IS IT WORTH INVESTING?

A case study about the return on investment in the Quito Water Protection Fund (FONAG)

FONAG Fondo para la Protección del Agua

EPMAPS Agua de Quito

The Nature Conservancy

This publication is based on the document “Calculating the Return on Investment in Conservation and Restoration. Case study for FONAG in the El Cinto-Quito river watershed” prepared in March 2018 by Max Lascano as part of the consultancy hired by FONAG with support from The Nature Conservancy and the Imperial College London and in collaboration with Boris Ochoa. The publication benefited from the contributions and review by: Timm Kroeger, Daniel Shemie, Alejandro Calvache, Galo Medina and Jaime Camacho from TNC; Bert de Bievre and Andrea Vera from FONAG; and Rafael Osorio from the “Quito Water Company” EPMAPS.

Adaptation
Jaime Camacho and Cristina de la Paz

Revision
Galo Medina, Cristina de la Paz,
Bert de Bievre, FONAG, Timm Kroeger, Claudio Klemz

Translation
Cristina de la Paz

Photography
Manthra Comunicación
FONAG

Design & Layout
Manthra Comunicación

This publication was possible thanks to contributions from

FONAG · EPMAPS AGUA DE QUITO · The Nature Conservancy

With support from

Alianza Latinoamericana de Fondos de Agua

TABLE OF CONTENTS

EXECUTIVE **SUMMARY**

A Return on investment (ROI) is a useful metric for comparing the benefits and costs of any investment. This is as true for investments in nature-based solutions (NbS) aimed at addressing specific water security aspects as it is for investments in grey water infrastructure. Notably, a ROI analysis allows for the assessment of the overall performance of a watershed investment program for the entire set of beneficiaries, as well as its performance for specific individual beneficiaries.

Fondo para la Protección del Agua (FONAG), Empresa Pública Metropolitana de Agua Potable y Saneamiento (EPMAPS) and The Nature Conservancy (TNC) implemented a pilot study to understand the ROI of FONAG's interventions. Due to information availability and budgetary constraints, this analysis was carried out in the upper watershed of the El Cinto river, which supplies approximately 10% of the water used by the city of Quito. Furthermore, it was determined that this initial study would evaluate the ROI of FONAG's watershed investments in El Cinto specifically for Quito's metropolitan water and sanitation company, EPMAPS, FONAG's main financial supporter.

The ROI results from the Net Present Value (NPV) of the benefits of the interventions divided by the Net Present Value of the costs of the interventions.

$$ROI = \frac{\text{NPV Intervention benefits}}{\text{NPV Intervention costs}}$$

In order to calculate the ROI, two scenarios were established:

1. **BAU (Business as Usual): A scenario without FONAG's interventions in the conservation, protection, or restoration of El Cinto's natural infrastructure, which allowed to estimate the impact of the current development pattern (expansion of urban, agricultural and livestock areas, among others) on the indicators of interest: water quality and quantity, that is, a current trend scenario.**
2. **SEM (Sustainable Ecosystem Management): A scenario with sustainable ecosystem management (with green infrastructure). It includes the development of conservation and restoration activities in water sources expected to increase EPMAPS's water service offer.**

The intervention benefits are evaluated in terms of hydrologic metrics and associated monetary values, assessed by a biophysical modeling that includes the analysis of the loading and concentration of pollutant compounds in surface waters, combined with operational and cost analyses. Potential intervention benefits included in the analysis are changes in conduction and treatment costs and avoided sales losses. The intervention costs are estimated based on the interventions that FONAG would have to carry out in the watershed over the next 20 years, including capital and operational expenses.

The results of the modeling represented in terms of water supply behavior are consistently beneficial in the SEM scenario with clear benefits regarding long-term maintenance of water flows, improved water quality from reduced turbidity and total solids which translates to lower water treatment costs.

The result of this study suggests a positive ROI of 2.15 of FONAG's analyzed interventions in El Cinto, indicating that, for every dollar invested in NbS in the El Cinto watershed, FONAG and EPMAPS obtain 2.15 dollars in benefits.

1

BACKGROUND

Water Funds are organizations that design and promote financial and governance mechanisms, articulating public, private and civil society actors in order to contribute to water security and the sustainable management of a given watershed. Water Funds help strengthen the integrated management of hydrographic watersheds and the management of water resources, through the financing of long-term conservation actions such as the protection of critical ecosystems, restoration, best agricultural and livestock practices, protection or restoration of riparian areas, environmental education and monitoring, and analysis of water security outcomes, among others.

The Water Protection Fund (FONAG) conserves and recovers water sources for the Metropolitan District of Quito (DMQ). FONAG was created in 2000 as a commercial trust and has an independent capital contributed by its original constituents and adherents, which allows it to have its own budget to implement and finance actions in accordance with its strategic plan. FONAG operates in the upper Guayllabamba River watershed and in the western and eastern hydrographic units located in the provinces of Pichincha and Napo, which supply the city of Quito.

FONAG's interventions are comprehensive and tailored to the various realities of the local environments. They seek to have a positive impact on the state of the moorland and forests to maintain or improve the availability of water. The strategic axes for their interventions are the generation of relevant information for decision-making; the restoration of vegetation and soil cover; the conservation of wetlands, moors, forests, and scrublands; the establishment of long-term commitments with various community, public and private actors; and environmental education and awareness.

FONAG's vision is to be a solid and transparent financial mechanism for the protection and restoration of the DMQ's water sources, recognized for its technical and managerial credibility, with innovative and flexible proposals adapted to changing social and environmental dynamics. For the 2021-2025 period, FONAG has established two strategic objectives. The first is the fulfillment of its mandate to “manage the areas of water interest in the water-regulating micro-watersheds for the Metropolitan District of Quito.” The second is to “position FONAG as a benchmark for the protection of water sources and guarantee their sustainability.”

The Nature Conservancy (TNC) is an international organization that seeks to conserve the waters and lands on which life depends. One of its main conservation strategies in Latin America is the creation and strengthening of water funds as a contribution to water security in the region. To fulfill this role and strengthen the work, the Latin American Alliance of Water Funds was created in 2011. In addition to TNC, members include the Inter-American Development Bank (IDB), the FEMSA Foundation, the Global Environment Facility (GEF) and the International Climate Initiative (IKI).

As a constituent of FONAG, TNC seeks to support the water fund through technical assistance and financing of priority activities. Taking advantage of its experience in other spaces, it proposed a return on investment (ROI) study for FONAG to determine whether the investments of FONAG’s constituents are profitable. During the years 2017 and 2018, a pilot study was developed with the active engagement of FONAG’s key constituent (Quito’s Metropolitan Public Water and Sanitation Company, Agua de Quito EPMAPS) that identified a specific watershed for the analysis (El Cinto). This study and its results are presented below.

2

CASE STUDY ABOUT THE RETURN ON INVESTMENT FROM IMPLEMENTING NATURE-BASED SOLUTIONS IN THE EL CINTO WATERSHED

There are few economic analyses of watershed conservation projects that provide credible, quantitative evidence on the returns on those investments. This information is important for potential funders' decisions to invest in watershed conservation (green solutions) rather than just in traditional infrastructure alternatives (gray solutions) for addressing water security challenges.

