ABSTRACT
TEEB Ecuador Study
The role of ecosystem services in Ecuador's new energy matrix

The TEEB Ecuador project aims to inform policymakers how investing in natural capital supports the transformation of the country's productive and energy matrix, demonstrating the dependence of large hydropower and irrigation infrastructure projects on the country's natural assets.

Background information

Ecuador is the smallest country on the list of the 12 most ecologically diverse countries. Its extraordinary geography encompasses the Andes Mountains, the Amazon rainforest, the Galapagos Islands, the Pacific coastal area, and a marine zone driven by productive sea currents. Ecuador's ecosystems are home to 18% of the world's bird species and orchids, 10% of the world's amphibians, and 8% of the world's mammals, many of them endemic to Ecuador and the Galapagos Islands.

The National Development Plan, known as the National Plan for Good Living (2013 – 2017), considers biodiversity as Ecuador's main competitive advantage and recognizes its central contribution to changing the country's productive and energy matrix. The change in the productive matrix represents a paradigm shift from an economy based on the extraction of non-renewable resources and the export of primary commodities towards a diversified economy based on added-value products, technology, human capital, and ecosystem services. The change in the energy matrix focuses on substituting fossil fuels with hydropower to meet the country's projected demand for energy, in addition to regulating its cost, eliminating the importation of fossil fuels, and reducing dependence on them.

The TEEB Ecuador project aims to inform policymakers how investing in natural capital supports the transformation of the country's productive and energy matrix, demonstrating the dependence of large hydropower and irrigation infrastructure projects on the country's natural assets. TEEB assesses the impacts of different incentive programs and land-use decisions on ecosystem services and biodiversity.

The Guayas watershed study, conducted by ESPOL, will inform policies related to the new productive matrix and aimed at promoting inclusive and sustainable growth in the cocoa value chain, facilitated by irrigation infrastructure projects.

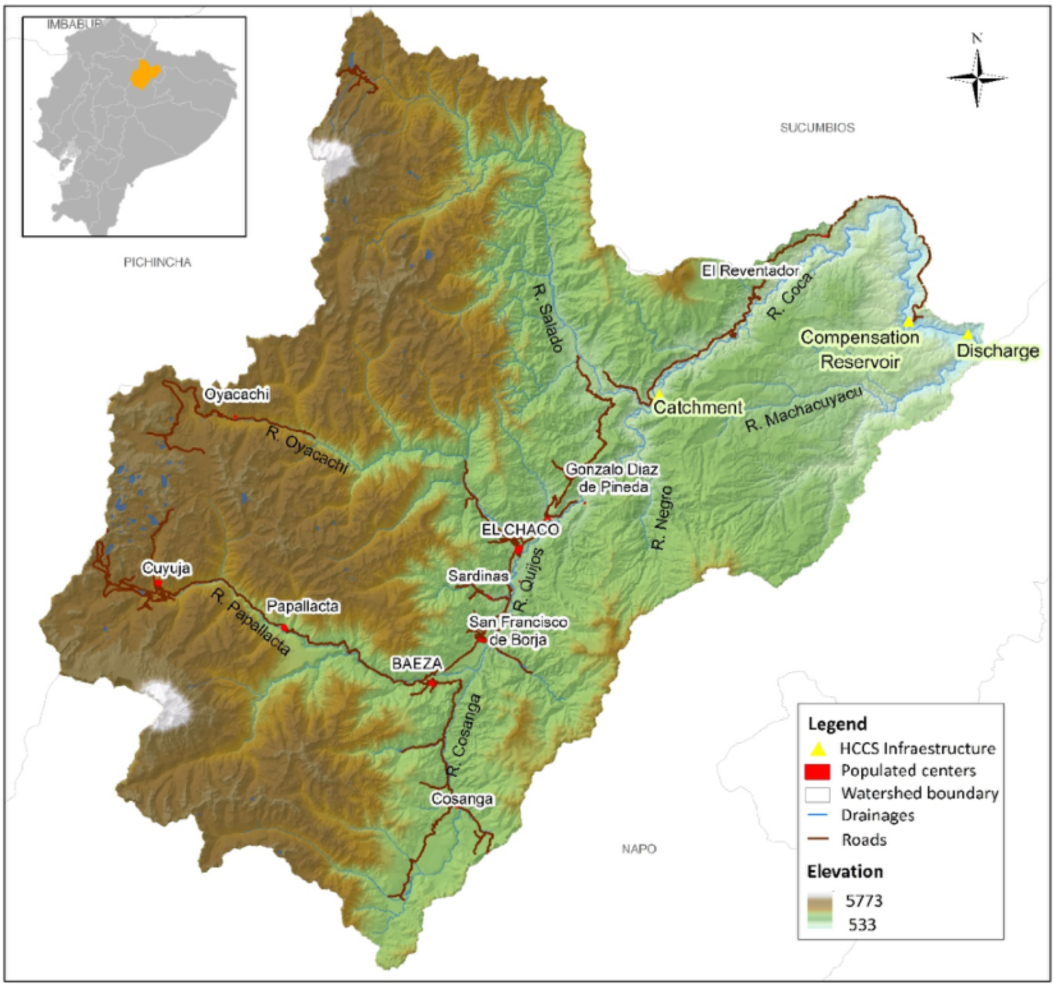
The Coca watershed study, conducted by EPN, will inform policy options for allowing hydropower plants to contribute to integrated water resources management at the landscape level, including protected areas. This paper refers to the Coca watershed study.

