

Water scarcity, climate change and Bolivia: Planning for climate uncertainties



View of El Alto from Chacaltaya ski resort, which closed in 2009 due to the disappearance of the glacier on its slopes. The shrinking glaciers and snow-line that provide up to 28% of water for El Alto pose serious challenges to this city of more than one million people. Photo by Mari Tortorella

Introduction

Bolivia, in the Andean region of South America, offers a clear illustration of how climate change will have the gravest impacts on those who are most vulnerable. This is especially evident in the city of El Alto, the sprawling metropolis of more than one million people that lies in the arid high plains at 4000 metres above sea level. On the one hand, this Andean city faces a rising demand for water from a rapidly increasing urban population and, on the other, falling supplies as glaciers in the surrounding Cordillera mountain range shrink dramatically. One of Bolivia's most critical challenges in coming years will be to plan and implement effective strategies for managing water under uncertain climate conditions.

El Alto: poverty, population and access to water

El Alto is a bustling city that sits high on the Andean plains next to and above Bolivia's capital city, La Paz, which spreads out in a bowl beneath it. The altitude, bitter cold and dry air make it a harsh climate to live in; nevertheless it has become one of the fastest-growing cities in Latin America as indigenous peoples have left rural areas to seek employment and livelihoods. Between 1976 and 1992, its population grew at a rate of 9.2% annually, slowing to 5.1% per year between 1992 and 2001. El Alto's population grew by at least 30% be-

tween 2001 and 2012, and the city's land area has expanded even more rapidly in the past decade, by 144%, spreading into the flat open countryside to the south and west.

Bolivia is the poorest country in South America, and El Alto is the poorest city in Bolivia. The 2001 national census identified 73% of the city's population as experiencing poverty, and reckoned 43% of the total population to be indigent.

This poverty has been felt acutely in terms of access to water and sewage services. The same census revealed that only 35% of households had piped water indoors, with 54% relying on outdoor piped water, while 11% had no access to drinking water at all. The difficulty of providing water services to a constantly growing population spread out over a large area has already posed huge challenges to an under-resourced municipal water utility, and contributed to the termination of a contract with one private operator, Aguas de Illimani.

The municipal utility – Empresa Pública Social del Agua y Saneamiento (EPSAS) – has run water services in La Paz and El Alto since 2007. EPSAS has succeeded in increasing connections to water services by 40% since 2007, but is highly dependent on international aid for investments in

Table 1: Current and proposed future water systems and their predicted performance under different climate-change scenarios.

	Water systems and sources	Population served	Resilience and vulnerability to climate change
Existing water sources	<i>Achachicala</i> Main source Milluni reservoir	Provides for 195,000 residents of La Paz	Good resilience. Reliability of between 95.08% and 98.06%, with a maximum period of failure of between 2 and 6 months
	<i>Pampahasi</i> Main sources: reservoirs of Incachaca, Hampaturi and Ajuankhota.	Provides for 300,000 residents of La Paz	Watersheds could reduce by up to 25%. Reliability up to 2030 could vary between 56.56% and 85.25% with a maximum failure period of between 4 and 8 months
	<i>El Alto</i> Main sources: Tuni dam and two water channels from River Huayna Potosí and Condoriri	Provides for 300,000 residents in La Paz and 850,000 in El Alto.	Low resilience – even without climate change. There is no capacity to recover from a failure if new sources aren't found.
	<i>Tilata</i> Source: 32 wells	Provides for 160,000 residents in El Alto	Impacts of climate change not studied because of lack of data for modelling the impact of subterranean water sources.
New sources of water or water-saving measures	Reduction of water losses in urban systems and irrigation		In the short term this would be the most effective strategy Could cover 20% of future water demand in El Alto. Irrigation losses in Tupak Katari, Taypichaca and Suriquiña water systems could be reduced from around 85% to 60%.
	New reservoir in Khotia Khota Lake (Khara Khota watershed); expansion of Taypicacha reservoir; improvements in irrigation infrastructure to reduce leaks; new pressurized irrigation system		Up to 2030, the most effective strategy A new reservoir in Khotia Khota Lake would have a capacity of 8.80 cubic hectometers (hm ³). Expansion of Taypicacha reservoir would enable a total capacity of 18.07 hm ³ .
	Prioritize El Alto for use of the Milluni reservoir from the Acachicala water system, and construct new reservoirs (Jankho Khota and Kaluyo) and new water channels from the Chacaltaya watershed and River Choqueyapu.		Most effective strategy up to 2050 New Kaluyo reservoir would have capacity of 9.24 hm ³ ; the water channel from Chacaltaya watershed 0.2m ³ /s; and the Choqueyapu river 0.5m ³ /s

