Country Overview

With the most biodiversity per square kilometre of any nation, **Ecuador** is one of the world's seventeen megadiverse countries encompassing the Andes Mountains, the Amazon rainforest, the Galapagos Islands, the most important watershed of the South American west coast, and a marine zone driven by productive marine 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.

These rich and diverse natural resources are recognized in **Ecuador's National Development Plan 2013-2017** (Plan of "Good Living"), which states that the government has the responsibility to defend the population's right to a healthy environment. The Plan outlines a transformation process for the country's productive and energy matrix. The *change of 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 of energy matrix* focuses primarily on the substitution of fossil fuels with hydropower. These transformations are aligned with the Ecuadorian constitution, which recognizes legally enforceable *Rights of Nature*.

Project Overview

The **TEEB Ecuador** project helps policy makers see how investing in natural capital supports the transformation of the country's productive and energy matrix. Through participative scenario analysis at the landscape level, **TEEB** assesses for the **Coca watershed** the impacts of different incentive programmes and land use decisions in ecosystem service provisioning under various scenarios of *ecosystem restoration*, *conservation and sustainable use* and particularly on the benefits of the **Socio Bosque** program.

The study interrogates the economic tools that could be applied to maintain adequate water quantity and quality in the watershed. Policy recommendations are made observing the principles of the Ecuadorian constitution including: the right to water, the rights of nature, and the importance of pursuing energy sovereignty without compromising food sovereignty.

The approach

The study identified several ecosystem services in the **Coca watershed** generating relevant benefits to humans and contributing to key economic activities. Among these are the regulation of water flows, production of drinking water, regulation of sediments, habitat for species, carbon sequestration, the provision of space for recreation and tourism. For their relevance as inputs to hydropower generation, water flow regulation (liquid flows) and sediments regulation (solid flows) were the two ES's evaluated in the study with the scope being the inputs that these two ecosystem services will potentially deliver to the country's largest hydropower project the **Coca Codo Sinclair** (CHCCS) (1,500 MW).

Four scenarios for land-use profile were developed according to the application of a determined set of conservation policies. This allowed the estimation of impacts on the the biophysical flows of the two ecosystem services analysed, water flow regulation and sediment regulation. A monetary value for the benefits that these two services represent to the CHCCS is estimated by inferring the impacts that each scenario represents on revenue generated with hydroelectricity[1] and avoided costs in sediment dredging[2]. A cost-benefit analysis (CBA) indicating the subsection of benefits considered in the study is presented for 2017 and represent the period 2017-2030. It uses the monetary values estimated for the two services as benefits whilst the cost is considered to be the total costs incurred in the implementation of the scenarios.

Table 1 details the objectives, assumptions and methodologies used for the development of the scenarios for the year 2030.

Table 1. Main characteristics of the scenarios.

Scenario	Goal	Assumptions	Methodology for land use map (2030)

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[1] To estimate the economic value of the water flow regulation service, biophysical data expressed as water flow (m^3/s), was converted into annual energy production (kWh), which allowed estimates to be made of the CHCCS energy production revenues (USD/year), using market prices.

[2] To carry out the monetary valuation of the sediment regulation service, the biophysical data expressed as sediment production (ton/year), was converted into volume of solids retained in the CHCCS reservoir (kg/m^3). This allowed estimates to be made of the accumulation of sediment in the reservoir and its removal cost.

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Business as Usual (BAU)	To analyze the impacts of the current policies (PSB) and; To create a baseline for comparison with the other scenarios.	Land use and land-use change trend for the period 2009 – 2014 is maintained; PSB continues operating and conserving an area of 24,897 ha of native forest and páramo;	Mathematical model (quantitative) GIS – TerrSet
Strengthened Socio Bosque (FSB)	To analyze the impacts of the current policies prioritizing areas of hydrological importance through the PSB.	Land use and land-use change trend for the period 2009 – 2014 is maintained; PSB incorporates an extra 6.250 ha in areas of hydrological importance for a total of 31.147 ha under PSB incentives.	Expert criterion (quantitative)
National Incentives Plan (PNI)	To analyze the impacts of the PNI implementation and the types of incentives which composes it, *restoration, conservation and sustainable use.*	Land use and land-use change trend for the period 2009 – 2014 is maintained; PSB incorporates an extra 8.624 ha in areas of hydrological importance for a total of 33.521 ha under PSB incentives; Forest restoration of 18.700 ha; Substitution of 27.855 ha of pastures into silvopastoral systems; All incentives under the PNI scenario are considered to occur simultaneously.	Expert criterion (qualitative)
Degradation (DEG)	To analyze the impacts of not having any type of policy for the conservation of native vegetation, restoration or sustainable production; Give an indication of benefits generated by the current incentives implemented under the PSB.	There are no public policies for the conservation of forests and páramos, restoration or sustainable production; Deforestation increases; PSB disappears; No PNI implemented.	Mathematical model (quantitative) InVEST

Results

LUC and CBA

The results are presented first in terms of land use changes (LUC) for each scenario, with 2016 as the base year and projected to 2030. Using this results the **BAU** scenario is set as baseline for the CBA. All money values are net present values with a discount rate of 6% and account for the entire period of policy application 2017-2030.