One of the main challenges for proponents of ecosystem conservation or restoration projects is to assess the financial returns on investments in these projects for prospective investors. It may be important to present to potential investors the return on investment (ROI) in a financial sense, that is, the monetary gains received per dollar of investment. This requires a direct, quantitative link between specific NbS interventions, the resulting changes in specific environmental services these interventions will produce, and the associated changes in an investor's cost-relevant operations. For example, for a hydroelectric plant, calculating the return on investment of the restoration of the vegetation cover in a specific area in the upper part of the plant's source watershed, requires assessing the impact of those interventions on sediment concentrations at the reservoir inflow points, which may impact reservoir management (e.g., dredging), and at the turbines, which may affect turbine wear.

Cities require sufficient quantity and quality of water and NbS can impact both. Therefore, water security investments should assess the performance of NbS alongside that of conventional alternatives. However, assessments of the ROI of water fund investments in NbS are still relatively rare.

The purpose of such ROI studies is to quantify the monetary values of the benefits resulting from watershed conservation, restoration, and improved management actions that a water fund develops and to calculate the return on investment for specific stakeholders (TNC 2012).

FONAG, EPMAPS and TNC implemented a pilot study on the ROI for Quito. Due to information availability and budget constraints, this analysis was carried out in the upper watershed of the El Cinto river, which supplies approximately 10% of the water used by the city. In addition, it was determined that in this phase, only the ROI for EPMAPS, FONAG's main contributor, would be assessed.

The objective of the study was to financially assess the monetary value of the water security benefits that EPMAPS received as a result of the interventions carried out by FONAG in the El Cinto basin, and to calculate the return on investment for EPMAPS.

3 PILOT SITE: **EL CINTO**

The El Cinto watershed is in the province of Pichincha, mainly in the Lloa parish of the Metropolitan District of Quito. It has an area of 17,095 hectares. In this case, the upper area of the watershed, which is 7,243 hectares, was prioritized for analysis. This area is in the western mountain range where the resource is scarce, and interventions there are thought to hold the potential to recover water supply intakes that are currently disabled by contamination.

The main ecosystems are páramo, montane forests and shrubs. This is an important intervention area where urban sprawl, plantations of exotic species, pastures and agricultural pressures are found (Escandón et al 2016).

Living in the watershed are approximately 1000 people dedicated to their own businesses or work on the land. There is also a significant percentage of people who do housework. The coverage of basic services is not optimal (Escandón et al 2016).

The main sources of pressure for natural ecosystems are:

- Agriculture and livestock
- Fires
- Plantations of exotic species
- Riverbank degradation
- Mining
- Pollution and waste
- Feral dogs
- Off-road activities in fragile ecosystems (motocross)
- Irregularity in land tenure
- Weakness of institutions and lack of coordinated water or land use governance (Escandón et al 2016)

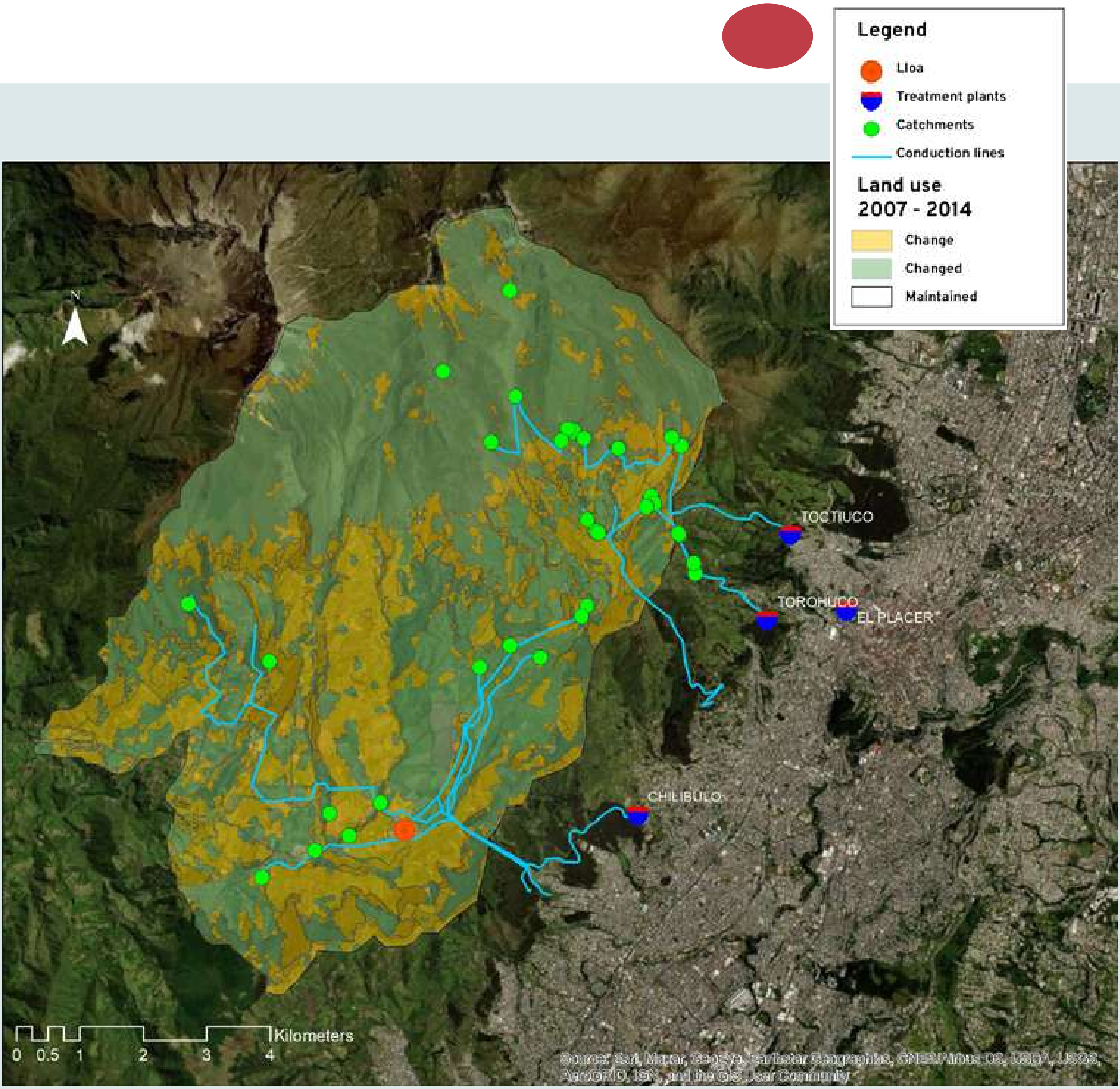


Figure 1. El Cinto Map

4 METHODS

The methodology used to determine the return on investment for the water company was based on the analysis of two main components: biophysical and economic. For the biophysical component, the study site was defined to understand spatially how the drinking water supply system works and where the intakes, pipelines, treatment plants, etc. are located. The next step was to make a multi-temporal analysis of land use change in the area by comparing a 2007 map with a 2014 one, identifying a loss of an altitudinal strip of 100 meters of moorland during that time. With that information, a projection for the next 20 years was made. This is how the "Business as Usual" (BAU) scenario was considered.