Recognize the wide range of benefits provided by ecosystems and biodiversity

The middle and upper Coca River watershed

The middle and upper Coca watershed occupies an area of 459,659 hectares ranging from 533 masl to 5,773 masl, located mainly in the Ecuadorian Amazon, with a small portion in the Andes region. It comprises three protected areas: Cayambe Coca National Park, Antisana Ecological Reserve, and Sumaco – Napo Galeras National Park, which cover 82.2% of the middle and upper watershed. There are also three protected forests in the basin.

62.2% of the basin's total area is covered by forests; 26.5% by páramos; 8.9% by grasslands; 0.1% by crops; and 2.3% is distributed among land without vegetation cover, water bodies, areas with herbaceous vegetation, glaciers and populated areas. The watershed is home to a large diversity of species, ecosystems and landscapes of great importance due to the ecosystem services they provide.



Map1. The Coca River upper and middle watershed.

The watershed contains highly acidic soils which, together with the high slopes, result in a low potential for the development of farming and livestock activities. Despite this, the main economic activity is cattle raising, followed by agricultural and forest production. However, productivity is low and poor soils and management practices lead to ecosystem loss and degradation.

According to official figures, 68.4% of agricultural production units possess property titles, while 9% are lands occupied without title; the remainder have other forms of tenure. The average size of agricultural production units is more than 50 hectares.

The population of the watershed is around 28,000 inhabitants, including indigenous peoples and local communities, concentrated along the main road axis. More than 30% of the economically active population is engaged in farming and livestock activities, which on average generate more than 60% of their income. According to the index of Unsatisfied Basic Needs (UBN), the percentage of people in this situation is approximately 80%, suggesting that the local population has a high degree of socioeconomic vulnerability.

The Ministry of Agriculture, Livestock and Fisheries, through the Amazon Productive Transformation Agenda, is promoting promising sustainable livestock and crop production initiatives, which have

not yet been consolidated. For its part, the Ministry of Environment's Socio Bosque Program[1] protects 24,897 hectares of forest on private land (outside protected areas).

Despite this, protected areas are under constant human pressure, with more than 6% of their area being used for agricultural and livestock activities. This pressure is mainly due to social and management conflicts that have gone unresolved for several decades, coupled with the settlement of families in the buffer zones who engage in farming activities.

The main water users in the basin are hydropower projects and users of water for human consumption, the demand for which comes primarily from the Metropolitan District of Quito, in addition to the local population. The basin's hydroelectric potential is 4,640 MW, of which 1,500 MW are harnessed by the newly-inaugurated Coca Codo Sinclair Hydropower Plant, one of the country's most ambitious and emblematic projects. There are 22 other hydropower projects in the basin in different stages of development.

