

## **GALAPAGOS REPORT 2013-2014**

### **HUMAN SYSTEMS**

#### **WATER SUPPLY ASSESSMENT ON SANTA CRUZ ISLAND: A TECHNICAL OVERVIEW OF PROVISION AND ESTIMATION OF WATER DEMAND**

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# Water supply assessment on Santa Cruz Island: A technical overview of provision and estimation of water demand

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## Introduction

A growing local population and expanding tourism on Santa Cruz Island have increased pressure on natural resources, especially water. The urban population of Santa Cruz, the second largest island in Galapagos, equals nearly 60% of the total of the province and lives primarily in the major urban settlement, Puerto Ayora, and its fast growing suburb, Bellavista, located 7 km inland (GADMSC, 2012). Population growth in Galapagos has increased exponentially, in contrast to population growth in the rest of continental Ecuador (Figure 1). In addition, the number of visitors over the past two decades has increased from approximately 17,000 visitors per year in 1980 to 204,000 in 2013 (DPNG, 2014; Figure 2).

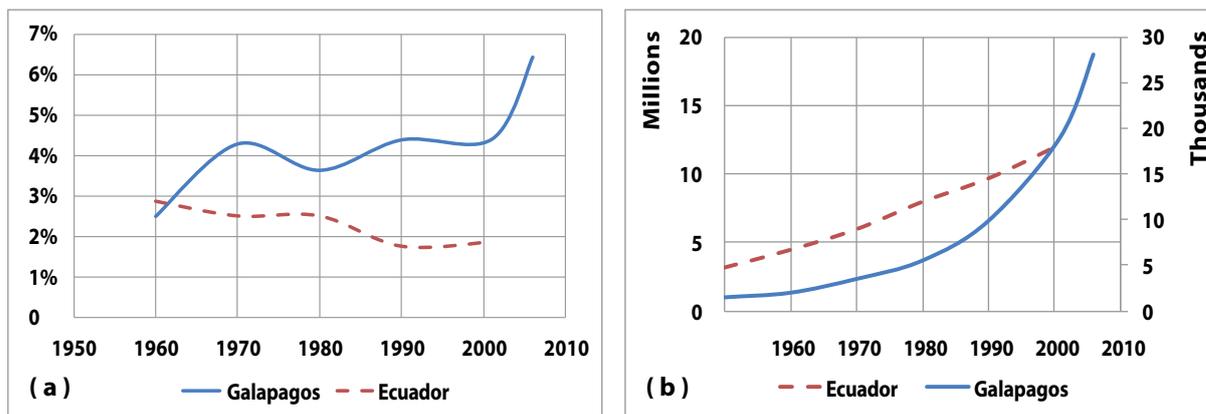
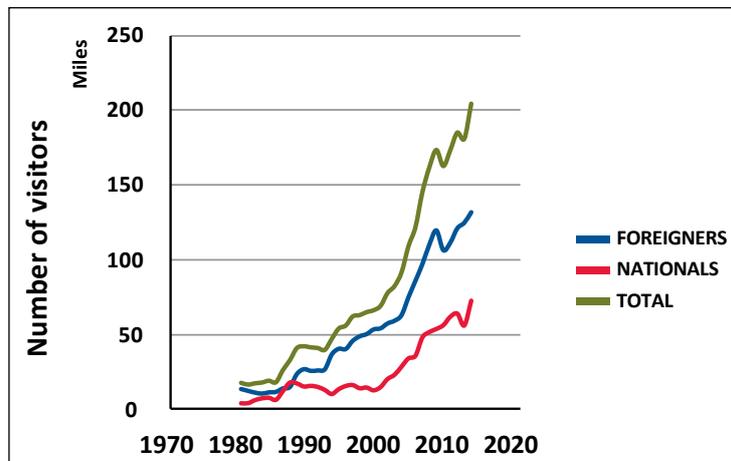


Figure 1. Population growth rates (a) and population growth (b) in Ecuador and Galapagos (INEC, 2010).

The elevated immigration from the mainland has resulted in several collateral effects, such as an increased demand for basic services including the need for a reliable water supply system (GADMSC, 2012). Unfortunately, the municipal supply system has had difficulties coping with the current demographic growth due to financial constraints, lack of personnel, and fixed tariff structures. Water is perceived as scarce and service poor. In addition, water conveyed along the network is untreated and of very low quality. The high concentration of chlorides (from 800-1200 mg/L) causes it to be brackish and unfit for human consumption.