For the "Sustainable Ecosystem Management" (SEM) scenario, it was projected that degradation would be avoided and that degraded areas would recover. In addition, as a starting point, 2016 was established as baseline, and it was decided that 2016-2020 would be the period analyzed to define the water and economic benefits of FONAG's interventions (4 years of intervention). Then, a list of all the interventions that would be carried out in that period was made, and the activities that directly affect the quantity and quality of water, which entered the hydrological model, were separated from indirect interventions that cannot be measured directly, but which are important and an integral part of management (environmental education, surveillance, etc.).

For the hydrological modeling, climatic variables, land use, water use, and water quality were considered. With this information, the base flow was calculated using historical precipitation data and the map of ecosystems and land use; then the flow projection was generated. To obtain the flow of the BAU and SEM scenarios, the land use maps for each scenario were used. With this information, it was possible to compare the water benefits of water quantity and quality between scenarios. The hydrological model that was used was developed by

FONAG with the participation of the Imperial College of London for the water quality component. The water benefits obtained from the modeling translated into economic benefits for the ROI calculation.

The ROI results from the Net Present Value (NPV) of the benefits of the interventions divided by the Net Present Value of the costs of the interventions.

$$ROI = \frac{\text{NPV Intervention benefits}}{\text{NPV Intervention costs}}$$

In order to calculate the ROI, two scenarios were established:

BAU (Business as Usual): Scenario without the evaluated additional interventions in conservation, protection, or restoration (green infrastructure) by FONAG, which allowed to determine the impact of the current development pattern (expansion of urban, agricultural and livestock areas, among others) on the indicators of interest: water quality and quantity, that is, a current trend scenario.

SEM (Sustainable Ecosystem Management): Scenario with sustainable ecosystem management (with green infrastructure). It includes the development of conservation and restoration activities in water sources that allow EPMAPS's water service offer to increase.

4.1 INTERVENTION **BENEFITS**

The benefits of the interventions were evaluated in terms of both hydrologic metrics and associated monetary values. To assess the hydrologic benefit, a biophysical modeling that included the analysis of the loadings and concentrations of pollutant compounds in surface waters was carried out (Ochoa et al 2017).

The model relates knowledge on the hydrologic processes in the watershed with parameters that cannot be measured directly, but that have a physical meaning and can be calibrated. The model considers the distribution of hydrozones[1] in the watershed, which are defined by land use and present a differentiated hydrological behavior. A calculation of the particular contribution of pollutants that modify water quality is adapted to these (Ochoa et al 2017).

1 Each ecosystem constitutes a hydrozone and each hydrozone has particular hydrological characteristics. It is a proper name within this model developed for the study.

The spatial scale at which the hydrological model calculates and generates results is distributed using variables and parameters in the form of raster images and generating results for each cell of the matrix. At each point, in addition to the runoff estimate from the hydrological model, estimates of the load and concentration of a compound are obtained. The accumulation of these values, using a digital elevation model of the terrain to determine the waterflow, generates as results the flow, the load, and the concentration of the compound with the contributions of the upstream watershed (Ochoa et al 2017).

In this case:

- Total solids
- Turbidity
- Fecal coliforms
- Phosphates
- Nitrates

The contribution areas (hydrozones):

- Páramos
- Andean forests and secondary forests
- Shrublands
- Agricultural areas
- Forest plantations
- Eroded and degraded areas
- Pastures
- Urban areas
- Water bodies

The determined threats were:

- Agrochemicals
- Garbage and debris
- Motocross
- Livestock
- Mining
- Abandoned dogs
- Fires

1
2
3
4
5
6

›

The available flows were determined by supply and demand. We calculated the change in flows available for use in the water catchments.

Using the ModelBuilder tool, by which a model structure is developed using ArcGis, the monthly mean concentration of the different compounds under analysis was determined and implemented in ArcGIS. This information is given by the type of area where the compound comes from and by the anthropic factors (threats) that influence it (Ochoa et al 2017).

Changes in the hydrologic parameters of interest were translated to their corresponding monetary values for EPMAPS using data on conduction costs, treatment costs, and water sales revenues (Ochoa et al 2017).

a. Conveyance/delivery costs

The conduction costs refer to all the operational costs involved in carrying the water from the catchment to the treatment plant that the water utility has to assume. The conduction lines are the pipes that connect the catchment with the treatment plants. These costs are essential for the study because they represent all the expenses in which the water company has to incur, and which have to be included in the analysis.

To calculate the cooperation costs, two inputs were required: i) the volume of the flow carried by each conduction line (measured in m3/year); and ii) the unit cost of conduction ($ dollars / m3). In both cases (BAU and SEM scenarios), in series of 20 years of analysis.

Regarding flows, this information is adequately systematized by the EPMAPS Operations Management, which provided a series of flow data for the period 2009 - 2016. While for 2015- 2035, a projection was made for both scenarios (BAU and SEM) using the results regarding increase or decrease of the biophysical model.

However, the calculation of the unit cost of conduction was somewhat more complex, since EPMAPS does not have cost information at the level of conduction line, but rather relies on the financial system presenting them as aggregates under the following systems:

- Atacazo system
- Lloa system
- Pichincha system
- Pichincha South system

The conduction lines analyzed in the biophysical model are part of the Lloa System (Tambillo dam) and the Pichincha System (Pichincha channel), but these systems include other conduction lines, so the costs are shared by each of the lines.

Due to this, to determine the conducting costs of the Tambillo dam and Pichincha channel, the total cost was distributed, based on the length (km) of each conduction line. Analyzing the cost by length allows for a better distribution of costs, since the volumes of water carried through each line could vary for different reasons. For example, the Pichincha conduction line represents 71% of the kilometers of conduction infrastructure that the entire Pichincha System has, so it is feasible to consider that it also assumes 71% of conducting costs.

Once the costs of the systems were distributed to the pipelines, it was possible to determine a unit cost for the 2009-2013 period, which is the period in which information is available for both volumes and costs. It is worth noting that EPMAPS changed its financial management software in 2014, so the required information was taken mainly from the previous system, obtaining a series of 13 years (2000-2013), but it was not compatible with the new system, so data could not be obtained for the years 2014-2016, which is why for those years and for future years (2017 to 2035) trends were applied based on the conduction volumes for each scenario BAU and SEM.

Finally, something that should be pointed out is that there are 6 conduction lines in El Cinto, but the biophysical model focused on two of them, which together account for 49% of the total water produced by the watershed.

b. Treatment costs

To calculate treatment costs, the financial system of EPMAPS has information on the treatment plants Chilibulo, Toctiuco, Torohuco and El Placer, as shown in Table 10. The Oriental or Tambillo line distributes 30% of the water that leads to the Chilibulo plant and 70% to the El Placer plant, while the Pichincha line distributes 24% to the Toctiuco plant and 76% to the El Placer plant.

This reality regarding the destination of the water from each pipeline is very important, since the biophysical model yields water quality results in the lines, but decisions regarding treatment costs are made in the plants, so understanding how the water is distributed and what happens in the treatment plants is important.

Thus, in the case of the Chilibulo plant, the information indicates that 67% of the water that is treated in this plant comes from the Eastern Line or Tambillo, while 33% comes from the Chazo-Garzón Line, which, in turn corresponds to groundwater considered of good quality, so it has been assumed that the treatment costs at this plant are directly related to the quality of the water that comes from the Eastern Line. These data are very important for the cost projections of the analyzed scenarios.

