Final Report on Modeling

Project:

Integrating Jurisdictional REDD with Colombia's climate mitigation policies including a national ETS

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ACRONYMS

ART	Architecture for REDD+ Transactions
BAU	Business as Usual
CEMR	Centro de Estudios Manuel Ramírez
CI	International Conservation
UNFCCC	United Nations Framework Convention on Climate Change
COP	Conference of the Parties
DANE	National Administrative Department of Statistics
EDF	Environmental Defense Fund
FREL	Forest Reference Emission Level
GLP	Liquified petroleum gas
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies
MPI	Multidimensional Poverty Index
JNR	VCS Jurisdictional and Nested REDD+
JREDD+	Jurisdictional REDD+
MRV	Monitoring, Reporting and Verification
LCC	Climate Change Act
LPG	Liquified Petroleum Gas
LEAF	
NDC	Nationally Determined Contribution
NG	Natural Gas
PNCTE	National Emission Trading Allowance Program
PNN	National Natural Park
REDD+	Reducing emissions from deforestation and forest degradation
REM	REDD Early Mover
RENARE	National Registry of GHG Reductions
ETS	Emissions Trading System
TNC	The Nature Conservancy
TREES	The REDD+ Environmental Excellence Standard
UA	University of los Andes
UNDP	United Nations Development Programme

EXECUTIVE SUMMARY

Colombia has set ambitious climate goals and has developed climate change policies, plans and programs as well as economic instruments to achieve them, such as the Carbon Tax implemented in 2017, and an Emissions Trading System (ETS) defined under the Climate Change Act (LCC for its acronym in Spanish). Meanwhile, the Colombian government has made some progress with the implementation of REDD+ programs of regional scope such as Visión Amazonía. This type of programs aligns with the concept of jurisdictional REDD (JREDD) programs that have been consolidated at the international level and that can access Results-based payments.

Using existing Marginal Abatement Cost Curves (MAC) estimates for the regulated sector (energy and industry) and the unregulated sectors (forestry) in Colombia, this discussion paper analyzes how to integrate JREDD into the country´s national mitigation policies. We consider scenarios where JREDD may be funded by three different sources: the national budged, a national ETS coupled with an offset mechanism that operates at the jurisdictional level and international sources of funding such as the Lowering Emissions by Accelerating Forest Finance (LEAF) Coalition. The analysis is carried out over 7 years, specifically for the 2024 – 2030 period. We calculate the seed funding from the National Budget required to meet the forest goals established in the country´s National Determined Contribution (NDC) under four financing scenarios. Table 0 provides results from the modeling exercise are provide.

Table 0: Minimum Funding from the National Budget Required to Meet Colombia´s forest NDC goals under Different Financing Scenarios

		Transfers from the planned national ETS	
		No	Yes
International Results-based Payments	No	*Scenario 1* 900 million USD	*Scenario 2* 84 million USD
	Yes	*Scenario 3* 88 million USD	*Scenario 4* 75 million USD*

** Under this scenario the country reaches its forest NDC goal by 2029 and can potentially sell Internationally Transferred Mitigation Outcomes (ITMOs) at a relatively higher carbon price.*

To the extent that not all transaction costs are considered in this study, e.g. the coordination costs in establishing a JREDD program are not modeled, these results should be interpreted with caution. While the absolute figures shown in table 0 may underestimate the seed funding required to meet Colombia's NDC deforestation target, the *relative* funding requirements across scenarios are likely to be unbiased. When JREDD is linked to a national ETS and/or International Results-based Payments such as those offered by the LEAF Coalition, the public funding needed to achieve the NDC deforestation target of 50,000 hectares in 2030 is about ten times lower when compared with the scenario where only Government funding is used. Thus, linking JREDD with the national ETS and with International Results-based Payments enables Colombia to achieve its NDC cost-effectively.

Harnessing funding from the ETS and/or international results-based payments result in large fiscal savings as they both generate a virtuous financial circle: mitigation results in a given year generate financial resources that can then be invested in actions that lead to further mitigation results. It is important to note that the calibrated model is highly sensitive to seed funding from the national Government. This suggests that, if seed funding is large enough. Colombia and its JREDD programs have the potential to generate internationally transferred mitigation outcomes (ITMOs) and benefit from extra revenues in international markets.

The ETS generates greater savings in government funding and it dynamizes the system faster than international result-based payments, due to the stringency of the latter instrument. In the international result-based payments scenario, the base-line used is given by the five-year average forest emissions prior to the payment period. On the other hand, in the national ETS scenario, the base-line is set according to the business-as-usual scenario given by the National Reference Level of Forest Emissions (NREF) which assumes that deforestation will peak in 2025.

The model examines outcomes in terms of emission reductions, as well as funding flows to communities and program implementers. Benefit-sharing payments for ethnic communities require that the implemented funding mechanisms have the capacity to generate sufficient resources to meet these obligations. A stable payment level helps buffer the risks of fluctuations in the income of ethnic communities, but it requires higher initial funding conditions from the national government. If indigenous revenues were a proportion of net income from participating in the corresponding JREDD program, the initial funding requirements would be lower but there would be no guarantee of resources for these communities.

It is important to highlight that the scenarios considered here sought to find the lowest budgetary contribution required from the National Government in order to comply with the goals of the forestry sector, but in all cases, they correspond to the minimum required. Higher initial government funding may also be warranted given the ancillary socio-economic and environmental benefits generated by a well-designed JREDD+ program. At COP27 in Sharm El Sheikh, the Colombian government pledged to create a fund to protect the Amazon. A JREDD+ approach can be an effective way to manage these resources while leveraging international finance.

1 INTRODUCTION

Colombia, within the framework of the global agreements on climate change, has formulated ambitious goals and has developed policies, plans and programs as well as economic instruments to achieve them. When updating its Nationally Determined Contribution (NDC) in 2020, the National Government raised its initial greenhouse gas emission reduction targets, which were between 20% and 30% (conditioned to international aid), to: i) a 51% emission reduction target by 2030, ii) and to achieve carbon neutrality by 2050 (Gobierno de Colombia, 2020). Taking into account that most of the emissions are generated in the energy sector and in the phenomenon of forest deforestation, a carbon tax on liquid fuels and fuel gas for industrial uses[1] was established in 2016, and the tax was allowed to be waived through the financing of verified emissions reduction initiatives. This stimulated the market for reduction certificates (also called carbon credits), which in turn has served to finance mainly afforestation/reforestation, clean energy, and reducing emissions caused by deforestation and forest degradation (REDD+) (Asocarbono, 2022).

While the carbon tax has served to finance these efforts, it is not the only carbon pricing instrument envisaged, as the Climate Change Act[2] (LCC) established the general guidelines for the implementation of an Emissions Trading System (ETS) in Colombia. An ETS is generally a type of carbon market in which emission rights issued by a government authority are traded and must be purchased by regulated agents to support their carbon emissions (Narassimhan, Gallagher, Koester, & Rivera, 2018).

On the other hand, in addition to opening the possibility of financing private emission mitigation projects, the Colombian government has made progress with the implementation of REDD+ programs of jurisdictional scope (JREDD+). With the support of international cooperation, it has begun to develop deforestation reduction programs of regional scope, such as Visión Amazonia[3], or the Orinoquia Emissions Reduction Program, which is currently in its design phase. This type of program aligns with jurisdictional emission mitigation programs for Colombia under discussion at the international level which, through certification programs or carbon standards such as ART TREES or VCS-JNR, could generate result-based payments, or credits tradable through the international voluntary carbon market (TNC, 2022).

This discussion paper analyzes the ETS and JREDD+ mechanisms in terms of their ability to generate incentives and the necessary financing to meet Colombia's NDC targets, either alone or in an integrated manner. This will ensure the sustainability of deforestation control policies and improve the living conditions of communities that conserve biodiversity and protect the

[1] According to the GHG inventories included as an annex in the Colombian biannual report BUR3 by IDEAM et. Al. (2021), these fuels covered by the tax presented in 2018 emissions for 76.8 $MtCO_2$ which represents about 25% of the country's total emissions for that year.

[2] Law 1931 of 2018

[3] The government of Colombia submitted a concept note to ART-TREES presenting the area of Visión Amazonia as a REDD+ jurisdiction. That concept note was approved in 2021 but the country has not yet taken any additional steps to register the REDD+ program and to certify its reductions (ART - TREES, 2021).

forest. First, the paper will introduce the Colombian ETS and other mechanisms related to carbon pricing. A brief contextualization of the JREDD+ programs and their financing will also be provided. Subsequently, the specifications of a JREDD+ financial simulation model integrating the ETS as a source of financing will be presented. Results of this modeling under different scenarios are discussed in the final sections of the paper.

2 CARBON PRICING MECHANISMS[4]

Reducing global GHG emissions is not an easy task for governments. Emissions are the by-product of technologies and practices in use for economic activity within a country. Private actors involved in these activities must change their practices and technologies in order to reduce GHG emissions. Emissions constitute an externality of productive activity- that is, they represent a social cost that is not naturally internalized within the prices of goods and services. The markets for these goods and services may function optimally for those who participate directly in them, but such markets are distorted and socially inefficient from the perspective of the externalized costs to society of the resulting emissions (Tietenberg & Lewis, 2020).

Carbon pricing seeks to correct this negative externality, transferring the cost of social damage to those responsible for GHG emissions— thus encouraging these same agents to adjust their productive activities, and to make the necessary investments to reduce their GHG emissions (World Bank, 2021). Knowledge regarding the appropriate price of carbon in each economy is essential for state regulation of polluting economic activities and (in the presence of such regulation) to decision-making economic agents, in order to develop efficient and effective mitigation actions.

Carbon pricing can be done through a direct tax on emissions, or through market-based solutions. These market-based solutions generally fall into two categories: (i) carbon credit markets[5], also called voluntary carbon markets (VCM) and (ii) legally mandated emission rights or permits markets, also called emission trading systems (ETS) (World Bank, 2020). Each of these instrument types are discussed below in the context of existing laws and institutions relevant to Colombia.

2.1 Carbon tax (Law 1819 of 2016)

A carbon tax is a levy or tax on the carbon content of fossil fuels, in other words, a price per tCO2e. For ease of implementation, the carbon tax is generally imposed on fossil fuels and varies according with their carbon content. In Colombia, a carbon tax was established by the 2016 Tax Reform (Law 1819/2016) to be levied at the beginning of the supply chain of liquid fossil fuels, and fuel gas (natural gas NG and liquified petroleum gas LPG) for industrial use. In addition, the aforementioned law also defined a non-causation mechanism for taxpayers who are able to demonstrate that they have made compensations. Large consumers can turn to the Voluntary Carbon Market, to acquire verified and certified reductions that meet the

[4] The concepts presented in this chapter can be found further developed in the policy report of this same study.
[5] Carbon credits are certificates of emission reductions or removals.

established conditions (Decree 926/2017) and when delivering these certifications to the taxable person, they can agree on a price that does not include the value of the tax (Econometría Consultores, 2022). A more detailed analysis of the operation and evolution of the collection of this tax can be found at the Centro de Estudios Manuel Ramírez (2022).

