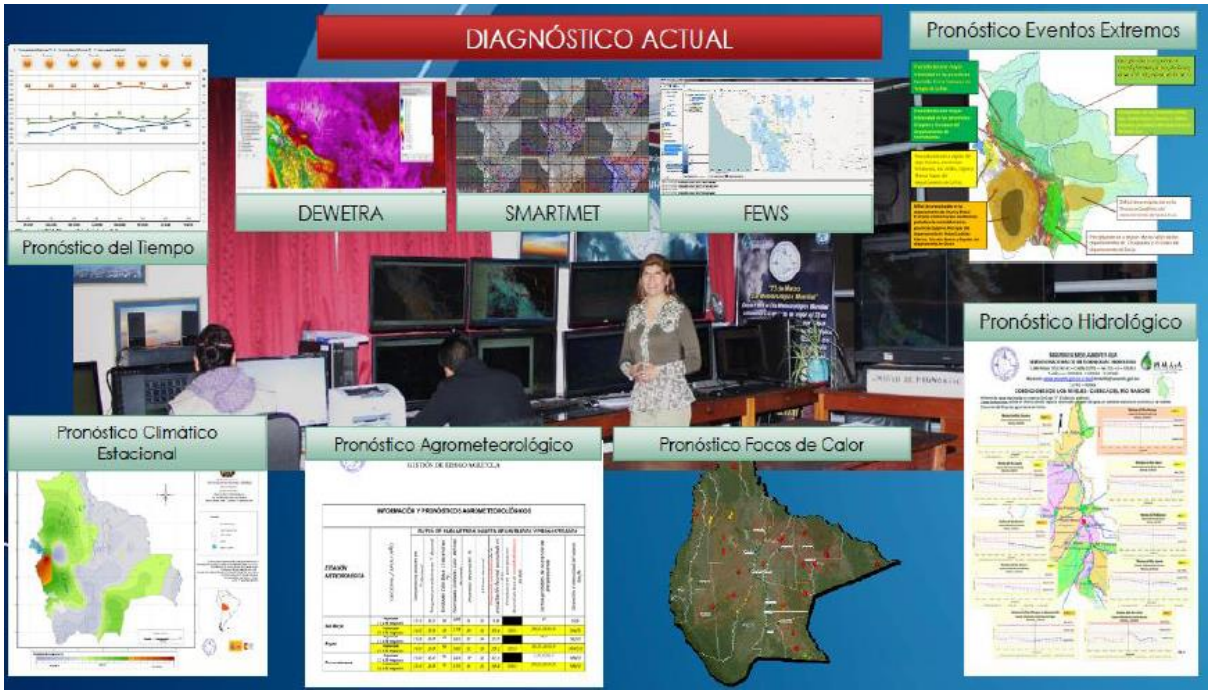

Figure 10 "Products provided to civil society" (source: SENAMHI)

Current systems used at SENAMHI include:

1. SISMET and HydrAccess databases (based on MS Access) as meteorological and hydrological databases. Currently a central database, based on MS SQL Server, is starting to be used as central database. This is part of the SOPHI platform that is being development together by the 4 hydro-meteorological institutes of the Andean region. To our understanding SOPHI is expected to replace SISMET and HydrAccess in the near future.

2. Smartmet (developed by the Finish Meteorological Institute) is a tool for the collection of meteorological data, visualization and analysis of meteorological observations and forecasts.

3. Delft-FEWS (developed by Deltares) is a platform for hydrological forecasting, which integrates meteorological data and forecasts and hydrological data on a national level, and runs models to develop a hydrological forecast. Its current use in Bolivia is mainly for flood forecasting.

4. DEWETRA (developed by CIMA) is a tool aimed for disaster management organization like the Civil Defense, which analyses and represents geographically distributed data of weather related risks.

4.2 Outline

The proposed set-up is based on the existing tools and capacities, mainly within SENAMHI.