Graphic 01 below uses the LUC results obtained for the BAU scenario as a baseline to calculate the impacts of all other scenarios on the existing natural vegetation.
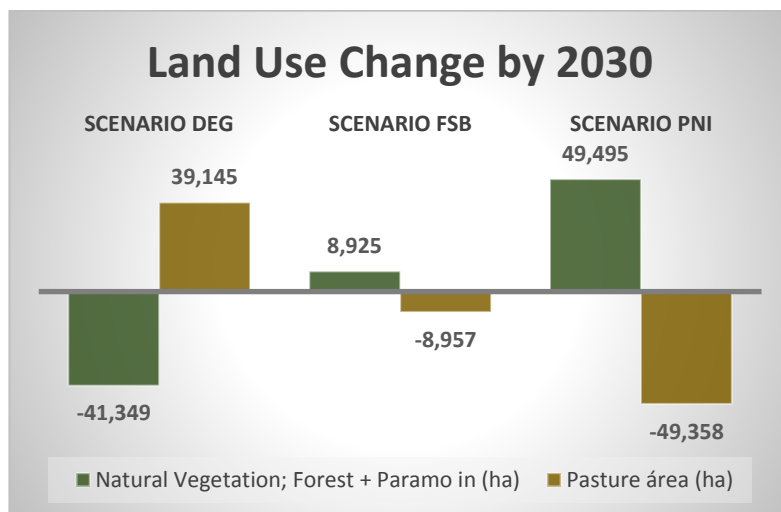
Graph 01 LUC for all scenarios in relation to BAU scenario by 2030

DEG

This scenario projects the closure of all incentives for conservation, meaning that the PSB incentives covering 24,897 ha in the BAU scenario cease to exist. Under these circumstances by 2030 it is projected a decrease of Forest and Paramo and an increase of pastures.

CBA for DEG

The estimated cost avoided for not implementing any policy is of 7 million USD for the entire period analysed. In the same period the CHCCS revenues with hydroelectricity is reduced in 6,2 million USD and costs of sediment dredging is increased by 117,000 USD. The net present value (NPV) for this scenario by 2030 if USD 644,018.

The depletion of the ecosystem means that the intensity of ES provided to CHCCS are reduced and, under the same circumstances, should remain as such into the future if no intervention occurs. For the DEG scenario the models projected a loss of 41,349 ha in natural vegetation in areas that are upstream the hydropower plant. A negative effect in terms of ES flows would be coherent with such loss in the natural vegetation. Although the net present value NPV is positive by 2030, the graphic 02 bellow shows that beyond 2023 the annual net benefits of the scenario becomes negative and suggests that the positive NPV observed may not be sustained for a longer analysis.

Graph 02 DEG - Annual net benefits Vs. accumulated balance (NPV) 2017-2030
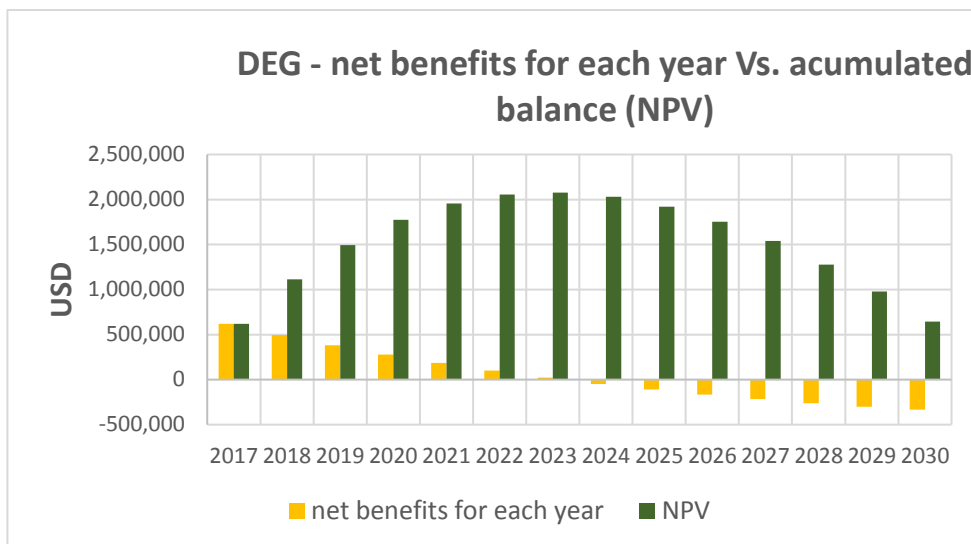
FSB

The FSB scenario projects the expansion of the area under PSB incentives to a total of 31.147 ha. The result in LUC by 2030 remains a decrease in forest and paramo, and increase in pastures, however the intensity is significantly less than that observed in the DEG scenario.