Something similar happens with the Toctiuco plant. Although the water it receives from the Pichincha line represents only 23% of the total volume of water that the plant treats, this water is possibly the one that largely determines the costs, since it is classified as raw and requires treatment and is mixed with water from the Atacazo line that brings better quality water.

Therefore, for the assessment of the economic benefits from the water impacts derived from the SEM and BAU scenarios, the Chilibulo and Toctiuco plants have been considered objects of investigation, requiring knowledge of the cost of treatment in both plants. For this purpose, it is necessary to have two inputs: i) the historical, current and projected treatment volume for the two scenarios (SEM and BAU); and ii) the current and projected treatment unit costs for the two scenarios.

For the first case, we had information provided by the EPMAPS operations management for the years 2009 to 2016. For the second case, we had annual treatment costs until 2013, which were divided by the volume of treatment determined the unit cost of treatment. For the years 2014 to 2015, trends were used and for the years 2017 to 2035, trends were used based on the impact of the SEM and BAU scenarios on the quality parameters of the water that arrives through the Oriental and Pichincha lines.

To determine the impact of the change in the quality parameters on the unit cost of treatment, the percentage of improvement (SEM scenario) or deterioration (BAU scenario) compared to the current situation was taken into consideration under the assumption that the unit cost varies in the same direction and magnitude than the percentage change in the water quality parameters.

In order not to overestimate the impact on unit costs, the average percentages without extreme values were considered. So in the BAU scenario, unit costs approximately doubled compared to the baseline, while in the SEM scenario they were reduced by 46% to 10%.

A better estimate of changes in unit costs would require chemical analysis in treatment plants over a long period of time, which is beyond the scope of this analysis and the efforts made in biophysical modeling.

Unlike in the case of conveyance, treatment costs are dominated by variable costs, which represent 86.4% of total costs in the Toctiuco plant and 82% in the Chilibulo plant, on average, for 2000 to 2013. The main drivers of variable treatment costs are labor, services provided by third parties, and purification products.

c. Avoided sales loss

In the BAU scenario, the biophysical model estimates reduced volumes of available water that are in demand, resulting in a loss for the EPMAPS due to unrealized water sales. While in the SEM scenario, the volume of water is expected to remain similar to the current situation and to even increase slightly during some months. There would be a guaranteed market for this water, since the western EPMAPS water production system is deficient in relation to the demand, which is covered with water pumping from the eastern system from the Santa Rosa station. This slight increase in water from the SEM scenario would help reduce the need for pumping.

To assess these losses and benefits, the following was done:

- Determine the volumes by which available water decreases (BAU) or increases (SEM) in each scenario.
- Subtract EPMAPS-projected operating losses from these volumes the percentages.
- From the resulting volumes, determine the gap between the SEM and BAU scenarios in cubic meters (m3) that would cease to be produced and multiply by the average selling price of water ($ 0.5) per m3 minus non-operating costs per m3 (administrative $ 0.14 and commercial $ 0.03), since the operating costs of conduction and treatment have already been considered in the previous analysis.

For both the BAU (water loss) scenario and the SEM (water increase) scenario, the impacts on water availability were assumed to be proportionally distributed throughout the 20-year projection of the biophysical model.

4.2 INTERVENTION **COSTS**

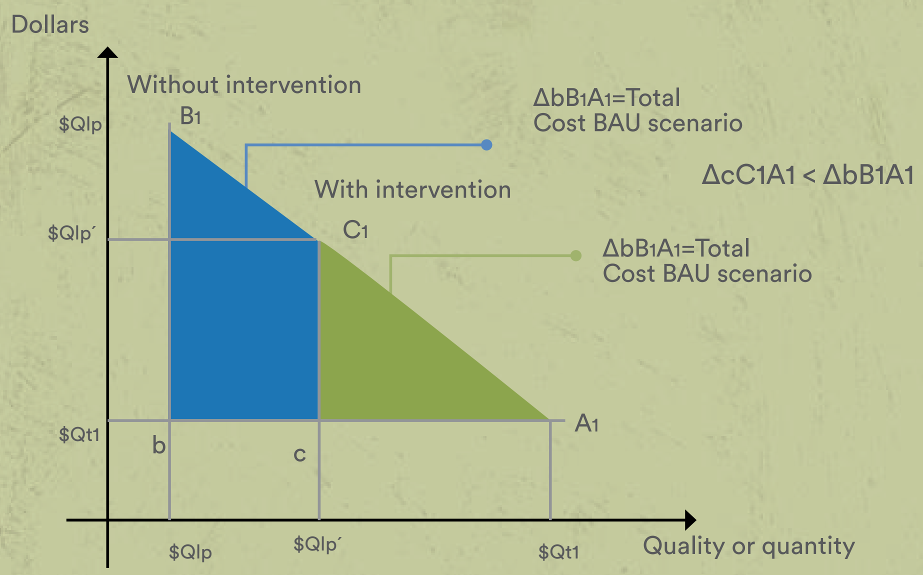
The interventions to be carried out in the watershed to meet the SEM scenario were determined with FONAG. The costs of these interventions were calculated both in capital expenses and operating expenses for 20 years (2015-2035).

4.3 ROI **CALCULATION**

This is the last step required to determine the rate of return on investment (ROI), for which the costs that FONAG would incur to obtain the quantity and quality results were incorporated in the future costs (SEM scenario) of the EPMAPS expected future water.

Graph 1 is a schematic representation of the difference in total costs between BAU and SEM scenarios for the water utility (EPMAPS), where the ΔbB1 A1 (big blue triangle) represents the costs of EPMAPS for the following 20 years without FONAG intervention; ΔcC1 A1 (smaller green triangle) represents the costs of EPMAPS for the following 20 years with FONAG interventions. The Y Axis represents the costs in dollars and the X Axis represents the water quantity and quality. As the graph shows, the costs that EPMAPS has to assume decrease with the interventions of FONAG, as the water quality and quantity increases.

Graph 1. Total cost for EPMAPS in SEM scenario.



Source and elaboration: Max Lascano

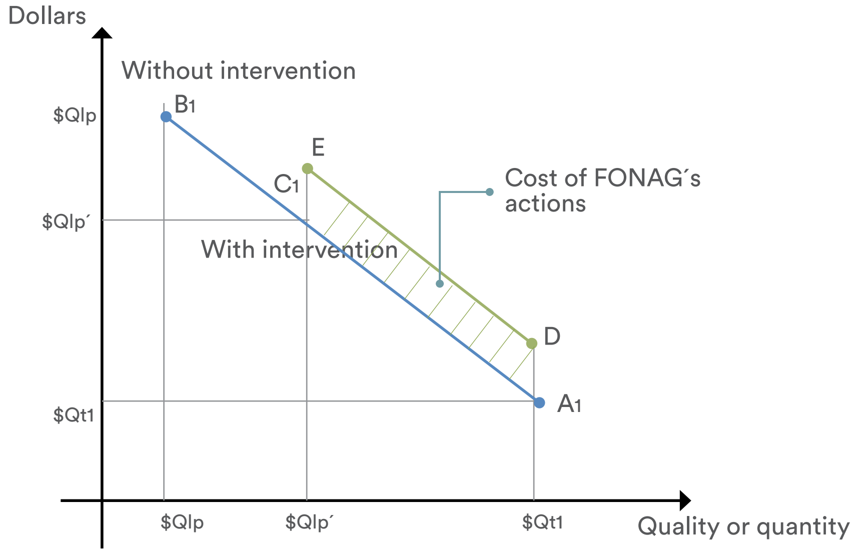
At this point, the following was done to determine the costs of FONAG:

- Determine the areas where biophysical modeling determines the greatest impact for: catchments, pipeline systems, tanks, or treatment plants.
- Determine the costs of conservation, protection, or restoration throughout the execution of the FONAG Roadmaps.
- Determine the long-term costs of conservation, protection, or restoration (until the moment in which the expected results are obtained in the quantity and quality, determined in the model):
  - » Operational and investment costs
  - » Monitoring and/or maintenance costs
  - » Financing costs (interests, opportunity)

Future costs were expressed in their present value to be able to compare them with present costs, for which a discount rate was used.