Ecosystem services

The deep páramo soils and soil texture in the upper basin, as well as the forest cover in the middle basin, especially in the subbasins of the Quijos and Salado rivers, play a key role in water storage and regulation, as well as in the control of erosion and sediment entrainment.

Between 2000 and 2014, 11.9% of the basin was deforested as a result of improvements to the main road axis and the opening of new roads. Other activities that have led to ecosystem loss and degradation include: irregular land tenure, including settlements prior to the declaration of the protected areas; the demand for land for agricultural purposes; improper land-use, crop and pasture practices; the development of infrastructure projects such as hydropower plants, drinking water systems, power transmission lines, oil pipelines and mining operations, which lead to the expansion of the agricultural frontier – all this added to weak protected area management.

Land use changes in the basin's vegetation cover result in the degradation and loss of ecosystem services, including the loss of soil fertility, erosion control, the loss of water storage and regulation capacity, habitat fragmentation, and an increase in sediment production.

Currently sediment production in the watershed is estimated at 4 million tons per year. Future land-use changes, including the loss of forests and their conversion to pasturelands, especially in the Salado River subbasin, could lead to a significant increase in sediment production and entrainment. This would directly affect the functioning of the Coca Codo Sinclair Hydropower Plant, in addition to modifying the morphology of the main river channel. This land-use change could also lead to problems in the regulation of the basin rivers' base and flood flows (peak flows).

Demonstrate ecosystem and biodiversity values in economic terms

The valuation component of the TEEB study will provide policy evidence to:

1. Demonstrate the economic benefits of investment by the Coca Codo Sinclair Hydropower Plant in integrated water resources management, including landscape and ecosystem conservation, sustainable use and restoration activities.

2. Demonstrate the economic benefits of sustained financing of the National Incentives Plan[2], including the forest areas currently protected by the Socio Bosque Program, over the long term.