A drought information and early warning system may include the following services:

1. National drought monitor, which provides technical information on the drought status in the country. This may be based e.g. on the Standardized Precipitation Index, soil moisture, and or vegetation impact.
2. Reservoir status. Relative water levels in the reservoirs (or combination of linked reservoirs).
3. Middle and long term forecasts of water levels in the major rivers (e.g. for navigation)
4. Weekly drought bulletin
5. A data portal (e.g. based on OpenDAP) that provides access to all available historical and real time meteorological and hydrological data.

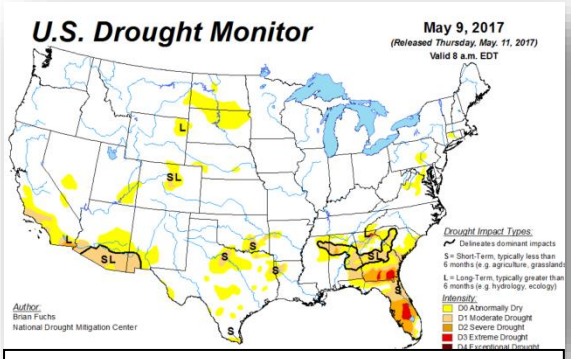

Figure 11 US Drought Monitor (http://droughtmonitor.unl.edu)

We recommend to develop a detailed diagnosis of the services needed based on the experience of the recent drought event, and an identification of the needs from the different users. The FEWS-Bolivia flood forecasting system, currently operational within SENAMHI, is an excellent basis for a national drought system, as data needs and system needs are very similar.

The following figure shows a general setup for a drought early warning system. It consists of the following systems:

1. Hydrometeorological Monitoring and Data Acquisition System
2. Historical time series database
3. Operational hydrological information and forecasting system
4. Communication and data distribution systems
5. Risk studies analyses by national, regional and local water managers