2.2 Voluntary Carbon Market

In the carbon credit markets, the supply is made up of unregulated agents that, through voluntary mitigation projects, remove GHGs from the atmosphere[6] or reduce potential emissions. These projects receive emission reduction certificates issued by recognized certifying entities, also called carbon standards, which, based on a set of methodologies applied by accredited validation and verification agencies, state that the declared reductions technically comply with their measurement standards. These certificates are demanded either by voluntary buyers who value these mitigation results, or by regulated agents who require them to compensate for an obligation imposed by the State (World Bank Group, 2016).

Thus, the development of VCM in Colombia is linked to the non-causation mechanism of the carbon tax. Between 2017 and 2021, about 37.52% of the estimated emissions covered by the tax have been offset by the non-causation mechanism. For more details on the evolution and functioning of the carbon market in Colombia, see the report on market diagnosis and policy proposal of this same study. (Centro de Estudios Manuel Ramírez, 2022)

In addition, there is ongoing international concern about the regulation regarding the operation of voluntary markets in relation to the integrity and double counting of emission reduction results. Article 6 of the Paris Agreement allows for different cooperation mechanisms between countries to comply with the NDCs:

- A first mechanism (under Article 6.2) allows for cooperation between countries and trading of results (internationally transferred mitigation outcomes or ITMOs) in a decentralized manner without the intervention of a central entity, promoting "sustainable development, environmental integrity and transparency, including in governance, and shall apply robust accounting". These are transactions between the Parties (signatory countries), or at least must be authorized by the participating Parties, in order for these transactions to be taken into account in international accounting (Article 6.3). The country of origin must also make the "corresponding adjustment" in its accounting to ensure that it will not include the transferred results and thus ensure that no double accounting is presented.
- The second mechanism (under Article 6.4) is a centralized and supervised market, which allows the participation of both public and private entities, with the authorization of the Parties. This mechanism will be an improved version of the Clean Development Mechanism established under the Kyoto Protocol, as it will be implemented according to the revision of its rules and methodologies (Naciones Unidas, 2021)
- The possibility of non-market collaborations is also established (Article 6.8). Within the Warsaw Framework, countries agreed that results-based payments for REDD+

[6] For example, by planting trees or regenerating ecosystems.

can be adopted through market or non-market approaches, while ensuring that environmental integrity is preserved (CI-EDF-TNC, 2022). This type of support would not require a corresponding adjustment.

At the 26th Conference of the Parties (COP 26) in Glasgow, progress was made in defining the corresponding adjustment methodology. At that COP, progress was also made with respect to Article 6.4 as a supervisory body was designated and entrusted with the development of methodologies based on the review of CDM methodologies and the establishment of the corresponding registry. The conditions for registering a set of mitigation actions as an "Article 6.4 activity" were established, and each Party must designate a national authority for that mechanism. In addition, mitigation projects must respect safeguards so as not to threaten the well-being of vulnerable populations, and tools will be established to evaluate how mitigation activities promote sustainable development. Likewise, it must be guaranteed that leakage and reversions are avoided, negative environmental and social repercussions are avoided, consultations are carried out and methodologies are followed (Naciones Unidas, 2021).

2.3 Planned Emissions Trading System (Law 1931 of 2018)

ETSs are also called Cap-and-Trade mechanisms, as the authority sets a limit or cap on total emissions[7] in its jurisdiction. Governments then issue an amount of allowances equal to the level of the cap and allocate them, in some cases for free or usually by auction. These auctions are referred to as the primary market, as it is common for companies to trade emission rights among themselves for a specified compliance period, after which they are handed over to the government to back their emissions[8]. Companies with lower reduction costs are expected to sell their emission rights to companies with higher reduction costs in the secondary market and, in general, emission reductions are theoretically achieved at the lowest cost (Narassimhan, Gallagher, Koester, & Rivera, 2018).

In the Colombian case, the ETS was defined by the LCC under the name of National Emission Trading Allowances Program (Programa Nacional de Cupos Transables de Emisión, PNCTE). The LCC established that Minambiente must determine the number of allowances that annually are compatible with the national GHG emission reduction targets for regulated sectors, which corresponds to the definition of the cap. These allowances may be acquired by regulated agents through auctions in which carbon tax payments may be recognized as part of the payment of the allowances acquired in the auction to support their emissions. A detailed description on how the PNCTE works is presented at the Centro de Estudios Manuel Ramírez (2022).

One of the fundamental aspects contemplated in the LCC that allows a link between the ETS and the JREDD+ is that the national government may grant an allowance (tradable emission right) for each equivalent ton that "is reduced or removed as a result of the voluntary implementation of public or private initiatives for the reduction or removal of emissions

[7] It may include emissions of all GHGs or only some, such as CO2.

[8] As in the case of reductions and removals, the measurement of these emissions requires the intervention of independent validators and verifiers to establish the veracity of the emissions measured and reported by the agents, and on which the requirement to obtain emission rights is made.

carried out by agents other than those regulated". And it explains that these GHG reductions or removals must be "duly verified, certified and registered in the National Registry of GHG Reductions to, among other purposes, avoid double counting."

Regarding the use of the resources collected by the ETS, this Law indicates that resources obtained from the auctioning of tradable GHG emission allowances will be used for initiatives to reduce GHG emissions and adapt to climate change, as well as for the management of the necessary information. It also contemplates the possibility of establishing a system of incentives aimed at natural or juridical persons, private, public or both, that carry out specific actions to adapt to and mitigate climate change.

In this sense, the ETS could be a source of financial resources for REDD+ programs in two ways: by granting an allowance for each ton of CO2e reduced or removed, which could be sold in the auction or in the secondary market; or by allocating part of the auction collections to these programs.

3 JURISDICTIONAL PROGRAMS

A REDD+ jurisdiction is a geographically defined area governed by an entity through which a program can be established for the purpose of monitoring CO2 inventories, deforestation rates and GHG emission reductions resulting from the implementation of REDD+ initiatives. A jurisdiction may cover an entire national territory or a 'subnational' part of it, such as a state or other subnational administrative territory, or a recognized Indigenous territory. In some cases, it could also be a defined ecologically homogeneous region that, although not defined by the country's typical political-administrative boundaries, has a national scope and is legally recognized by the authority (American Carbon Registry, 2012).

3.1 Standards and financing mechanisms

As mentioned, international voluntary carbon markets have raised debates about the adequacy of existing policies, procedures and standards for climate change mitigation in the forestry sector. In particular, the debate focuses on whether the approach based on independent projects is sufficient to ensure the credibility and integrity of the results.

For this reason, standards that support a REDD+ jurisdictional approach have gained importance since the approval of the Warsaw Framework for REDD+ under the UNFCCC in 2013 (UNPD, 2021). Jurisdiction-scale crediting systems avoid or mitigate many of the issues that challenge the integrity of project-scale approaches, including concerns regarding additionality, leakage as well as permanence. It has been argued that the robustness of CO_2 reductions critically depends on scale of actions and policies (Schwartzman et al, 2021). A group of leading organizations came together to develop a Tropical Forest Credit Integrity Guide for companies, recommending rapidly shifting demand to jurisdictional-scale programme credits (COICA, CI, EDF, IPAM, WCS,WRI, TNC,WWF, 2023).

Through carbon market standards that support the REDD+ jurisdictional approach, high-integrity carbon credits can be generated by large-scale programs implemented at the national or subnational level (understood as a level below the national level).

Examples include the Architecture for REDD+ Transactions Environmental Excellence Standard (ART/ TREES), which allows for subnational accreditation until 2030, and the REDD+ Jurisdictional and Nested Framework (JNR) under Verra (Naciones Unidas, 2021).

There has also been growing interest in jurisdictional REDD+ credits from corporate investors and sovereign buyers. Among them is the LEAF Coalition, a large-scale public-private initiative to protect tropical forests, which aims to mobilize at least US$1 billion to purchase ART/TREES-certified jurisdictional REDD+ credits. During its first call for proposals, the initiative received more than 30 proposals from jurisdictions covering more than 500 million hectares of forest (UNPD, 2021).

Article 5 of the Paris Agreement expressly calls on countries to implement and support REDD+ approaches, based on the 2013 Warsaw Framework. Among other elements, the Warsaw Framework established rules for results-based payments for REDD+ efforts at the national level, or provisionally at the subnational level, recognizing that policy and financial reforms at the national level may offer the best opportunity to transform the forest sector (Naciones Unidas, 2015).

3.2 Nesting initiatives

National REDD+ strategies may have different approaches for nesting initiatives according to the rules that are defined to ensure that funding flows appropriately to the activities that require it, as shown in the following box.

Box 1 - Nesting Approaches (TNC, 2022)

There are different nesting approaches when implementing REDD+ depending on the role played by the National Government.

Jurisdictional Program: If the national government actively participates in REDD+ planning and implementation, receiving and distributing payments and ensuring compliance with REDD+ safeguards, we refer to this as a jurisdictional program. A jurisdictional program is global and encompasses all scales of REDD+ implementation and therefore requires extensive coordination of stakeholders across the country or subnational areas. National jurisdictional programs can count on the implementation of REDD+ programs at lower (subnational) levels through pay-for-performance, using a benefit-sharing approach.

Centralized nesting approach: If the allocation approach is quantitative and based on the performance of lower level jurisdictions or projects, then it could be considered a centralized nesting approach. It is called centralized because all REDD+ results are monetized and then distributed by the National Government. Performance is measured through MRV systems at the national or subnational level, and MRV systems at the project level, usually with independent verification. The verified results of lower level jurisdictions and projects are used to distribute payments.

Decentralized nesting approach: It occurs in the case where a National Government allows carbon credits to be obtained independently by sub-national jurisdictions or lower tier projects, i.e., that participate in carbon crediting[9] (certification) programs and can receive payments. This approach requires the involvement of the national government to ensure that double counting does not occur at all scales and that REDD+ safeguards are applied.

Project-based approach: This is one in which only projects receive payments after obtaining carbon credits from an accreditation program (certification). This is equivalent to saying that there is only one scale of

[9] Also known as carbon standards.