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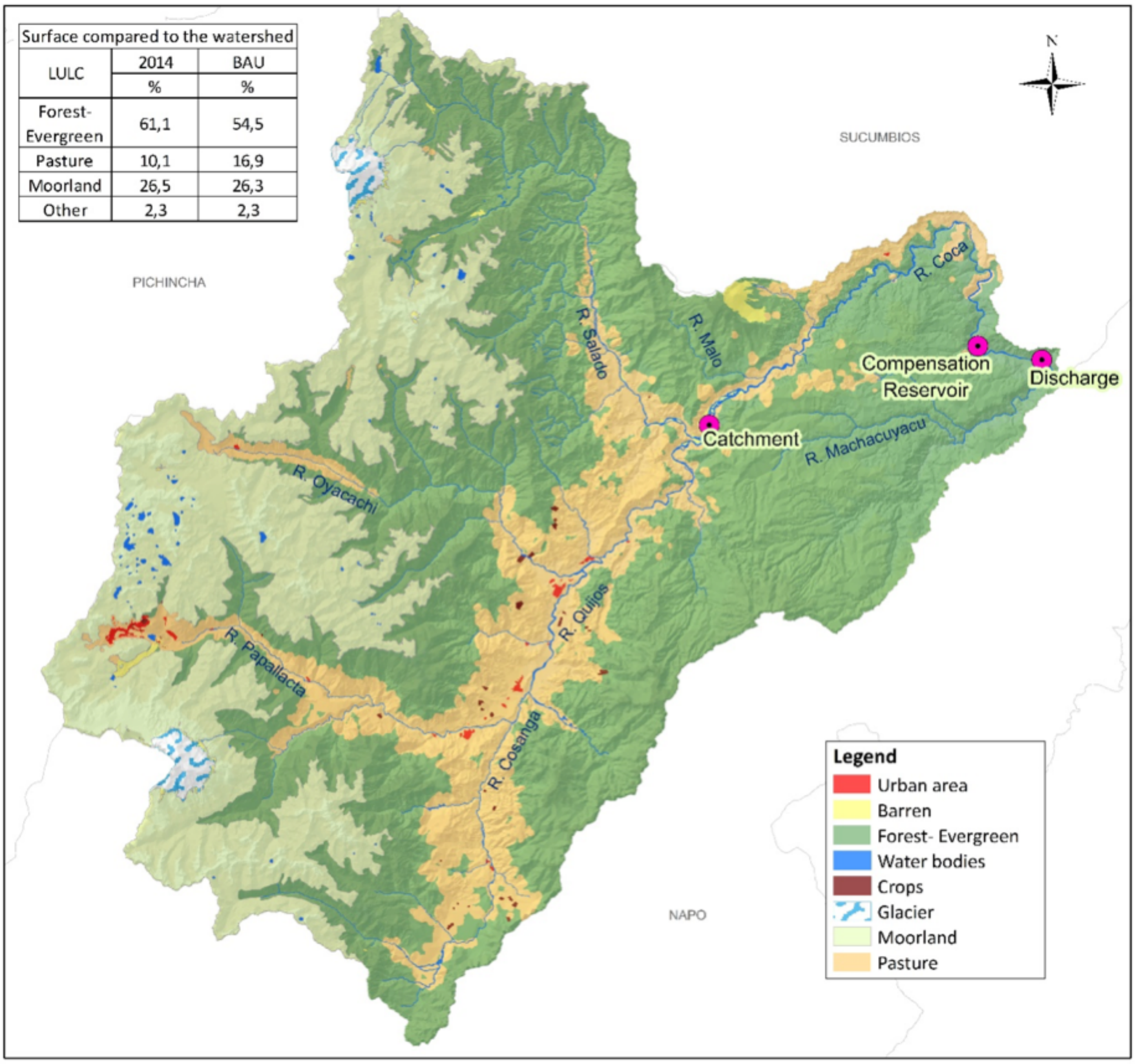
[1] The Socio Bosque Program was created by the Ecuadorian government in 2008, as a program that provides economic incentives to farmers and indigenous communities that voluntarily commit to the conservation and protection of their natural forests, páramos or other native vegetation. For more information: http://sociobosque.ambiente.gob.ec/node/755

[2] The National Incentives Plan refers to the National Program of Incentives for Conservation and Sustainable Use of the Natural Heritage, "Socio Bosque," established in 2013 (Ministerial Agreement 131), aimed at integrating all incentives initiatives in one national program that includes conservation, restoration, forest management, biotrade and sustainable finance components. For further information: http://sociobosque.ambiente.gob.ec/files/images/articulos/archivos/am131.pdf

