technical paper
Water Management

water e-journal
Online Journal of the Australian Water Association
ISSN 2206-1991
Volume 1 No 2 2016
http://dx.doi.org/10.21139/wej.2016.014

WATER MANAGEMENT IN NSW AND COLOMBIA: SIMILARITIES AND DIFFERENCES

RESULTS OF AN ANALYSIS CONDUCTED OF BOTH NEW SOUTH WALES AND COLOMBIAN WATER MANAGEMENT FRAMEWORKS

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ABSTRACT

Rapidly changing external factors, such as climatic conditions, population growth and migration, pose significant challenges to water policy-makers and water resource administrators alike.

Due to its semi-arid climate, recurrent dry weather conditions and increasing water demands, water regulation in New South Wales (NSW) has evolved considerably during the last century. To effectively address the water management challenges, NSW has developed regulatory frameworks and mechanisms to move towards a more resilient approach.

This paper outlines characteristics and challenges of NSW and Colombian water regulatory frameworks, to identify potential opportunities for improvement to delineate and implement more efficient and effective water management and regulatory frameworks, considering the particulars of each case.

INTRODUCTION

Water Resources In Colombia

Given its geographic location, orography and a variety of climate regimes, freshwater availability in Colombia is high compared with average worldwide values. In fact, Colombia is one of the countries with the most water resources available worldwide (Arango *et al.*, 2012). Some hydrologic parameters in Table 1 highlight this.

Table 1. Water availability comparison (adapted from BOM (2013); CEPAL (2010); CSIRO (2005).

Parameter	Colombia	Worldwide	NSW
Average annual precipitation (mm)	3,000	900	553
Average effective runoff production (L/sec·km^2)	58	10	0.94

The rainfall pattern in Colombia is highly variable temporally and spatially, with some areas reporting less than 500mm/year precipitation (northern peninsula), and others recording more than 9,000mm/year rainfall (Pacific coast) (IDEAM, 2014).

In terms of water availablility per capita in Colombia, the estimated value is 47,949 m^3/person·year under natural conditions (World Bank, 2013). The total volume of water sourced is between 5% and 6% of surface water available (CEPAL, 2010); therefore, in general, water is an abundant resource in Colombia. However, water stress tends to increase across the country, as discussed in the next section.

The capacity of storage of surface water in swamps, ponds, lakes and natural reservoirs is about 38km^3, whereas the capacity of storage of water in artificial reservoirs is 7km^3 approximately (MAVDT, 2010).

Vulnerability Of Water Resources In Colombia

At the end of the last century, Colombia was ranked the fourth highest country for water availability per capita (IDEAM, 2008). At the beginning of this century, the United Nations reported that Colombia occupied 24th position among 203 countries with a similar ranking (UN, 2003).

The vulnerability of water systems in Colombia due to climate impacts has been documented by international agencies (e.g. OECD, 2013).

Most of the Colombian population resides in two areas: the Andes, which is exposed to water shortages; and coastal areas that are exposed to floods (World Bank, 2015). Rapid population growth, urbanisation and internal migration into urban areas, along with extreme dry conditions, pose significant risks to national long-term water security.

More than 80% of the urban settlements source their water from small mountain rivers and creeks, which are highly vulnerable to climatic changes as they don't have storage systems (MAVDT, 2010; IANAS, 2012).

There are several challenges in water management in Colombia, such as large losses in drinking water distribution systems and poor water quality (SSPD, 2007). Drinking water distribution system losses in the six

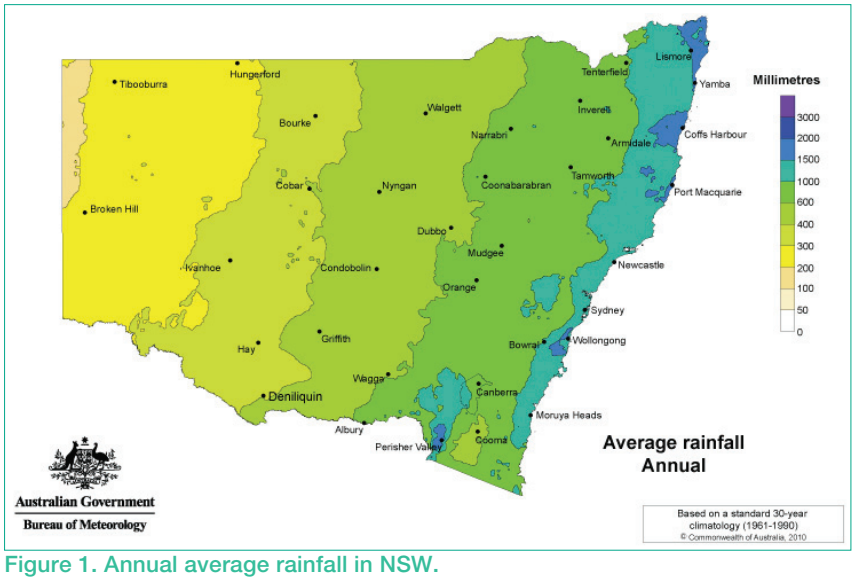

Figure 1. Annual average rainfall in NSW.