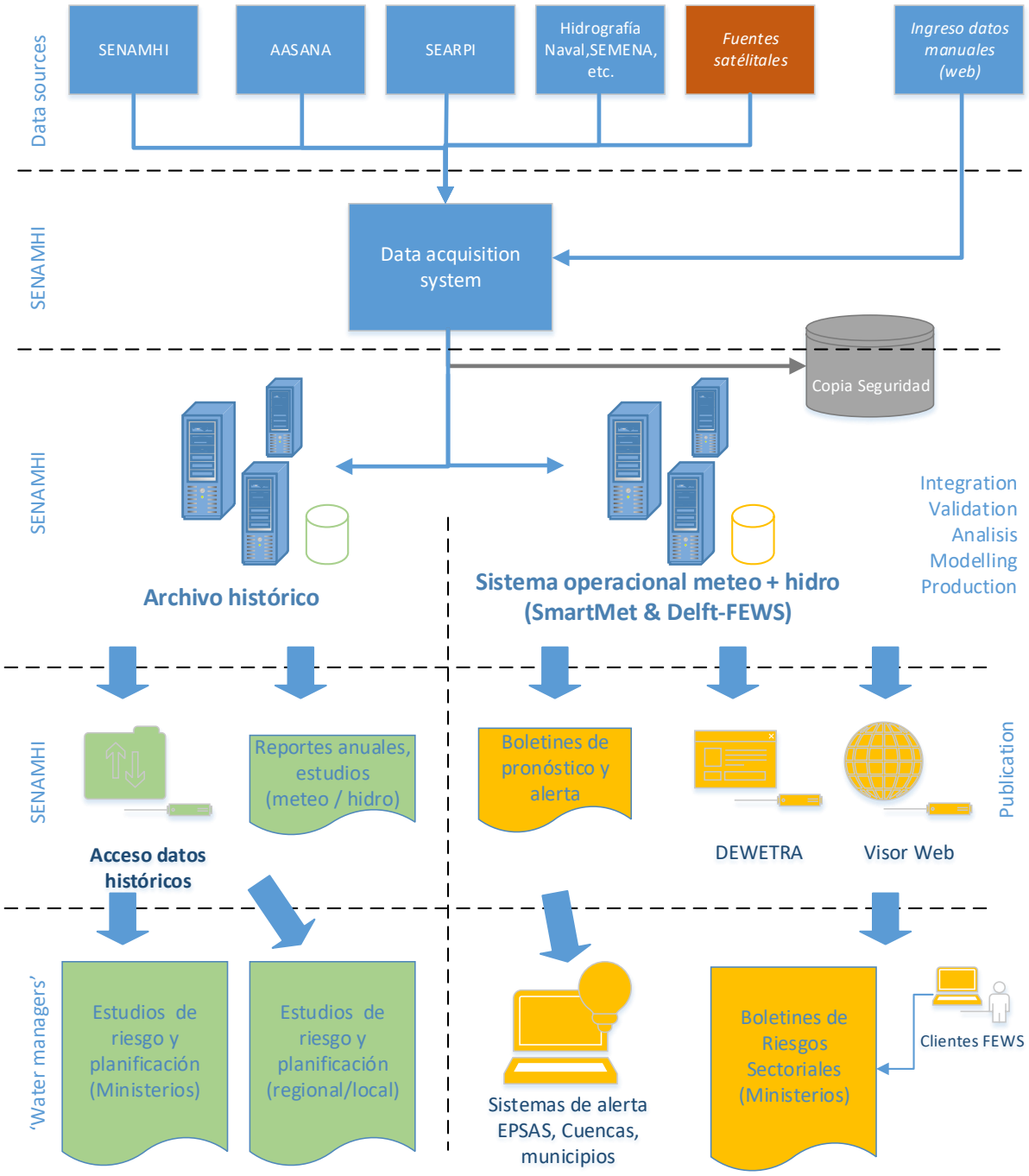

Figure 12 Possible structure of a drought information and forecasting system

4.3 Approach

Here an initial setup for the steps towards a national drought information and early warning system is presented. This should be considered an initial approach and a basis for dialogues in the near future.

Two complementary components are presented here, one with focus on institutional strengthening of monitoring and early warning, and another focused on implementation of a drought information and forecasting system. .

4.3.1 Institutional Strengthening of monitoring and early warning

The component presented here is based in part on a critical review of the Final Report of the Conceptual Design of a National Water and Climate Information System, that was elaborated in the framework of the PPCR[11] by a team of consultants lead by Dr. Francisco Villalpando from the WMO. The SNICA concept has not been elaborated specifically for drought monitoring but as a proposal to strengthen Bolivia's capacities in managing hydro-meteorological and climatic information in general.

We recommend that SENAMHI, as the national hydro-meteorological institute, maintains responsibility for the validation and also the integration of historical and real-time hydro-meteorological data on a national level. SENAMHI must make these data easily available giving access to governmental institutes and the public in general.

It is important however to differentiate between hydro-meteorological information and water management information, which includes impacts and vulnerabilities. We recommend the creation of an (inter-sectorial) monitoring and early warning committee that advices the water authority (Minister of Water) before and during extreme events, and facilitates the availability of relevant hydro-meteorological and water management information. On the other hand we recommend the creation of a Water Management Centre (name to be defined), which receives these data and complements these with data on drought vulnerability (the impact), e.g. water use and demand on a national level or distributed vegetation impact.

4.3.2 Monitoring / Early Warning Committee

The interinstitutional Monitoring / Early Warning Committee consists of providers and users of water data, as well as some national and (optionally) international experts. As indicated above, for the establishment of the committee and to support the functioning during the first months, technical assistance through a specialized external consultant is considered useful. This interinstitutional committee should be led by a senior representative from the Ministry of Environment and Water, and have support from a technical team (e.g. the Water Management Center).

The Monitoring/Early Warning Committee must focus on *providing relevant and current information* on water related *risks* and *impacts* including droughts and floods. It must also promote improvement of monitoring, data acquisition and quality standards at a national level; with the Water Management Centre as the technical muscle to achieve this effectively.

[11] The Pilot Program for Climate Resilience – Water Basin Management Project financed through the Climate Investment Fund and implemented with the support of the World Bank seeks to strengthen Bolivia's capacities in water resources management.