Several studies have confirmed contamination by *E. coli* and many water related diseases have been reported (Liu, 2011). Moreover, the water supply system is unreliable

and intermittent, operating for an average of three hours per day. This limited service has resulted in inhabitants building their own supply and storage systems.



**Figure 2.** Number of national and foreign tourists entering Galapagos from 1980 to 2013 (DPNG, 2014).

Ever-increasing tourism in Galapagos potentially threatens both natural areas and resources, including water. However, documenting water consumption by large consumers such as hotels, restaurants, and laundries has been a challenge as the information available in public records does not always match reality. The Municipality of Santa Cruz has registered approximately 40 water connections in the hotel category, while the tourist authority (Ministry of Tourism) has a list of approximately 160 entities that provide accommodation. For this study, only information provided by the Municipality of Santa Cruz was used.

Currently, the Islands have low quality, contaminated, and undrinkable water. Furthermore, proper sanitation is lacking as a result of source contamination caused by the proximity of poorly built septic tanks in urban settlements, and aged and unreliable water distribution networks (Liu & d'Ozouville, 2013). These problems are primarily due to a combination of technical shortcomings, a decentralized water supply, lack of consumer awareness of water conservation, and inadequate water tariffs.

The Galapagos Islands are in urgent need of water management solutions. Some studies of water resources in Galapagos have been carried out in the past, but none of them assessed the overall water supply and demand situation in Santa Cruz. As a consequence, the implementation of management measures has been limited. Currently, no systematic solutions have been developed to respond to persisting water supply and sanitation problems. This study compiles existing information and identifies knowledge gaps.

The goal of this research was to analyze the current situation of water demand in the Galapagos Islands by carrying out an assessment of water supply and

quantification of demand from surveys of the local population on Santa Cruz Island. The village of Bellavista, where water meters are used and demand is generally known, has more solid data, while surveys completed in Puerto Ayora only provide estimates of water consumption by category and source.

### Water sources

Three main sources of water exist in Santa Cruz Island: 1) municipal supply; 2) bottled (desalinated) water, and 3) 'private' extractions.

The Municipality of Santa Cruz provides water through two independent and separate systems, one for Bellavista and the other for Puerto Ayora. Each system has its own extraction source, storage tanks, and network. The water is mainly brackish and consequently considered non-potable according to national and international regulations. Neither system includes water treatment.

Bottled water is the main source of drinking and purified water. In general, private companies desalinate brackish water with small scale, reverse osmosis plants. Costs for this water are elevated; given that drinking water is a basic need, desalination businesses are very profitable.

Several "private" water crevices located on private lands provide water for various premises in Puerto Ayora and Bellavista. Pumping from these crevices is unregulated and lacks monitoring. Therefore, the number of pumps and the amount of water extracted are unknown. This creates a challenge for authorities since water sources belong to the government of Ecuador, while the land belongs to its owner. Some proprietors manage the water sources as their own and consequently distribute it in

water trucks or via other systems to the local population (Table 1). Given the lack of monitoring of these private users, approximations of demand are based on scarce information from governmental institutions including the Municipality of Santa Cruz and SENAGUA (National Water

Secretariat). Two of these crevices, Barranco and INGALA, used to be the main extraction sites of the municipal network; however, due to the detection of high levels of contamination, the municipal extraction sources were changed.

**Table 1.** Various "private" water sources located in the urban settlement of Puerto Ayora.

Name of crevice	Uses
Misión Franciscana	Desalination of water for private company
Tortuga Bay (3 crevices)	Hotels and private properties from Punta Estrada neighborhood, laundries, etc.
El Barranco (2 crevices)	Private trucks selling water
Gallardo	Mechanic garage and water desalination company
Martin Schreyer - A&B	Owner's cruise ships and hotels
Pampas Coloradas	Private trucks selling water
Grieta Charles Darwin	Water uses of personnel of Charles Darwin Foundation
INGALA	Pampas Coloradas Stadium, Energy Utility, etc.