REDD+ implementation, that is, at the project level. This approach is not eligible under the UNFCCC and is the most common approach in the Voluntary Carbon Market (VCM).

Source: CEMR's own development based on TNC (2022)

For the purposes of this document, a jurisdictional program approach will be assumed with nested regional jurisdictions and within these, a set of mitigation projects and activities, articulated with each program.

3.3 Benefit Sharing

Each jurisdiction should, in principle, define its benefit-sharing plan following the national policies defined in this regard, but agreeing and planning the specific aspects of this distribution in a participatory manner. These benefit-sharing decisions are often based on legal factors (land and resource ownership), stakeholder priorities and other negotiated agreements between indigenous peoples, local communities and/or other stakeholders, as well as defining REDD+ projects' way of participation.

In a broad classification of benefits, these could be found in three categories:

- Payments for the development of REDD+ projects
- Payments to local stakeholders (producers and communities) that require an incentive or economic support to transform their land use.
- Payments for ethnic communities related to historical and future forest conservation.

The following are some considerations in an attempt to find a general rule for establishing payments to these three types of stakeholders.

3.3.1 Decision on payments to REDD+ projects

Under a jurisdictional approach planned and executed in an articulated manner at all scales, a series of intervention measures would be established in each jurisdiction that could include for example: awareness campaigns, environmental education, rural extension or technology transfer, delivery of supplies/tools, public goods, restoration or reforestation work etc. (Centro de Estudios Manuel Ramírez, 2021).

These tasks could be carried out directly by one or more state entities, but they could also be financed and contracted out to private parties at their own cost and with a reasonable profit margin. In the case of existing and new projects, jurisdictional programs could incorporate them as executing agencies or, if no agreement is reached and the regulation allows it (as is currently the case in Colombia), exclude the area from the jurisdiction. MinAmbiente Resolution 1447/2018 establishes the conditions for non-compatible overlap between projects and REDD+ programs and the option of incorporating the project as an implementing partner of the Program or the exclusion of the area.

One option shown in Box 1 is to have each project within the program measure, verify and certify its mitigation results and the payments it obtains are calculated in relation to the volume of those results. In this case it is necessary to establish a price for the settlement of these payments. This would entail incurring in transaction costs for the payment of validation

and verification services, for which the baselines of each of the projects would need to be made compatible with the jurisdiction's reference level.

3.3.2 Decision on incentive payments to producers and communities

Reducing deforestation, as well as restoring degraded or deforested areas, and productive transformation in the rural sector are generally measures that require the participation of private producers and communities in order to generate an effective change in productive practices and land use. However, in many cases, changes in use imply a change from developing an activity with high private profitability and high environmental costs to one with lower private profitability but high social benefits. For this reason, it is common for REDD+ programs, and in general for payments for environmental services programs, to include among their actions the delivery of monetary and non-monetary incentives to promote commitments by producers and communities to make these changes (CIFOR, 2014).

To calculate opportunity costs, both for the BAU scenario and the intervention scenario, the transformation of land use areas before and after the program is considered. For each economic activity associated with the initial or final land use, the expected cash flow of the activity must be known, and calculate its net benefit in Present Value. The opportunity cost of each transition i,j will be given by the difference between the net benefit in the BAU scenario and the net benefit in the program scenario (Centro de Estudios Manuel Ramírez, 2021).

3.3.3 Decision on payments for ethnic communities

The benefits that should be received by the ethnic communities that inhabit the territory of these jurisdictions are not clearly defined in the Colombian regulations, partly because the concept of the JREDD+ program has not yet been explicitly incorporated into the regulations. However, there are regulations that speak of the possibility of making payments for environmental services to indigenous communities, which could be extrapolated to other ethnic communities with collective ownership or control over a forest territory where they have historically carried out conservation activities and can continue to develop them in the future.

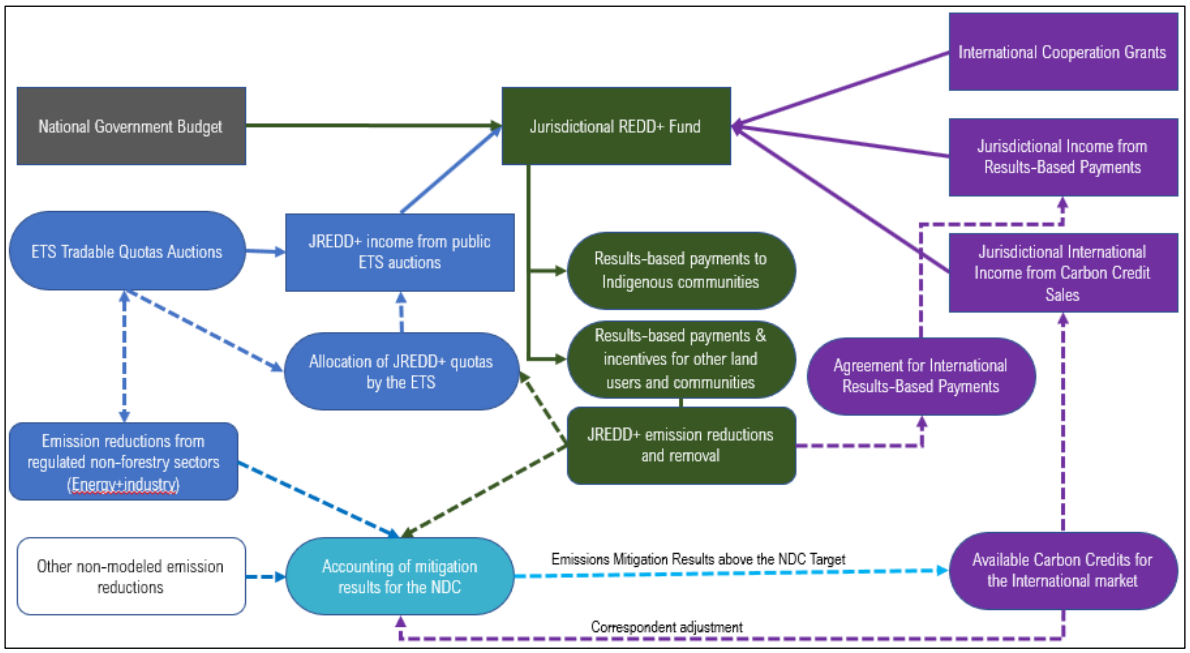
Regarding the definition of the benefits associated with ethnic communities, particularly indigenous communities, a joint construction process is expected to be carried out to define them. Decree 1007 of 2018 indicates that, in general, the valuation method used for PES is the opportunity cost of the land. However, Decree-Law 870 of 2017 indicates that the implementation of PES on indigenous territories (ancestral territories) must be regulated by the rules of the PES, the precepts of " higher law", "own law", " law of origin" and the environmental laws of the indigenous communities The Ministry of Environment and Sustainable Development and the Permanent Committee for Consultation must issue guidelines for calculating PES in the case of indigenous peoples, taking into account cultural and spiritual intangibles. However, this has not yet been developed and implemented (Econometría Consultores, 2022a).

4 MODEL SPECIFICATION

The objective of this model is to simulate the emissions mitigation results and resource flows of a national jurisdictional program, where one of its funding sources consists of resources allocated by an emissions trading system. This is performed for different scenarios and assumptions for the period between 2024 and 2030.

In this sense, the results will depend both on the assumptions made about the operation of the ETS and on the criteria for the distribution of benefits within the jurisdictional program. The following diagram presents the different funding sources (rectangles) and resource flows (continuous arrows), as well as some processes (rounded boxes) including the generation of results in terms of emission reductions/removals, and the information flows on the results (dashed arrows).

Figure 1 - Sources of funding and modelled processes



Source: Own development by Uniandes-EDF-CEMR

4.1 Revenue sources for the jurisdiction

It assumes the existence of a national Fund that manages the resources of all national jurisdictions, received from the different established sources such as:

- Revenues coming from the national budget (IPN_t) allocated to the JREDD+. These may come from carbon tax revenues, the ETS, or other sources such as current revenues, or financing projects from the General Royalties System.
- Grants from international cooperation agreements (ICI_t) other than those corresponding from result-based payment.

- Revenues from sales of tradable emission allowances (IVC_t). These revenues will depend on the results in terms of recognizable emission reductions with allowances[10] (REC_t), and on the price of the allowances defined in the current year's ETS auction (PSC_t), which in turn depends on supply and demand interacting in the allowance market.
- Revenues from international result-based payment[11] (IPR_t) agreements, which depend on the amount of emissions from the previous year that are eligible for result-based payments (REP_{t-1}), and the price agreed with those who grant these payments (PPR_t), such as the LEAF Coalition or other non-market cooperation entities.
- Revenues from carbon credit sales in the international voluntary market (IMVt), which depend on the availability of emission reductions for the voluntary market[12] (REM_{t-1}), and the international voluntary market price (PMV_t).

Thus, the total jurisdictional income (ITJ_t) in each year will be:

$$ITJ_t = IPN_t + ICI_t + IVC_t + IPR_t + IMV_t \quad \text{Equation 1}$$

$$ITJ_t = IPN_t + ICI_t + PSC_t * REC_t + PPR_t * REP_{t-1} + PMV_t * REM_{t-1} \quad \text{Equation 2}$$

The first step of the model process is to calculate the remaining revenues available from these incomes after deducting the pre-established payments for conservation activities to ethnic communities in all jurisdictions[13] (BCE_{jt}) (Section 3.3.3).

$$IRD_t = ITJ_t - \sum_{j=1}^{J} BCE_{jt} \quad \text{Equation 3}$$

The remaining revenues will be earmarked for emission mitigation programs and projects carried out by other stakeholders and/or land users (IRD_t). Taking into account the cost structure of these activities, the National Fund responsible for administering the resources must make an optimal allocation of resources to finance the most cost-efficient set of mitigation measures. In other words, the allocation of resources must achieve the greatest possible reductions taking into account the costs of the different existing measures.

4.2 Decision on forestry emission reductions

The forest jurisdiction manager seeks to maximize total benefits from reduced deforestation B_t subject to the budget constraint and the mitigation potential of each period t. The total benefits in period t are given by.