infrastructure. EPSAS also depends heavily on rate payers in La Paz, who provide 75% of its revenue. This could undermine the long-term financial sustainability of El Alto's water services, particularly since La Paz is proposing alternatives that may include setting up its own municipal water utility.

Climate change impacts

Temperatures in the region have risen by 0.5°C in the period 1976 to 2006, and the people of La Paz and El Alto can ob-

serve evidence of climate change in the form of the shrinking snow-line in the mountains above them. One glacier on Chacaltaya mountain (which rises above El Alto and which once hosted the world's highest ski resort) has already completely disappeared. Two glaciers (Tuni-Condoriri) that provide water for El Alto and La Paz lost 39% of their area between 1983 and 2006, at a rate of 0.24 km² per year.

Both regional and global climate models suggest that El Alto and La Paz will see temperatures rise by a further two degrees by 2050, which would lead to the complete disappearance of many small glaciers and the dramatic shrinking of others. Glaciers are estimated to provide 20–28% of water for El Alto and La Paz, therefore glacier loss will have a considerable impact, which will be felt particularly during the dry season, when glacial water provides the majority of urban water. Glaciers and mountain water systems also support agriculture, power generation and natural ecosystems throughout the region.

It also appears that more rainfall will not compensate for glacial melt: although some climate models suggest an increase in rainfall of up by 4.3%, most suggest a reduction of up to 10.3% by 2050. Furthermore, patterns of rainfall under conditions of climate change are much harder to predict than patterns of glacial melt.

Climate and population crunch: reduced supply against increased demand

By 2009 demand for water in El Alto had already outstripped supply, a situation that could become a lot worse in the face of demographic pressures: for example, El Alto is predicted to double in population to two million people by 2050. One of the

Water Evaluation and Planning (WEAP)

The major challenge for administrators of water resources is how to calculate all potential external impacts and recognize uncertainties that accompany climate change, and to develop strategies in response that can adapt and be flexible to changing circumstances, and that can address a range of risks. That is why SEI developed a unique free software tool – the Water Evaluation and Planning system (WEAP) – that allows water stakeholders to measure and model impacts and uncertainties in order to generate projections and choose the best options. In the context of El Alto, SEI developed six possible climate scenarios and their likely impact on local watersheds, testing their vulnerability, resilience and reliability. These scenarios enable local policy-makers to make decisions that aren't necessarily ideal, but which are robust and adaptable and can work under a wide range of uncertain futures.

<http://www.weap21.org>

causes of this influx into the city will be climate change. Evidence from El Alto's history indicates that the fastest periods of population growth coincided with droughts, floods and bad harvests associated with the meteorological phenomena of El Niño and La Niña. The years 1985-1987, when migration into El Alto reached heights of 65,000 new immigrants, were also years of poor harvests.

Total average water use in El Alto is very low – 52 litres per person per day (l/p/d) – but this is predicted to grow to 77 by 2050. In richer areas of La Paz (those provided by the Achachicala water system) consumption will rise less steeply, but from a much higher rate of 222 l/p/d to 227 l/p/d. In the context of this increased demand from urban users, combined with a growing population and a growing demand from irrigation for agriculture in surrounding areas (predicted to be a 20% to 40% increase by 2050), it is clear that pressure on water supplies will become a serious problem.

