# Striving for Integrated Water Resource Management in Quito, Ecuador: Public Good or Economic and Political Good?

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*"The 'right to water' is a fundamental human, citizen and collective right…No person, for no reason, neither racial, social, religious, economic, nor political, can be excluded from their right to water."*

*"The State should guarantee the preservation, conservation, protection, restoration, sustainable use and integrated management of watersheds, including necessary quality and quantity of ecological flows to sustain the integrity of all ecosystems associated with the hydrologic cycle, in order to safeguard the satisfaction of individual and collective human needs in function with societal health, including respecting the rights of nature and preserving biological diversity."*

Declaration of Water
National Constitutional Assembly
19 February 2008

**Introduction**

These phrases are echoed by many in Quito, Ecuador at 2800 meters above sea level, where water resource management has become a central focus for local and regional governments. While growing urban populations have demanded greater access to water, shifting land uses that reflect demographic changes and urbanization have affected regional water availability. Claiming that water is a public good to which no citizen should be denied access, Ecuadorian water management attempts to frame this issue in the context of social justice and regional development. Regional authorities also realize that water exploitation, overuse and poor management have put at risk the watersheds, water quality, hydrologic cycles and biological diversity necessary to provide clean water for Quito. To achieve these social and environmental goals, regional water authorities have attempted to regulate the resource among competing uses—large-scale agricultural irrigation, small-scale agricultural water diversions, urban and rural potable uses, industrial uses and flows for hydroelectric projects—by prioritizing them: (1) Human consumption, including cultural and spiritual development, (2) Irrigation for agriculture and livestock in order to insure food production sovereignty, and (3) Public use in the Energy, Industry and Recreation sectors. Throughout all of these uses, water resource administration agencies are instructed to take into consideration water budget requirements for territorial planning and development, including social, geographic, economic and environmental needs (Asamblea Consituyente, 19 February 2008). In this way, they hope that future planning and development will not spend more water than is actually available.

Unfortunately, current development and water use patterns in this region do just that. More water is consumed or rendered unusable, leaving less clean water for citizens, businesses, agriculture and development activities, putting at risk the health of regional populations and environments and compromising the success of regional development. Simultaneously, environmental degradation and agricultural expansion into important ecosystems have threatened the regional hydrologic cycle and thus water provision for many uses. Traditionally, local water providers have sought to remedy these ills by seeking clean and plentiful water sources in other regions and thus increasing water supply to the endlessly growing city. One should question, however, how long this strategy can be viable. To what water sources will the city turn when it has exploited or contaminated all those that are close by? More importantly, can integrated water resource management be achieved simultaneous with continuing regional development in this developing country? Or, must the region first exploit its natural resources to support its development and only then be able to implement effective water resource conservation, when it may be too late?

In examining the current structures and status of water resource provision, demand and management in the Quito region, the goal of this paper is to identify the challenges to attaining sustainable[1] and integrated water resource management in this area. Methods included a review of published and unpublished studies focusing on water resources in Quito, interviews with representatives of relevant regional institutions and interviews with community leaders to ascertain local water users' opinions of water management. Such an analysis reveals that challenges include relatively high rates of consumption, inefficient water infrastructure, subsidized water pricing, contamination, population growth and associated urban expansion and land cover changes, conflicting uses, lack of up-to-date information and monitoring and a lack of water resource management collaboration among national ministries and local administrative units. It is important that this analysis is contextualized within the social and environmental goals stated above as well as the national government's promise to manage its water resources as a public good, not an economic one nor a political one.

## Water Provision

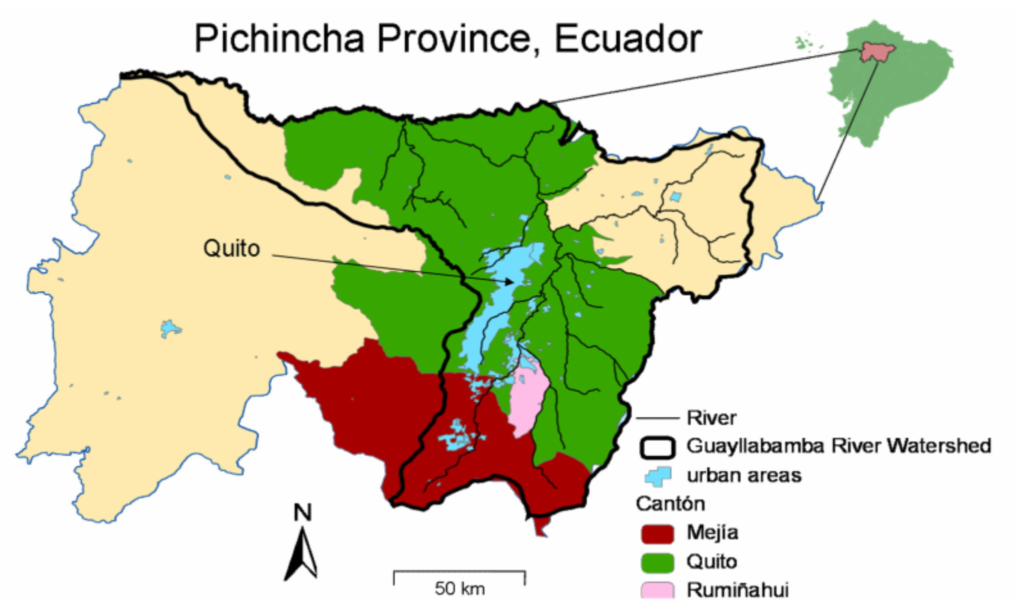


**Figure 1:** Quito, Ecuador lies in an inter-Andean valley at 2800m asl. The upper Guayllabamba River watershed surrounds Quito. It is approximately 4,700km$^2$ and feeds the regional river system. All water from these rivers flows into the Guayllabamba River, which forms at the union of the Machángara and Pisque Rivers just northeast of the city, and then into the Esmeraldas River, which empties out into the Pacific Ocean.

[1] "Sustainable" water resource management implies the equitable distribution of water resources to satisfy current and future needs without endangering the ecosystems which maintain and depend upon the specific hydrology of this region.

*Quito, Ecuador in Brief*

The city of Quito is located in the Pichincha Province of Ecuador, just below the equator (0.15 S, 78.35 W). Lying in an inter-Andean valley, it rests at 2800 to 3200 meters above sea level (m asl) and is home to approximately two million of Ecuador's ten to eleven million citizens (one million of whom reside outside of the country). The Pichincha Province is comprised of nine *cantones* (counties)—Quito, Cayambe, Mejía, Pedro Moncayo, San Miguel de los Bancos, Pedro Vicente Maldonado, Puerto Quito, Santo Domingo and Rumiñahui—three of which (Quito, Mejía and Rumiñahui) occupy the majority of the Guayllabamba River watershed (also known locally as La Hoya de Quito). The area is the highest elevation and most eastern portion of the Esmeraldas River watershed, and into which almost the entire Quito region fits, including those areas experiencing the highest rates of growth. The Guayllabamba River joins the larger Esmeraldas River in the Esmeraldas Province to its west, eventually draining into the Pacific Ocean. The Guayllabamba watershed is the central focus of this analysis; it covers 4,707 $km^2$ of highland territory in Ecuador including multiple environments, which are the product of the highly varied topography in this region.

*Precipitation*

Temperatures in the sierra region are relatively constant year round at 12.5 degrees Celsius with larger variations occurring on a daily basis. Precipitation patterns are regulated by the Intertropical Convergence Zone (ITCZ) generated by equatorial Hadley cells of large-scale air movement over the planet. The ITCZ shifts from ten degrees North at the June solstice to five degrees South at the December solstice passing twice over Quito each year. These shifts produce two rainy seasons and two dry seasons each year. The most pronounced dry season is in July and August, with a much less pronounced one in January (Figure 2). High rainfall occurs from March to April and then again in October, usually in the form of violent thunderstorms. Mean annual precipitation is approximately 1250mm (Neill, D.A. and P.M. Jorgensen). Annual rainfall at any one specific location within the Quito region ranges from 425 to 2400 mm per year, which is influenced heavily by altitude. The greatest annual precipitation occurs on mountain sides at high elevations (as high as 5000m asl to 6000m asl) and decreases as one approaches the lower-lying valleys (the lowest being approximately 2600m asl) (De Bievre and Coello 2007b). Together, temporal and spatial variations in rainfall result in lower-lying areas that have less local water resource availability especially during summer months, during which time areas at higher elevations continue to have considerable precipitation (approximately 40 mm per month). Summer precipitation at high elevations feeds the headwaters of local rivers and is important to the freshwater hydrologic cycle that includes the *páramo* (high altitude Andean grasslands) and ice-packs on volcanoes (De Bievre and Coello 2007b).

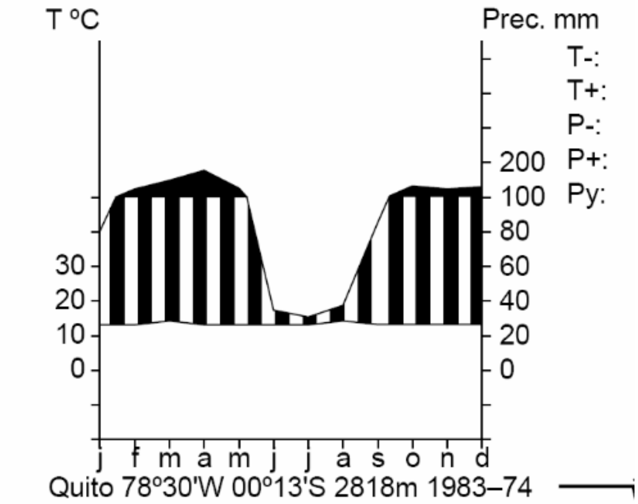


**Figure 2**: Mean monthly precipitation and temperature in Quito. Right scale is mean monthly precipitation in millimeters; left scale is mean monthly temperature in degrees Celsius. Months of the year from January to December are located on the x-axis. Months with more than 100mm precipitation are indicated by the black area above the vertical lines. (Taken from Neill and Jorgensen).

*Surface Water*

Quito is locally referred to as being located in the "Valley of the Gods" given the number of volcanoes that surround the city and which indigenous peoples associate with specific deities—Antisana at 5753m asl, Cotopaxi at 5897m asl, Illiniza at 5200m asl, and Pichincha at 4784m asl. Run-off from these glacier and snow-packed volcanoes is an important source of water for the city and smaller communities in this region (more for irrigation and hydroelectric projects than potable water, as will be discussed below). The *páramo* ecosystem, which begins at 4000 meters above sea level, acts as a sponge that soaks up ice-melt in addition to precipitation. Together, the ice and the *páramo* trap and regulate freshwater in the region, ensuring regular provision year-round, even during dry seasons (albeit it is less).