[10] As explained by the CEMR (2022), the regulation of the Climate Change Act may incorporate conditions and restrictions for the delivery of these allowances, so that the total emission reductions of the previous year would not necessarily be fully recognized with tradable emission allowances during the current year.
[11] These are bilateral agreements or through the GCF or LEAF coalition where countries or subnational jurisdictions receive payments without having to transfer titles to their REDD+ results (TNC, 2022).
[12] Which are those that exceed the trajectory towards the goal.
[13] In the section 4.6 a proposal for Benefit Sharing is presented.

$$B_t = \sum_{kt} (p_t - c_{kt}) \times r_{kt}$$ Equation 4

where $p_t - c_{kt}$ represents the net benefits of implementing strategy *k* in period *t* and r_{kt} is the emissions reductions from implementing that measure. All prices are in constant 2022 US dollars. Total emission reductions in period t are given by $R_t = \sum_{kt} r_{kt}$. The budget constraint is given by the condition where the sum of the costs of emission reduction measures c_{kt} must be less than or equal to the revenues from the previous period IRD_{t-1}. Particularly, c_{kt} denotes the unit cost of reduction using the measure k in each period. Furthermore, it is not possible to reduce emissions beyond each measure's potential for each period or $\overline{r_{kt}}$. The optimization problem to be solved each period *t* can be expressed as follows:

$$\max_{r_{kt}} B_t$$ Equation 5

subject to:

$$\sum_{kt} c_{kt} \times r_{kt} \leq IRD_{t-1}$$ Equation 6

$$0 \leq r_{kt} \leq \overline{r_{kt}} \quad \text{for all } k$$ Equation 7

This optimization problem can be solved deriving the corresponding Kuhn–Tucker conditions[14]. In practice, we implemented a simple algorithm in Microsoft Excel® that maximized total emissions reductions each period or R_t, instead of B_t, subject to the corresponding restrictions.

4.3 Abatement cost curve

In order to achieve the optimization of the model, it is necessary to use an abatement cost curve. This curve is calculated by ranking the costs of each forest emissions mitigation measure $k$from lowest to highest, in relation to the emissions reduction potentials of these measures. This ensures that the maximization process complies with the cost efficiency condition. In particular, the implementation of silvopastoral systems, avoided deforestation activities and restoration processes were considered as mitigation measures.

In this particular case, the mitigation costs constructed for Colombia in 2021 by the CEMR[15]were used. These costs were calculated by type of activity for each of the country's biomes (Centro de Estudios Manuel Ramírez, 2021). Table 1 contains the following: 1) calculations of opportunity costs plus intervention costs; 2) column with total abatement costs

[14] Following a Lagrangean appach, the maximization problem in period *t* is given by:

$$\max_{r_{kt},\lambda,\gamma_{kt}} \sum_{kt} (p_t - c_{kt}) \times r_{kt} + \lambda_t \times \left[IRD_t - \sum_{kt} c_{kt} \times r_{kt} \right] + \sum_{kt} \gamma_{kt} \times [\overline{r_{kt}} - r_{kt}],$$

where λ_t and γ_{kt} for all *k* are the Lagrangean multipliers.

[15] Data was produced for the cost-effectiveness study of forest restoration and management actions conducted by the World Resources Institute (2021).

including administrative costs, monitoring costs, and a profit margin for each measure (USD 0.25/tonCo2); 3) potential emission reductions; 4) cumulative potential reductions per year, for each mitigation measure. Overall, it is observed that the implementation of silvopastoral systems are the least expensive, while restoration activities are the most expensive. However, the order of the costs of these measures varies according to the characteristics of the biome. For example, in the Pacific biome, restoration activities are less expensive than avoided deforestation.

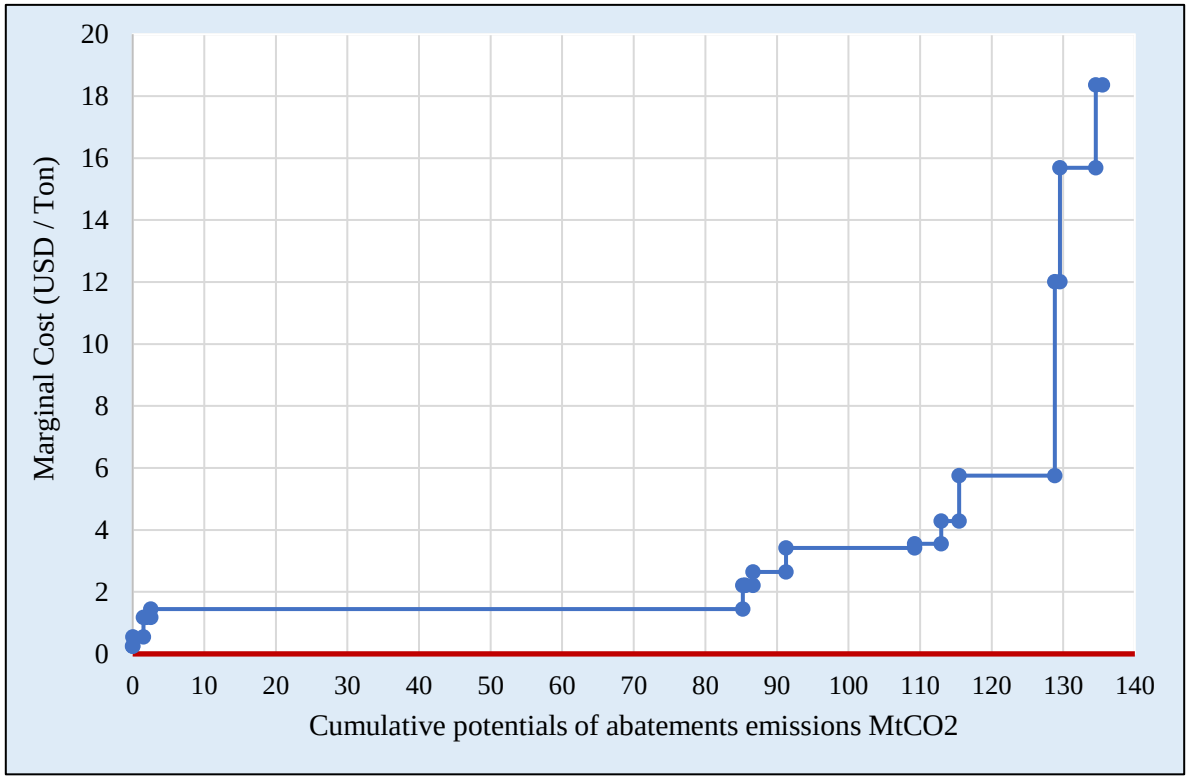
Table 1 - Marginal abatement costs

Type	Biome	Opportunity Costs + Intervention USD/tCO2	Total abatement cost including administrative, follow-up and utility costs USD/tCO2	Reduction Potential MtCO2 reduction per year	Cumulative Reduction Potential MtCO2 reduction cumulative year
Silvopastoral system	Pacific	0.00	0.25	0.05	0.05
Silvopastoral system	Caribbean	0.30	0.55	1.45	1.50
Silvopastoral system	Amazon	0.92	1.17	0.35	1.84
Silvopastoral system	Orinoquía	0.92	1.17	0.69	2.54
Avoided Deforestation	Amazon	1.20	1.45	82.71	85.25
Silvopastoral system	Andes	1.96	2.21	0.30	85.55
Restoration	Pacific	1.96	2.21	1.12	86.67
Avoided Deforestation	Caribbean	2.39	2.64	4.60	91.27
Avoided Deforestation	Andes	3.17	3.42	17.98	109.25
Avoided Deforestation	Pacific	3.30	3.55	3.71	112.97
Avoided Deforestation	Orinoquía	4.03	4.28	2.47	115.44
Restoration	Amazon	5.50	5.75	13.39	128.83
Restoration	Caribbean	11.76	12.01	0.71	129.54
Restoration	Andes	15.43	15.68	5.01	134.54
Restoration	Orinoquía	18.12	18.37	0.96	135.50

Source: Uniandes-EDF-CEMR based on (Centro de Estudios Manuel Ramírez, 2021)

Figure 2 presents the abatement cost curve for forestry measures, which is constructed by relating the marginal abatement costs and reduction potentials, ranking from lowest to highest marginal cost, and accumulating the corresponding emission reduction potentials.

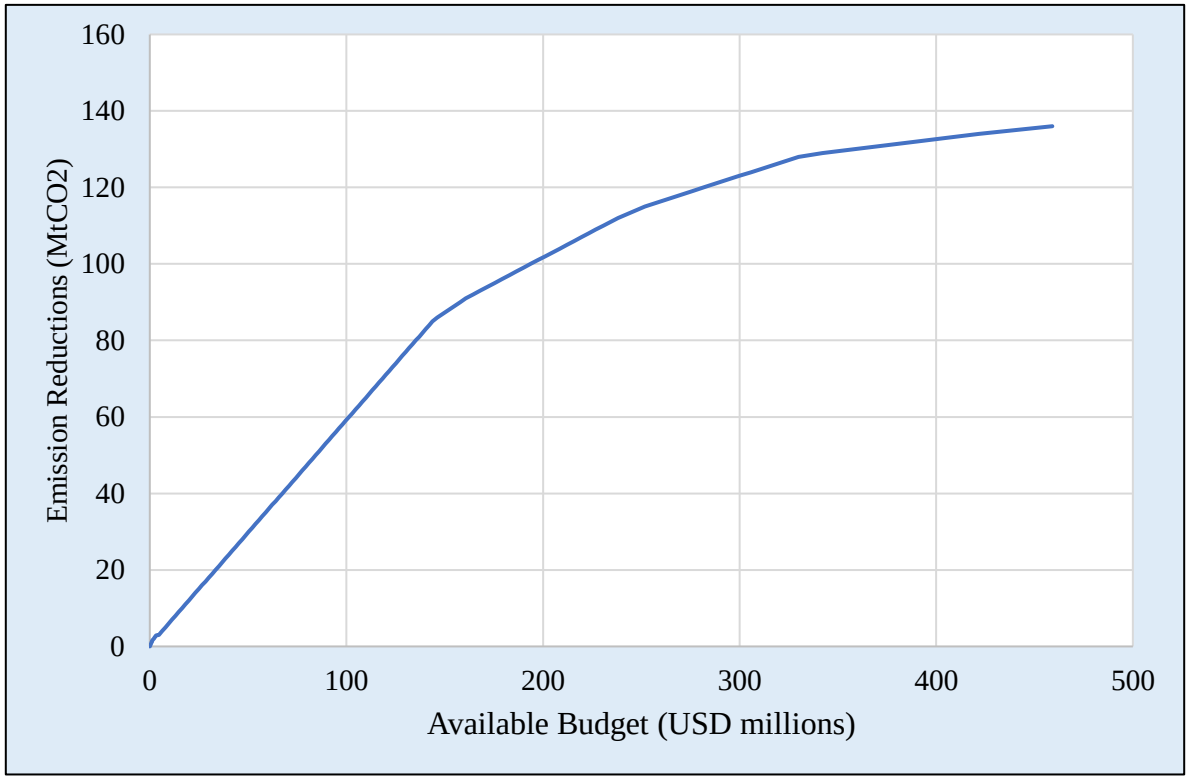
Figure 2 Abatement Cost Curve for forestry measures



Source: Uniandes-EDF-CEMR based on (Centro de Estudios Manuel Ramírez, 2021a)

Based on this curve, it is possible to calculate the relationship between the budget available for mitigation and the volume of emissions that can be reduced with these resources. This relationship is shown in Figure 3.