main cities fluctuated from 33% to 54% in 1995 (CEPAL, 2010). The volume of sewage treated is about 3.1% of the total water sourced in Colombia (MDE, 1996). In a typical year during dry weather conditions water availability is reduced by between 50% and 65% (IDEAM, 2010).

The vulnerability and lack of resilience of water management is particularly evidenced during extreme dry conditions, which are influenced by the El Niño-Southern Oscillation (ENSO) phenomenon. During 2015–16, dry weather conditions triggered low record flows in some rivers and dams (IDEAM, 2016), resulting in about 200 towns not having enough water to meet current demand (MADS, 2015).

The Colombian climate agency, based on information reported by international agencies, has indicated that the current ENSO event could remain strong until March 2016. Other experts predict that the current ENSO could continue until mid-2016, and its effects are expected to be particularly strong in the most heavily populated areas. The dry season in Colombia will coincide with the strongest intensity of the ENSO event, meaning the dry conditions will be accentuated (IDEAM, 2015).

Furthermore, 75% of the electricity in Colombia is produced by hydropower (MinMinas, 2012), which also makes the energy sector vulnerable to extreme dry weather conditions.

Water Resources In NSW

Australia has one of the most variable rainfall and streamflow conditions in the world (BOM, 2015). In addition, the supply of water in NSW is inherently unreliable relative to many other parts of the world (Brennan and Scoccimarro, 1999).

This variability can be observed by comparing the ratios of maximum annual flow to mean annual flow in lotic systems. These variabilities have been documented in different research studies (e.g. Dettinger and Diaz, 2000; McMahon *et al.*, 2007). Some references suggest that in North America this ratio commonly ranges between 3:1 and 15:1, while in Australia it ranges from 300:1 to 1000:1 (Brennan and Scoccimarro, 1999). A variation of 10000:1 has been reported for the Darling River (Powell, 1989), which drains three-quarters of NSW.

To attenuate the variability, several measures have been implemented. One of these is water storage. Irrigation storage in NSW holds four times more water per hectare of irrigated land than Egypt and 10 times the volume held in India (Crase *et al.*, 2000). Further, surface and groundwater availability is increased in NSW by adequately managing short- and long-term economic needs as well as environmentally sustainable requirements.

The key strategies that contribute to water security in the Sydney Metropolitan area are: dams augmentation; water recycling; desalination; and water efficiency improvement (Metropolitan Water Plan, 2010). The following section describes the regulatory framework in NSW and the mechanisms implemented to optimise the allocation and use of water and mitigate its vulnerability. The potential opportunity to implement some of those to reduce the vulnerability of the water sector in Colombia is also discussed.

PROCESS

A compilation of the main attributes that characterise water regulation in NSW and Colombia was done and the results are summarised in Table 2. It also highlights whether each of these have been implemented at each location.

NSW Water Regulatory Framework

Water management policy and regulatory frameworks in NSW have evolved significantly and currently rely on a range of legislation, initiatives and cooperative arrangements with the Commonwealth and other state governments (WaterNSW, 2015). The characteristic features of the water framework are:

- Water charges are a function of usage in both the urban and rural sectors, and in most cases reflect the full (or close to it) economic cost of managing the resources;
- Water allocation (availability) recognises the needs of the environment and is a function of climatic conditions;
- Water entitlements (licences) are perpetual and break the connection between land and water titles;
- There is a mature water market for trading water allocations and entitlements;
- Water agencies are required to provide efficient water service delivery, separating regulation/ management and water delivery functions; and
- Water industry infrastructure investments are encouraged only if they fulfil economic viability and sustainability criteria.