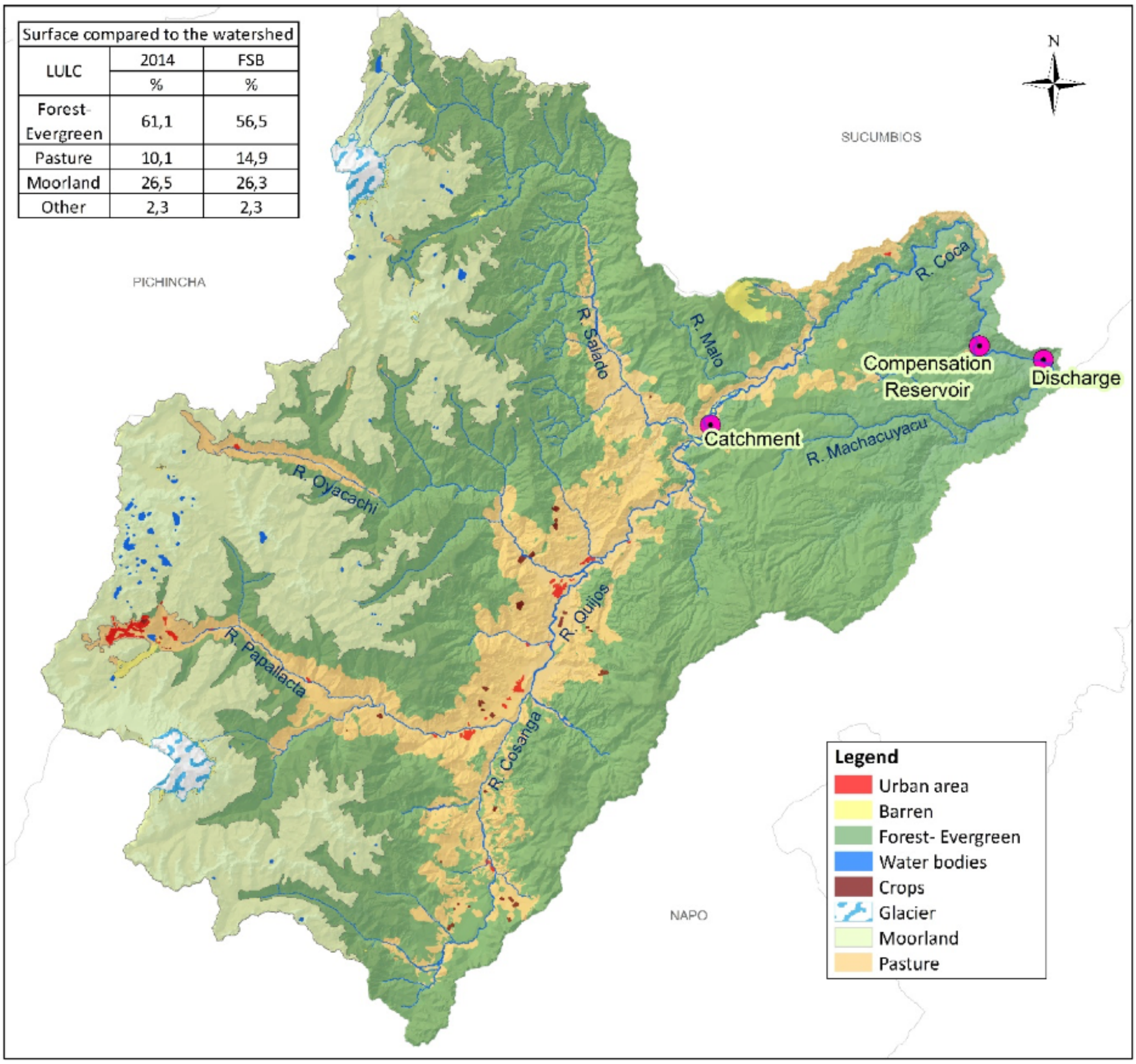
3. Provide information for a tariff mechanism to charge hydroelectric projects for the use and management of water (a new window of opportunity that emerged during the implementation of the TEEB study).

The study will assess the change in ecosystem services provisioning and its economic value in the following four scenarios, all of them for the next 14 years (year 2030 SDG):

- **Business as Usual (BAU) scenario:** Assumes that the trends of land use and land-use change continue on their current trajectory, including the forest area currently under the Socio Bosque Program, with no change, with weak governance and weak incentives for sustainable development. See Map 2.