Throughout Latin America, a common mechanism to protect drinking water sources has been the establishment of national parks, reserves and protected forests (Echavarria 2002). For Quito, Ecuador these include Cotopaxi National Park to the southeast of the city, Ecological Reserve Cayambe-Coca to the east of the city, and Ecological Reserve Antisana to the southeast of the city (Figure 3). When they were established, some 20,000 people were living in them. These families continue to occupy lands in these regions, though their land management practices can have a large impact on water resources (Echavarria 2002).


**Figure 4:** Location of Cotopaxi National Park, Ecological Reserve Cayambe-Coca and Ecological Reserve Antisana. These protected areas were originally established to protect water sources for the region while also satisfying later goals for biodiversity protection. Quito is circled in black. (Taken from De la Torre 2004).

Water from direct precipitation, ice-melt and slow release from the *páramos* (including those located in the protected areas mentioned above) is fed into streams and rivers that ultimately form the Guayllabamba River, passing directly to the east and then north of Quito and emptying out into the Pacific Ocean. Two important tributaries of this river, which originate to the south and southeast of Quito, are the San Pedro River and the Pita River, respectively. The San Pedro watershed includes 749 square kilometers and the Pita watershed 585 square kilometers.

There is no longer enough water in the river system in this region to satisfy regional water demands. Estimated natural flows of rivers that feed into the Guayllabamba River are shown below (Table 1). The majority of these flows are exploited for agricultural, hydroelectric and some potable uses in the region. In the Pita and San Pedro rivers, this exploitation demands almost all of their flows during the dry season when it is used for hydroelectric generation and agricultural irrigation.

| River Name (drainage area) | Estimated Natural Flow ($m^3/s$) |
|---|---|
| Pita (585 $km^2$) | 11.0 |
| San Pedro (749 $km^2$) | 13.5 |
| Machángara (197 $km^2$) | 3.6 |
| Chiche (407 $km^2$) | 5.4 |
| Pisque (1226 $km^2$) | 18.3 |
| Monjas (164 $km^2$) | 1.2 |

*Hydroelectric Station

**Table 1:** Estimated natural flows of rivers leading into the Guayllabamba River. The majority of these flows have been exploited for diverse uses within the region, including agricultural, hydroelectric, and some potable. (De la Torre 2004).

*Aquifers*

Regional water providers continue to investigate regional aquifers as potential sources of potable and irrigation water. The Machángara, Monjas, Pisque and El Valle de los Chillos aquifers have been used in the past (Figure 4). From the Máchangera and Monjas, extraction from more than 100 wells reached its highest at 900 L/s causing severe overexploitation. Over time, water providers moved away from using groundwater due to deterioration of wells and the growing convenience (both financially and physically) of using surface water to meet demands. Now that water demands in Quito have exceeded what surface water sources can provide, water providers are looking at aquifers once again as a potential solution. Recent explorations have indicated that it is possible to extract 7 million cubic meters (mcm) of water per year from those aquifers within Quito by maintaining a high density of wells. Additional studies have speculated that 30 mcm/year from other aquifers in the region could be extracted, mentioning that any extraction should be very careful to prevent likely overexploitation (De la Torre 2004).

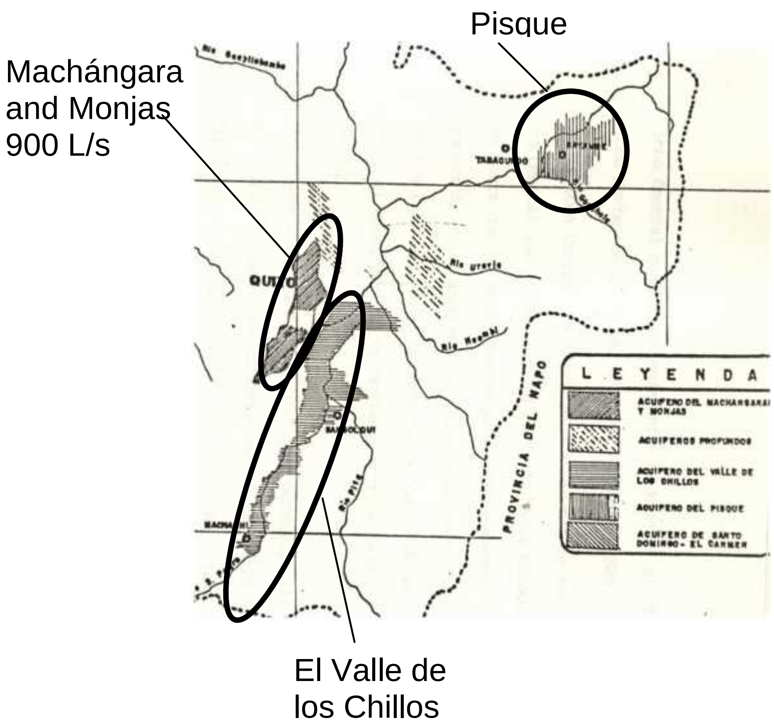


**Figure 4:** Aquifers in the Quito region. Water providers are exploring options to use groundwater to satisfy new water demands (both potable and agricultural), including aquifers other than those pointed out here. (Taken from De la Torre 2004).

*Water Supply and Transfers*

In 2004, Quito was receiving an average of 5.9 $m^3/s$ of water for potable and industrial uses from seven principal systems exploiting various surface water sources (Figure 5, Table 2). Of these seven systems, Papallacta, constructed in 1991, was the first to transfer water to Quito from outside of the region; it conducts water from the Amazonian region, just over the continental divide. The Mica-Quito Sur systems also transfers water from the Amazonian region to serve southern Quito.

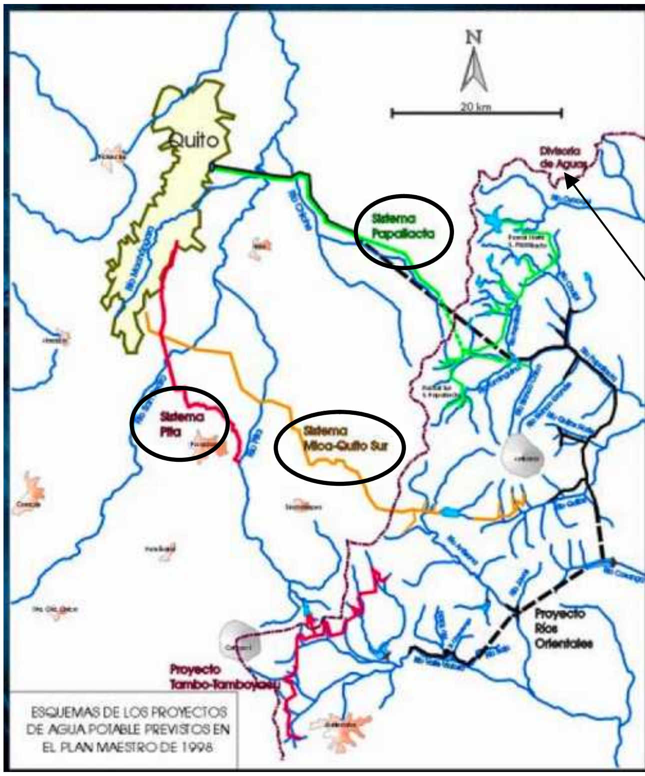


**Figure 5:** Location of the three largest water provision systems in Quito: Papallacta, Mica-Quito Sur and Pita. (Taken from Ayabaca 2005).

| System | Water Provision in 2004 ($m^3/s$) | Comments |
|---|---|---|
| Papallacta | 1.14 | Previously supplied 3.9 $m^3/s$, but decreased due to oil contamination in a tributary. |
| Pita | 2.0 | Capture system is located in the *páramos*. Water is conducted by gravity to treatment plant Puengasí. In the dry season, this system uses all available water in the Pita River. |
| Mica-Quito Sur | 2.05 | This water is conducted to a hydroelectric plant. One of its storage lagoons provides flows to the Puengasí treatment plant so that it can operate efficiently. The same lagoon conducts water to another treatment plant to provide water for southern Quito. |
| Pichincha | 0.08 | These smaller systems provide water for communities in western Quito. |
| Noroccidente | 0.14 | |
| Lloa | 0.3 | |
| Atacazo | 0.2 | |

**Table 2:** The seven major systems that provide drinking water to Quito. Two of them, Papallacta and Mica-Quito Sur, draw water from sources in the Amazonian region, on the other side of the continental divide.

Currently, the average daily provision of these systems has reached 7.37 $m^3/s$, which does not quite reach the total estimated source capacity of 8.85 $m^3/s/day$. Over the last couple of decades, maximum daily demand has risen to 8.33 $m^3/s$ as Quito has grown in size and population (Ayabaca 2005; Gómez, personal communication).

Anticipating future growth in this region, and thus an increasing water demand, the Quito Metropolitan Area Sewage and Potable Water Agency (EMAAP-Q) has been planning for additional water transfer projects from regions outside of Quito (Table 3). The most notable is the Oriental Rivers (Ríos Orientales) project, whose water source rests at 3100m asl, just to the east of the water sources for the Mica-Quito Sur system and the Tambo-Tamboyacuo system, which came online in 2002 (Figure 5).

| Project Name | Projected Supply ($m^3/s$) | Location | Source | Cost (million USD) |
|---|---|---|---|---|
| Piedra Azufre | 0.200 | Eastern Slopes* | Ice-melts from Volcán Antisana | 2.152 |
| Quito Aquifer | 0.300 | Inter-Andean Corridor | 120 square km groundwater | 3.0 |
| Tesalia (Amaguaña-Conocoto) | 0.400 | Inter-Andean Corridor | Groundwater in Cantón Mejía | 12.0 |
| Mindo Bajo-Calacalí | 0.100 | Western Slopes* | Mindo River (sides of Volcán Pichincha) | 4.0 |
| Papallacta Ramal Sur Upgrade | 0.425 | Eastern Slopes* (Papallacta System) | Tambo, Guamaní and Tuminguina Rivers | 15.0 |
| Pifo-Bellavista Amplification | 1.300 | Inter-Andean Corridor | Papallacta, Tuminguina, Blanco Chico and Salve Faccha Rivers | 32.0 |
| Tambo-Tamboyacu | 0.800 | Eastern Slopes (Pita-Puengasí System)* | Tambo, Tamboyacu Rivers | 35.0 |
| Oriental Rivers | 17.00 | Eastern Slopes* | 28 Rivers on Eastern Slopes of the Andes | 700 |
| Northeastern & North-Central Parishes | 0.100 | Western Slopes* & Inter-Andean Corridor | Optimization of currently used sources | 0.25 |

**Table 3**: Anticipated water transfer projects to satisfy Quito's current and future water demands. The project will tap into different water sources located both within and outside of the upper Guayllabamba River watershed.
* Indicates water that will be diverted from sources outside of the Quito region (Ayabaca 2005).