Table 2. Key characteristics of NSW and Colombian water regulatory frameworks.		
Attribute	NSW	Colombia
Water sharing arrangements enshrined in legislation	✓	×
Long-term water supply/demand planning in major urban cities	✓	×
Regulate monopolies in water sector	✓	✓
Water rights separate from land	✓	×
Tradeable water licences and allocations	✓	×
Different categories of water licences with different levels of water security	✓	×
Focused on achieving economic efficiency of water utilities	✓	✓
Allows for flexibility depending on market conditions	✓	×
Is streamlined with public health regulation	✓	✓
Incentives for innovation, diversification and encourage efficiency in the water industry	✓	×
Includes robust compliance and enforcement mechanisms	✓	×
Encompasses private works as irrigation districts, private water trusts	✓	×
Monitor and evaluate effectiveness of water management	✓	✓
Has developed schemes to deliver substantial water savings for the environment	✓	×
Considers a fit-for-purpose approach for water quality	✓	×
Allowable water extractions vary year to year based on climatic circumstances	✓	×
Licenced consumptive water rights for individuals	✓	✓
Limits on annual extraction of water for consumptive use	✓	✓
Water ordering system for consumptive users	✓	×
Environmental water entitlements	✓	×
Indigenous water rights	✓	×
Cost recovery for regulatory frameworks	✓	✓
Separation of regulators and operators	✓	✓

Pricing Of Water In NSW

The efficient pricing of water is an integral component of the water regulatory framework, and NSW has been at the forefront of pricing reform for bulk water (Furmage, 1998). The Independent Pricing and Regulatory Tribunal of NSW (IPART) regulates the prices charged for monopoly services provided by certain metropolitan water utilities, as well as prices charged by providers of monopoly bulk water services. In making determinations and recommendations, IPART considers issues such as:

- Cost of providing the services;
- Protection of consumers from abuses of monopoly power;
- Appropriate rate of return on public sector assets;
- Need to promote competition in the supply of water services;
- Social impact;
- Need for greater efficiency in the supply of services to reduce costs for the benefit of consumers and taxpayers.

Water Administration And Licensing In NSW

The water administration framework in NSW encompasses a range of aspects including local and state water-sharing and environmental plans and policies, private works (e.g. irrigation districts) and private water trusts. There are also some 50 aspects of state legislation that govern the activities of licence holders (Schroo, 1998).

Water access licences (WALs) control the shares of access to water governed under a water-sharing plan under the *Water Management Act 2000* (or Water Resource Plan under the Commonwealth Basin Plan). These plans establish rules for making water available to WALs and, thus, the sharing of water between the environmental needs of rivers or aquifers, water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation.

WALs are valuable assets recognised by legislation and provide a clearly defined, perpetual and tradeable entitlement that is separate from land ownership. WALs define a right to a share of the available water in a particular water source and provide opportunities to trade water through the separation of land and water rights, allowing

Figure 2. Magdalena River in Colombia during extreme dry weather conditions.

for flexibility depending on trading rules and market conditions.

There are different categories of WALs, with different purposes, conditions and levels of water security, including: regulated rivers, aquifers, estuarine, coastal, major utilities, local water utilities, irrigation, domestic and stock; and aboriginal cultural.

The water supply and demand for water in major urban cities considers long-term projections of supply and demand and there is a clearly defined, fit-for-purpose approach for water quality required based on exposure risk levels for specific uses of water.

The amount of water released from dams in NSW is calculated on a daily basis, using water balances that include information provided from consumptive users by a water ordering system and to meet environmental, flood mitigation or downstream states' requirements. Relevant information for water users is available at www.waternsw.com.au, including water entitlements, dam and river levels and environmental flows.

NSW water regulation includes robust compliance and enforcement mechanisms (e.g. periodic auditing), including substantial penalties in case of breaching licence conditions or contravening the relevant legislation. Additionally, incentives for innovation, diversification and encouraging competition and water efficiency in the water industry are key elements of the water regulation framework. Most of the features described in this section are summarised in Table 2, indicating whether the regulatory framework in Colombia considers each of those.

Water Regulation In Colombia

The environment ministry coordinates the water sector policy and defines water resources general management strategies at a national level. Other ministerial departments provide technical guidelines to the Minister and collect hydrologic and meteorologic information. There are 33 regional environmental authorities responsible for administering the water resources (quantitative allocations and licensing) in different areas across the country. Local councils are also responsible for developing and implementing water management projects. Other ministries and departments also have responsibilities related to water resources management (MAVDT, 2010).

One of these organisations regulates water services tariffs and monopolies, and a department verifies compliance and enforcement in more than 2,000 public water utilities. The number, dispersion and heterogeneity of public water utilities make the application of regulation demanding and challenging (SSPD, 2007).

DISCUSSION

The water regulatory frameworks in NSW and Colombia have some similarities and key differences, as outlined in Table 2. The fundamental reasons for the differences are related to historical water resources availability and variability, drivers for the evolution of legislative frameworks, and also different socio-economic conditions. As a result, some of the regulatory drivers and water resource management in NSW and Colombia are notably different. The regulatory framework in NSW is focused on providing mechanisms to ensure the adequate provision of water services for economic, social and environmental purposes (including a long-term sustainability vision).