CBA for FSB

Under FSB scenario the natural base in 2030 is diminished when compared to that of 2016. However, when the comparison of the natural base is made between FSB and BAU, FSB has an extra 8,903 ha of forest and a reduction of 8,957 ha of pasture. This positive result generates an additional revenue in hydroelectricity for the CHCCS of USD 2,128 million and USD 10,956 in avoided sediment removal costs. The estimated cost of implementing the policies assumed in the FSB scenario is of 1.7 million USD for the entire period analysed. The NPV of this scenario by 2030 is 376,000 USD, suggesting that relocating part of the hydropower revenue from the plant analysed to finance this conservation policy is economically viable. Also in contrast with the DEG scenario, Graph 03 showing annual net benefits Vs. net present value suggests a positive result for an analysis going beyond 2030.

Graph 03 FSB - Yearly net benefits Vs. accumulated balance at the end of each year 2017-2030
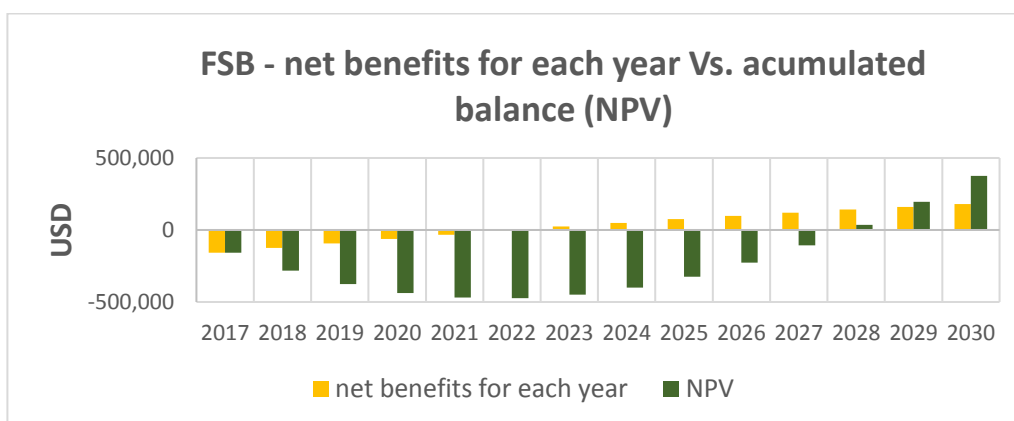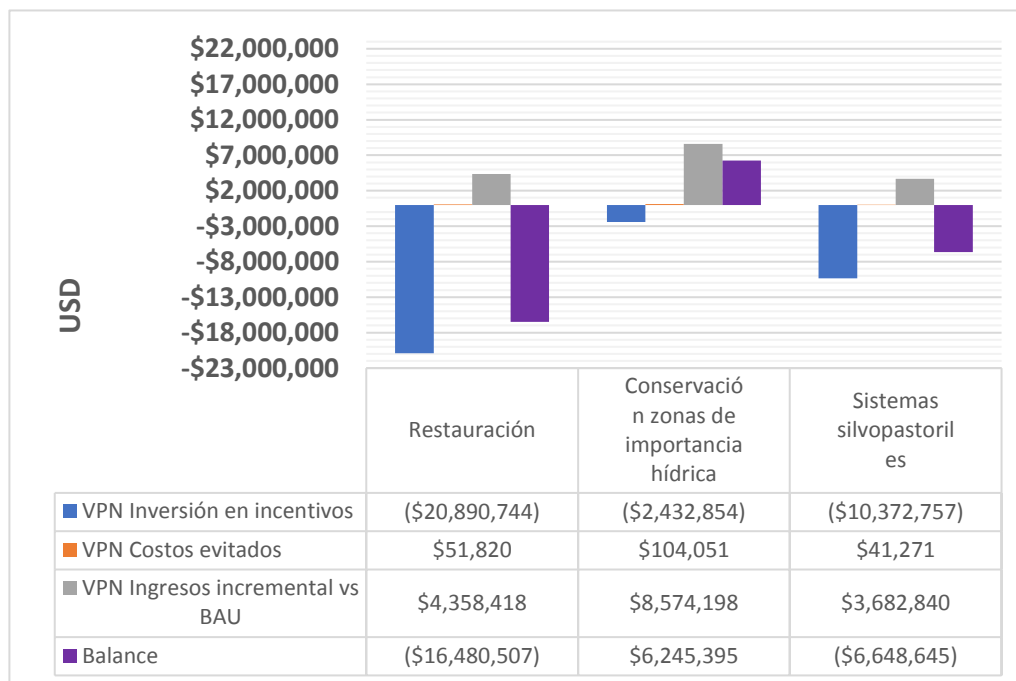