Additionally, Graph 2 shows the costs of FONAG's actions, where the shaded area shows FONAG's interventions total cost ($C_1E\ A_1D$) and implies avoiding a state of water quantity and quality in the BAU scenario (point B1) by moving it to a SEM scenario (point C_1).

Graph 2. Cost of FONAG's interventions in SEM scenario.



Source and elaboration: Max Lascano

Once the FONAG costs were determined, the rate on return (ROI) was determined by calculating the ratio of the NPV of the benefits to EPMAPS from FONAG's intervention, and the NPV of the intervention costs:

$$ROI = \frac{\text{NPV Intervention benefits}}{\text{NPV of FONAG and EPMAPS Intervention costs}}$$

Where:

- NPV is the acronym for the net present value of a flow of future values.
- Intervention Costs are the costs incurred by FONAG (in the time horizon of the evaluation) of the sustainable management actions plus the costs that EPMAPS itself incurs in only incremental aspects (not operational) and that correspond to actions to monitor the impacts.
- Intervention Benefits are the economic value of the impacts of FONAG's interventions and is calculated by:

Economic value of water benefits = BAU = Conduction costs - Costos Escenarios
SEM = Scenario cost + avoided sales loss

Where:

- BAU scenario costs = BAU conduction costs + BAU treatment costs
- SEM scenario costs = SEM conduction costs + SEM treatment costs
- Avoided sales loss = Surplus sales volume * Sales price - Surplus sales volume * (Sales cost + Administration cost)
- Surplus sales volume = (SEM volume - BAU volume) * % of losses in the system

4.4 DISCOUNT RATE, TIME HORIZON AND CURRENT PRICES

To calculate the ROI of the interventions in El Cinto, all costs and benefits were converted to their present value equivalents. The appropriate discount rate was determined in discussions with EPMAPS.

According to EPMAPS policies, the company's contribution or financing to FONAG is deemed an investment, which could be made to other potential alternatives, such as financial investments. This means that, if EPMAPS decides not to invest in FONAG, the closest alternative (opportunity cost) would be to invest the same resources in some other financial instrument.

An analysis based on the Monetary and Financial Policy and Regulation Board's resolutions No. 034-2015M of January 27, 2015, and 133-2015M of September 29, 2015 was carried out. The authorized rate for investments that a public sector entity may make corresponds to the benchmark deposit rate for over one year issued by the Central Bank, which in September 2017 was 7%. Therefore, the discount rate used in this study was 7%.

5 RESULTS

5.1 INTERVENTION **BENEFITS**

The model obtains results for water quantity and quality parameters that represent a year-on-year average for year 20, for the two channels analyzed: Pichincha channel (Pichincha line) and Tambillo dam (Eastern line), which together represent 49% of the total water volume contributed in 2015 by El Cinto to the western pipeline system that supplies water to the population of the Metropolitan District of Quito. In addition, these two lines are the only surface lines and, therefore, more likely to be affected by environmental impacts, unlike the others which are underground and thus, their water is classified as high quality.

Regarding quality, it was modeled under the parameters: coliforms, sediments, phosphates, turbidity and nitrates. The results regarding sediments and turbidity are presented in table 1.

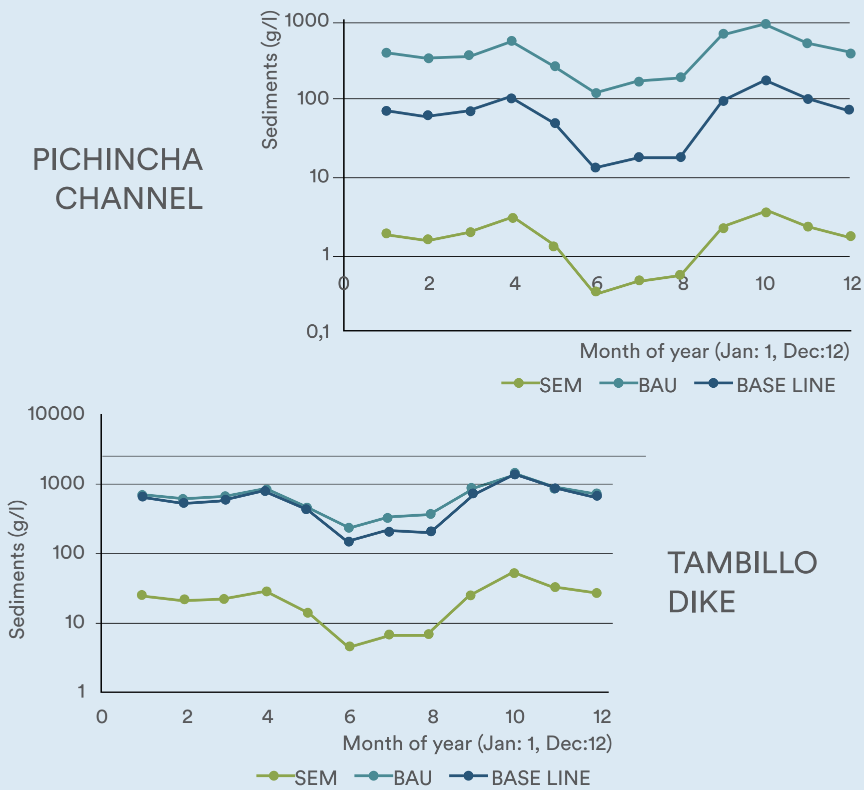
Table 1. Results of turbidity for SEM and BAU scenarios

	Pichincha L. (monthly average)			Tambillo D. (monthly average)		
Parameters	**Baseline**	**BAU**	**SEM**	**Baseline**	**BAU**	**SEM**
Sediments g/l	881	4.946	1	617	667	22
	Toctiuco P. (monthly average)			**Chilibulo P. (monthly average)**		
	Baseline	**BAU**	**SEM**	**Baseline**	**BAU**	**SEM**
Turbidity NTU/year	347	605	7	83	118	6

Source: FONAG, 2017.