Figure 3 Possible reductions according to available budget



Source: Uniandes-EDF-CEMR based on Figure 2

Finally, it is necessary to define in the accounting of this model the maximum amount of emissions that can be reduced during the period under study. For this purpose, it should be noted that emission reductions at the national level are measured in relation to a national reference level of forest emissions ($NREF_t$),[16] which is calculated as the forest emissions pathway in a scenario in which there are no interventions to reduce deforestation (*Business as usual*). Therefore, emission reductions generated by mitigation measures cannot exceed baseline emissions. Consequently, feasible emission reductions (REF_t) can be defined as the minimum between the optimal total reductions and emissions at the reference level.

$$REF_t = min(R_t, NREF_t) \qquad \text{Equation 8}$$

4.4 ETS pricing

This model assumes the implementation of an ETS in which the primary market for tradable allowances is of a monopolistic nature, since the National Government is the only agent that issues emission allowances through an auction or primary market for regulated sectors. Specifically, it is assumed that the ETS will regulate emissions from the energy sector (energy consumption of all economic sectors) and emissions associated with non energy-related processes within the industrial sectors.[17] For this purpose, it is assumed that the

[16] This level is known in English as FREL but for the equations we will use the acronym in Spanish NREF

[17] According to Colombia's ETS design study, it could also cover fugitive emissions from the power sector (Vivid Economics, Econometría, EDF, 2020b).

number of allowances offered to these sectors must correspond to the emissions target defined by the country for each year, which must be less than or equal to the reference level of these sectors (Business as Usual). It is also assumed that the price of this allowances is unique, or that the price of the allowances in the primary and secondary markets will tend to move around the same value, to facilitate the model.

On the other hand, this model considers that the non-causation mechanism of the carbon tax has been replaced by granting allowances to jurisdictional programs. This means that the National Government can grant a percentage of the emission allowances to the JREDD+ program, depending on the level of emission reductions achieved in each year, which would be purchased by agents belonging to the regulated sectors. This would function as a source of funding for the JREDD+ program, assuming that these allowances will be sold by the National Government in the primary market, who will then allocate these revenues to the jurisdictional program.

Tradable emission allowances demand represents the willingness to pay by regulated agents and it is determined by the production of the regulated sectors, their emission factors for non energy-related processes, and their energy consumption (Sousa, y otros, 2018). Thus, the total demand will be equivalent to the greenhouse gas inventory for the IPCC[18] energy and industrial process sectors. As a result, it is expected that the willingness to pay for emission allowances will be influenced by the following aspects:

- **The marginal cost of the mitigation measures that could be implemented by each regulated agent.** All else equal, the model assumes that if the price of an allowance is higher than a mitigation measure's costs, the agent will prefer to implement the mitigation measure, thus avoiding the need to purchase emission allowances.
- **Expectations of price increases.** In an ETS it is known that the emissions target (cap) size each year must be smaller in order to reach the target in the foreseen horizon. This could mean that, if there is the possibility of using current allowances in the future, the current demand for issuance allowances will increase, and with it the willingness of agents to pay in order to secure ownership of these allowances. With this, regulated actors can reduce the uncertainty of allowance prices in the future.
- **The cost of penalties**. Fines or other penalties associated with unmet emissions reduction requirements may also increase willingness to pay for allowances, since the number of allowances offered is lower than the demand for them. The risk of not being able to reduce emissions and having to pay the fine makes agents willing to pay a little more.

The last two factors are difficult to quantitatively estimate. They depend on agents' perceptions and expectations, as well as on their risk propensity, and these factors can hardly be measured when agents do not yet know either the instrument or their GHG emissions. Although using the marginal abatement costs of the industrial and energy sectors may somewhat underestimate agent´s willingness to pay and lead to simulating lower prices, this allows us to work on a conservative scenario against the possible revenues from the ETS. Table 2 presents the cost

[18] For the emissions inventory according to the Intergovernmental Panel on Climate Change (IPCC) classification, see the Annex to Colombia's biennial report to the UNFCCC. (IDEAM et. al., 2021)

per ton of the positive net cost measures included in an abatement cost study developed by the Universidad de los Andes (Uniandes, 2014). The abatement potentials ($\bar{e}_{m,i,t}$) were adjusted to make them compatible with the latest GHG inventory available for these sectors (IDEAM et. al., 2021). The above was done: 1) calculating $s_{m,i,t}$ the emissions share $e_{m,i,t}$ of mitigation measures m over the total 2014 emissions of the regulated sector i ; 2) multiplying the share of each mitigation measure by the net emissions of each sector c in 2018 $e_{c,i,t+1}$.

$$s_{m,i,t} = \frac{e_{m,i,t}}{\sum_{m}^{M} e_{m,i,t}}; donde \qquad \text{Equation 9}$$

$$m(m_1, \dots, m_n);\ i(energy, industry);\ t(2014{,}2018)$$

$$\bar{e}_{m,i,t} = s_{m,i,t} * e_{c,i,t+1} \qquad \text{Equation 10}$$

Table 2 - Abatement costs of industrial and energy measures

Mitigation Measure	Original Potential Reduction ($MtCO_{2e}$)	Original Potential Reduction adjustment [1] ($MtCO_{2e}$)	Cost-effectiveness (USD/ tCO_2)	Adjusted Cumulative Potential ($MtCO_{2e}$)
Electric vehicles in the public transportation fleet-Transportation	13.0	3.3	206.0	3.3
Hybrid vehicles in the private transportation fleet-Transportation	9.0	2.3	125.0	5.7
Hybrid portfolio ZNI 2-Elec Group	0.1	0.0	98.0	5.7
Hybrid portfolio ZNI 1-Elec Group	0.03	0.0	71.0	5.7
CO2 capture and storage in refineries-Hydrocarbons	20.0	12.1	65.0	17.8
Electric vehicles in the private transportation fleet-Transportation	19.0	4.9	59.0	22.7
Electric vehicles in mass transportation fleet (main cities)-Trans	17.0	1.5	56.0	24.2
Substitution of road to rail transportation-Transportation	6.0	1.5	51.0	25.8
CO2 capture and geological storage - Cement-Industry	27.0	4.6	47.0	30.4
Photovoltaic solar energy in refineries-Hydrocarbons	8.0	2.7	43.0	33.1
Hydrogen recovery in ammonia production-Industry	0.4	0.2	34.0	33.3
Thermal energy management and fouling control-Hydrocarbons	20.0	6.8	33.0	40.1
CNG Cargo Fleet-Transportation	18.0	4.6	28.0	44.7
Methane recovery in underground coal mines-Hydrocarbons	0.6	13.2	13.0	57.9

Mitigation Measure	Original Potential Reduction ($MtCO_{2e}$)	Original Potential Reduction adjustment [1] ($MtCO_{2e}$)	Cost-effectiveness (USD/ tCO_2)	Adjusted Cumulative Potential ($MtCO_{2e}$)
Improved performance standards in private transportation and Green driving-Transport	33.0	8.5	12.0	66.4
Preheating of water with solar energy-Residencial	4.3	5.6	10.0	72.1
Recycling - transversal-Industry	55.0	18.7	4.0	90.7
Production changeover from wet to dry process - Cement-Industry	15.0	4.3	4.0	95.0
SIN alternative UPME 4B + Non-conventional renewables-Electricity	53.0	8.3	1.0	103.4
Improving bagasse boiler efficiency - Food & Beverage-Industry	25.0	2.8	0.4	106.1

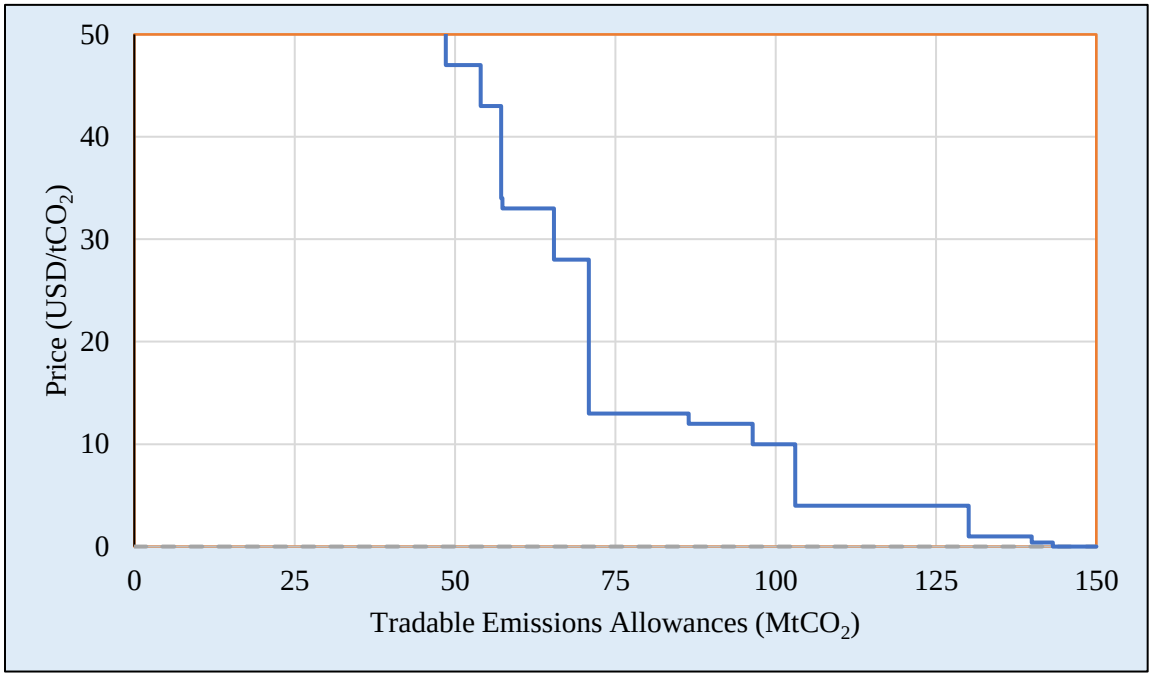
Note: [1] Measures that had an identifiable GHG inventory in 2018 were assigned that value as an adjusted potential reduction.