4.3.3 Water Management Centre

A basis for the Water Management Centre is already established recently by the Ministry as the department of hydrological studies; however it should also include *operational tasks* and become the 'information portal' to drought and water management information on a national level.

Note that the Water Management Centre, though (initially) within the Ministry of Environment and Water, has a *multi-sectorial* function as it provides relevant drought information and early warning for different sectors including agriculture, irrigation, energy and drinking water. Initiatives, e.g. by the ministry of Rural Development and Land, need to be integrated.

SENAMHI, and other data providing institutions, are responsible for the quality and validation of data they monitor. The integration of meteorological and hydrological data we would expect to be a task of SENAMHI as they have the systems to manage this. Though the Water Management Centre could provide a portal with access to historical hydro-meteorological data, it seems reasonable that these data are provided by the monitoring institutions themselves through their own data portals. The Water Management Centre and the Monitoring / Early Warning Committee however may support the development of these data portals, and verify that meteorological and hydrological data are secured by these institutions through offsite backup systems.

It is critical to strengthen the capacities of SENAMHI and resolve institutional challenges this institute currently faces. It is unfortunate that SENAMHI lacks the capacities to develop and run its own weather model (though the WRF-Bolivia model is run at the SENAMHI office, SENAMHI depends completely on external support in case of any problem or for improvements). SENAMHI will only be able to comply with its tasks if the professional level of its experts increased, which in practice means that its team is *complemented* by IT-experts, hydrologists and meteorologists with at least an MSc degree. Professionalizing system administration and development should be one of the key priorities to improve data management capacities.

Main outcomes / components:

1. Interinstitutional Monitoring and Early Warning Committee;
2. Strengthened institutional and professional capacities at SENAMHI;
3. A 'Water Management Centre', which provides access to water information for regional and national water users and authorities, based at the Ministry of Environment and Water.

The proposed Water Management Centre and the monitoring committee have several similarities with the conceptual design of the SNICA that has been prepared within the PPCR project. We believe that the establishment of a monitoring and early warning committee and the strengthening of a water management center that focuses on water related risks, rather than building a more general SNICA that might take on activities that are currently competence of SENAMHI is more likely to be sustainable and provide the needed information. We highly recommend the MMAyA and the World Bank to take these recommendations under consideration when entering a more detailed planning of the SNICA implementation.

4.3.4 From hazard to tailored drought impact information

The existing FEWS-Bolivia system provides an important basis for a *national drought information and forecasting system*, as it already integrates the relevant meteorological and hydrological observations of SENAMHI and other monitoring institutions, and as well provides a basis to include models and present information according to the user's needs. In Chapter 4.2 an outline of such a system has already been given, including a list of services this system may provide.

Components for the developments of a national drought information and early warning system include:

1. Diagnosis and identification of relevant drought indicators;
2. Strengthen data acquisition, internal data flows and database management;
3. Inclusion of relevant satellite data, e.g. vegetation index;
4. Implement real-time calculation of drought statistics and forecasts;
5. Reservoir status: water level and inflow discharge;
6. Implement long term hydrological forecast for the main rivers;
7. Reporting, communication.