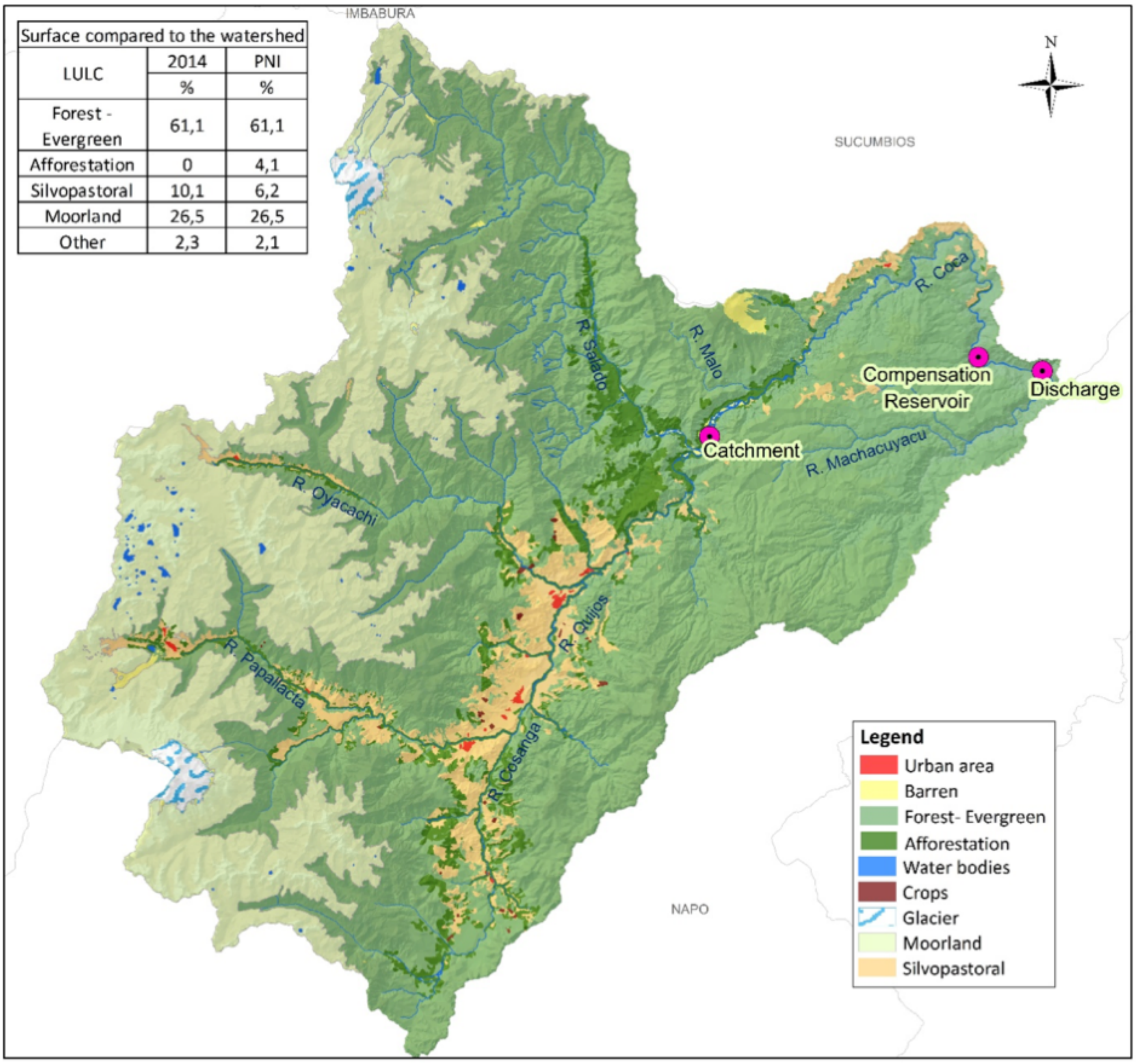
Map 2. The Coca River upper and middle watershed: Business as Usual scenario.



Surface compared to the watershed		
LULC	2014	FSB
	%	%
Forest-Evergreen	61,1	56,5
Pasture	10,1	14,9
Moorland	26,5	26,3
Other	2,3	2,3

Map 3. The Coca River upper and middle watershed: Strengthened Socio Bosque Program scenario.

- **Strengthened Socio Bosque Program (water incentive) scenario:** Legal framework in place for the hydropower plants to contribute to the Socio Bosque Program, including the maintenance of the forest areas currently under the Socio Bosque Program and the inclusion of new areas in priority water regulation areas, for a total area of around 60,000 hectares receiving the Socio Bosque incentive. Assumption: land tenure issues resolved and new legal framework in place. See Map 3.