In NSW, water management and allocation is carried out in a cyclical way (ie, planning, implementation, monitoring and evaluating) to ensure resources protection and future availability. These processes are progressively developed for surface water and groundwater systems across NSW, accordingly with the *Water Management Act 2000*. To determine water availability, calculations are performed at the start of each year and subsequently reviewed depending on the actual weather conditions, flows and water demand.

Figure 3. Magdalena River under normal conditions.

The water market is mature and redistributes the water made available by the Government to its highest economic use. The value of water is, therefore, established by this market and varies depending on climatic conditions.

Synthetising, some elements such as monitoring seasonal and demand fluctuations, creating incentives for reuse resources and innovation, are part of the water management strategies in NSW. Much of this has been driven by NSW's inherently dry and highly variable climate, where demand usually exceeds supply.

In contrast, Colombia has historically had abundant quantities of water resources available that are also reasonably well distributed. A relatively high inequality of economic resources has focused the Colombian policies on ensuring its population has access to minimum water quantities and standards of water services at affordable prices (e.g. definition of a minimum volume of water for basic needs per customer, tariff cross-subsidy methodology and uniform conditions contracts).

Accordingly with Colombian legislation, water is considered a public good and the government regulates its uses. The amount of water allocated (water right) is defined as a certain flow for specific activity or use, linked to the land where it is intended to be used.

Water Sector Current Situation In Colombia

In response to the substantial reduction of water in Colombia during ENSO events, the government has adopted reactive measures to mitigate the consequences. These measures have included imposing water restrictions, operating some schemes intermittently, imposing fines for wasting water and/or electricity and, at the driest locations, distributing water-using tankers.

This situation is the result of a lack of 'long-term view' national policies, an inflexible water regulatory framework, ineffective coordination among authorities and stakeholders, weak institutional administrative capacity, and fragile enforcement and compliance mechanisms.

Potential Opportunities For Improvement

Creating a market of water rights in the form of tradeable water licences is an effective mechanism to optimise the use of water for its highest value, and encourages efficiency and equity in the adjustments of water allocation in NSW. This mechanism has created conditions for directing a scarce resource to productive outlets, while generating income for irrigators in NSW.

Establishment of tradable water rights could play an important role in improving the efficiency, equity and sustainability of water use in developing countries (Rosegrant and Binswanger, 1994). Similar institutional arrangements have been implemented in countries such as Australia, Chile, China, South Africa and the western United States (Grafton *et al*., 2011).

Given its average overall water availability, water infrastructure and storage capacity, lack of adequate, timely information, the levels of inequity and potential market distortions caused by concentrations of power and weak institutional administrative capacity, I consider the afore-mentioned approach would not be adequate to optimise water management in Colombia at this stage.

Currently there are mechanisms and economic tools in Colombia created to balance equity and drive changes in behaviour of water users and pollutant agents. However, the existing regulatory framework is not implemented adequately across the country, and there is a lack of coordination between local and national authorities.

In that sense the evidence suggests that the water sector's current situation is not sustainable in Colombia and a more effective water management approach is required (IDEAM, 2014).

An example is the absence of a comprehensive and systemic approach of local environmental authorities responsible for allocating water rights. The order of priorities to allocate water rights in Colombia is: human consumption, agricultural, industrial and hydropower generation (IANAS, 2012). Note that environmental flows are not considered in the water allocation process.

In terms of infrastructure, reducing the percentage of losses in drinking water distribution systems can contribute significantly to making the schemes less vulnerable to scarcity conditions. Also, developing surface water storage infrastructure allows river flows to be regulated during both dry and wet seasons, reducing the vulnerability of the systems.

The water regulatory framework in Colombia is not dynamic; therefore it does not adequately address the challenges from external factors such as climate variability and rapid increase in water demand. The water regulatory framework should allow for flexibility regarding the volumes extracted from catchments, considering variable climatic scenarios. Water balances at catchment level and projected demands of use of water are key information that should be calculated regularly to ensure the availability of resources in the short and long terms.

The 2014 Intergovernmental Panel on Climate Change report predicted reductions in average precipitation in most of Colombia, and retreat of Andean glaciers in the next century. Further, Gutierrez and Dracup (2011) have identified that it is possible to predict long-term discharge volumes of Colombian rivers based on ENSO indicators.

These are examples of elements that could be considered by Colombian policy-makers to make water regulation more efficient, effective and resilient.