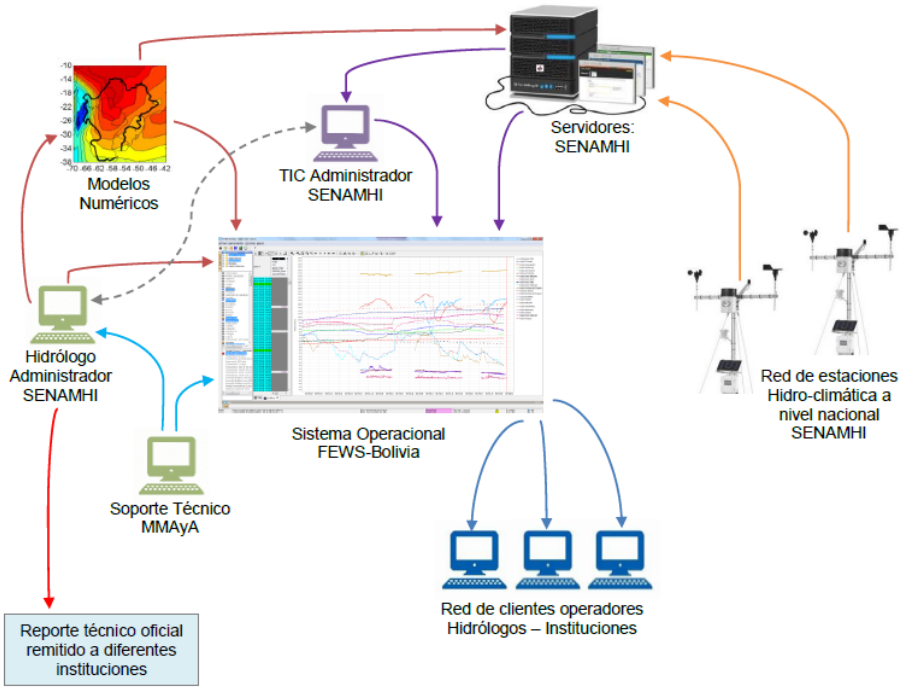

Figure 13 Hydrological forecasting system FEWS-Bolivia[12]

Taking into consideration the recommendations on institutional strengthening, it is important to differentiate clearly between responsibilities of SENAMHI and the Ministry of Environment and Water. Tasks related to meteorological and hydrological data and forecasts are responsibility of SENAMHI, while tasks related to water management, usage and vulnerability (e.g. reservoirs, vegetation index, and water usage) are responsibility of the Ministry or Water Management Center, see Table 1.

Table 1 Comparison responsibilities SENAMHI – Water Management Center

SENAMHI	**Water Management Centre**
Scope: Meteorology and hydrology	**Scope**: Impacts and drought communication
Seasonal weather forecast	Development and publication of drought indicators; e.g. a national drought monitor
Forecast of river discharges and water levels	Forecasting of water demands, reservoir releases and reservoir status
Data portal providing access to historical meteorological and hydrological data	Use of satellite data on impacts, e.g. vegetation
Downloads of hydrometeorological observations	Drought impact bulletins, drought decision-support studies, impact news releases,

[12] Ministerio de Medio Ambiente y Agua, 2017. Sistema de Monitoreo de Alerta Hidrológica (FEWS-Bolivia)

When observing Figure 12 (page 27) it is relevant to mention the differentiation between the operational ‘real-time’ system(s) and the historical database, which have different approaches to data management, particularly validation and storage. Vital is that these systems provide services to different user, e.g. authorities, universities and the public in general. This can be a service to download historical time series for hydrological modelling activities; but also real-time information services with distributed drought forecasts for coming weeks and/or months.

5 Current national and international support initiatives

The recent drought has caused a lot of attention from bilateral and multilateral donors to support Bolivia in resolving the drought issue. Different initiatives are currently in development, and a (potential) risk of overlap exists. In an effort to prevent such overlap between DRR and WorldBank initiatives, the mission was set up and timed in such a way to align objectives and to maximize possible effectiveness and impact of recommendations for Bolivian counterparts. The World Bank is developing a detailed overview of all initiatives and projects that are currently implemented or in development within its study. Here we present some of the most relevant ones:

1. World Bank PPCR project- Pilot Program for Climate Resilience. The Project Development Objective (PDO) of the Climate Resilience - Integrated Basin Management Project of Bolivia is to strengthen Bolivia's capacity to adapt to climate change effects at the national level and set the foundations to improve the climate resilience of socioeconomic and natural systems in three sub-basins of the Rio Grande by implementing a river basin management approach. The project will support the implementation of Bolivia's strategy towards climate change adaptation. This strategy proposes the adoption of an integrated, multi-sectoral, participatory, basin-scale approach to climate change adaptation. Within the project it is foreseen to establish the above mentioned SNICA to strengthen Bolivia's capacity in the use of hydrometeorological and climatic data in water resources management and climate change adaptation. In response to the drought, the World Bank managed to redirect further funding for establishing a drought monitor.