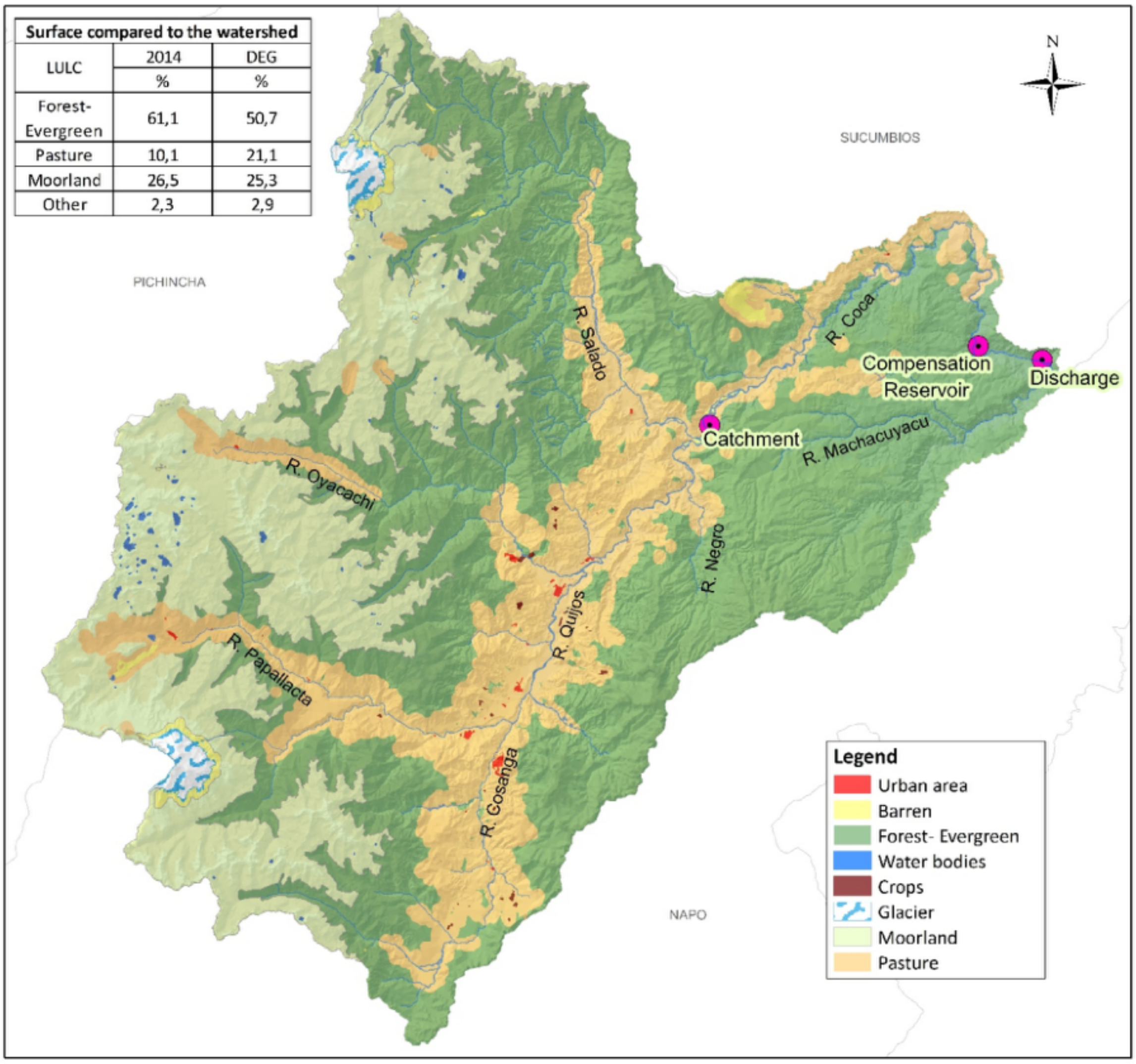


Surface compared to the watershed		
LULC	2014	PNI
	%	%
Forest - Evergreen	61,1	61,1
Afforestation	0	4,1
Silvopastoral	10,1	6,2
Moorland	26,5	26,5
Other	2,3	2,1

Map 4. The Coca River upper and middle watershed: **National Incentives Plan** scenario.