Actual and potential new sources of water

In terms of supply, La Paz and El Alto currently have four systems of drinking water: Achachicala, Pampahasi, El Alto and Tilata. Three of these systems are based on reservoirs and dams in the Cordillera mountain range, 72–80% of the water in these systems comes from rainfall and 20–28% from glaciers. The Tilata water system takes advantage of subterranean water pumped out from 90 meters below the earth via 32 wells.

The Stockholm Environment Institute (SEI), supported by the Inter American Development Bank (IADB), looked at the vulnerability, resilience and reliability of existing and potential new water sources under six different climate change scenarios. The aim was to identify the most robust options for water management in coming years. The **vulnerability** of a water source is defined as the maximum length of time water supply won't match demand; **resilience** the amount of time a water system will take to recover after a failure; and **reliability** refers to how frequently a water supply fails. SEI's studies showed that the current El Alto water system would almost permanently fail (i.e. be unable to meet water demand) in the period 2011 to 2030; while the Pampahasi system would only have a reliability of 74.59% and could fail to meet water demand for up to seven months a year.

Examination of new water sources showed that up to 2030, the construction of a new reservoir in Khotia Khota Lake (Khara Khota watershed) and the expansion of Taypicacha reservoir would be the most robust investments. Up to 2050, new reservoirs in Jankho Khota and Kaluyo (combined with prioritizing El Alto for use of Achachicala water) offers the most robust investment (see Table 1).

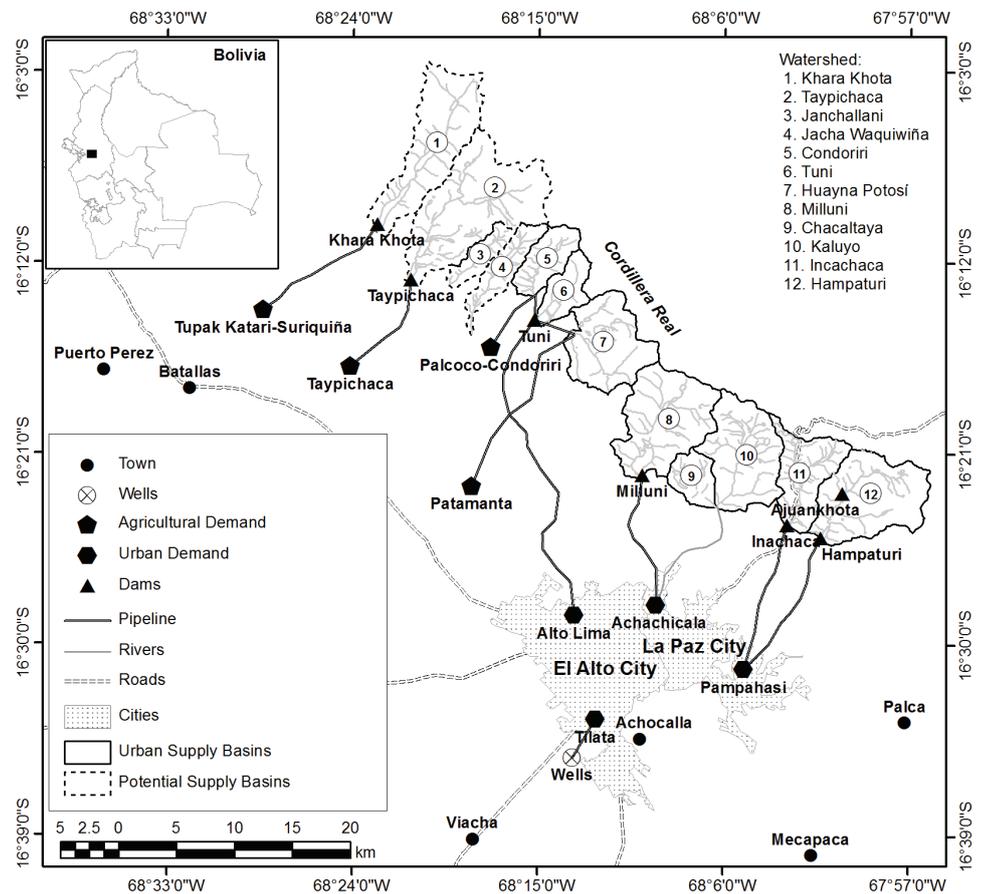


Figure 1: Current and potential water sources for La Paz and El Alto.