EMAAP-Q predicts that the Oriental Rivers water diversion will satisfy Quito's water needs until 2050, providing an average flow of 20.46 $m^3/s$ and a minimum flow of 17 $m^3/s$ to the city. Construction is projected to begin in 2013 and will cost US$700 million, with an initial flow of 1.4 $m^3/s$ in 2016. Sources include 28 rivers along the eastern slopes of the Andes Mountains, which extend into the Amazon Basin (Gómez, personal communication).[2] The infrastructure will transmit the water by gravity from 3100m asl to Quito at 2800m asl along a network of 67 kilometers of tubes and 42 kilometers of tunnels, passing through two water treatment plants and four hydroelectric stations (estimated to generate 172 MW of power) along the way (Ayabaca 2005). EMAAP-Q estimates that within the next few decades the city will not require all 17 $m^3/s$ of minimum flow. Therefore, additional water can be diverted to the hydroelectric stations to

[2] Orographic cooling along eastern slopes of the Ecuadorian Andes leads to large amounts of precipitation, providing Ecuador's part of the Amazon Basin its lavish water supplies.

allow the water provider to recover its investments in less than 15 years (De la Torre 2005). So far, EMAAPQ has explored project alternatives and conducted a large proportion of initial feasibility studies. Its rationalizes this project declaring that it will provide water not only to the city of Quito, but also to those areas into which the Department of Planning of the Metropolitan District of Quito (DMQ) expects the city to grow. EMAAP-Q claims that the Oriental Rivers Project is the best alternative that Quito has to satisfy the growing demand for potable water on medium and long-term time frames since there no longer exist other close water sources that can provide flows and quality sufficient for domestic and industrial use and which can be provided using gravity (as opposed to a pump system). They also assert that the project is acceptable because it will not interfere with other water users or consumers—it will leave 4.68 $m^3$/s of "ecological flow" in the 28 rivers, which represents 20 percent of the existing average flow (Ayabaca 2005, De la Torre 2004).

For the most part, irrigation systems in the Quito region have separate infrastructure systems from those of potable and industrial uses. For example, the Pisque and Tumbaco projects were constructed by the state in the central-northern area of the Guayllabamba watershed in the 1940s and provide water for irrigation to 12,200 hectares. The water comes from rivers within the Guayllabamba watershed (including the Granobles, Guachalá, Tumbaco and Pita Rivers). Other projects include Tabacundo (from Arturo River, Boquerón River and San Marcos Lagoon, serving 17,545 hectares), Cangagua (from Oyacachi River, serving 3,500 hectares) and Perucho (serving 1,660 hectares) (De la Torre 2004). Like potable water provision, irrigators are now looking to exploit Amazonian water sources to satisfy their growing demand. As of yet, no such projects have been constructed.

## Water Demand

### *Urban Growth*

The Quito region is characterized by water-dependent livelihoods and land uses. Migration and changing demographies has led to rapid urban expansion over the last half-century, shaping land use and directly influencing both potable and irrigation water demands. The city now measures forty to fifty kilometers long and five to ten kilometers wide, unfolding along the trough-shaped inter-Andean valley in which it lies (Carrión 2005, Riaño 2001). Surrounding are agricultural lands, with both small-scale and large-scale enterprises, which support both rural and urban populations. With a population that is projected to reach approximately 3.8 million in the next ten to 15 years, the IUCN estimates that demand for water for human consumption in the Quito region will increase by 46 percent until 2021 (De Bievre and Coello 2007a) (Table 4).

| | Demand for Water (mcm/ month) | | | |
|---|---|---|---|---|
| **Cantón** | 2001 | 2007 | 2015 | 2025 |
| Quito (urban) | 16.7 | 19.6 | 22.0 | 25.4 |
| Quito (rural) | 3.53 | 4.29 | 5.29 | 6.64 |
| Mejía | 0.37 | 0.43 | 0.54 | 0.70 |
| Rumiñahui | 0.37 | 0.45 | 0.58 | 0.80 |
| **Totals (mcm/ month)** | **20.97** | **24.77** | **28.41** | **33.54** |
| **Totals (mcm/ year)** | **251.64** | **297.24** | **340.92** | **402.48** |

**Table 4**: Past, present and projected demand for potable water in three *cantones* of the Quito region (De Bievre and Coello 2007a).

On average, De la Torre (2004) reports that where a person lives greatly determines the amount of water that her or she demands on a daily basis (Table 5). As urban and peri-urban populations grow faster, they are more likely to increase per capita water demand based upon urban or rural residence, thus placing higher demand upon deteriorating central water systems and smaller suburban and peri-urban water systems (Table 6).

| Location | Domestic and Industrial Water Demand ($m^3$/person/day) |
|---|---|
| Large cities (like Quito) | 0.3 |
| Medium-size cities | 0.25 |
| Small cities | 0.2 |
| Rural areas | 0.15 |

**Table 5:** Water demand per capita per day in different size cities. Data is based upon calculations of water demand from the entire Esmeraldas River watershed, of which the Guayllabamba River watershed is a part (at the highest altitude) (De la Torre 2004).

| Cantón | Urban Population 2001 | Rural Population 2001 | % Urban Population |
|---|---|---|---|
| Quito | 1,662,327 | 178,873 | 90.28 |
| Mejía | 30,583 | 32,622 | 48.38 |
| Rumiñahui | 58,647 | 7,458 | 88.71 |

**Table 6:** Composition of urban and rural populations in three *cantones* located in the Guayllabamba River watershed. As pointed out in Table 5, the per capita water demand between urban and rural populations differs. With a majority of the population in these three areas being urban, their per capita consumption of potable water is greater (De la Torre 2004).

As the city has grown, it has also consumed the fertile agricultural lands and natural areas surrounding it, which in turn has prompted the agricultural frontier to expand outward into protected *páramo* and native forests, vital ecosystems which store and regulate regional freshwater. This outward expansion has resulted in an increasing strain upon limited water resources (De Bievre and Coello 2007a, De Bievre and Coello 2007b; Recalde, personal communication). According to the National Council for Water Resources (CNRH), in 1989 the agricultural frontier did not extend past 2700m asl but now can be found at 3600m asl (Recalde, personal communication). As of 2006, 62 percent of areas in this region originally covered with native vegetation had been altered or replaced (De Bievre and Coello 2007b).[3]

*Potable Water*

For potable and industrial water infrastructure (the water provision systems described above)[4], inefficient systems lead to water loss that hovers around 35 percent in urban Quito as well as in Mejía and Rumiñahui (Table 7). In rural areas of the Quito region, water loss reaches 51 percent, which is representative of many water infrastructure systems throughout the country. An efficient system, according to EMAAP-Q should allow no more than 25 percent water losses (Iñiguez, personal communication). Correcting leaky systems and combating losses due to "water robbing" at illicit connections is a time consuming process for a water company that is struggling to keep pace with demand and which also lacks sufficient economic resources (Iñiguez, personal communication).

| **Cantón** | **Net Provision ($m^3$/p/day)** | **Lost Water (%)** | **Gross Provision ($m^3$/p/day)** | **2007 Population** | **2007 Net Provision ($m^3$/day)** | **2007 Gross Provision ($m^3$/day)** |
|---|---|---|---|---|---|---|
| Quito (urban) | 0.196 | 34 | 0.297 | 2,180,000 | 427,280 | 647,460 |
| Quito (rural) | 0.178 | 51 | 0.361 | 384,077 | 68,365 | 138,651 |
| Mejía | 0.120 | 40 | 0.200 | 71,862 | 8,623 | 14,372 |
| Rumiñahui | 0.120 | 30 | 0.171 | 79, 588 | 9,550 | 13,609 |
| **Totals ($m^3$/day)** | | | | **2,715,527** | **513,818** | **814,093** |
| **Totals ($m^3$/year)** | | | | | **187,543,774** | **297,157,467** |

**Table 7**: Efficiency of potable water infrastructure in three *cantones* of the Quito region. Net provision and gross provision are measured in cubic meters per person per day. Lost water refers to the percent of water that is unaccounted for after leaving the storage facility and before arriving at its metered destination. This infrastructure serves households and those industries that are connected to their municipal networks (irrigation infrastructure is not included). (The slight discrepancy between water demand for 2007 shown in Tables 4 and 7 is due to author calculations in Table 7 based on printed figures without all decimal places shown (De Bievre and Coello 2007a).

Only a percentage of the region's inhabitants receive potable water from the municipal water companies. Figures in Tables 6 and 7 are a combination of metered figures for water provision from municipally supplied potable water as well as estimates for informal and communal water provision systems. Rapidly growing urban areas and associated landscape changes combined with an Ecuadorian cultural proclivity for community service projects in lower-income urban and rural areas has resulted in communities that construct their own water infrastructure including

[3] Characterization of land use in upper Guayllabamba River watershed as of 1980 (at the time of this writing, FONAG and the IUCN are creating an updated map and groundtruthing it): 36.9% agriculture, 13.4% livestock pastures, 7.7% natural and cultivated forests, 3.13% urban areas, 7% natural vegetation, 25% *páramo*, 6.87% eroded areas and bodies of water (De Bievre and Coello 2007b).
[4] All "potable" uses refer to both domestic and industrial uses. Municipal networks supply both domestic and those industrial uses that are connected to the network.

storage tanks and tubing. These systems draw on local sources and are referred to as "tubed water" ("agua entubada") in order them distinguish them from municipally supplied water, which rely more on water transfers from areas outside of Quito. In many cases, these community-built water systems are prone to failure and inefficient provision (Quintana, personal communication).

All municipal systems and community-built systems are constructed using water storage tanks. In the case of community-constructed systems, tubing is often PVC piping and provides direct household connections for users. The open-air storage tanks or lagoons are usually located near the water source at higher elevations than the community itself to allow for gravity flow instead of pumping. Water treatment before use is often provided for municipally supplied water, but not necessarily for water provided by community-built systems; the absence of such treatment could lead to health problems among community members if their water source were to become contaminated.[5]

*Irrigation*

Together, public and private irrigation systems within the upper Guayllabamba River watershed serve 140,075 hectares of agricultural land (De Bievre and Coello 2007a). Seven of them are public systems that cover 62,652 hectares. A mixture of twenty-one distinct private irrigation systems and many smaller private systems serve the remaining irrigated area. The twenty-one distinct, larger-scale systems are located predominantly in the valleys, on gentle slopes and in other areas where there are fertile lands suitable for irrigation. The smaller private systems can be located in these areas, as well as in more unconventional areas where small-scale agriculturalists settle. The IUCN estimates that there is a 50 percent overlap between areas served by the public versus private irrigation systems (De Bievre and Coello 2007b).

| | **Water Demand** | |
|---|---|---|
| **Month** | **Public Irrigation (mcm/month)** | **Private Irrigation (mcm/month)** |
| July | 67 | 120 |
| April | 23 | 29 |
| November | 15 | 18 |

**Table 8:** Water demand for public versus private irrigation systems in specific months. For both types of systems, water demand peaks in July, during the dry season, and it decreases during rainy seasons (April and November). In the upper Guayllabamba River watershed in which the Quito region lies, there are seven public and 21 private irrigation systems that serve 62,652 hectares and 77,423 hectares respectively. Individual public irrigation systems cover anywhere from 2,000 to 20,000 hectares. The largest individual private irrigation system covers no more than 10,000 hectares, the majority of private systems serving less than 5,000 hectares. One of the most water-demanding public irrigation systems (Proyecto Tabacundo) serves flower plantations that target international markets. The private irrigation systems demand more water throughout the year compared to the public irrigation systems (De Bievre and Coello 2007a).