- **National Incentives Plan scenario**: Legal framework in place for the National Incentives Plan, which includes the funding of ecosystem conservation, restoration and sustainable use activities for the whole basin (including the forest areas currently under the Socio Bosque Program). This includes a balance between social, environmental and economic objectives and the implementation of plans for biotrade and water tariffs, among others. Assumption: land tenure issues resolved and new legal framework in place. See Map 4.

• **Degradation scenario**: Assumes that trends are worsening and that the National Incentives Plan or the Socio Bosque Program is not in place. Land-use change from forests to pastures takes place according to the current national rate of deforestation. See Map 5.



Map 5. The Coca River upper and middle watershed: Degradation scenario.

Biophysical information on the water and sediments regulation ecosystem services was generated using SWAT (Soil Water Assessment Tool). The biophysical data obtained will be used to conduct an economic valuation exercise. The study assessed water regulation service in terms of the amount, distribution and timing of water resources, analyzing liquid flows and their influence on the storage, seasonality and control of water flows, as well as on ecosystem stability. Liquid flows were estimated through hydrological modeling, which allowed the simulation of hydrological cycle variables. The methodology for quantifying the service of water regulation involves hydrological modeling of each of the four land-use change scenarios established.

Sediment regulation service is understood as the set of conditions provided by ecosystems that make it possible to control soil loss, without which the different watershed erosion processes would cause greater land-surface subsidence. Sediment production in the watershed under study is governed by geodynamics (tectonics, volcanism and seismic activity), so the estimation of solid discharge was made based on sediment classification curves developed by the Ecuadorian Institute of Electrification in 1992. The estimation of solid discharge was linked directly to hydrological

simulation because it depends on the liquid flows generated by the model. The seasonality of the results is due to the hydrological model.

The economic valuation methodology will generate information about the economic value of ecosystem services that regulate water and sediment. The basic assumption for the economic valuation is that the land-use change for each scenario is directly related to flow and sediment patterns. Consequently, water and sediment regulation services will affect the energy production of the Coca Codo Sinclair Hydropower Plant and, therefore, its operational and maintenance costs.

Capture ecosystems and biodiversity values in decision-making

The Constitution of the Republic of Ecuador (2008) and the Law on Water Resources and Use and Exploitation of Water (2014) and its Regulations (2015) contain the regulatory framework that allows for the establishment of a fee for water use and exploitation for productive purposes, such as hydropower plants, multi-purpose projects, and other industrial uses.

The results of this study will help generate solid science-based data to quantify the direct relationship between the maintenance and restoration of the vegetation cover in the Coca watershed and the costs that the Coca Codo Sinclair Hydropower Plant and other projects in this basin would have to bear to control the amount of sediments produced by deforestation and land-use changes. These sediments would be washed into the power plants' reservoirs, clogging them and damaging the turbines.

The hypothesis posed suggests that the higher the level of vegetation cover or the less degradation occurs, the lower the costs per unit area for maintenance. Therefore, the existence of páramos and forest ecosystems, both in and outside of protected areas, helps hydropower plants to reduce maintenance and operation costs related to sedimentation processes. This affects the costs of hydroelectric power generation, which are passed on to the end users of the service through fees. The maintenance of natural vegetation in the watershed also contributes to developing water storage services, especially in extreme weather events, and to regulating water flows.

Aligned with the above, one concrete policy option to which TEEB will provide solid science-based data is the establishment of a tariff mechanism to charge hydroelectric and multi-purpose projects for the use and management of water. The funds generated by this new tariff could be used to finance the National Incentives Plan that includes ecosystem conservation, restoration and sustainable use activities and biotrade. TEEB data provision for a new tariff mechanism was not considered a goal when the study started; however, policymakers have expressed a clear interest in this topic in recent months, opening a window of opportunity for the TEEB study to have a concrete impact on policymaking concerning ecosystem services conservation in Ecuador.

For more information:

María Cristina Torres
maria.torresg@epn.edu.ec
Escuela Politécnica Nacional (EPN)
Quito, Ecuador

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