Mesilla; and Ciudad Juarez takes water from the Hueco Bolson. El Paso and Ciudad Juarez represent the largest population centres in the basin where the main challenge is fulfilling the municipal water needs (Kelly 2002, Parcher et al. 2010).

The PdN region is one of the most irrigation intensive and environmentally damaged areas in the RGB (Riley 1995). With an average rainfall of about 150mm of rain and increasing evaporation rates, crops such as maize, alfalfa, pecans, chili, and cotton are growing in this semi-arid region. Climate change is expected to have consequences in the water cycle by reducing surface flows and aquifer recharge rates. It is also expected to affect the quality of aquatic environments and accentuate sustained drought and water scarcity. This regional environmental damage translates into water quantity and water quality issues. Water quality degradation is imperiling and stressing the delicate ecosystems supported by the river. Issues such as salinity, bacteria, ammonia, chlorophyll, and nitrate; residual pharmaceuticals in wastewater; and lack of green corridors and loss of biodiversity are accentuating impoverishment of natural ecosystems (Kelly 2002, Parcher, et al. 2010, USBOR 2011, Texas Clean Rivers Program 2016).

A greater likelihood of a water crisis is occurring in the PdN region. Water is scarce, and competition for water resources is intensifying. Agricultural water use is relatively constant; increased water demand is being driven by urban growth; and intensive human use of water is impoverishing natural ecosystems. The PdN region continues to experience rapid population growth despite its diminishing water resources. Institutional fragmentation and hydrological organization in this binational and tri-state region prevents water managers' preparedness for upcoming climate challenges as well as the development of adaptive management strategies (Nava and Sandoval-Solis 2014). Furthermore, stakeholders' competing and conflicting interests tend to accentuate the unsustainable extraction and use of the region water resources, and therefore the design of policies. Laws and regulations governing water in the PdN region need to adapt to this reality. Failure to adapt will only jeopardize the satisfaction of the regional needs in a sustainable manner, leading to water crises.

METHODOLOGY

Institutional Resilience

Institutions determine 'the rules of the game' (Commons 1934, North 1990, Veblen 1909). Water security in the arid PdN region is a binational challenge requiring *resilience in institutions* by means of political will and stakeholders' insights. Institutions have to be well thought-out, clearly targeted and made context specific by adopting new strategies to manage risk. For this purpose, *resilience* is an important notion. The Oxford English Dictionary defines resilience as the ability to spring back into shape; a certain degree of elasticity (Oxford Dictionaries, 2016). The term can be conceptualized in many ways. Here, it is about how institutions governing water resources may absorb changes, cope with major climatic challenges, and adapt to new conditions and imperatives. In this context, applying the notion of *resilience* to management and governance helps to understand how institutional frameworks adapt and prepare for uncertain futures.

Institutions can no longer be perceived of as isolated, independent, and perennial from the social-ecological context in which they operate, since they are in constant interaction to manage environmental, social and economic domains. A *resilient institution* translates into a flexible framework for adapting to the current climate vulnerabilities threatening water resources. It also represents a strategic opportunity to move forward in a new direction to sustain and secure water. Building *institutional resilience* by means of enabling regional openness and flexibility of the existing ensemble of rules and policy processes is paramount to respond to new imperatives (Boyd 2012; Folke 2006, Handmer and Dovers 1996, Pahl-Wostl 2007, Pahl-Wostl et al. 2007). Stakeholders from the PdN region provide insights into what they wish could done to enable institutional resilience and foster regional water security.

Qualitative methods

This research employs an interdisciplinary and qualitative approach to problem identification and analysis. Our qualitative approach is composed of various methodological tools, including case-study analysis, collection of documents, and field work and semi-structured interviews. The PdN round of field work consists on the application of a questionnaire (40 multiple-choice questions, and 10 open-ended questions) to gain information on water resources management and sustainable practices. A total of 23 interviews were conducted between October–November 2015. Taking into account the location of the respondents, the questionnaire was applied on the basis of their availability, in places that respondents preferred, either their workplace or a public place. In situations where travel was difficult, the questionnaire was sent by the internet. In some cases, answers to open-ended questions were recorded with a digital recorder, and transcribed with Nvivo9 and Nvivo10 software. We used NVivo 10 to do qualitative content analysis (Nava Jimenez 2015). For ethical reasons, we ensure the confidentiality of the participants. However, more specific details on the stakeholders' profile and questionnaire process can be found in Nava et al 2016.

RESULTS AND DISCUSION

All those questioned in this assessment agreed on the importance of enhanced water resources management to deal with vulnerability in an arid context (**Figure 3**). Stakeholders' insights have been systematized in three solutions-options reflecting their main visions to solve common problems and foster water security in the PdN region.