Source: Uniandes-EDF-CEMR based on Uniandes(2014)

Abatement costs are at 2014 prices; however, there are no subsequent studies that update them. Although it could be considered an inflationary effect, it can also be considered that the prices of technology, especially emissions mitigation technology, have been falling in recent years due to the increase in supply in international markets (Niranjan, 2020). Therefore, the initial cost estimates are retained as indicative of the proportions between measures, since there is no better alternative information that could lead to a more accurate demand curve.

Based on this information, the demand curve is obtained by accumulating the potentials in descending order of the abatement cost, as a proxy of the regulated agents' willingness to pay.

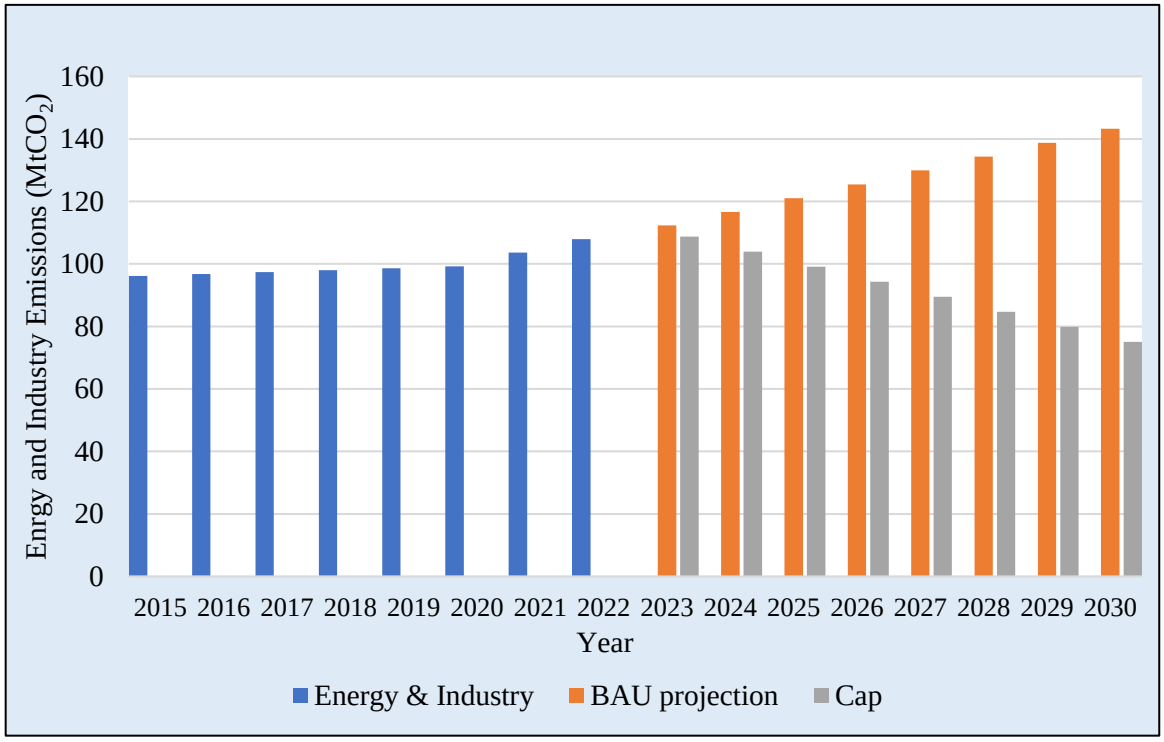
Figure 4 Assumption on the demand curve for tradable emission allowances



Source: Uniandes-EDF-CEMR based on Uniandes (2014)

The supply curve, on the other hand, is price inelastic and is constituted by a vertical line located at the amount of emissions corresponding to the cap of each year. To determine the cap, the simplest method is to project the emissions pathway of the regulated sectors assuming a scenario without ETS intervention, or Business as Usual scenario. Once the projection up to 2030 is available, the emissions target can be calculated, which in the Colombian case is defined as 51% of the projected emissions in that same year. Then, to find the trajectory of the cap, the emissions are interpolated taking as a starting point the year immediately prior to the ETS implementation, and ending in the year 2030 (Figure 5). The period chosen for the simulation of the model is from 2024 to 2030.

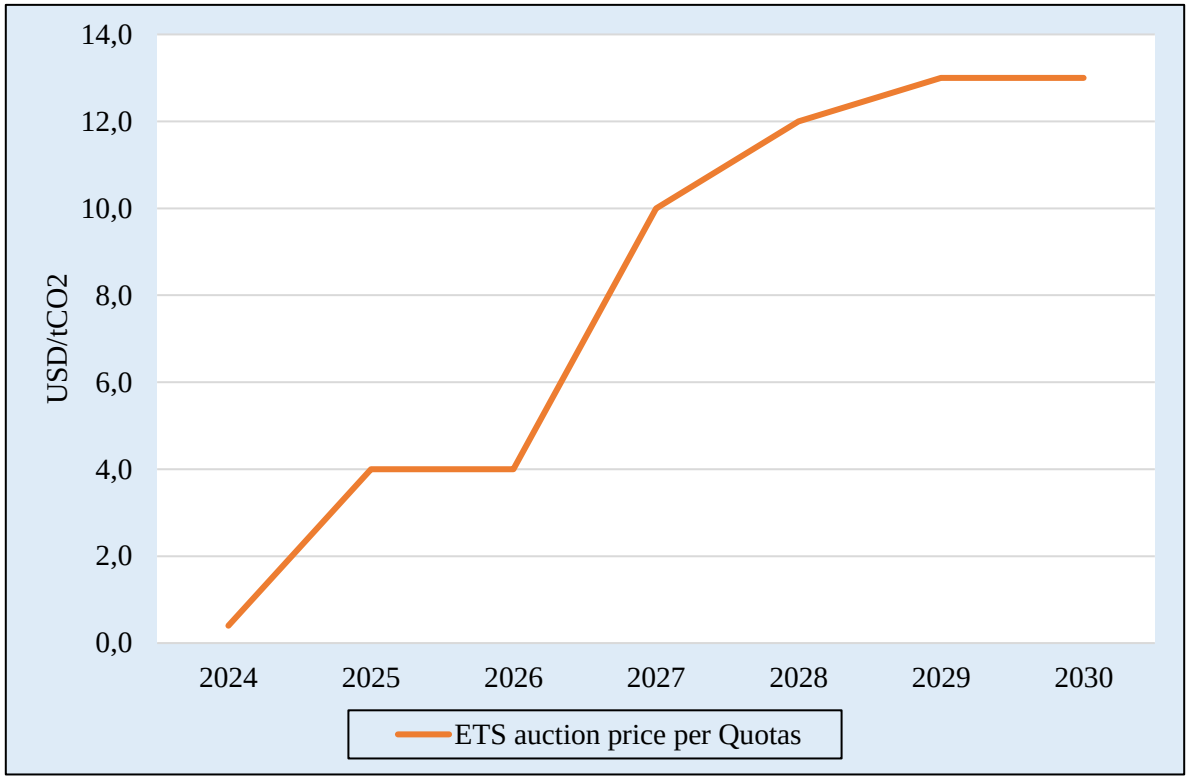
Figure 5 Assumption concerning the trajectory of the cap



Source: Projections by Uniandes-EDF-CEMR based on IDEAM and others. (2021)

Starting from the cap projection and the estimated demand curve, an estimate of the behavior of the market equilibrium price (PEM_t) between 2024 and 2030 can be obtained, as shown in the following figure.

Figure 6 ETS allowance price trajectory



Source: Projections made by Uniandes-EDF-CEMR

Due to the fact that in the first years of the ETS the market price is very low (even lower than the carbon tax US$4), a proposal is made to establish a floor price (PP_t) for the auction, which is equivalent to the value of the carbon tax in the corresponding period. This would guarantee that the carbon price does not fall below the tax already established. In other words, if the market equilibrium price (PEM_t) is below that floor price, the auction price will be the floor price, and the total auction revenue (ITS_t) will be calculated at that price.

$$PSC_t = \min(PEM_t; PP_t) \qquad \text{Equation 11}$$

$$ITS_t = PSC_t * CAP_t = \min(PEM_t * CAP_t; PP_t * CAP_t) \qquad \text{Equation 12}$$

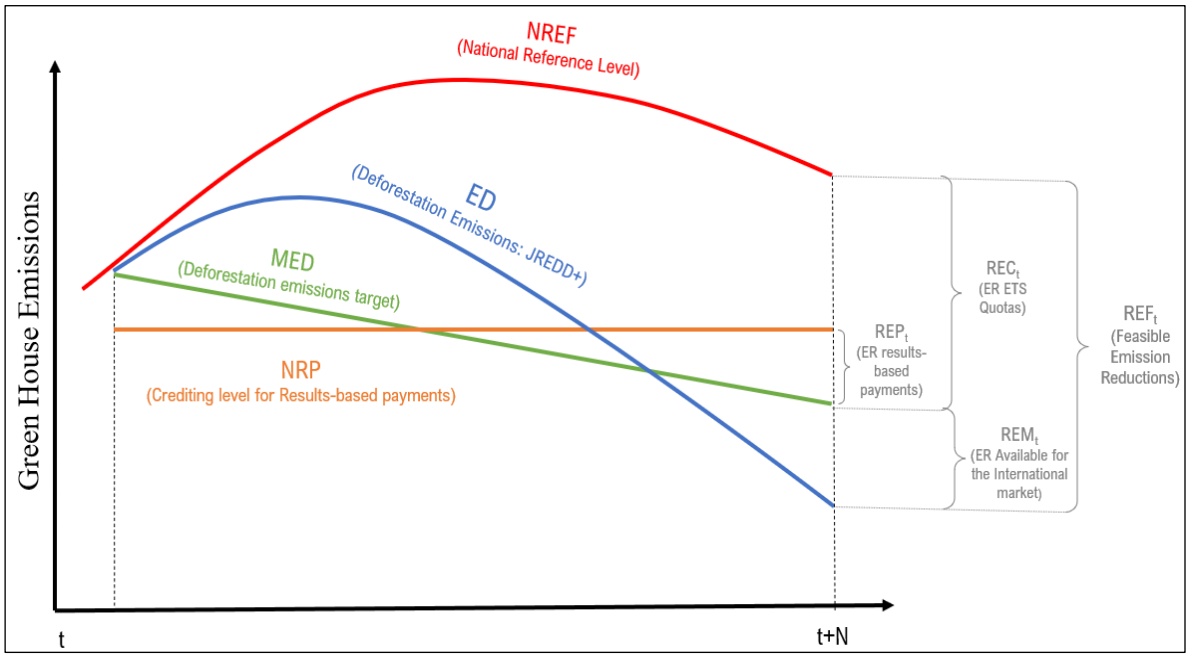
When the price is restricted in an auction, it may happen that the demand for allowances is reduced and not all the allowances issued are sold. However, taking into account the two factors previously mentioned (price expectations and the possibility of penalties), it is considered that agents with payment availabilities lower than the floor price (due to their low abatement costs), could be willing to pay the floor price to avoid the penalty or protect themselves against future price increases. For this reason, Equation 11 considers that the total of the allowances offered (determined by the cap) is sold at this price.