The results of the modeling for the data projected for 2035 are presented in graphs 3 to 5. Graph 3 shows the results for the concentration of sediments. For both Pichincha and Tambillo, the concentrations of sediments in the SEM scenario in all months are well below current (baseline) concentrations, while sediment concentrations in the BAU scenario exceed current concentrations, especially in the case of Pichincha, indicating an important deterioration of this water quality parameter under BAU assumptions. Therefore, the SEM scenario is expected to lead to a clear improvement in the resource in the case of sediment pollution.

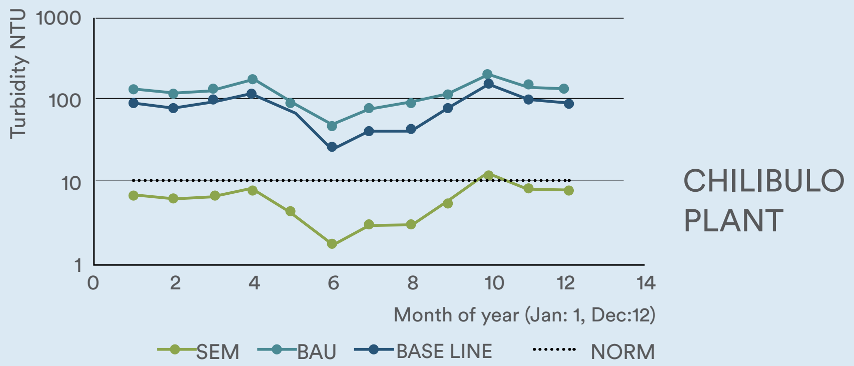
Graph 3. Sedimentation results

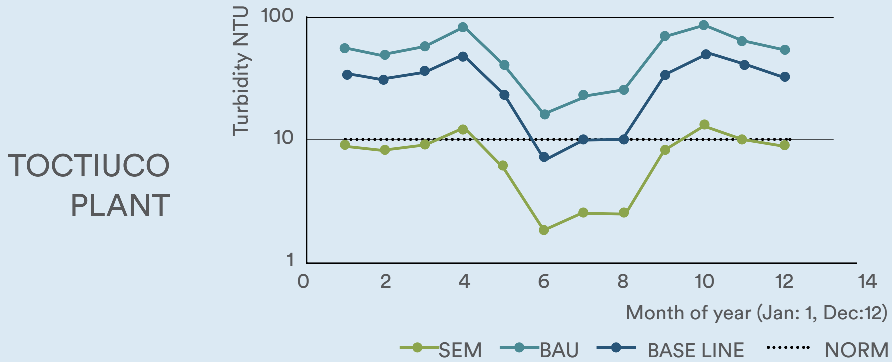


Source and elaboration: FONAG, 2017.

Graph 4 shows the results for another water quality parameter, turbidity, assessed at the Chilibulo and Toctiuco treatment plants, which receive water from the Tambillo dam and Pichincha channel, respectively. Regarding sediments, in the SEM scenario turbidity lowers dramatically below the baseline levels, while in the BAU scenario turbidity increases above baseline levels, especially at the Toctiuco plant (Pichincha channel). Importantly, in the SEM scenario, in all but one month (Chilibulo plant) or all but three months (Toctiuco plant) of the year, respectively, turbidity concentrations at both plants drop below the threshold value atwhich treatment is required by law (10 NTU). In contrast, in the BAU scenario, concentrations exceed this threshold in all months.

Graph 4. Turbidity results

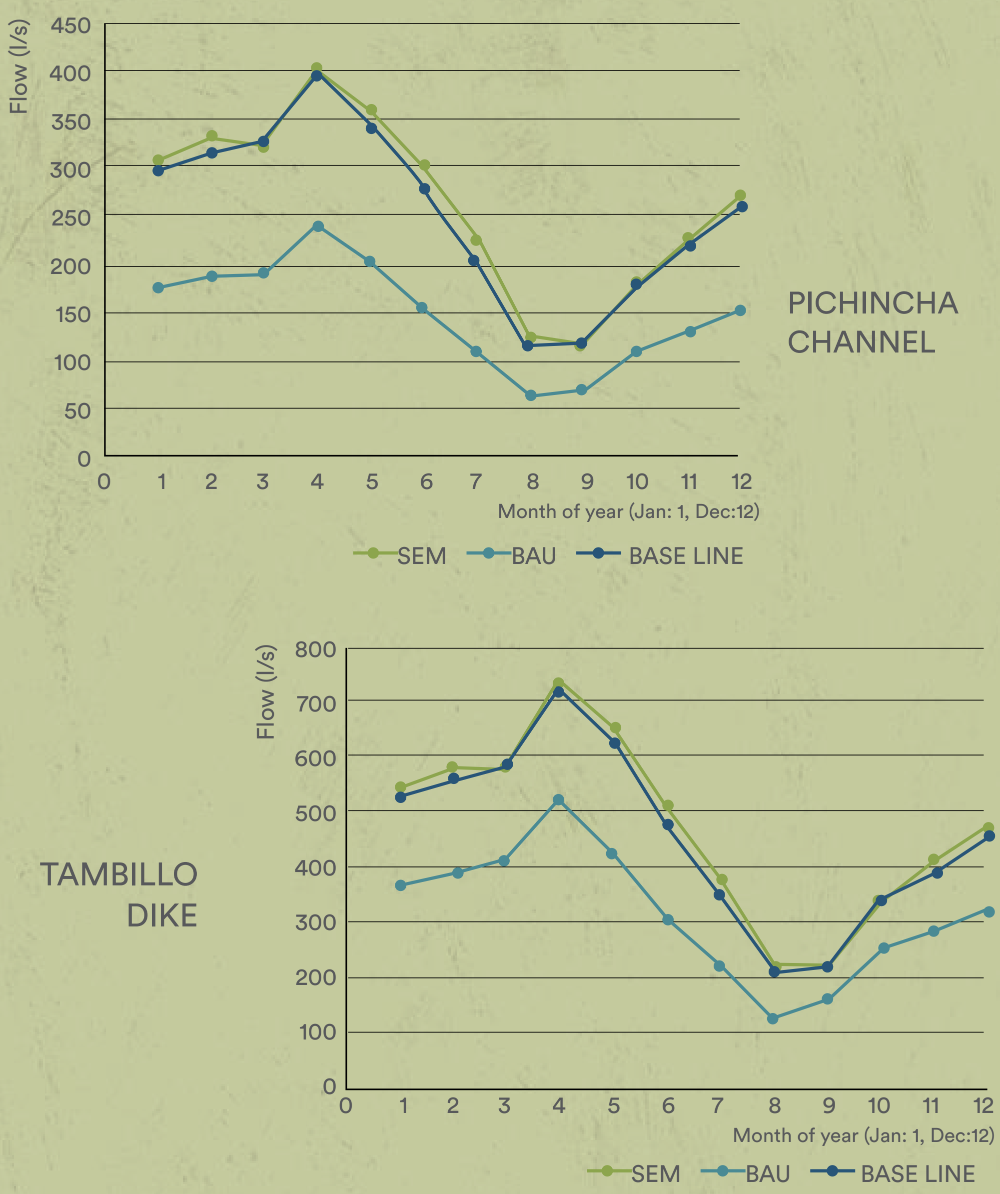




Source and elaboration: FONAG, 2017.