1. Living in an arid context translates into a set of challenges, and a region of opportunities:
    a. A set of challenges:
        i. Water is not an abundant available resource,
        ii. Droughts may become more frequent and severe in nature,
        iii. Water resources competition will likely increase, and
        iv. Potential risks of conflicts over water supplies and access to water.

    b. A *region* of opportunities:
        i. The capacities of plants and animals to adapt and survive,
        ii. The determination and willingness of people to adapt and survive,
        iii. The development of unique customs, procedures, and technologies to address difficulties in this region, and
        iv. The potential to adapt water allocation and management approaches, and to conform to current and future water issues.

2. There is a great need to:
    a. Strengthen communication and collaboration among all of stakeholders and related water agencies;
    b. Provide environmental education across the regional river basin;
    c. Manage surface and groundwater jointly; and
    d. Update water allocation agreements between the parties.

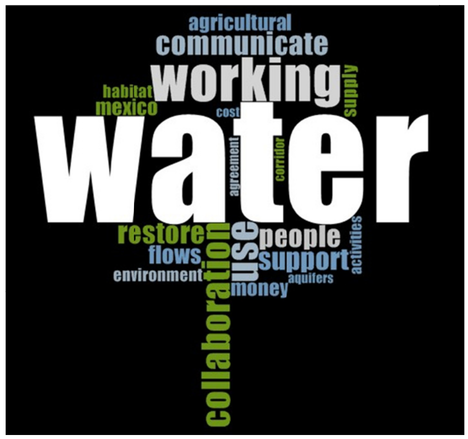

Figure 3. Qualitative results on stakeholders' insights

3. At the moment, the only binational mechanism available to solve a water-related problem and secure water in the PdN region is the *Minute process*.
    a. The *Minute process* represents the institutional instrument to frame stakeholders' concerns related to water quantity and water quality issues.

CONCLUSION AND POLICY RECOMMENDATIONS

North American countries are known for their water wealth. A total of fifteen surface water sources are shared along the border areas. Canada and the U.S. share twelve rivers and lakes, while the border between the U.S. and Mexico is drained by three river basins. By means of the International Joint Commission (IJC), Canada and the U.S. cooperate to manage their waters wisely and to protect them for the benefit of its citizens and future generations. For their part, the U.S. and Mexico cooperate through the IBWC to solve issues that arise during the application of binational treaties regarding national ownership of waters, sanitation, water quality, and flood control in the border region.

The binational capacity to prevent a water crisis and secure water in the transboundary PdN region hinges on the ability to create *resilient water institutions* by means of recognizing the need to plan for the unexpected, to involve stakeholders, and to learn from and replicate successful initiatives. The U.S.– Canada International Watersheds Initiative (IWI) is a neighboring experience from which the U.S. and Mexico can learn new practices to address water issues and secure through an integrated ecosystem approach, stakeholders' involvement, and iterative assessment of the effectiveness of decisions over time (IJC 2016). The IBWC is called upon to play a major role in this process. Stakeholders from the PdN region provide insights into what they wish to be done to enable institutional resilience and foster regional water security.

Having said that, the main argument guiding our preliminary set of policy recommendations to foster water security and build water resilient institutions in the PdN is that:

> The *Minute Process* is the binational mechanism allowing flexibility to the 1944 Water Treaty by enabling a common interpretation on a water-boundary issue (Nava et al. 2016).

The 1944 Water Treaty is the cornerstone for managing shared waters crossing the U.S.-Mexico border. Its importance is due to fixing the distribution of water resources and establishing the *Minute process* as the binational mechanism allowing for flexibility to address new circumstances. This process allows to update the Treaty on an *ad hoc* basis. Learning from the International Watersheds Initiative (IJC, 2016), a new *Minute for Binational Water Security through Institutional Resilience in the transboundary Paso del Norte region* may be jointly agreed on the following six points:

1. The acknowledgement that the transboundary Paso del Norte represents a regional watershed ecosystem integrated by local communities and flora and fauna resources.
    a. Practicing an ecosystem approach to manage water, living resources, and land may promote conservation and sustainable water security.
2. The recognition that managing water scare resources in an arid context requires the development of regional techniques and procedures to optimally accentuate their benefits.
    a. In this case, it is a responsibility shared by the signatory countries to facilitate the necessary means to achieve this requirement.
3. The establishment of an inclusive process to address the interests from organized stakeholders and environmental groups.
    a. The creation of an exploratory Water Task Force to obtain recommendations from regional stakeholders, such as in the Tijuana River Basin, the Lower Colorado River, and the Colorado River Delta is crucial (Nava et al. 2016).
4. The exploration of a sustainable water use and allocation system for the comprehensive sustainability of the region.
    a. Water resources may be reallocated from upstream to downstream users, from one use to another, and vice versa, in times of drought and abundance of water.
5. Both, the U.S. and Mexico are aware of the issues influencing regional transboundary water quality and water flows.
    a. Sustaining water flows may be hydrologic and economic feasible with the region.
6. The effectiveness of decisions over time will lead to *water resilient institutions* ensuring water security in the region.
    a. *Institutional resilience* may be an ongoing process as stakeholder needs and concerns are evolving. Iterative adaptation of institutions may secure water in a sustained manner.