4.5 Recognizable emission reductions

In order to assess the revenues available for the national fund for JREDD+ programs, it is necessary to know how much of the emissions obtained can be recognized by the ETS, the non-market mechanism of result-based payment, and by the international voluntary market.

The following figure shows an example of the types of emission reductions that can be obtained in this context. It is necessary to consider these types of reductions in order to correctly value the income from the JREDD+ program. This will be explained in the following subsections.

Figure 7 Example of emission reductions by type of income



Source: Developed by Uniandes-EDF-CEMR

4.5.1 Recognizable reductions by the ETS

The LCC authorized MinAmbiente to deliver a tradable emission allowance for each ton of carbon reduced or removed from the atmosphere by mitigation initiatives of non-regulated agents. However, although MinAmbiente is authorized to do so, compliance is not mandatory. Taking into account the experience of other ETSs that limit the amount of emissions that can be offset with forestry reductions, in this particular model a maximum offset percentage of 20% of the cap was established. In this sense, if the effective reductions are less than this percentage, they are fully compensated, while if they are higher, the National Government will grant in allowances the equivalent of 20% of the cap.

On the other hand, the recognized reductions calculated for the ETS that exceed the target could be sold on the international market if the price is higher.

Thus, a policy coefficient ϕ is defined to simulate different levels of this constraint

1. $REC_t = \max(\min(REF_{t-1}; \phi * CAP_t); NREF_t - MED_t)$ Equation 13

4.5.2 Recognizable reductions for result-based payments

The amount of emission reductions recognized in a jurisdictional program's results-based payment scheme will depend on the type of agreement reached with bilateral funding partners or other mechanisms, such as the LEAF coalition, the GCF, or funds administered by the World Bank (Forest Carbon Partnership Facility FCPF, BioCarbon Fund, etc.). Although the Conservancy indicates that the availability of funds for this type of mechanism is not as high, these types of alternatives or programs can be additive or complementary, which facilitates the ability to generate higher revenues.[19]

The objective of the jurisdictional programs is to help the country meet its NDC targets, so offsetting forest reductions allows the country to maintain ownership of the credits and count them towards its NDC targets. In this case, the emissions from deforestation target is defined for the year 2030, thus an annual trajectory of the emissions from deforestation target was constructed that corresponds to the interpolation between the emissions from deforestation in 2023 (ED_{2023}) and the target in 2030 (MED_{2030}).

$$MED_t = MED_{t-1} + \left(\frac{1}{8}\right)(MED_{2030} - ED_{2023}) \text{ for } t=2024\ldots2028 \quad \text{Equation 14}$$

These results-based payment agreement programs consider a reference or baseline level of emissions from deforestation in the jurisdiction, where emissions below this level are credited as effective reductions for result-based payments. Generally, this baseline is defined by program standards as the average emissions from net deforestation[20] (Edt)ED_t) over a prior period to the implementation agreement. In this way, program standards recognize effective emissions reductions only when emissions mitigation is below the reference level for result-based payments (NRP_t). A complication generated by this mechanism is that the reference level of the standards of voluntary agreement programs do not coincide with the reference level of forest emissions (NREF) used by the country as a baseline for its accounting of reductions.[21]

For this model, the reference level of the ART-TREES standard is used to credit a jurisdiction's agreement for five years, which corresponds to the average deforestation for the five years prior to the beginning of the program. Assuming that the jurisdictional program starts in 2024, it is estimated that the reference level for crediting the period between 2024 and 2028 has an approximate value of 100.7 million tCo2. Now, to calculate the reference level for the remaining years of the study period, 2029 and 2030, the reference level is

[19] As in the case of the Visión Amazonía REM Program, which received result-based payments from three countries (Germany, Norway and the United Kingdom).

[20] Considering that it is measured by forest cover changes, it includes not only avoided deforestation but also forest growth through afforestation, reforestation, restoration, agroforestry and silvopastoral systems, as well as natural regeneration.

[21] This is the reference level established by the country before the UNFCCC.

recalculated according to the results obtained by the model simulation in the previous five-year period.

$$NRP_t = \left(\frac{1}{5}\right) \sum_{s=2019}^{2023} ED_s \text{ for t=2024…2028} \quad \text{Equation 15}$$

$$NRP_t = \left(\frac{1}{5}\right) \sum_{s=2024}^{2028} ED_s \text{ for t=2029, 2030} \quad \text{Equation 16}$$

Given that in general, contributors to these types of agreements to reduce deforestation do not review how the jurisdiction internally finances its results, the emissions recognized and compensated by the ETS could also receive payments for results derived from the JREDD+ program. This would make it possible to achieve complementary funding to implement deforestation mitigation measures in the jurisdiction.

This is valid within the Colombian legal framework[22] considering that, although the delivery of emission allowances by MinAmbiente for mitigation results is a form of accreditation of reduced emissions, the results-based payment of JREDD+ programs could not be considered an "offer through projects" in the market. As explained earlier, the result-based payment approach of a jurisdictional program does not generate double counting of emission reductions with the ETS, since it does not involve a transfer of ownership of carbon credits, does not require a corresponding adjustment in the country's carbon accounting, and is not carried out through a supply and demand market mechanism.

However, a parameter was included in the modeling to simulate the scenario in which there is a restriction on behalf of the donors that implies not recognizing the emission reductions that have been financed internally through the ETS. This restriction makes sense if it is assumed as an insurance for funders in case, they do not have sufficient resources to finance the country's total emission reductions. A parameter δ is then set that takes the value 1 if the emissions recognized for the ETS can be taken into account for the result-based payment of the JREDD+ program.

Additionally, it is necessary to consider in the model that jurisdictional carbon standards have rules associated with reducing the uncertainty of monitoring and verification processes of emission reductions, which imply a discount on recognizable reductions of each period. Specifically, discount rates associated with uncertainty due to deforestation leakage, measurement inaccuracies, political commitment to reduce deforestation, among others, are applied. As a consequence, the volume of certified results for each period is lower than the country's accounting. This decrease in accounting for emission reductions can be expressed as a factor ψ affecting the calculation of reductions, or as a decrease in the price affecting the settlement of revenue.

For this model, a discount factor of $\psi = 0.7$was assumed, which results in recognizable emissions for result-based payments:

[22] Paragraph of Article 175 of Law 1753 of 2015 indicates that "*Reduced emissions accredited by the Ministry of Environment and Sustainable Development in the framework of national or subnational GHG emission reduction programs, may not be subsequently offered through projects in the market*."

$$REP_t = \begin{cases} \psi * [(NRP_t - ED_t) - (1-\delta) * REC_t] & si\ EDt\ \leq NRP_t \\ 0 & si\ EDt\ > NRP_t \end{cases}$$ Equation 17

Where emissions from deforestation would be calculated as:

$$ED_t = NREF_t - REF_t$$ Equation 18

Notice that the last equation assumes that the different types of measures (including those that are not strictly deforestation control measures, but reforestation or sustainable development measures) reduce the net deforestation projected by the National Government in the NREF, and that the emissions that remain after the implementation of optimal measures are due to remaining deforestation that was not avoided or otherwise compensated for.

Thus, performance payments for eligible emissions are those that do not exceed the target but meet the reference level for performance payments. These are sold at a fixed price. For example, the LEAF Coalition defined a price of US $10/ton/$CO_2$ for jurisdictional programs.

4.5.3 Reductions to offer in the international voluntary market

According to Article 6 of the Paris Agreement, signatory countries can collaborate in centralized (Art. 6.4) or non-centralized (Art. 6.2) market schemes through ITMOs. This is as long as it does not generate double accounting. Thus, it is reasonable to assume that these results should not be delivered unless they achieve emission reductions above the trajectory to the NDC target for the forest sector[23].

Once the verified emissions reductions (REF_{t-1}) exceed the forest sector's NDC target reductions ($NREF_t - MED_t$), the surplus could be offered on the international voluntary market. The implications of this would be that credits sold in this market would grant ownership of the credits for a higher price, and would imply a corresponding adjustment in the country's carbon accounting. In other words, credits sold on the international market cannot be accounted for in the country's NDC, but their sale would function as an additional source of financing for forest emission reduction activities.

Thus, the reductions that can be offered in the international market are calculated as follows

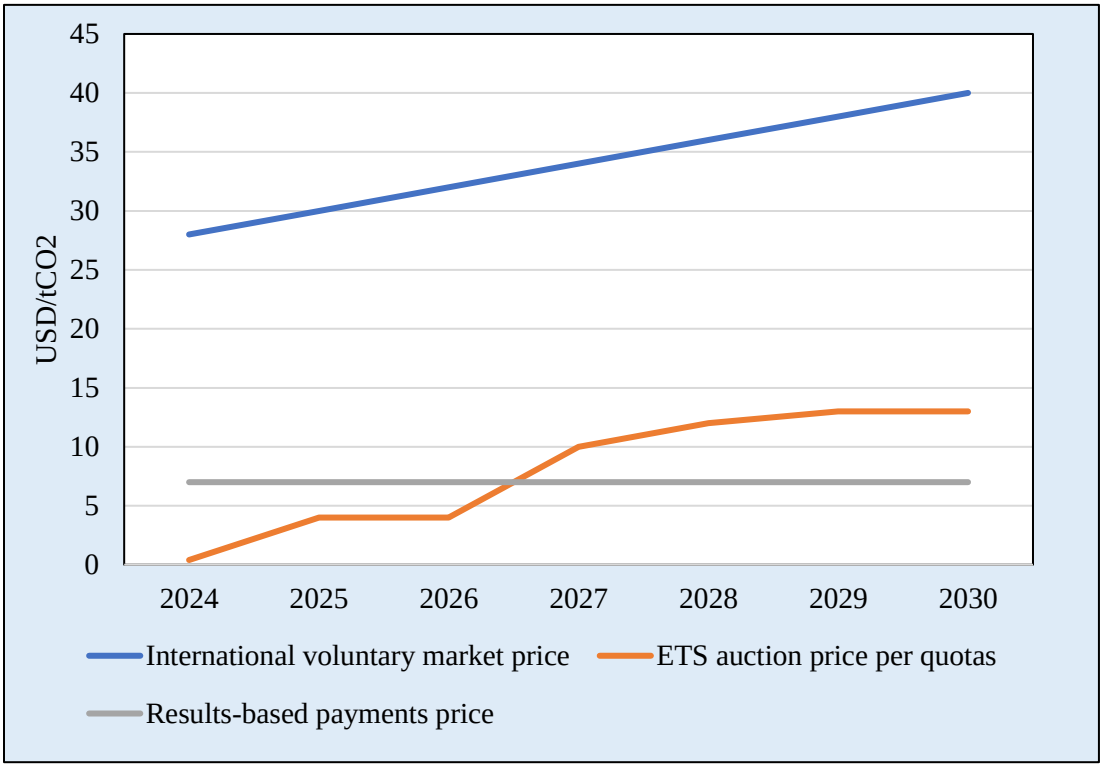
$$REM_t = min(0; REF_{t-1} - (NREF_t - MED_t\ )\ \text{for t=2024…2028}$$ Equation 19

These reductions are expected to be sold on the international market at a price higher than that of the ETS, or pay by results mechanisms. For the purposes of the model simulations, an increasing price between 28 USD/tonCO_2 and 40 USD/tonCO_2 was considered.