[5] Data was not available to analyze the number of health problems associated with drinking contaminated water from community-built infrastructure systems.

The southern area of the Guayllabamba watershed, where the San Pedro River and the Pita River sub-watersheds are located, rests at a higher elevation than that of the central and northern areas and thus receives more rainfall. Approximately 30 percent of these two sub-watersheds receives 1000-1250mm of rain per year and 50 percent receives 1250-1550mm/yr. In contrast, the sub-watershed of the Pisque River, to the northeast of Quito and lying at a lower elevation, receives 500-1000mm/yr, which explains why there is more intensive agricultural irrigation in the Pisque sub-watershed. Of the lower-lying areas, the Pisque sub-watershed generally experiences greatest precipitation deficits during the summer months, causing irrigation to claim much of the river's flows to sustain large-scale agricultural production, particularly floriculture.

Like the supply of water varies temporally with rainy seasons and dry seasons, so does demand. Consumptive water demand for human use (consumption) and industry remains relatively stable throughout the year. Water demand for irrigation, however, varies greatly throughout the year. From late September to late May demand fluctuates moderately around 75 hectometers3/month from late September to late May. During the pronounced dry season in June, July and August, demand for irrigation water increases dramatically to approximately 210 hectometers3/month, peaking in July (De Bievre and Coello 2007b).

Satisfying total water demand for both public and private irrigation systems over the course of one year requires around 1200 mcm of water, not including the losses that can reach up to 70 percent and which result from inefficient and poorly maintained infrastructure (De Bievre and Coello 2007a; Recalde 2007, powerpoint presentation). Small scale agriculture water use rests outside of these estimated irrigation demands. For the most part, small-scale agriculturalists work with less than 10 hectares and the majority of them with only a few. Many rely on rain-fed agriculture, though some do construct their own irrigation systems.

*Industrial Use*

There are approximately 1800 industrial water users in the Quito region, of which 1400 obtain their water from municipal water networks. Of these 1400 industries, approximately 435 have connections reported for industrial use within the city of Quito itself, meaning that they consume water locally and on a medium to large range (according to the National Polytechnic School, Quito, EPN). On the other hand, according to the Water Agency of Quito (Agencia de Aguas de Quito, AAQ), as of July 2007 there were only 300 legal water concessions for industrial use in the Quito region. They cite that the mismatch of data is due to the fact that many industrial users drill wells on their properties without registering them and that those which are connected to municipal water supplies do not necessarily declare their industrial water uses (De Bievre and Coello 2007a). Unfortunately, at the time of this writing there is little to no information on quantities of water used by any specific industry in this region (studies in the near future hope to determine them). Although attempts to estimate these values have relied on figures of industrial water concessions (which may not necessarily reflect actual use) or resorted to measuring flows of industrial effluents, results are sparse and inaccurate.

*Hydroelectric Use*

In the Guayllabamba watershed, the total possible energy generation from hydroelectric stations is 128.38MW. Five of these stations are public and have a power generation capacity of 96.89 MW, representing 6.02 percent of all hydropower generation in the country. Three of these plants—Guangopolo, Cumbayá and Nayón—generate most of this power (90.62 MW) and are located just south of Sangolquí in El Valle de los Chillos. For these particular stations to operate, all of the available water from the Pita River is conducted to the San Pedro River, where it is channeled to the Guangopolo station to produce 20.92 MW. From the foot of this station, the water is diverted to the Cumbayá plant to produce 40 MW. After passing through Cumbayá, it is taken to the Nayón plant to produce 29.70 MW, having moved its way progressively northward. Finally, the remaining water is released into the river system of the watershed flowing to the Guayllabamba River and then out to the Pacific Ocean. Of the other existing plants, EMAAP-Q owns one (El Carmen), which produces 8.2 MW to satisfy its own needs and part of which is sold to the national grid. Five private hydroelectric plants in the watershed produce 23.29 MW (De la Torre 2004). Specific data was not available to determine the flow demand of these hydroelectric projects other than comparing them to the other uses in the region (Table 9).

| Use | Relative Demand (%) | Relative Flow Concessions (%) |
|---|---|---|
| Potable/Domestic | 17 | 12 |
| Irrigation | 66 | 49 |
| Industry | 12 | 33 |
| Hydroelectric | 5 | 6 |

**Table 9:** Relative demand and flow concessions of the four principal water uses in the Quito region—potable/domestic, irrigation, industry, hydroelectric. In cases where data was scarce or unavailable, relative demand was estimated (De Bievre and Coello 2007a).

Regional water providers do not anticipate constructing any more hydroelectric plants within the watershed. Those that will be built in the future are associated with potable drinking water transfers from the Amazonian region. These projects are still being reviewed for their potential to conflict with potable water flow needs.

## Water Management

### *National to Local*

Up until 1972, access to water for all was not guaranteed by the law. Rather, similar to an antiquated riparian doctrine, those who owned land adjacent to water bodies controlled the use of the water and could limit others' access to it. In theory, this changed with the Water Law of 1972, which ended private water ownership and deemed it a public good to which all could have access through concession from the state (Recalde, personal communication).

The granting and management of these concessions falls primarily to the National Council for Water Resources (CNRH), which is in charge of creating "policies, norms, standards and coordination for all areas of water resources" (Recalde 2007, powerpoint presentation). Under this normative umbrella there are various ministries that organize and regulate different water uses. The Ministry of Agriculture (MAG) regulates irrigation, agricultural drainage and flood control through its Project Implementation Unit (UEP) and its Project for Technical Assistance to the Irrigation Subsector (PAT). The Ministry of Energy and Mines (MEM), including its National Institute for Meteorology and Hydrology (INAMHI), manages information and data. The National Council for Electricity (CONELEC) is in charge of hydroelectric projects and watershed management. The Ministry of Urban Development and Housing (MIDUVI), including its Sub-secretary for Environmental Sanitation (SSA), regulates potable water and sanitation. The Presidential Office of Planning (Of. Planif. Presidencia) provides institutional approval for decentralized water management agencies (CRD's). The Ministry of the Environment (MA) regulates water quality standards and along with the CONELEC manages the country's watersheds. Finally, the Ministry of the Economy (Ministerio de Economía) regulates financing for the CRD's (Recalde 2007, powerpoint presentation).

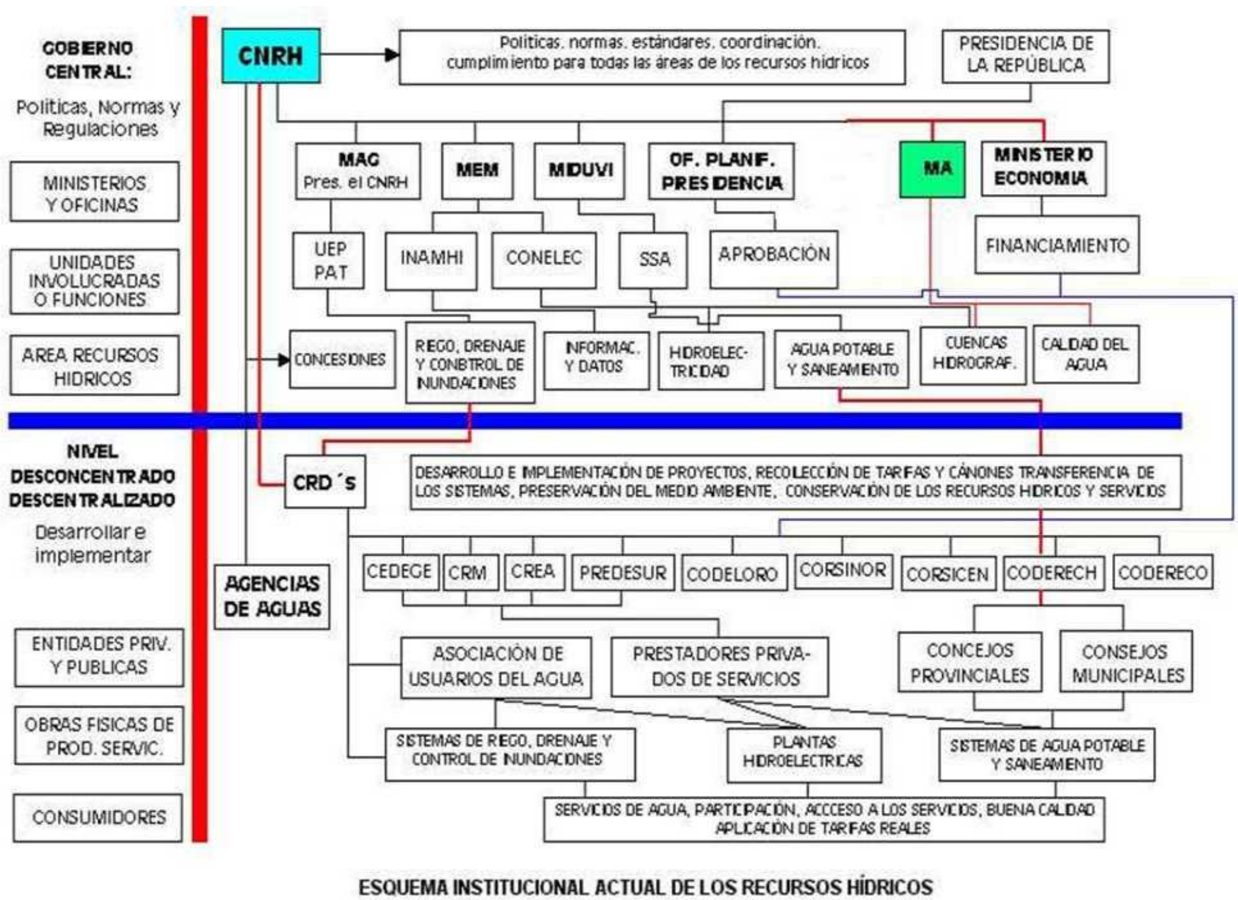


**Figure 6**: Institutional diagram of water resource management in Ecuador. Those organizations above the blue line operate at the national level and those below the blue line at the local level. (Recalde 2007, powerpoint presentation).