### Water supply systems in Bellavista and Puerto Ayora

The two public water supply systems of Santa Cruz provide service to Bellavista and Puerto Ayora. Bellavista has a smaller system with only about 444 connections (as of December 2013), serving approximately 2500 inhabitants. The system for Puerto Ayora is more complex, with 2156 water connections, corresponding to approximately 12,000 inhabitants (INEC, 2010).

The water source for Bellavista is a constructed well called *Pozo Profundo* or Deep Well, where water is pumped with a single pump, which extracts 6 l/sec for an average of 12 h/day (Table 2). Water is conveyed from the source to a 300-m<sup>3</sup> storage tank and to a sub-pumping station with a stationary 30-HP pump of horizontal axis with a flow of 12 l/sec during 4 h/day, delivering water to two storage tanks with capacities of 500 m<sup>3</sup> and 100 m<sup>3</sup> (Moscoso, 2009). In 2013, another 1000 m<sup>3</sup> tank was built, and all three are now located on the same site, 218 m above sea level. Water is then distributed to the village by gravity.

**Table 2.** Specifications of the water supply systems of Bellavista and Puerto Ayora..

Name	Pumping flow (l/s)	Pump power (HP)	Average pumping (h)	Approximate leakage*	Extraction (m <sup>3</sup> /d)	Volume supplied (m <sup>3</sup> /year)	Water treatment
Deep Well (Bellavista)	6	25	12	15%	259.2	94,608	NO
La Camiseta (Puerto Ayora)	35 (2 pumps)	50	12	25%	302.4	1,103,760	NO

\*Leakage estimates are based on information from the Municipality of Santa Cruz.

The primary water source for Puerto Ayora is the crevice *La Camiseta*, located 2.8 km from town. It has one pumping station with three pumps, with only two pumps working at a time (Table 2). The pumps extract 70 l/sec during 12 hours/day and convey water through a 315-mm-diameter PVC pipe to two storage tanks (600 m<sup>3</sup> and 800 m<sup>3</sup> respectively), located 2.8 km from the source and 64 m above sea level. Water flows from the storage tanks by gravity to the households for an average of three hours per day, distributed by neighborhood (Consulambiente, 2011). According to the Department of Potable Water and Sanitation, 95% of the population of Santa Cruz has direct access to municipal water, while the remaining 5%

has indirect access, including provision by water trucks or direct extraction from so-called "private" crevices.

The current municipal supply system in Puerto Ayora is old and in poor condition, primarily due to the lack of regular maintenance, which results in a high Non Revenue Water (NRW) value and high levels of leakage. NRW, according to the International Water Association (IWA), is defined as water that has been produced and is somehow lost before it reaches the consumer. These losses may be caused through leakage, bursting pipes, illegal connections, and metering inaccuracies.



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Water tariff systems differ between the two supply networks. The system in Bellavista uses water meters and water fees are based on usage (US\$1.21/m<sup>3</sup>), while in Puerto Ayora each customer is charged a fixed fee according to their demand category, regardless of the volume consumed (Table 3). Puerto Ayora's system of fixed tariffs has persisted over the years because supply is intermittent and the water is of low quality. Raising the tariff while these conditions persist is considered politically unwise.

According to the water department, any change in water

fees must be accompanied by a major improvement in system infrastructure. The current water tariffs, established for different categories by the Municipality of Santa Cruz in 2004, were based on an analysis of costs including maintenance and operation. However, the tariffs do not cover 100% of the costs and thus the system must be subsidized by the Municipality. Subsidies are required for both Bellavista and Puerto Ayora, and cover approximately 30% of the total cost of supplied water. These financial restraints result in few improvements, which in turn make any price increase unacceptable to the public due to the poor and unreliable service.

**Table 3.** Water tariffs and number of connections in Santa Cruz (all are from Puerto Ayora except the first entry).

Category	Number of connections	Fixed value (USD)
Metered (Bellavista)	435	1.21/m <sup>3</sup>
Domestic	1152	5.24
Commercial	936	11.24
Industrial/Hotels	14	45
Industrial/Water Industry	2	45
Industrial/ Laundries	5	45
Industrial/Residential	20	28.5
Official Category	28	6.12
Industrial/Pool	1	28.5
<b>TOTAL</b>	<b>2593</b>	<b>--</b>

Source: Water cadastre from Municipality of Santa Cruz (2013).