The behavior in terms of water quantity can be observed in Graph 5. The Pichincha Line, in the BAU scenario shows a decrease in flow for all months of the year. While for the SEM scenario, the results show a very slight increase in flow compared to the current situation. Something similar happens for the Tambillo dam (or Eastern Line). Thus, it can be deduced that the intervention of FONAG (SEM scenario) will mainly allow maintenance of current flows with a small increase. Given that flows decline in the BAU scenario, the SEM scenario delivers considerable flow benefits.

Graph 5. Flow results



Source and Elaboration: FONAG, 2017.

The model yielded results for the flow level in two of the main channels in the El Cinto river watershed: Pichincha channel and Tambillo dike. In the BAU scenario, there will be a 41% reduction in the flow of the Pichincha channel in 20 years compared to the baseline year, while in the case of the Tambillo dike there will be a 31% flow reduction. In the SEM scenario, minimal increases in flow are expected. There will be a 3.3% increase in the Pichincha channel and a 2.6% increase in the Tambillo dike.

Thus, the water resource improvements from FONAG's interventions are:

a. Long-term maintenance of flows, avoiding the declines expected in the BAU scenario. This implies avoiding a reduction in the volume of water sold for the EPMAPS, evidenced in the significant gap between flows in the SEM and BAU scenarios; thus, in the Tambillo dam, the drop in flow reaches 31% of the baseline and 41% in the Pichincha channel (see Table 2). This implies that the SEM scenario projects equal volume of water which translates to significant income from water sales.

Table 2. Variations in flow by type of scenario in 20 years.s

Scenario	Pichincha line	Difference	D. Tambillo	Difference
Baseline (lt/s)	3.057,82		5.474,55	
SEM (lt/s)	3.159,88	+ 3,3%	5.619,39	+ 2,6%
BAU (lt/s)	1.802,35	- 41%	3.756,06	- 31%

Source: FONAG, 2017.Elaboration: Max Lascano

The model assumed that flow decreases in the BAU scenario start from the first year in which FONAG would stop intervening in the area and would be projected linearly over 20 years until reaching the expected reduction for each pipeline (31% in Tambillo dam and 41% in Pichincha channel).

Something similar was done to distribute the slight increase in flows in the SEM scenario; that is, the increase in flows was projected linearly over the 20 years (2.6% in Tambillo dam and 3.3% in Pichincha channel).

In both cases, the assumptions were based on the fact that the actions to intervene in the watershed identified by FONAG are ones that impact the flows from their implementation (agreements with cattlemen for watering holes, protection of channels, among others).

However, it is worth highlighting that the main benefit is preventing the projected losses from EPMAPS's lower water commercialization volume in the BAU scenario.

b. Improvement in water quality. In both conduction lines analyzed (Pichincha channel and Tambillo dam), the model projected an improvement in some parameters of water quality (Table 1), which means that these two lines will provide better quality water to the treatment plants to which they are directed, which translates to a reduction in water treatment costs.

In addition, as with flow, an important benefit is the significant gap in the quality parameters between the BAU and SEM scenarios; which implies

that the treatment costs in the BAU scenario are higher than in the SEM scenario, a cost which would be avoided with FONAG's intervention.

The model assumed that the cost reduction per treatment in the SEM scenario occurs after the first year of implementation of FONAG's actions in El Cinto; that is, its effect on costs occurs from year 2, which would be justified due to the type of actions that FONAG has decided to implement (fencing of channels, agreements to keep cattle away from channel, closing of motocross areas, etc.) that would take effect the following year after their implementation.

As for treatment costs in the BAU scenario, it was assumed that these will increase (due to ecosystem deterioration) in a linear way, showing their full impact at the end of 20 years.

Once the costs of the two scenarios had been established, the Net Present Value (NPV) of each of them was determined to find the avoided cost and, therefore, the economic value of the water benefits.

VNet benefits of interventions	=	NPV of BAU scenario costs	-	NPV of SEM scenario costs + net revenue from the increase in water sales between SEM and BAU scenarios

5.2 INTERVENTION **COST**

The interventions identified for the SEM scenario in the El Cinto watershed include:

- Control and surveillance in high area
- Restoration in the upper area
- Control and surveillance in the middle and lower area
- Productive alternatives to livestock
- Productive alternatives to agriculture
- Turism
- Environmental education
- Agreements and alliances
- Organizational and governance strengthening
- Comunication

In addition, it was determined that in the SEM scenario, the support from EP-MAPS will be required in matters of water quality and quantity monitoring.

Through the valuation of the cost of said interventions, we obtain the following:

The total cost of FONAG's and EPMAPS's interventions for the sustainable management of the El Cinto watershed reaches a total of USD 3,679,411 for a period of 20 years, of which 19% corresponds to investment expenses and a 81% to operating costs. By bringing these costs to net present value, a value of USD 2,080,052 is obtained.

Year	FONAG		EPMAPS		TOTAL		
	Investment	Operative	Investment	Operative	Investment	Operative	Total
1 (2016)	12,000	23,804		24,461	12,000	48,265	60,265
2 (2017)	97,872	45,115	18,358	112,306	116,230	157,421	273,651
3 (2018)	165,850	61,284	3,548	87,518	169,398	148,802	318,200
4 (2019)	131,850	92,844	3,548	87,518	135,398	180,362	315,760
5 (2020)	96,850	83,644	1,892	97,518	98,742	181,162	279,904
6 (2021)	65,600	74,644	1,183	87,518	66,783	162,162	228,945
7 (2022)	13,600	64,084	14,382	109,866	27,982	173,950	201,932
8 (2023)	9,000	66,196	1,183	97,518	10,183	163,714	173,897
9 (2024)	4,000	51,588		87,518	4,000	139,106	143,106
10 (2025)	9,000	51,588		87,518	9,000	139,106	148,106
11 (2026)		56,868		97,518	0	154,386	154,386
12 (2027)	5,000	56,868	13,199	109,866	18,199	166,734	184,933
13 (2028)		56,868		87,518	0	144,386	144,386
14 (2029)		56,868		97,518	0	154,386	154,386
15 (2030)		56,868		87,518	0	144,386	144,386
16 (2031)		56,868		87,518	0	144,386	144,386
17 (2032)		46,308	13,199	119,866	13,199	166,174	179,373
18 (2033)		48,420		87,518	0	135,938	135,938
19 (2034)		51,588		87,518	0	139,106	139,106
20 (2035)		56,868		97,518	0	154,386	154,386
TOTAL	610,622	1,159,183	70,492	1,839,135	681,114	2,998,318	3,679,432
NPV Interv cost:		$2,080.052					
Discount rates		0,07					

5.3 ROI **CALCULATION**

As mentioned, the ROI calculation results from the Net Present Value of the benefits of the interventions divided by the Net Present Value of the costs of the interventions.

$$\text{ROI} = \frac{\text{NPV Intervention benefits}}{\text{NPV Intervention costs}} = \frac{4{,}478{,}880}{2{,}080{,}052} = 2.15$$

El resultado de este estudio refleja un ROI positivo de 2,15, lo cual implica que, por cada dólar invertido en temas de manejo sostenible en la cuenca de El Cinto, FONAG y EPMAPS, se recuperan 2, 15 dólares.

6 CONCLUSIONS AND RECOMMENDATIONS

Good ROI analyses require systematic and quality information. The greatest challenge in conducting this type of study is being able to quantify the benefits of the interventions, since the information is often inadequate or unavailable. In this case, the information was valid and robust enough to perform the analysis.