At the local level, water resource management powers have been decentralized and granted to Regional Development Corporations (CRD's) (both public and private), which fall under the authority of the CNRH, the Presidential Office of Planning and the Ministry of the Economy. In addition, decentralized Water Agencies (Agencias de Aguas) act as local representatives of the CNRH, granting and managing water concessions. In Quito, this body is the Water Agency of Quito (Agencia de Aguas de Quito – AAQ). At this decentralized level, CRD's are responsible for "development and implementation of projects, collection of fees, norms for operating the systems, environmental protection and conservation of water resources and services" (Recalde 2007, powerpoint presentation). Working within each of these CRD's are the water user associations (Asociación de Usuarios del Agua), private service providers (Prestadores Privados de Servicios) that often work very closely with the area's CRD, the provincial government (Concejos Provinciales) and the municipal governments (Concejos Municipales). Each of these entities team together in various ways to provide services to water consumers. These services include irrigation, drainage and flood control systems, hydroelectric plants and potable water and sanitation systems.

Of the characteristics and uses of water regulated at a national level—irrigation, agricultural drainage, flood control; information and data; hydroelectricity; watershed management; water quality—only the last two (watershed management and water quality) are not explicitly listed in the local management scheme. It is assumed that these foci are incorporated into the management activities for the other categories (Recalde 2007, powerpoint presentation).

The Water Agency of Quito manages approximately 6000 water concessions in its jurisdiction, which includes not only the upper Guayllabamba River watershed (Table 10), but the entire Esmeraldas River watershed (of which the Guayllabamba River is a part). In the Guayllabamba watershed, the AAQ reports that it is working through about 700 different water use conflicts and that existing concessions do not necessarily respond to present and real needs of water use, nor are they prioritized well. In addition, of those concessions, only 160 have a flow of 100 L/s or more, three have 10-100 L/s and 35 have 1-10 L/s; the majority of concessions in this region are for less than 1 L/s of flow (De la Torre 2004).

*Guayllabamba Watershed*

The Guayllabamba River watershed encompasses nine distinct *cantón* (county) administrative units.[6] The three *cantones* that occupy the majority of the watershed are Quito, Mejía and Rumiñahui. Both Quito and Rumiñahui have a Department of Potable Water and Sanitation that make unilateral decisions at the cantonal level. In contrast, water resources in Mejía are governed by the Parish Administrations of seven distinct parishes, each of which has several water user groups. Together, there are 131 different water user groups in Mejía (González, personal communication), which make decisions collectively at a parish level and theoretically in accordance with the regulations and plans of development of the *cantón*. Each parish administration focuses on increasing access to potable water for the citizens of their respective water user groups, some through community infrastructure projects.

In the southern region where Quito, Mejía and Rumiñahui meet, the Pita and San Pedro Rivers are tributaries of the Guayllabamba River, with watersheds of 749 square kilometers and 585 square kilometers, respectively. They share their watersheds between Mejía, Rumiñahui and Quito, with the rivers themselves passing through either Mejía or Rumiñahui before entering Quito.

[6] The nine *cantones* are Quito, Cayambe, Mejía, Pedro Moncayo, San Miguel de los Bancos, Pedro Vicente Maldonado, Puerto Quito, Santo Domingo and Rumiñahui. This particular study focuses on the dynamic between Quito, Mejía and Rumiñahui.

*Water Pricing*

EMAAP-Q currently charges an average of 59 cents per cubic meter of water to Quiteño water users, while it costs it 87 cents to provide it (Iñiguez, personal communication). EMAAP-Q routinely adjusts these prices according to their internal needs, and not necessarily according to the needs of the population that it serves. In Quito, there is no organization that regulates control and provision of such service in defense of water consumers. Instead, EMAAP-Q makes unilateral decisions (be they appropriate or inappropriate) regarding tariff structures. They have strived to alter their water pricing structure to mimic an increasing block rate[7] so as to incentivize users to consume less water. A rebate structure is also included within the water pricing to account for economic status of the water users; it is determined according to the land economics of the sector in which the water user lives. The percentages of these rebates have increased over time since the dollarization of the Ecuadorian Economy in 2000 (EMAAP-Q, Tariff Charts for Potable Water from 2000-2003). EMAAP-Q recognizes that their power to dictate water prices will affect use and thus quality of life in the region—water prices that are too high will affect quality of life today, while water prices that are too low will affect future quality of life when subsidized water is wasted. According to Iñiguez (personal communication.), despite recent efforts, Quito continues to have a high rate of water consumption at 36 cubic meters of water per connection per month. According to EMAAP-Q, other cities throughout the world with climates similar to Quito's only use between 17 and 20 cubic meters per connection per month (Iñiguez, personal communication).

Those administrative areas outside of Quito and not serviced by EMAAPQ (i.e., Mejía and Rumiñahui) have different rates per cubic meter of water. Rumiñahui for example sets its water rate at 0.10 cents per cubic meter in addition to a fixed rate per connection (Salazar, personal communication). In general, Rumiñahui is one of the wealthier *cantones* in the region (if not wealthier than Cantón Quito); in the last ten to twenty years it has become more attractive as a place of residence to those wishing to live outside of Quito to escape problems of congestion, environmental contamination and crime (Ramirez, personal communication).

The most frequently mentioned reason for a sustained high water use has been a lack of "water consciousness" or "mentality of water conservation" in the region, which many claim is fueled by the subsidized water rates (Salazar, Quintana and Marcillo, personal communications).

*Water Contamination*

In the Quito region, much of the waste produced ends up the rivers of the Guayllabamba watershed. Activities in industrial, agricultural and domestic areas are the main contributors. Industrial effluents, agrochemicals, animal wastes, trash and solid waste contaminate Quito's waters, the last input being the greatest in volume. Urban expansion in the southern and central areas of the watershed has also had huge impacts upon riparian vegetation, especially when

[7] In Quito's increasing block rate structure, they charge a flat fee per connection to which they charge an additional rate per cubic meter of water used. Additional per unit rates increase as water use increases as defined by the defined blocks: 0-25 m3, 26-40 m3 and greater than 40 m3 per month. These blocks apply to domestic and commercial uses. Industrial water uses are charged at the maximum additional per unit rate.

considering uncontrolled housing construction without any kind of erosion control. The Metropolitan Waste Company of Quito (Empresa Metropolitana de Aseo de Quito - EMASEO) estimates that per capita production of trash (for 1,841,200 inhabitants in Quito) was 0.72 kg/day. EMASEO is responsible for retrieving 1,172 tons/day, covering approximately 80% of the population. However, this leaves a deficit of 286 tons/day. A private waste collection company, QuitoLimpio, retrieves some of this, though data are not available to ascertain just how much trash is not recovered (De la Torre 2004).

There is no defined landfill for the city. The one currently being used has reached its capacity. Although the city is looking into two or three alternatives, it has yet to establish one. Due to poor drainage construction, other landfills that have been used in the past continually drain into nearby rivers. In some areas trash collection is more regular and covers a greater percentage of the local population than in other areas. However, throughout the Quito region there are many clandestine garbage dumps (54 in the city alone) and domestic waste continues to end up in diverse zones along river shores and next to bridges that cross over them. De la Torre (2004) claims that this result is due to an abundance of trash collection personnel, but a great deficiency of needed infrastructure to do the job well.

Wastewater is not treated at all, anywhere in the Quito region—there are no existing wastewater treatment plants. The city hopes to construct much needed treatment plants starting in 2012. Despite the high level of contamination of the river network in this region (Tables 10 and 11), in some areas this water is still put to use. For example, the Machángara River is used to irrigate 880 hectares with an average flow concession of 0.365 $m^3/s$ (De la Torre).

| **Parameter** | **Range of Values that Define Water Contamination** | | | |
|---|---|---|---|---|
| | No Contamination | Slightly Contaminated | Contaminated | Very Contaminated |
| BOD (mg/L) | < 2 | 2 – 10 | 10 – 20 | > 20 |
| DO (mg/L) | > 6 | 5 – 6 | 3 – 5 | < 3 |
| Fecal Coliform (MPN/100mL) | < 200 | 200 – 600 | 600 – 4000 | > 4000 |
| Total Coliform (MPN/100mL) | < 1000 | 1000 - 3000 | 3000 – 4000 | > 4000 |

**Table 10:** Ranges of contamination levels for Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Fecal Coliform and Total Coliform (De la Torre 2004).

| River | Elevation (m asl) | Measured Flow ($m^3/s$) | Parameters | | | | | Conclusions |
|---|---|---|---|---|---|---|---|---|
| | | | BOD (mg/L) | COD (mg/L) | DO (mg/L) | Coliform (NMP/100 mL) | Weighted BOD (kg/h) | |
| Pita | 2480 | 1.87 | 8 | 34 | 7.2 | 90000 | 21 | Not good quality for many uses |
| San Pedro | 2460 | 10.43 | 23 | 68 | 6.0 | 100000 | 864 | Water not usable without prior treatment |
| Machángara | 2680 | 3.44 | 143 | 211 | 4.6 | $10^7$ | 1171 | Not fit for any use |
| Chiche | 2160 | 6.87 | 27 | 50 | 7.9 | 10000-100000 | 668 | Some uses, but with many restrictions |
| Guambi | 2360 | 2.00 | 2 | 17 | 7.5 | 1000 | 12 | Can be used in some ways, with restrictions due to coliform |
| Uravia | 2230 | 1.45 | 7 | 54 | 7.2 | 1000-10000 | 36.5 | Water use restricted due to high bacteria levels |
| Coyago | 2110 | 0.51 | 8 | 41 | 6 | 100000 | 14.7 | Water use restricted due to high bacteria levels |
| Pisque | 2000 | 3.67 | 3 | 22 | 7.5 | 1000 | 39.6 | Water use restricted due to coliform levels |
| Monjas | 2380 | 0.98 | 41 | 148 | 4.5 | $10^7$ | 144.1 | Not good for any use. Hydroelectric use only with prior treatment |
| Cubi | 2040 | 0.91 | 2 | 9 | 7.7 | 100 | | Water is of good quality for all uses |
| Guayllabamba | 1920 | 30.60 | 7 | 45 | 6.4 | 100000 | 771.2 | Can only use after specific treatments |

**Table 11:** Values of BOD, COD, DO and Coliform for rivers in the Guayllabamba watershed, which indicates levels of contamination. Almost all rivers in this region are highly contaminated; their water should not be used without previous treatment and in some cases not used at all. (De la Torre 2004).