2. Meteo France International. Project to be approved (about USD 15 million) to modernize the meteorological data management and forecast systems within SENAMHI. Strengthening with the state-of-the-art systems used by Meteo France.

3. Project Modernización y ampliación del sistema nacional de observación hidrometeorológica. Investment of ca. 40 million Pesos Bolivianos by the Ministry of Rural Development to support to SENAMHI. Mainly the acquisition and installation of around 200 automatic meteorological and hydrological stations with main focus on the agricultural sector.

4. Programa de Monitoreo y Gestión Optima de Embalses (MMAyA). Hydrological monitoring of 9 reservoirs in Bolivia and integration in national information system.

5. DRIVE proposal study phase, by RHDHV. Improve the efficiency of water supply in the La Paz – El Alto and surrounding areas by reducing water losses, improved capacity of water treatment and an optimized use of the available surface water resources.

6. Deltares. Technical assistance, training and guidance to strengthen and extend the national hydrological forecasting system FEWS-Bolivia. A team from the MMAyA and SENAMHI is working on updating data inputs and extending the system towards drought and reservoir information.

7. FAO and Italian cooperation. Strengthen the capacities of VIDECI for early warning on multiple risks; including a situation room.

In addition to these projects directed at improving the monitoring and knowledge base on drought, the MMAyA prepared a US$500 million drought emergency plan prioritizing investment to improve

water supply in major cities of Bolivia. Many of these infrastructure projects financed through CAF, BID and other donors include activities to strengthen demand and supply management, as well as, monitoring of water sources.

The above mentioned initiatives have link with the objective of the DRR mission; and in particular the World Bank initiatives provide interesting opportunities on the short term to follow up on the main recommendation of this DRR report.

6 Recommendations

The 2016 drought in Bolivia has caused an enormous impact in Bolivia, both economically and socially. The lack of accessible and up-to-date drought information has hindered an adequate and proactive management of the drought situation and could have reduced significantly the effects on the (urban) population and the agricultural sector.

To prevent these circumstances a drought management plan is needed, including a *national drought information and early warning system*. Such a system enables to identify and evaluate drought conditions and quantify drought impacts before and during the drought event. The system can then also be used to provide timely warnings about the actual drought status in real time to decision-makers and water users alike; making it possible to prevent potential water cut-offs as happened during the 2016 drought in La Paz. The system also provides an overview of drought severity in the different areas of the country so priorities can be managed on a national level.

Based on the 1-week Dutch DRR mission to Bolivia, in cooperation with the World Bank, we provide some recommendations regarding the technical as well as the institutional aspects. We believe that the SNICA concept/project may be refocused on the first three recommendations below.

1. **SENAMHI** has a central role in providing up-to-date data, forecasts and hydro-meteorological knowledge on current and upcoming drought events. Though its staff is in general very motivated the institute lacks professional capacities as it is unable to attract strong staff, e.g. with an MSc or PhD degree. Also a clear vision to where the institute should stand in the medium and long term is lacking: focus needs to be put on the core functions of SENAMHI. The institute is completely unprepared for the current challenges a national hydro-meteorological institute faces as state-of-the-art knowledge provider to national and regional authorities.

   We strongly recommend strengthening the professional capacities of SENAMHI as well as its financial basis. The professional working environment (office space and flexibility) must be improved and salary scales must make it possible for SENAMHI to attract talented meteorologists, hydrologists and IT personnel with an MSc and PhD degree. This implies a significant improvement of administrative capacities as well. This should go hand in hand with improving transparency of institutional processes as well as public data access.

2. We recommend the creation of a national **Monitoring/Early Warning Committee**. This committee should be led by a senior delegate of the Ministry of Environment and Water, and include representatives from SENAMHI and other data providers as well as from the main water users. National and optionally international water management experts can complement the committee. For the establishment of the committee and to support the functioning during the first months, technical assistance through a specialized external consultant is considered useful.

   This Committee will be responsible for advising the Minister on drought and flood risk management, the upgrading of monitoring programmes, guiding the development of the drought information system. It will also be responsible for the identification of drought impact indicators, based on consultations with administrative bodies, different users and sectors, and facilitating the development of a national-level drought impact assessment.