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### Assessment of supply and demand

The water supply assessment in Bellavista was based on information from the records of the Department of Potable Water and Sanitation of Santa Cruz for 2013. Given that Bellavista has a metered water system, it was possible to determine actual use (Table 4).

The monthly average of non-working devices was 32%, which corresponds to approximately 137 water meters out of a total of 434. The high average appears to be mainly due to the significant amount of non-working

devices in March and April. The reason for so many dysfunctional meters is unknown. Meters registering zero consumption (non-working devices) contribute to a higher value for Non-Revenue Water, which is then included as leakage and/or water theft. Average demand per premise per month was based on total consumption and number of connections registering consumption (Table 5) and then expanded to include the entire system assuming all water meters to be functional (Table 6). An estimated NRW could then be calculated for both actual measured usage and estimated usage if all meters were functional (Table 7).

**Table 4.** Water usage in Bellavista for 2013.

Month	Registered consumption (m <sup>3</sup> )*	Calculated consumption (m <sup>3</sup> )*	No. connections	No. connections registering no consumption	Percent connections registering no consumption
January	5375.6	5454.6	428	79	18
February	5370.2	5453.2	429	83	19
March **	330.2	733.2	429	404	94
April **	440.8	856.81	429	417	97
May	4605.4	4676.74	430	71	17
June	6513	6599	433	72	17
July	6262.2	6342.2	434	80	18
August	5559	5641	435	82	19
September	5653.8	5742.8	437	89	20
October	5653.8	5743.8	438	90	21
November	5097.8	5185.8	441	88	20
December	4964.8	5051.8	444	87	20
TOTAL	55,826.6	45,564.0	5207	1642	
Average/month	4652.2	3797.0	434	137	32

\* The first column of consumption refers to the actual consumption registered by meters, while the second column of consumption adds one m<sup>3</sup> of consumption for each dysfunctional meter. The municipality has the policy of charging one m<sup>3</sup> when the reading is zero.

\*\* Months with low consumption due to unknown reasons.

**Table 5.** Estimation of domestic demand excluding non-working water meters for Bellavista.

Month	Consumption (m <sup>3</sup> )	No. of connections registering consumption	Average consumption per premise (m <sup>3</sup> )
January	5375.6	348	15.4
February	5370.2	345	15.6
March*	330.2	25	13.2
April*	440.8	12	36.7
May	4605.4	358	12.9
June	6513.0	360	18.1
July	6262.2	353	17.7
August	5559.0	352	15.8
September	5653.8	347	16.3
October	5653.8	348	16.2
November	5097.8	352	14.5
December	4964.8	356	13.9
<b>TOTAL</b>	<b>55,826.6</b>	<b>3555</b>	<b>206.4</b>
<b>AVERAGE PER MONTH</b>	<b>4652.2</b>	<b>296</b>	<b>17.1</b>

\* Months with low consumption due to unknown reasons (consumption not considered for the overall calculation of consumption per premise).

**Table 6.** Actual and estimated demand per year for Bellavista based on working meters and if all meters were functional.

	Tariff (USD/m <sup>3</sup> )	No. of connections	Volume of water used (m <sup>3</sup> /year)
With working meters only	1.21	296	55,826.6
If all meters were functional	1.21	435	55,826.6 + [ 86 lpcd * 5.7 inhabitants per premise * 137 non-working meters] = 80,339.1

**Table 7.** Non-revenue water estimates for Bellavista based on working water meter usage data and estimated water usage if all meters were functional.

	System input volume (m <sup>3</sup> /year)	Revenue water (m <sup>3</sup> /year)	Non-revenue water (m <sup>3</sup> /year)	ASR (%)
With working meters only	94,608	55,826.6	38,781.4	40.1
If all meters were functional	94,608	80,339.1	14,244.8	15.1

The average consumption per premise per month is 17.2 m<sup>3</sup> and the consumption per capita per day, assuming there is an average of 5.7 family members per household in Bellavista (based on total population and total number of premises), is approximately 86 liters. While this is a reasonable figure, there is additional water consumption for drinking water.