The *Minute process* makes of the 1944 Water Treaty a *resilient institution; it* enables the Treaty to respond to emerging issues and design new policy initiatives. Stakeholders from the transboundary Paso del Norte may advocate for a binational zest for political willingness to secure water in the region. They may call upon the Commission to play the role of chief negotiator in this process.

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Long-Term Scheduling of Provincial Power Grid With Rich Hydropower

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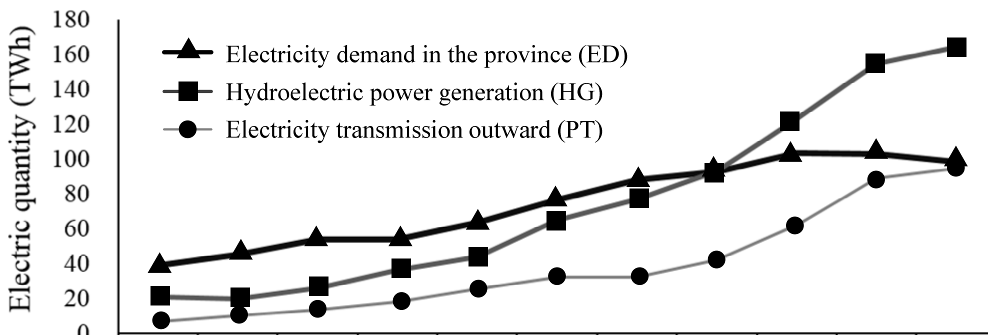
Abstract

Southwest China has experienced a rapid development of hydropower in recent years. In contrast, the power demand growth is very slow in the region. The increasing imbalance between power supply and demand have led to great challenges on the hydropower absorption and operation of provincial power grids with rich hydropower. In this paper, a practical method for long-term scheduling of provincial power grids with rich hydropower is proposed. An optimization model with maximizing the absorption of hydropower is formulated. A coordination strategy, which is capable of minimizing the thermal power generation according to the energy-saving scheduling principle, is employed to increase the absorption of hydropower. The proposed method was implemented on the generation scheduling of yunnan power grid (YNPG), with more than 60GW hydropower capacity and 160 large and middle-sized hydropower plants. The case study presents different simulation results by considering scenarios of inflow and demand. It is demonstrated that our method can obviously increase hydropower absorption. It is effective and practical.
Keywords: Hydropower absorption; Optimal operation; Coordination strategy; Provincial power grid with rich hydropower

1. INTRODUCTION

In recent years, the fast growing demand for energy in China has stimulated an expansion of renewable energies (e.g. hydropower, wind, solar). China possesses the world's largest hydropower resources and about 70% of hydro resources are concentrated in the southwestern regions. Powerful political emphasis on future hydroelectric development and environmental protection targets cooperated to make hydropower the key component in achieving renewable energy targets as part of energy conservation and emission reduction policy (Huang and Yan, 2009; Cheng et al., 2012). Now power system in Southwestern China is a hydro dominated system with few integration of thermal power and large integration of renewable energies. Along with the continuous expansion of installed hydropower capacity and power grids interconnection, the optimizing operation of hydropower systems is characterized by large-scale, seasonal abundance and trans-province, which presents great challenges with the absorption of large-scale hydropower. The scheduling calculation of power grid with large-scale hydropower involve a complicated set of constraints with multi-objectives, so the operation and management of power grids in southwestern China are in great need of practical large-scale hydropower optimization scheduling method. Furthermore, with the sustained and rapid increase of renewable energies generation capacity, especially the hydropower, power grids such as Yunnan Power Grid may appear a large amount of surplus electricity for months, which will increase year by year (see Figure 1).



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ED	39	45	54	53	63	76	88	93	103	103	98
HG	21	20	26	36	44	65	77	93	123	155	164
PT	6	10	13	18	26	32	32	42	62	89	95

Figure 1. Hydropower capacity growth process of Yunnan Power Grid

It can be seen that the majority of hydropower consumption in southwestern China is derived from local power consumption and large-scale electric power transmission. How to consume hydropower generation scientifically and reasonably, and how to effectively increase the proportion of hydropower absorption by taking targeted measures are urgent problems for us to solve. The rational allocation of hydropower resources requires strategic and coordinating solutions of coordinating problems among hydropower plants, basins, grids, as well as trade-off analysis among different power resources (Zambon et al., 2011).

This paper presents an optimization model using practical solution methods for large-scale complex hydropower system operation and a coordinating strategy for maximizing the hydropower generation, according to the energy-saving scheduling principle. Both methods can promote the absorption of hydropower energy from different aspects and YNPG is selected as the application example to verify the effectiveness of the proposed method. In summary, this paper is organized as follows. In Section 2, key problems of this study are introduced, and the optimization model and coordinating strategy are developed. The solution method of the proposed model is presented in Section 3. Next, results of case studies taking YNPG as background are shown and discussed in Section 4. Conclusions of this study are given in the last section.