3. To develop and strengthen *drought risk management* capacities, we recommend the formal creation of a '**National Water Centre**', (initially) within the Ministry of Environment and Water. This National Water Centre needs to develop and provide relevant information in relation to drought risks and other water related risks, to all relevant regional and national authorities. It needs to have capacities for the development of strategic models as well as to maintain operational systems including a national drought monitor.

   The recently created 'Unidad de Estudios' within the Ministry is expected to form a basis for the Centre, as current activities in relation to reservoir monitoring and analysis of the precipitation index are relevant for the function of this National Water Centre. Close coordination with other ministries including Rural Development, Energy and Civil Defence is crucial.

   The Centre will also be the technical arm of the Monitoring/Early Warning Committee and give follow-up to decisions taken within this Committee.

4. We recommend the elaboration of an in-depth **national-level drought impact assessment**. This assessment, to be based mainly on the 2016 drought but also on other droughts, should result in recommendations on drought impact indicators to be used for the different water use sectors and on different scales.

5. The DRR mission recommends implementing in Bolivia **a national drought information and early warning system** as one of the central elements of drought management. Such a system enables to identify and evaluate drought conditions and the quantify drought impacts during the drought event. The national system should be comprehensive, comprising of appropriate parameters and indicators for the different sectors. Such an information system can then also be used to provide timely warnings about the actual drought status in real time to decision-makers and water users like EPSAS and the irrigation sector. The system should also integrate local and regional data on critical infrastructure like reservoirs. The system need to be jointly implemented between the Water Management Centre and SENAMHI as described in Chapter 4.3.4.

6. We recommend the Bolivian government to integrate **Drought Management Plans** in their current efforts to build organizational frameworks at the basin scale. An Integrated Water Resources Management approach is fundamental and more emphasis should be put on policies that promote full protection of watersheds and recovering measures in the mining areas. On the other hand, the drought made clear that there are serious issues with the definition of competences in the water sector, we recommend to study this further and restructure where necessary.

   The Drought Management Plans should include the *strengthening of water management capacities* within the local and regional water users and managers. Water management decisions need to be taken on the lowest possible scale according to the subsidiarity principle, as long as the necessary capacities are available. This implies that drinking water companies of large cities, like in La Paz / El Alto and Potosí, need to take their own responsibility to manage (and monitor where necessary) their water resources including reservoirs in a transparent way. They need to have access to state-of-art information and forecasts on a national level, and contribute with their data and information to national information systems.

The following key events are expected during in 2017, which provide opportunities for potential follow-up to DRR recommendations, possibly in collaboration with the Netherlands (through DRR or other funding initiatives):

1. National Interinstitutional workshop to develop a roadmap towards a National Drought Forecasting and Early Warning System (2nd week of July). This workshop is organized by the Ministry of Environment and Water and Deltares with support from Helvetas, Switzerland.

2. World Bank Mission Report

3. UNCCD conference in La Paz (August)

4. Definition SNICA project (WB) based on the recommendations regarding strengthening SENAMHI, the creation of a Monitoring and Early Warning Committee and the development of a Water Management Centre.

5. Definition/design of a drought information and early warning system to be implemented and financed through the PPCR program (WB).

Annex A. Executive Summary of World Bank report[13]

The drought 2016 affected the lives of a large part of the Bolivian rural population, and resulted in drinking water rationing in 7 major cities. The drought displayed Bolivia's high vulnerability to extreme weather. The objective of this study was to analyze the 2016 event and identify strengths and weaknesses in the prevention, preparation and response to drought events, and develop recommendations to increase the country's drought resilience. A detailed reconstruction of the drought was made at the national level and for the highly affected Metropolitan Area of La Paz and El Alto.