PNI

The PNI scenario comprehends tree types of incentives and assumes their combined application. 33.521 ha is assumed to be under PSB conservation incentives; 18.700 ha of degraded land is restored into forests and 27.855 ha of pastures is substituted for silvopastoral systems. The result in LUC by 2030 is positive for forest and paramo and a decrease in pastures with all its remaining area having been transformed into silvopastoral systems.

CBA for PNI

The PNI scenario brings for the CHCCS an extra USD 16,694 million in hydroelectricity revenue and avoids USD 221,126 in costs of sediment removal. But with the largest investment of all the scenarios by 2030 the NPV remains negative at USD 16,781 million. However, the improved natural capital means that the extra 48,672 ha of forest area that PNI would have in relation to BAU positively impact all ES's being provided for a period beyond that established by the CBA. For this reason, research examining this scenario over a longer period of time and perhaps considering a broader subsection of ES's is required to appraise it from a policy view point.

The results show that the type of incentive used as part of the PNI scenario, the conservation of zones of hydric importance, is the most cost effective of all. If separated from the other aspects of the PNI scenario, this type of conservation incentive has a NPV of USD 6.2 million by 2030. Figure 01 summarizes the CBA of the PNI scenario for each of the incentive types that composes it.

Figure 01 CBA for the different incentives composing PNI scenario 2017-2030

	Restauración	Conservación zonas de importancia hídrica	Sistemas silvopastoriles
■ VPN Inversión en incentivos	($20,890,744)	($2,432,854)	($10,372,757)
■ VPN Costos evitados	$51,820	$104,051	$41,271
■ VPN Ingresos incremental vs BAU	$4,358,418	$8,574,198	$3,682,840
■ Balance	($16,480,507)	$6,245,395	($6,648,645)

Policy Implications

The cost-benefit analysis made in this report indicates how the benefits of two of the 14 ecosystem services identified compare with the implementation costs of the policies assumed in each scenario. It contemplates the total costs involved in the implementation of the policies but only a small subset of the benefits produced. This scope of analysis was defined as to capture only the benefits generated to the CHCCS. For a more broad appraisal the valuation of benefits could expand to cover other ES's and longer period. This is specially important given the time that takes for ecosystems to respond to the type of interventions being analysed.

This study demonstrates the important role of ecosystems through their potential to generate ES that support and enhance the production of economic sectors. The information generated by economic analysis of ecosystem services such as this study can inform decision making processes, particularly in places with diverse and abundant natural capital. Although the assessment focuses on one watershed, the TEEB aims to inform national policy, as Socio Bosque is a nationwide program and land use change is a nationwide threat.

Policy recommendations at the *national level* propose to institutionalize the economic assessment of ecosystem services in national policy making. Analysis and evaluation of ecosystem services should be part of land use planning tools and processes.
Finance hydrometeorological information systems to improve data availability, streamline data collection processes, and invest in biophysical modelling capacity to increase the effectiveness of ecosystem services assessments as an input to policy making.

Create watershed councils or committees at watershed and micro watersheds levels, promoting the participation of multiple stakeholders in decision making, which links with better governance arrangements and the implementation of the ecosystem approach.

Secure long term financing of the PSB focusing on areas of hydrological importance. TEEB study in the Coca watershed demonstrated a direct relationship between the conservation of native ecosystems, especially in areas of hydrological importance, and the generation of ecosystem services with a positive impact on the provision of water for hydroelectricity production, to supply around 30% of the national energy demand and around 40% of Quito´s population drinking water demand.

For the new hydropower plants and other infrastructure projects in watersheds, the Environmental Impact Studies should analyze the impact of the new infrastructure on the ecosystem services, using a watershed approach and considering other projects at different stages of development. This analysis will allow the development of watershed conservation strategies, that could funded by different water users.

The Salado and Cosanga micro watersheds located within the SNAP, are the most important ones for the provision of flow and sediment regulation services, needed for the CHCCS operation, so its conservation is a priority. The Ministry of Environment should encourage partnerships with water users as CELEC EP to promote control and monitoring activities and avoid land-use change, or propose a management agreement with the participation of local governments.

At local level, local governments could play a key role in the implementation of forest restoration activities in areas of hydrological importance within their territories, outside the SNAP, with local stakeholder's participation, under the Ministry of Environment (MAE) and the Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) guidelines.