Beyond the numerical results of this study, a positive factor was the rapprochement and collaboration between FONAG and EPMAPS. Although the relationship was already positive, the completion of this study allowed the exchange of information and a better understanding of the needs of EPMPAS and the opportunities and benefits that FONAG can provide.

The environmental and social benefits of the protection of ecosystems are beginning to be measured and show positive results in several areas of FONAG. However, demonstrating economic benefits is also positive because it justifies the need to continue investing and attracting new partners.

The results of this analysis should be used in the context of what they are, the results of a pilot study. Since the results are positive, it is necessary to share them and show the benefits of investing in conservation. Communication and dissemination of this effort can be helpful in encouraging other water funds and constituents to invest in these analyses.

This study should also be expanded to other areas of FONAG intervention and should include other current or potential constituents. One of the scaling challenges is that neither FONAG nor EPMAPS have the financial information associated with the intervention areas (hydrographic watersheds). FONAG has information, but it is detailed by programs and not by areas. EPMAPS's information, on the other hand, is aggregated by large systems that sometimes include several watersheds.

Another important challenge is that FONAG's planning is detailed for 5-year periods. Therefore, projecting the analysis into the future requires identifying possible long-term interventions.

Based on this study, FONAG decided that it was important to expand the scope of study to its entire area of intervention, together with EPMAPS (water utility) and ATUK (a specialized technical support consultancy). This study was the basis for creating a line of action in hydroeconomics[2] where the analysis of the water and economic benefits generated by FONAG interventions for its constituent partners was improved. Subsequent studies have included a better conceptualization of the scenarios, better economic analysis and other hydro-economic indicators have also been quantified. This has allowed FONAG to have other indicators in addition to ROI. This process has also strengthened the relationship between the water company and FONAG and other academic partners have been involved.

2 Hydroeconomics refers to the field where hydrology related to the strategies of protection and restoration of water sources with the economy.

7 REFERENCES

Bartram J, Corrales L, Davison A, Deere D, Drury D, Gordon B, Howard G, Rinehold A, Stevens M., 2009. Manual para el desarrollo de planes d, e seguridad del agua: metodología pormenorizada de gestión de riesgos para proveedores de agua de consumo. Organización Mundial de la Salud. Ginebra.

EPMAPS, 2014. Estudio de Impacto Ambiental Ex-Post Sistema Centro-Occidente. EPMAPS. Quito.

EPMAPS, 2017. Cédulas Presupuestarias de Egresos 2015. EPMAPS, Quito.

Escandón S., Intriago M., Torres S., Cadena D., Aguirre J., Pérez C., Consultoría para levantar una línea base de la unidad hidrográfica del río El Cinto, occidente del DMQ y proponer un plan de acción, FONAG, Quito, 2016.

Escandón S., Intriago M., Torres S., Cadena D., Aguirre J., Pérez C., Consultoría para levantar una línea base de la unidad hidrográfica del río El Cinto, occidente del DMQ y proponer un plan de acción, FONAG, Quito, 2016.

García, J., 2008. Evaluación económica, financiera y social ¿Cuáles son sus diferencias?, Equilibrio Económico, Año IX, Vol. 4 No. 1, pp. 77-82.

Greenspace, 2012, ¿Qué es la infraestructura verde?, Boletín de la Red de Infraestructura Verde, Septiembre 2012 Número 1.

INEC, 2017. Datos estadísticos sobre inflación en Ecuador. Disponible en línea: http://www.ecuadorencifras.gob.ec/inflacion-diciembre-2016/.

Ochoa-Tocachi, Boris F., Vera Andrea, Chicaiza, Paúl; Lahuatte, Braulio, De Bièvre, Bert, 2017. Módulo de Transporte de Compuestos Orgánicos e Inorgánicos Adaptado al Modelo Hidrológico FONAG. Quito.

The Nature Conservancy 2012, Mejorando los Retornos por Inversiones en Conservación para la Gente y la Naturaleza en el Oriente del Valle del Cauca, Colombia. Colombia.

The Nature Conservancy 2016, Valoración económica de programas de conservación de cuencas: Asuntos claves y estudio de caso. Presentación durante taller organizado por TNC y FONAG, 16 y 18 de noviembre de 2016.

Vega, V., 2016. Diagnóstico Hidro-Social y la Caracterización de Ecosistemas y Usos de Suelo en las Áreas Ampliadas de Intervención del FONAG. Caracterización de ecosistemas y uso de suelos de las áreas ampliadas del ámbito geográfico del FONAG, caracterización física del área ampliada en la parte occidental del ámbito geográfico para la aplicación del análisis hidro-social y caracterización socio-económica en el ámbito geográfico que enmarca la configuración hidro-social. FONAG, Quito.

Vega, V., 2016. Diagnóstico Hidro-Social y la Caracterización de Ecosistemas y Usos de Suelo en las Áreas Ampliadas de Intervención del FONAG. Caracterización de ecosistemas y uso de suelos de las áreas ampliadas del ámbito geográfico del FONAG, caracterización física del área ampliada en la parte occidental del ámbito geográfico para la aplicación del análisis hidro-social y caracterización socio-económica en el ámbito geográfico que enmarca la configuración hidro-social. FONAG, Quito.

Vega, V., 2016b. Diagnóstico Hidro-Social y la Caracterización de Ecosistemas y Usos de Suelo en las Áreas Ampliadas de Intervención del FONAG. Análisis de las Geometrías de Poder, Descripción; Análisis De Las Fuentes De Presión Y Análisis De Conflictos En El Ámbito Geográfico Que Enmarca La Configuración Hidro-Social. FONAG. Quito.

Vega, V., 2016b. Diagnóstico Hidro-Social y la Caracterización de Ecosistemas y Usos de Suelo en las Áreas Ampliadas de Intervención del FONAG. Análisis de las Geometrías de Poder, Descripción; Análisis De Las Fuentes De Presión Y Análisis De Conflictos En El Ámbito Geográfico Que Enmarca La Configuración Hidro-Social. FONAG. Quito.

Vega, V., 2016c. Diagnóstico Hidro-Social y la Caracterización de Ecosistemas y Usos de Suelo en las Áreas Ampliadas de Intervención del FONAG. Elaboración de los Planes de Acción Requeridos para Minimizar las Presiones sobre la Cantidad y Calidad de Agua de las Fuentes que Abastecen al Distrito Metropolitano de Quito dentro del Área de Análisis Hidro-Social. FONAG, Quito.

Vega, V., 2016c. Diagnóstico Hidro-Social y la Caracterización de Ecosistemas y Usos de Suelo en las Áreas Ampliadas de Intervención del FONAG. Elaboración de los Planes de Acción Requeridos para Minimizar las Presiones sobre la Cantidad y Calidad de Agua de las Fuentes que Abastecen al Distrito Metropolitano de Quito dentro del Área de Análisis Hidro-Social. FONAG, Quito.

Wageningen University and Research Centre, 2016. El modelo SWAP. Consulta en línea: http://www.swap.alterra.nl/ The Natural Capital Project, 2016. El modelo InVEST. Consulta en línea: http://www.naturalcapitalproject.org/InVEST