Water demand in Puerto Ayora was difficult to assess due to the absence of meters and lack of reliable data. The

estimates presented here are based on a survey made to 240 households. Demand was also calculated based on questions on volume and filling of storage tanks, frequency of water bought from water trucks, and volume of bottled water purchased (Table 8).

Total water demand corresponding to the different sources and categories was estimated based on surveys made to major consumers from tourist and laundry categories (30 hotels, 30 restaurants, and 16 laundries; Table 9).

**Table 8.** Estimate of domestic water demand in Puerto Ayora.

Municipal (m <sup>3</sup> /year)	Bottled water (m <sup>3</sup> /year)	Water trucks (m <sup>3</sup> /year)	Total demand (m <sup>3</sup> /year)	Demand per capita (lpcpd)	NRW (%)
712,188	7242.7	57,518.1	776,948.8	177.4	35

Source: Surveys conducted from September 2013 to January 2014.

**Table 9.** Total estimated demand for different sources and categories in Puerto Ayora.

Category	Municipal water demand (m <sup>3</sup> /day)	Bottled water demand (m <sup>3</sup> /day)	Water trucks demand (m <sup>3</sup> /day)	Total demand (m <sup>3</sup> /day)
Domestic	1951.2	19.8	157.6	2128.6
Hotels	1107.2	20.6	1788.8	2916.6
Restaurants	69.3	7.6	51.1	128.0
Laundries	28.5	0.0	20.1	48.6
<b>TOTAL</b>	<b>3156.2</b>	<b>48.0</b>	<b>2017.6</b>	<b>5221.8</b>

Source: Surveys conducted from September 2013 to January 2014.

## Conclusions

This study has compiled results from previous studies and strengthened them by providing a more technical analysis of the current situation of the water systems on Santa Cruz.

Accurate information on water supply and demand in Santa Cruz is impossible to obtain due to faulty water meters in Bellavista and to the lack of metering in Puerto Ayora. Nevertheless, the information available was used to make estimates on water usage and NRW for the municipal source. Even though Bellavista has a meter-based tariff structure and water collection is more organized than in Puerto Ayora, revenues remain insufficient to cover maintenance and necessary improvements, especially due to the high percentage of faulty meters.

A significant percentage of non-working meters in Bellavista contributes to a higher estimate for NRW. With better meter management, the NRW may be lowered to nearer to 15%. Ensuring functional meters throughout the system would also result in more accurate estimates of water demand per capita, as well as increased fees paid to the Water Department, which could then be used to help improve the system.

For Puerto Ayora, the estimates of water consumption from the municipal source suggest a NRW of approximately 35%, which is considered high. According to the demand from different categories, the highest demand belongs to hotels. Also, the high figure for water trucks (from private crevices) highlights the need for further research and the implementation of a metering system in order to confirm estimates.

Water habits and behavior of consumers differ significantly among the two urban settlements, mainly because of the difference in water tariffs. This is shown in demand per capita from the municipal source. Puerto Ayora's demand is estimated at nearly twice that of Bellavista. This difference in consumption could be due to the excessive water waste observed in Puerto Ayora (Guyot-Tephiane *et al.*, 2012). Lack of awareness of water conservation needs is evident. A more complete analysis is required for Puerto Ayora to determine the actual levels of water waste.

Information on municipal water extractions is reliable based on different studies previously done by consultants, but information on desalinated drinking water and extraction from crevices is incomplete. This needs further research and verification in order to estimate and conclude the total water balance in Santa Cruz.

## Recommendations

This study has highlighted several problems in the current water distribution systems and in water demand in Santa Cruz. Based on the results we recommend the following:

- Create policies, regulations, and management practices to ensure the conservation of water resources on Santa Cruz Island, defining tasks and responsibilities for each institution involved.
- Strengthen capacity of personnel working in the relevant water management institutions.
- Improve the infrastructure of water systems of the municipality and increase the price of water.

- Improve water meter management and monitoring of water use in Bellavista.
- Verify water demand in Puerto Ayora through the installation of meters in pilot areas.
- Abolish the fixed tariffs in Puerto Ayora in order to create awareness within the population of the value of water; a fixed tariff system results in indiscriminate waste of water.
- Install water meters for each customer in Puerto Ayora and ensure their maintenance and management.
- Carry out additional studies of NRW to identify and eliminate significant losses and leakages.

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