*Watershed Conservation, Education, Capacity-Building and Research – FONAG*

The Fund for the Protection of Water (FONAG) is a non-declining endowment founded in 2000 which sponsors watershed conservation, environmental education, environmental capacity-building and research activities in the upper Guayllabamba River watershed around Quito. Since many of the water infrastructure projects in and around Quito had been constructed with national and international financing, EMAAP-Q decided that it needed to take measures to protect the city's water sources to prevent contamination and decreased flows so that its investments would not have been in vain (Pugh 2004). EMAAP-Q, together with The Nature Conservancy, launched FONAG, providing the original seeds grants for its initial years of funding. Today, these funds are complemented with continuing commitments from EMAAP-Q of one percent of monthly drinking water sales in the city (about US$14,000 per month) and US$45,000 per year from the Quito Electricity Agency (EEQ), which obtains its electricity from the regional hydropower projects (Echavarria 2002).

Within the watershed conservation model, FONAG's efforts target best management practices for small-scale agriculturalists and pastoralists around Quito. Their education programs work with peri-urban and rural school groups of young children to teach them about environmental stewardship related to water resource protection. They also train "forest guards" ("guardabosques") in their capacity-building programs in order to strengthen community management programs of native forests and *páramo* ecosystems, in addition to supporting a handful of eco-tourism projects with educational materials and training sessions. An extension of the capacity-building program includes several native species reforestation projects in which FONAG involves the forest guards and local communities. Finally, their research focuses exclusively on the impacts of various water uses and land uses on important water resources and micro-watersheds in the upper Guayllabamba River watershed. They do not work within the city of Quito to educate water users (FONAG, website).

## Challenges and Opportunities to Move Forward

As described above, the Quito region is characterized by water dependent livelihoods and land uses. All water uses fall into four general categories—irrigation, human consumption, industry and hydroelectric. They are sustained by three principal water sources—surface water in the region, Amazonian water via inter-basin transfers and groundwater. Allocating these water resources (which are either scarce or have been obtained through heavy investments) between the different uses and from the distinct sources has been a great challenge. On top of this challenge is the national government's promise to manage water resources for social and environmental justice goals. Based upon the above summary of the status of water resources, their use and management in this area, it is obvious that there remain obstacles to successfully meeting these challenges and to promoting integrated water resources management. The following section highlights these obstacles and proposes possible solutions.

Urban growth in Quito is one of the largest challenges for regional water authorities to manage when balancing provision for future needs and avoiding overexploitation. For the most part, city growth has been attributed to rural-to-urban migration as rural Ecuadorians come to Quito seeking employment, education and the amenities of living near a large urban center. Because of this shift, peri-urban populations in this region are growing faster than in the consolidated city itself, which implies increased demands on more informal community water systems and the need to extend the existing municipal infrastructure. The expansion of water infrastructure will include piping, storage tanks and, hopefully someday, treatment systems. With a greater number of community-built, "tubed" water systems, more diverse local water sources will be tapped, reducing water available for natural and "ecological" stream flows.

In order to stem and control the expansion of local water resource use in this area, regional water providers should encourage those migrating to the city to settle in areas where there is already an established water and sanitation infrastructure. Suggesting that the national government make rural life more attractive in order to entice rural residents not to migrate is an option that could occur at the large scale. For now, however, near future success should target adaptation measures to the continuing influx of people and families. In those areas where "tubed" water systems are being constructed, it is important for the municipal water providers to continue working with local communities as well as the private sector to ensure proper construction, treatment and provision to households. There is capacity for greater coordination between communities and local government to regulate water infrastructure expansion.

Along with urban growth and shifting land uses comes increasing competition between water uses. Small-scale agriculture dominates on steeper slopes and at higher elevations. These agriculturalists work with less than 10 hectares of land (the majority of them with only a few hectares) and do not rely on the public nor the large private irrigation systems. The majority of their crops are rain fed with some water diversions from small, local sources.[8] As urbanization and diversification of land uses continues, the number of downstream water users impacted by their land management practices increases. Often, this impact includes contamination of local sources with livestock waste and eroded soils from fields. The two most important downstream impacts are on hydroelectric projects and potable water capture tanks.

Improving land management practices of upstream water users will be an important step. Such activities are already taking place through FONAG, which also represents EMAAP-Q (metropolitan water and sanitation) as well as EEQ (metropolitan electricity). Strengthening working relationships between these small-scale farming communities and the organizations that manage drinking water and hydroelectric projects (outside of disparate activities for best land management practices conducted by FONAG) should be a next step.

Regarding competition for water resources between potable water and hydroelectric systems, De la Torre (2004) concludes that the majority of the hydroelectric systems in the watershed do not interfere with potable water supply. Those potable water systems that are planned for the future, most of which will transfer water from the Amazonian region, are currently being reviewed for their potential to conflict with potable water supply needs. As the Oriental Rivers project points out, potable water can be provided and also generate power from hydroelectric stations. Until Quito requires all of the 17 m3/s minimum flow that this project can supply, what is not used will be diverted to hydroelectric plants to be constructed in the region. Thought should be given

[8] This is especially true for those who cultivate at higher elevations where there is greater precipitation and thus more available water. They plant primarily broccoli, potatoes, carrots and other vegetables that they use to subsist as well as to sell to local markets (Ludema, personal communication).

to how these hydroelectric plants will operate or otherwise be used once flow is no longer being diverted to them from the Amazonian potable sources.

Competition for water resources among small-scale farmers and medium-scale farmers is also problematic. Although the Water Law of 1972 ended private expropriation of water and deemed it a public good, in many peri-urban and rural areas, medium-scale agriculturalists with seven to ten acres of land adjacent to water bodies, continue to consider themselves the owners of that water and prevent any other community members from accessing it (Ludema, personal communication).

In this case, it is important to increase publicity of water users' rights and responsibilities, as well as those rights and responsibilities conferred and managed by local and national government. Of course, enforcement of these rights and responsibilities needs to follow. As will be discussed below, monitoring and enforcement pose great challenges in this area.

When it comes to small-scale agriculturalists' livelihoods, there are very few programs that help them to resist selling their land when faced with decreasing profits and the need for increasing investments (Velásquez, personal communication). These programs focus on technology transfer and provide technical assistance. Often, large-scale agriculture[9] takes advantage of this opportunity, seeking to incorporate nearby, smaller agricultural terrains, adding to their holdings and thus increasing the water demand from their irrigation systems. As water demand for irrigation continues to grow, providers are now looking to Amazonian sources to satisfy their needs, putting them into conflict with potable water providers.

Improving the profitability of small-scale farming while controlling the insatiable thirst of large irrigators should be a two-step approach. First, as Velásquez (personal communication) points out, programs of technology transfer and technical assistance are designed to help small-scale farmers adopt more profitable farming techniques. Often, they manage their lands according to family and community traditions, even if that management may not be the most sustainable (for their lands or for their incomes/livelihoods). Such capacity-building programs will only be successful if farming families are willing to adopt them. If there are large cultural barriers or resistance, there is not much that local agricultural agencies can do. On the other hand, these agricultural agencies often operate on small budgets and with few staff. If they could increase their budgets and their staff they might have become more effective in holding more workshops, working with more farming families and testing new capacity-building techniques in these communities. Often, adoption of new technologies and diffusion of that innovation requires capacity-building organizations to identify influential individuals and families within the communities who will help others to adopt new and more sustainable practices.

Second, controlling the thirst of large irrigators should focus on improving their farming techniques so as to conserve water as well as improving infrastructure to reduce loss. Along these lines, the CNRH should require water conservation measures and plans when granting water permits and concessions.[10]

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[9] For the most part, these enterprises cultivate fruit trees, corn, flowers (for export) and maintain pasture for livestock (De Bievre and Coello 2007b).

[10] Depending on the irrigator, this measure could also consider increased training of farm workers and managers.

To satisfy growing needs from potable water users, irrigators as well as hydroelectric projects and industry, efforts have focused on increasing water supply rather than decreasing (per capita or per hectare) demand. Interviews with representatives of water and sanitation departments revealed their preoccupation with investing in new water sources including water capturing, storage and piping infrastructure in order to satisfy growing demands (Salazar and Gómez, personal communications).

The ease with which water providers have sought to increase supply to Quito has manifested itself in inter-basin water transfers, such as the Oriental Rivers project described above. In part, water providers have sought out inter-basin transfers due to the high levels of contamination of local rivers in the Guayllabamba watershed. Many of these rivers are unfit for use unless they have been extensively treated, and some should not be used at all, whether the water is treated beforehand or not. The danger in turning to inter-basin transfers to satisfy needs (without any past or current investments in wastewater treatment plants) is that it not only reinforces the public's acceptance of unlimited demand and expensive, highly technical solutions, but it also downplays the impacts of these transfers on the ecosystems of the water sources. The 28 rivers that will be tapped as part of the Oriental Rivers project are headwaters of the Amazon River. It may be possible to assert that the project will not affect other *human* water uses and users in this region. Taking water from them to the degree of leaving only 20 percent of existing average flow, however, has the potential to disrupt flows and habitats for many ecosystems and ecological communities downstream. If Quito's need for more water prompts water providers to extract more from this region via additional transfer projects, then impacts may only increase.

Seeking additional water sources to meet growing demands is inevitable as the city continues to grow. However, the amount of water extracted and provided via inter-basin transfers, as well as from many other sources, can be reduced by simultaneously focusing on improving water infrastructure and decreasing water demand. The high rates of loss from potable water systems (hovering around 35 percent overall and up to 50 percent in rural areas) and irrigation water systems (up to 70 percent) could be reduced with better and more frequent infrastructure maintenance.

Water demand could be reduced by incentivizing conservation through an appropriate water pricing mechanism. Water pricing in this region fails to reflect the true cost of water provision. In interviews, representatives from various municipal water providers and water regulatory boards suggested that subsidized water pricing leads to excessive use and fuels a lack of a "water consciousness" on the part of the general water-using public. EMAAP-Q is currently working to adjust their water-pricing structure to better resemble an increasing block rate in order to promote conservation. Over the years, they have redefined block ranges and pricing. However, they continue to struggle with balancing social justice goals, recovering costs and conserving water resources. Water tariffs are heavily subsidized for the many poor Quiteño families who cannot afford even the lowest block rate pricing. To better reflect a user's ability to pay, one idea that is being considered includes increasing or decreasing block rate potable water tariffs according to a redefined system of economic sectors in the city. In that way, pricing would be tied not only the quantity of water used, but also to the household's ability to pay for the resource as reflected by the economic sector in which it is located.