The report[14] analyzed the conditions that preceded the meteorological drought early 2016, which evolved into a hydrological, agricultural and eventually in a socio-economic drought. We conducted a detailed reconstruction of the institutional measures and political decisions that were taken during the crisis. The evaluation included an analysis of the legal and institutional framework for disaster risk management in Bolivia and its application during the crisis. Despite the presence of appropriate regulations that promote proactive risk management, and despite great efforts to ensure water availability, the drought hit hard. The country's vulnerability to droughts are the lack of knowledge of drought risks, the low capacity for monitoring and forecasting of drought risks (due to limited resources for hydro-meteorological services and the absence of specific tools for drought monitoring) and a weak capacity for inter-institutional coordination. The weak capacity for coordination is mainly a result of low institutional capacity, in particular at the local level, to implement effective coordination mechanisms as stipulated by the law. The delays in important investments, especially in water supply infrastructure in the fastgrowing urban areas is further contributing to Bolivia's high vulnerability.

Because of the severe impact of the 2016 drought on the Metropolitan Area of La Paz/El Alto, a more detailed evaluation was undertaken for these cities. The evaluation focused on an analysis of the climatic conditions; an evaluation of the most important political decisions and measures taken by local and national stakeholders during the crisis; and an assessment of the existing water supply system, its operational capacity and vulnerability to droughts. Both cities are highly vulnerable to water scarcity as their water supply systems have limited storage capacity while the demand for water is increasing rapidly. There is no adequate water source monitoring system in place and the exchange of water resources information prior and during drought events showed major deficiencies. The coordination during the crisis between the water utility EPSAS, the National Water Supply and Sanitation Control Authority AAPS, municipality and the Ministry of Environment and Water MMAyA was ineffective. The Bolivian national government installed an ad-hoc Water Cabinet at the highest level to better organize the necessary emergency actions. A particularity for La Paz/El Alto was how poorly prepared the population was (not having experienced a similar drought situation before) to deal with the crisis.

As a response to the 2016 drought, many initiatives are being initiated to increase the country's resilience to droughts. These projects include important infrastructure investments, which often were already part of existing sectorial plans and projects to strengthen the capacities in the management and

[13] Fischer, C, García Ágreda, C.O. y Salinas Villafañe, Á. LA SEQUIA 2016 EN BOLIVIA Y SU REPERCUSIÓN EN LAS CIUDADES DE LA PAZ Y EL ALTO; Reconstrucción del evento, evaluación de capacidades de gestión y recomendaciones hacia el futuro. Junio, 2017.

[14] The study, prepared by a team of World Bank consultants and funded by the Water Partnership Program (WPP) is based on extensive desk study of existing information and documentation on the drought 2016 and interviews with key representatives of national and local entities involved in risk management and water resources management. The work was closely coordinated with the Disaster Risk Reduction Team of the Netherlands and with the Ministry of Environment and Water of Bolivia.

monitoring of droughts in different sectors and at different levels of governments. Without an effective mechanism to coordinate these initiatives, the risk of duplication of efforts and of not benefiting from possible synergies is high.

Based on the detailed reconstruction of the 2016 drought at the national level and local level, and taking into account the legal and institutional framework, as well as, existing knowledge and management capacities, we developed a set of recommendations to strengthen drought risk management.

To increase drought resilience at the national level we recommend to

- develop a national drought plan,
- integrate drought management into water resources management policies,
- improve supply management capacities in water utilities and strengthen demand management with water users,
- establishment of an interinstitutional monitoring and early warning committee,
- develop a drought monitoring system.

To increase resilience in La Paz / El Alto we suggest to

- strengthen the operation and maintenance of the water systems,
- implement demand management policies, while preparing the population for droughts,
- improve the management and exchange of water resources information,
- conclude the EPSAS intervention by national authorities to improve coordination with local
- governments, and
- resume the implementation of the Metropolitan Master Plan of La Paz / EL Alto.

After the severe 2016 event, the awareness for the need to strengthen drought management capacities is high. There are many projects in different planning stages and the disposition, both from the government and from development partners, to finance such initiatives is high. This report aims to contribute to a strategic planning and a more effective coordination of activities to increase drought resilience in Bolivia and in the Metropolitan Area of La Paz/El Alto.