There are other opportunities for improvement in water management in Colombia, such as adopting a catchment approach and considering long-term water supply and demands. Further, it is possible to create regulatory incentives to stimulate innovation, and encourage water use efficiency and reuse in the industry sector in Colombia (e.g. encourage treating sewage and/or stormwater harvesting).

Adequate participation of public health, and environmental authorities assessing the risks of those processes, are fundamental to ensuring the quality of water produced is effectively fit for the intended purposes and has acceptable environmental standards.

Another key element that can be improved in water management in Colombia is the mechanism to obtain and make relevant information available to departments and the public. Implementing integrated online systems that are easily accessible to provide information (water demands) and obtain key data (e.g. hydrologic) in the water sector by catchments would help to optimise resources planning and management. This approach would also allow for verifying compliance, and facilitates making decisions to optimise the overall outcome for water users.

It is also important to ensure that there are effective public consultation mechanisms that allow water users and other relevant stakeholders to participate and provide feedback in different processes of the water management and resources allocation.

Current legislation in Colombia requires continuous increase in the water sector investment across the country. However, current water sector investments are insufficient to optimise the treatment and distribution systems accordingly, with long-term estimated demand and pressure from possible climate variability scenarios. The existing public services tariff cross-subsidy scheme is not sustainable in the long term and does not encourage water efficiency. The difference between the water available and water demand is reducing rapidly, particularly in the sub-catchments where most of the Colombian population resides.

As mentioned previously, the water rights allocation process does not include scientific-based allocations to required environmental flows. This situation inadvertently creates incentives for the depletion of natural water resources, transferring costs to the environment and increasing the vulnerability of water resources.

CONCLUSION

Based on my experience working in both Colombian and NSW water regulation authorities, along with an understanding of the main drivers of the water regulation policies in both scenarios, I consider that there are grounds for the development of water regulatory frameworks that can potentially be transferred between countries, considering the local context.

Some of the lessons learned in the development and implementation of water management in NSW could be extrapolated and potentially increase the efficiency and effectiveness of the development of water regulatory policies in Colombia. Also, some of the mechanisms created and adopted in NSW to reduce the vulnerability of water scarcity in the short and long terms potentially could be adopted by water regulatory administrators in Colombia.

Adopting a reactive approach to mitigate the effects of external factors such as the ENSO phenomenon is not acceptable in a country with traditionally abundant water resources. That approach would not be warranted if a more resilient water management policy were in place.

The population in Colombia is expected to continue growing (DANE, 2010) and climate variability events (such as ENSO) will probably continue to occur; therefore, policy-makers should ensure that the country is adequately prepared to address those challenges.

Increasing sewerage coverage, and improving domestic and industrial wastewater treatment, are critical in Colombia to improve the quality of water bodies and the availability of water resources downstream.

Water policy in Colombia contains key elements and principles of an integrated water management (IWM) strategy; however, these are not implemented adequately across the country. The hydraulic and hydrologic monitoring networks should be improved to ensure enough information is available continuously, allowing the decision makers to manage the resources efficiently and effectively with long-term vision.

The climate variability must be considered to effectively address the social and economic risks of inadequate water management, and adequate programs should be implemented accordingly. Similar recommendations have been made in Colombia by IDEAM (2010).

Colombian water policy provides principles, strategies, objectives, targets and indicators to regulate water resources (MAVDT, 2010); however, it has not been effective in providing adequate water management across the country.

Although the water regulatory framework in Colombia includes a range of provisions and mechanisms (e.g. IWM, economic tools to incentive changes in user's behaviours, etc), there are a number of measures that could be used to contribute to a more efficient, effective and resilient water industry:

- Implement a long-term national level view in strategic water policy, considering worst-case scenarios from external factors such as climate variability, and prepare them adequately in advance.
- Adopt a cyclic approach to define water management and allocation from a catchment perspective.
- Consider environmental flows in water allocation process, considering the catchment as a whole, and ensure those flows are maintained.
- Adopt a flexible approach in water allocation processes, including climate variability scenarios.

- Create incentives and opportunities for innovation and diversification, and encourage efficiency and water reuse in the water industry.
- Ensure adequate stakeholder consultation and participation mechanisms are allowed, and relevant information is available in a transparent manner in real time, if possible.
- Continue developing water storage infrastructure projects to regulate river flows during dry and wet seasons.
- Implement efficient and effective compliance and enforcement mechanisms.
- Provide adequate resources and technical support to ensure the regulatory lineaments are correctly implemented at local level.

This paper was presented at the 2016 YWP Conference in Sydney.

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