Throughout all uses—potable, irrigation, hydroelectric, industrial—information is vital for effective management. The best data available is that for potable and irrigation water use, though there remain certain areas that are not covered and many illicit uses go unrecorded. For industry, there is very little data, as noted above. A great amount of hydroelectric information exists on power produced or anticipated, but less so when it comes to flows required to generate that power and even less on how this non-consumptive use may conflict with consumptive uses.

In addition to lack of accurate water use statistics, information on concessions granted and individual water management practices are poorly managed. The National Council for Water Resources claims that inefficient water use and management also results from granting excessive flow concessions for specific uses[11] (Recalde, personal communication). Moreover, the excessive number of small flow concessions makes their management even more chaotic.

Real time data on uses and management would be ideal, but is unrealistic to achieve in this region. Organizing the structures and networks to ease water use reporting and monitoring is necessary. Without more realistic information, authorities have limited abilities to enforce more sustainable water use systems (including the prosecution of illegal and unregistered connections) and thus fairly allocate and conserve water resources.

In order to improve communication, collaboration and responsibility for water resource management and use, in addition to achieving greater water conservation, more and better managed data is indispensable. For example, standardizing a reporting system for water users and allowing them direct access to enter it themselves would ease the public institution's burden of gathering data itself. Making this data more available to the public (such as quantities of use in households, industries, and agriculture in their areas) on a regular basis, especially to the local water users themselves, could make water managers more accountable and responsive to local and regional needs as expressed by the area's users. Consolidating small flow concessions would be incredibly helpful for an overwhelmed AAQ as well.

Collaboration across water resource regulatory sectors and between distinct administrative units is often nonexistent or ineffective. Sector based management at the national level, for example, includes many distinct agencies, each of which regulates a specific characteristic of water resources or its specific uses, such as water quality, watersheds, irrigation, potable water, or flood control. Unfortunately, communication between these agencies is poor. Zurita et al. (2003) recognize this coordination challenge, writing that throughout Ecuador's history of water and sanitation management (since the first laws were implemented in the 1940s), responsibilities for different aspects of water resource management have been continuously divided among government institutions as those institutions have been created, themselves divided, have disappeared or been incorporated into other institutions. Such a reinforced sectoralization of management for a continuous resource in addition to the lack of continuity of management

[11] There are nine categories of concessions for specific water uses that are awarded by the National Council for Water Resources (Consejo Nacional de Recursos Hídricos – CNRH). They include irrigation, hydropower, domestic use (not including potable water), industry, potable water, water for livestock, thermal pools, spring or bottled water, and "mechanical cooling water" ("fuerza mecánica") (De Bievre and Coello 2007a).

institutions over time has lead to very limited management visions, has increased opportunities for conflict, and has perpetuated unstable management authority.

To remedy these impediments and spread out the burden of efficient water provision and management investments, Zurita et al. (2003) suggests that national policy should be constructed to encourage private sector investment for water, including increasing predictability and support for the current Ecuadorian business environment to invest in water provision, management and conservation. The structure of Ecuadorian investment laws is one example which has proven important for the creation of the Fund for the Protection of Water (FONAG), an organization that will be discussed in more detail below. Allowing public agencies to invest in private markets enabled EMAAP-Q to create FONAG, which invests its funds in such markets, using only the interest accrued to fund its water conservation projects. In Ecuador in general, there is a certain resistance to such a suggestion. Many Ecuadorians fear that private sector involvement will lead to water resource privatization. With the backlash of the water privatization failure in Cochabamba, Bolivia, resistance to private sector involvement in water provision and management is very strong.

Two of the only aspects of water and its use not extending from the national into the local level are watersheds and water quality. These are regulated at the national level by the Ministry of the Environment (MA) and in the case of watersheds, the National Council for Electricity (CONELEC) as well (Figure 6). Considering that water quality in rivers in the Guayllabamba watershed is very poor and that water resource management defers to decisions based on administrative unit needs rather than entire watershed needs, regulation of such aspects are not that effective when remaining only at a national level.

The Declaration of Water (19 February 2008) states that any new Ecuadorian constitution will provide for an approach to water resource management that takes into consideration the entire hydrologic cycle—the flows that connect different sources, uses and users. While it is a step forward, translating this goal into practice, especially at local, decentralized levels, will be challenging.

Even though the upper Guayllabamba river watershed does not respect political administrative boundaries and encompasses six distinct *cantón* administrative units, there is little effort for water resource management coordination and collaboration between the *cantones* at the local level.

In both Mejía and Rumiñahui, interviews with directors of water departments and water user groups revealed that there is a need for more coordinated watershed management and planning in the region, especially in the watersheds of the San Pedro River and the Pita River, in which these *cantones* are located (Figure 1) (Salazar, personal communication). The creation of the Metropolitan District of Quito in 1993 was a first step toward decentralization of powers from a national to a more local level. While national ministries and programs continue to operate on a somewhat participatory basis in other *cantones* around the country (as long as resources allow), the creation of the DMQ has afforded it special legal powers to regulate its own urban growth, natural resource, water resources, sanitation, health and education, among others (González, personal communication). As a result, its management policies tend to dictate management on a regional scale, forcing adjacent *cantones* into more reactive management positions (Ramirez, personal communication). Quito does lend some technical assistance to its cantonal neighbors, thought beyond this assistance there is no real collaboration nor coordination of management strategies on a watershed level. In fact, interviews with representatives from Rumiñahui and Mejía indicated that there could be future quarrels with Quito over water resources since the watersheds of the San Pedro River and the Pita River are located in the southern portion of the Guayllabamba watershed. Both rivers pass through Mejía and Rumiñahui, respectively, before entering the DMQ (Salazar, Ramirez and Velásquez, personal communication). Their watersheds and tributaries are used by those two *cantones* to supply their populations with water as well.

Sectoralization and decentralization of water resource management authority has not necessarily lead to increased efficiency since it has not been coupled with sustained and meaningful collaboration and coordination between the many agencies involved (both at national and local levels), even though they are required to strive for the same social and environmental justice goals as well as comply with the same laws and regulations. In an interesting study targeting the irrigation subsector in the Andean region of Ecuador, Cremers et al. (2005) point out that, "the complementary roles of central Government, local governments and water user organizations in water resources management [should be] emphasized as [should] the need to strengthen enabling legal and policy frameworks. The importance of translating constitutional recognition of local and indigenous rights and common property systems into practical procedures and institutional structures [should] also [be] stressed." In general, there is a large disparity between policy and practice at the national and local levels. Ecuador has struggled to integrate and close the gap between the tow. The distribution of international aid and resources for water and sanitation projects in this region which are channeled through national ministries is as effective as the collaborative efforts of the particular ministry to which they have been given or lent.

De la Torre (2004) suggests that three foci for successful local implementation of any national goals for water resource management include: (1) local institutional capacity (2) clear local priorities and (3) consensus and collaboration among distinct actors. Unfortunately, only one of these three usually exists in any one local administrative unit (usually the second point). Local institutional capacity is hindered by lack of resources and limited training of staff[12] and as described above consensus and collaboration among distinct actors, even within the same administrative unit, is often missing. Clear local priorities are discussed extensively in plans of development for a particular *cantón* and thus pose the smallest hurdle to achieving more integrated water resource management.

Water resource management on a watershed scale can be described as existing on a gradient. On one end of the gradient sits political administrative units and on the other end, watersheds. The three general positions along the gradient include: (1) the absence of watershed-level management for water resources and thus no collaboration among distinct stakeholders, (2) a vision for watershed-level collaboration, achieving this with existing political-administrative institutions and boundaries in place, and (3) a watershed-level management vision with a reorganization of existing institutions to fit that watershed scale. De la Torre (2004) vehemently

[12] Local staff are often trained in strict disciplines in the university system that allow for little interdisciplinary exposure to encourage cross-fertilization of ideas and natural resource management approaches.

opposes option three, but realizes that option one is undesirable because it will not achieve conservation. He suggests that the best approach is option two—to retain a planning focus: "The management of watersheds should be a process, on the one hand, the establishment of policies and strategies and the planning of integrated watershed management and, on another hand, involvement and action according to the institutional system of the country, which is, *planning* in order to organize and to assign to all involved actors the actions that correspond to them in each watershed, as determined by the planning institutions of the country: The National Secretary of the Office of Planning of the President and the Ministry of the Environment, with the help and participation that they consider necessary for each action/use. Any required action should be taken by the responsible party without attempting to create a new, unnecessary and surely inoperable institutional figure in charge of *watershed management*, except in the case of inter-sectoral and inter-institutional coordination by the sector regulator in each specific situation" (De la Torre, 2004 pg. 65). Of course, his argument against option three is that it will only increase bureaucracy and that reorganizing political-administrative institutions is an exercise in futility since it will only achieve overlap instead of efficient management. However, as discussed in many areas of this analysis, existing collaboration among distinct management institutions is poor. If no reorganization is going to take place, then success of the watershed-scale management vision proposed by De la Torre will require implementation of appropriate collaboration networks and incentives among the many institutions and agencies involved. The collaborative process will also have to avoid or minimize opportunities for corruption to take place, often one of the toughest challenges to overcome.

When discussing hurdles to efficient operation and management of water resources at any level, after mentioning the lack of resources, managers often point to corruption. Corruption, loosely defined for this analysis, occurs when a resource manager takes advantage of his or her position of power to make a management decision that better serves either his or her own interests or the interests of a selected few, rather than the interests of the public that elected him or the government that he represents. Managing any natural resource (not just water) in the face of corruption in Ecuador presents challenges. The overlap of natural resource scales with political-administrative scales makes accountability harder to assign to particular managers. This is especially true when adverse or undesirable impacts are felt in other areas and at later times or when they result from a decision-making process that is complex and often convoluted involving many actors. Overcoming such a socio-cultural hurdle will require not only more responsible managers, but also a more educated, motivated and participatory public with conservation in mind and which can hold managers accountable.

FONAG is a partnership that attempts to bridge the gap between water resource management policy and effective implementation while addressing the need for a regional, long-term water resource management approach and a more conservation-educated water-using public (which can lead to less tacit acceptance of corruption). As a multiple stakeholder platform, it "combines the strengths of government, NGOs and private industries. The fund is supported in part by users of the municipal potable water, and management salaries are paid by the city of Quito, but FONAG also relies on contributions from the Quito electric company and on capacity-building and strategic direction from relevant NGOs" (Pugh 2004, pg 306). It also collaborates with local governments, international donors and technical assistance organizations for projects and studies.