Map provided by PPCR/SPCR, 2012

Water conservation and recycling

Bolivia cannot rely on new sources to resolve its water crisis, given both the costs and also the potential range of climate change impacts. In the most pessimistic of climate change scenarios, the new water sources proposed for the watersheds of Khara Khota and Taypicacha could see reductions of 37.14% and 28.79%, respectively. Other conservation and recycling methods will be essential for El Alto and La Paz to build the resilience of its water systems to climate change. These include the following:

1. Reduction of water losses in urban and agricultural areas

This has the best potential for water resilience in the short-term. The municipal water authority EPSAS calculates that losses in El Alto's water system are currently at 38%. This is an improvement since the 1980s when losses ran at 50%, but given that the average in industrialized countries is 15%, there is potential – with international aid, investment and training – for El Alto to meet 20% of future demand by reducing leaks. There is also great potential to reduce losses from irrigation systems, which tend to run at almost 90% but could be reduced to 60% with improvements in infrastructure.

2. Recycling of industrial waste water

El Alto is an industrial city, which generates high quantities of water contaminated with metals, textile dyes, and waste from tanneries and abattoirs. This has heavily polluted the main urban rivers – Seco, Seque and Hernani – which provide irrigation to surrounding farming areas and also flow into Lake Titicaca. In 2010, EPSAS inaugurated a treatment plant for wastewater in Puchukollo that can help reduce use of subterranean water. However, it is hampered by a lack of piping to link



Río Seco is one of El Alto's main rivers and flows into Lake Titicaca. High levels of water pollution caused by industries in this growing city pose a major challenge to the need to provide sufficient clean water for urban dwellers, farmers and fishermen.

Photo: Linda Shi, Institute for International Urban Development

the treatment plant to the different industrial zones of El Alto. A program of support and subsidies for industries to develop their own treatment plants could be a more effective means of conserving water and preventing contamination.

3. Change in land use laws to integrate water conservation

Although regulations for land use are under-developed and not often enforced, they could have a significant impact on current and future water use. Planning of new municipal projects should integrate and encourage water conservation and support measures – for example in new housing in suburban areas – such as rainwater capture, dry sewage, reuse of wastewater and greater housing density.

4. Reduction in water consumption

Although current water consumption in El Alto is very low, the municipality and water authority could achieve water savings among users who consume the largest quantities. These are mainly industries and commercial enterprises, but also include a small number of domestic consumers based largely in the center of El Alto and parts of La Paz.

Recommendations for policy-makers managing water in climate-stressed regions

These recommendations are based on ones put forward to stakeholders managing water resources in Bolivia, but are equally applicable in other regions facing challenges of climate change.

1. Form a group of technicians to develop models such as WEAP

Tools such as WEAP can serve as politically neutral platforms for making assessments and planning for water-management based on different climate scenarios. They can

also be continuously revised to allow for adapting plans as circumstances change.

2. Carry out more studies and maps on use of water

In the case of Bolivia, more studies are needed on the current uses of water, the types of users, and where they are based in order to better understand urban demand. There also needs to be more studies on the impact of migration caused by climate change in adding to pressure on existing water sources.

3. Establish working groups able to develop flexible and effective water management strategies

All the government, municipal and water entities involved in water as well as city planning, development and infrastructure departments, experts, specialists and community groups need to be brought together to improve current water resource management and ensure that all future projects and planning involve effective water conservation strategies.

4. Coordinate based on watersheds not municipal boundaries

Watersheds and sources do not stick within municipal or other territorial boundaries, therefore water management strategies require effective coordination between different jurisdictions.

5. Strengthen technical capacity and financing for land-use regulation and enforcement

Effective land use regulations can prioritize water conservation and effective water use, which is particularly important in cities that are experiencing high migration and growth.

6. Community participation in developing strategies and decision-making

It is crucial that community organizations and social movements are involved in decision-making around water resource management so that plans for water use both most effectively meet local needs and encourage sustainable long-term water use.

Acknowledgements:

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