Implementation of conservation measures has become increasingly popular in Latin America and Ecuador, targeting both monetary and ecological benefits.[13] In many of these countries, including Ecuador, "the environmental non-governmental organizations have increasing opportunities to attract international funding in lieu of the previous government-directed disbursal of foreign aid" (Pugh 2004, pg. 306). International lenders are beginning to prefer the option of funding private and non-profit sector projects (with governments as secondary collaborative agents) to avoid government corruption and misuse of development aid, plus possible refusals to accommodate donor needs. Such a preference raises the question: When it comes to natural resources, are NGOs starting to provide a solution that was once a government responsibility? This is a possibility, though government may take a more active role in sharing this responsibility with NGOs if it can foster a policy and funding environment that allows NGOs to operate more efficiently. How far the pendulum between NGO and government will swing to the NGO side, however, is hard to predict and depends on many country-specific factors. In Ecuador, for now, NGOs that focus on goals for sustainable natural resource management and community development are doing good work, which could be better supported by government policies at larger scales.

With new funding opportunities and collaborative networks among private and public sector managers, FONAG has become more empowered to reach out to individual water users through their projects and environmental education programs. Currently, they work primarily with rural communities located near Quito's water sources to provide training in best land management practices. One weakness they have been trying to strengthen includes the visibility of their work with water users located in the city itself. The first Environmental Fair in Ecuador was held in Quito in mid-June 2007 with tens of environmental organizations participating and interacting with the public. At the fair, it was evident that most Quiteños who visited did not have any idea that FONAG existed or what kind of work it accomplished, nor did they know that they contributed to FONAG's mission by paying their water bills. A city-wide public education campaign to increase FONAG's visibility should be a priority if it is going have a meaningful impact in educating water users about local water sources as well as water conservation. Conversations with local community leaders and a handful of community members in a southern peri-urban area of the city revealed that many household heads do not know where their water comes from (Toalombo, Salazar, personal communications, Cutuglagua).

In addition to their capacity for public education, FONAG has published several detailed documents analyzing the condition of water resources in two important sub-watersheds to the south and southeast of Quito—the San Pedro River watershed and the Pita River watershed, respectively. In the course of this research, they have seriously explored the importance of ecological flows to maintaining healthy aquatic and riparian ecosystems (Rosero 2005). Incorporating ecological flows into policy and the granting and monitoring of flow concessions remains a future goal.

[13] Like EMAAP-Q's investment in FONAG, in Cuenca (a mid-sized city in the Andean highlands to the south of Quito) the Municipal Telephone, Potable Water and Sanitation Company (Empresa de Teléfonos, Agua Potable y Alcantarillado—ETAPA) has invested in water resources protection. Its strategy relies more heavily on the purchase of watershed land to facilitate protection, as opposed to the training, education and watershed security enforcement program pursued by FONAG (Pugh 2004).

As FONAG continues to work with rural farming communities, educate water users, perform research and propose new water conservation needs and approaches, it is important that they align themselves with other environmental organizations in this region striving to achieve the same goals with other resources. These connections will provide them more leverage to achieve their resource conservation and protection goals. To a degree, this has already occurred in specific locations where FONAG has several on-going projects both with local NGOs and international environmental organizations (e.g., the IUCN and The Nature Conservancy).

Overall, FONAG has provided a unique solution to a water provision challenge. Although its approach nor the target population with which is works is completely comprehensive, it provides a good basis from which to build more awareness and to test more effective management approaches. One of these management approaches includes a vision for watershed-scale management decision-making.

**Discussion**

The Quito region faces a serious challenge in balancing how it invests its time and money in both short-term and long-term solutions for water needs. Short-term solutions, for example, may include investments in providing more water infrastructure as well as water transfers from other regions.

The region's water resource management authorities do poorly, however, in incorporating long-term solutions that take into consideration not only human water needs, but also equitable and sufficient allocation among competing uses, including water needs to sustain important ecosystems. Solutions and investments should target water conservation, including (1) addressing a water infrastructure system that suffers a 30 percent loss of water, (2) reducing demand from potable water users that when compared to other cities is uncharacteristically high—such a solution could include better water pricing structures that incentivize conservation as well as public education and capacity-building both inside and outside of academic settings, (3) investing in better land use management and planning (both urban and rural) according to a changing water budget, (4) enforcing and regulating clandestine and unregistered water uses and users as well as polluters, (5) increased conservation of important watershed ecosystems including the *páramo* and native forests (which is occurring to some degree), and (6) determining how to make various agencies and stakeholders best work together across many scales and thematic foci.

FONAG has started addressing point three. It has also contributed to aquatic habitat and riparian ecosystem conservation in some of the peri-urban communities in the San Pedro and Pita watersheds. EMAAP-Q has been working on constructing a better water pricing structure that incentivizes conservation. In general, The Ministry of the Environment and the National Government have done well with point five by creating National Parks and Reserves and declaring all *páramo* ecosystems as protected. Enforcement of these declarations, however, remains a challenge. Almost all institutions claim that they lack sufficient resources to do their jobs as they should, which includes the municipal water provider's claim that the absence of such resources prevents them from adequately addressing inefficient water infrastructure (point one).

Despite all of these claims, politics plays a large role in the efficiency of water management in this region. Focusing on addressing short-term solutions through large, expensive and highly visible water infrastructure projects allows politicians to rally support for their political agendas. In general, there is a lack of clear rights and responsibilities for each actor involved in water resource management, including water providers, water managers, water users and even water project financers. The important objective is that such rights and responsibilities are not only agreed upon by these actors, but that they adequately address water needs and conservation challenges at both regional and local scales. This point addresses the unit of management analysis and whether that should continue to be the political-administrative unit or the watershed and to what degree political reorganization and collaboration should occur to adapt to the watershed scale.

Constructing an integrated water management framework involves many components that need to come together at relatively the same time to make sustainable water management and conservation viable and attractive. In many ways, the necessary components will not only impact water resource management, but also the agency, participation and self-determination of individual water users in other areas of their lives (i.e., education, safety, livelihoods and income, etc.). James Kundell, in his analysis of water allocation issues in the state of Georgia, suggests a suite of necessary components that should be reflected in policy and practice in order to achieve successful integrated water resource management (Kundell 1998) (Table 12).

| **Component (James Kundell)** | **Status in Ecuador (this analysis)** |
|---|---|
| Water as a Public Resource<br>All uses/permits are equal | **No –** excessive flow permits for some uses. Ensuring equality among permits and uses is frustrated by poor monitoring and enforcement. |
| Flexibility and Site-specific Approach<br>To allow for targeted intervention | **Yes/No –** decentralization of management powers provides a framework for better response to local needs. Implementation, remains weak; absence of coordination between local managers for a collective resource. |
| Watershed Approach | |
| Coordination | **No** |
| Prioritization | **Yes –** but implementation is difficult in the face of competition. |
| Funding | **No –** lack of resources. FONAG is a financing mechanism for some activities. |
| Water Rates for Conservation<br>Includes revenue to support program administration, tying the cost to the user, permit fees, seasonal sur-charges, increasing block rate structure | **Yes –** though still weak. EMAAP-Q working on better tying rates to the economic status of the user to achieve social justice goals. **No –** no seasonal (dry season) sur-charges. |
| Comprehensive Water Planning Approach<br>Reduced sectoralization, treating groundwater and surface water as the same, connected resource | **No –** new constitution attempting to integrate this focus. |
| Stakeholder Input | **No –** only exists to a very limited degree (plans |

| | |
|---|---|
| Clear rights and responsibilities, active participation | of development). Rights and responsibilities are expressed but weakly implemented in the face of corruption. FONAG is working to better educate land managers and water users and targets stakeholder participation through environmental education. |
| Regulated Riparian Water Model Code | **No** – not incorporated in policy. FONAG is promoting inclusion of "ecological flows" for future policy and management. |
| Organization Consolidation<br>"Special entities" | **Yes/No –** exists at a national level, which produces bureaucracy and is largely ineffective. Does not exist at a local/regional level at which it might be a more effective approach. |
| Information to Regulate Well/Realistically<br>Supply vs. Demand for all sectors, summary of recent trends in Quito region and other regions | **No** – large absence of data for some uses (i.e., Industry). Data is often guarded heavily and not shared readily among decentralized water management institutions. |
| Enforcement Measures<br>Common Law, Registration Permitting | **No** – enforcement remains weak. Registered uses are often poorly monitored. Lack of data contributes to this weakness. |
| Watershed Conservation Measures in Permitting | **No** – watershed conservation is incorporated to the discretion of the permitted user. Not mandated in granted concessions. |
| Special Provisions for Inter-basin Transfers<br>Review to ascertain if other measures could be taken first to address the problem | **No** – inter-basin transfers are often pursued as the first option. They are desirable for their visibility and are often used to bolster political agendas. |

**Table 12:** Status of components for integrated water resource management in Quito, Ecuador using Kundell's framework (1998). Many components exist in a policy setting, but are poorly translated into management practice. Others don't exist at all. In some cases, there are efforts to strengthen a particular component, though these often remain at early stages.

Looking again at Ecuador's water management goals—to provide every citizen with adequate access to water while protecting the landscapes and biodiversity that supply and maintain those water resources—introduced at the beginning of this analysis, it is evident that many challenges still exist. Integrated water resource management, and its components as proposed by Kundell (1998), is one avenue to achieving these goals. Though, as pointed out (Table 12), many of these components remain relatively weak.

Beginning with the Water Law of 1972, Ecuador adamantly stated that it would treat water as a public good and strive to provide access to all. It would no longer be treated as an economic nor a political good. However, throughout its history from that point forward, water resource management and the ability of water managers to achieve the goals above have been subject to both economic and political constraints, being managed according to available economic resources as well as local political agendas and the leverage it could provide for those agendas, as has occurred in many other countries throughout the world. Social justice and environmental justice concerns have been applauded, but little progress toward those goals has occurred. Many in the Quito region recognize this political correctness lip-service and also disdain it; progress towards integrated water resource management is stagnant. Returning to public good management will require a significant turn-around on the part of water resource regulators, managers and also users.

There is a new opportunity to achieve this turn-around: The new Ecuadorian constitution that is currently being written. It will have the power to re-articulate important ground rules for the regulation, allocation and overall ethic of water use in Ecuador—that is, water managed as a public good. But just as important, if not more so, it has the opportunity and power to institutionalize the nature of working relationships between and decision-making processes among the various agencies and actors that regulate and use water resources in this region. Such institutionalization should encourage transparent, democratic decisions. It should also foster both authority and accountability for water managers.

In this sense, the responsibility of the water user should be to remind water managers of the accountability they owe to those they represent and legislate for. The components for integrated water resource management are known, it is only their implementation that is lacking. Only when the public itself agrees to take on some responsibility for and invest in the democratic management process by joining the water resources management discussion will regulators and managers become more accountable for their decisions.

Despite the many challenges still ahead, integrated water resource management in the Quito region can be achieved simultaneous with continued development. Many of the actions for better water management (as described above) can lead to improved and more equitable decision-making processes and outcomes for all water users. Even though Ecuador relies on its natural resources for regional development, integrated water resource management does not have to occur at the expense of that development.

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