The Figure 8 allows us to compare the prices considered in the simulation, which did not change within the scenarios considered. Notice that to simplify the simulation, the adjustment factor ψ was applied directly to the result-based payment price.

[23] This means that they are offered if they obtain lower emissions than those of the trajectory to the deforestation emissions target calculated in 19.

Figure 8 - Assumption on carbon prices by income type



Source: Developed by Uniandes-EDF-CEMR

4.6 Benefit sharing mechanism.

In order to have a preliminary order of magnitude of the payment required under the PES concept, it was used an approximation of the government's opportunity cost to maintain the forest areas conserved by the indigenous. For this purpose, an average cost per ranger of US$6,000 per year was calculated, and a density of 6,337 ha/ranger, which corresponds to the international average. The cost of surveillance per hectare-year is calculated at US$0.94/ha, and this unit cost is applied to the area of forest within the reservations and collective territories for an annual estimate of US$29.2 million.

During the workshops for the socialization of results, as can be seen in product 5 of this study, there was significant participation by representatives of the indigenous peoples of the Amazon. In these workshops, the possibility of establishing other methods for calculating the payment of jurisdictional projects to indigenous peoples was raised. For instance, a percentage of the total costs of the program, and a cost of the projects required to develop the communities' life plan. It was also emphasized that in order to use payment for environmental services it is important to advance in the valuation of other ecosystem services in addition to the simple monitoring of the forest. For the purposes of this version of the model, the strategy described in the previous paragraph will be used, which guarantees the stability of benefits.

As for the determination of payments made to entities and executing partners, as well as incentives to producers and communities, it will be assumed that the values derived from the

marginal abatement cost curves will be remunerated. If the jurisdictional program can hire the execution of the intended measures with third parties for a fee per hectare or per beneficiary, it is reasonable to think that nested REDD+ projects that become implementing partners could receive a similar payment for that same work, thus avoiding the need to incur in validation, verification and certification costs. Thus, in the simulation model, the implementers receive the intervention cost that establishes the abatement curve according to their region and type of activity.

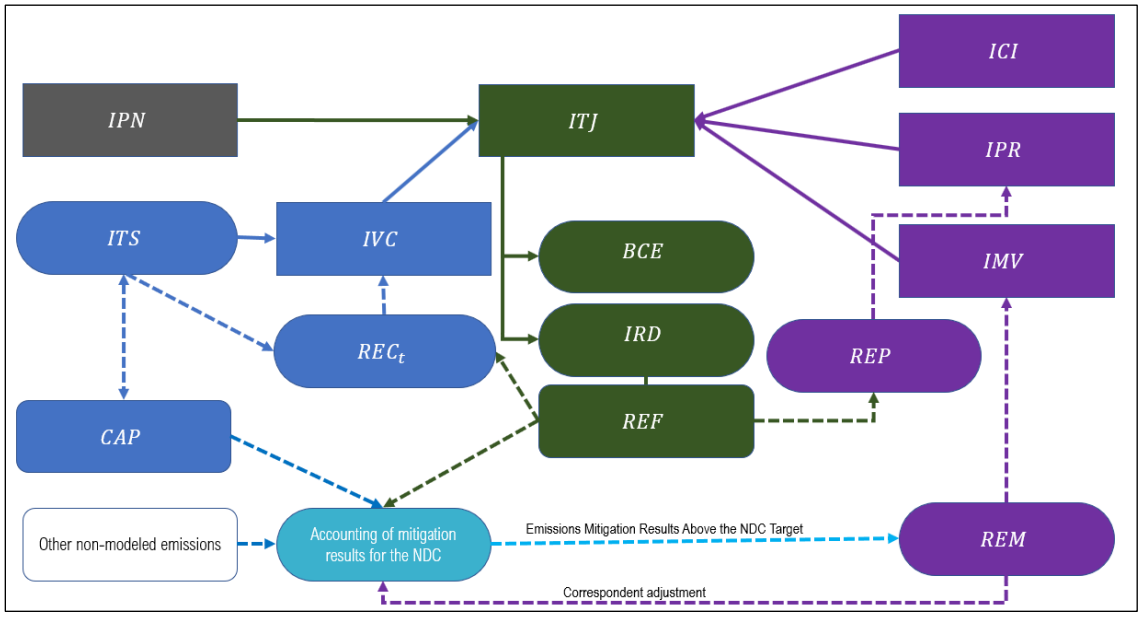
However, in the activities of involvement and socialization of the model, it was stated by the representatives of the voluntary market actors that the nature of the private projects implies the initiative of investment with the possibility of participating in the market. This would mean a regulation that recognizes the price of auctioning allowances to private project results and/or the possibility of international trading with the authorization of the Government when additional results to the NDC targets are achieved at the country level. This possibility will be considered for future versions of the model.

To distribute payments between incentives and intervention costs, the percentage found by CEMR of 63% for intervention costs and 37% for opportunity costs (incentives) is used. However, this does not affect the mitigation results of the model, as will be seen below, since they are considered in an integrated manner as part of the abatement curves.

5 SCENARIOS AND RESULTS

Figure 9 presents the main variables whose calculations have been described above, based on the diagram presented in Figure 1.

Figure 9 - Main variables of the model



Source: Developed by Uniandes-EDF-CEMR based on Figure 1

In order to establish the effects of the different financing mechanisms and their interaction, some of these flows will be varied for the simulations. On the other hand, other parameters will be kept invariant between scenarios to ensure comparability. These common parameters are:

- The amount of the annual benefits destined for ethnic communities
- The participation proportions between incentive payments and payments for implementers within the cost of the intervention.
- The annualized targets: the linear trajectory for the total NDC; the trajectory for net deforestation emissions target[24]; and the cap in scenarios that include ETS as this corresponds to the emissions target for the modeled non-forest sectors.
- The price trajectory of the auction of tradable emission allowances in ETS scenarios
- Pricing of results-based payment mechanism in the scenarios that include it and also incorporates the discount factor to use an equivalent effective price.
- The price projection of the international voluntary market in the scenarios in which it appears.
- Income from international cooperation donations is not considered, although it could be assumed that this is part of what is classified as national budget resources and would not affect the results.

5.1 Definition of scenarios

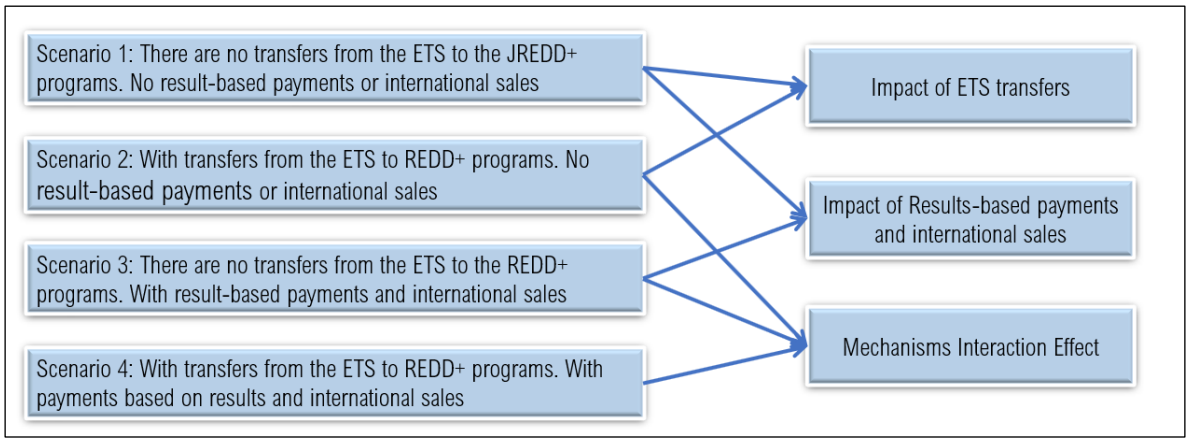
The definition of scenarios serves to evaluate isolated aspects of the system independently of other aspects that also influence the outcome. Four scenarios were defined:

- Scenario 1: There are no transfers from the ETS to the JREDD+ programs. No payment based on results or international sales.
- Scenario 2: With transfers from the ETS to REDD+ programs. No payment based on results or international sales.
- Scenario 3: There are no transfers from the ETS to the REDD+ programs. With payment based on results and international sales.
- Scenario 4: With transfers from the ETS to REDD+ programs and with payments based on results and international sales.

The effects to be measured are shown in the following figure:

[24] It is a forestry coverage target that considers reductions in deforestation and the increase of forest vegetation cover.

Figure 10 - Simulation scenarios



Source: Developed by Uniandes-EDF-CEMR

In the first scenario, only revenues from the National Government are considered. This makes it possible to know the cumulative cost that the Government would have to incur in order to meet the goals. For this reason, these revenues are calibrated so that they are adjusted to meet the trajectory of goal achievement without surpluses.

The second scenario, a limit for the delivery of allowances to the jurisdiction of 20% of the cap was assumed, that is, $\phi = 0.2$. This parameter was used to calculate the minimum contribution required from the National Government during the first two years, in order to meet the emissions reduction target by 2030, following any trajectory.

The third scenario uses the same national budget contributions found in scenario 2 for comparison purposes but incorporates the possibility of results-based payments and international market sales.

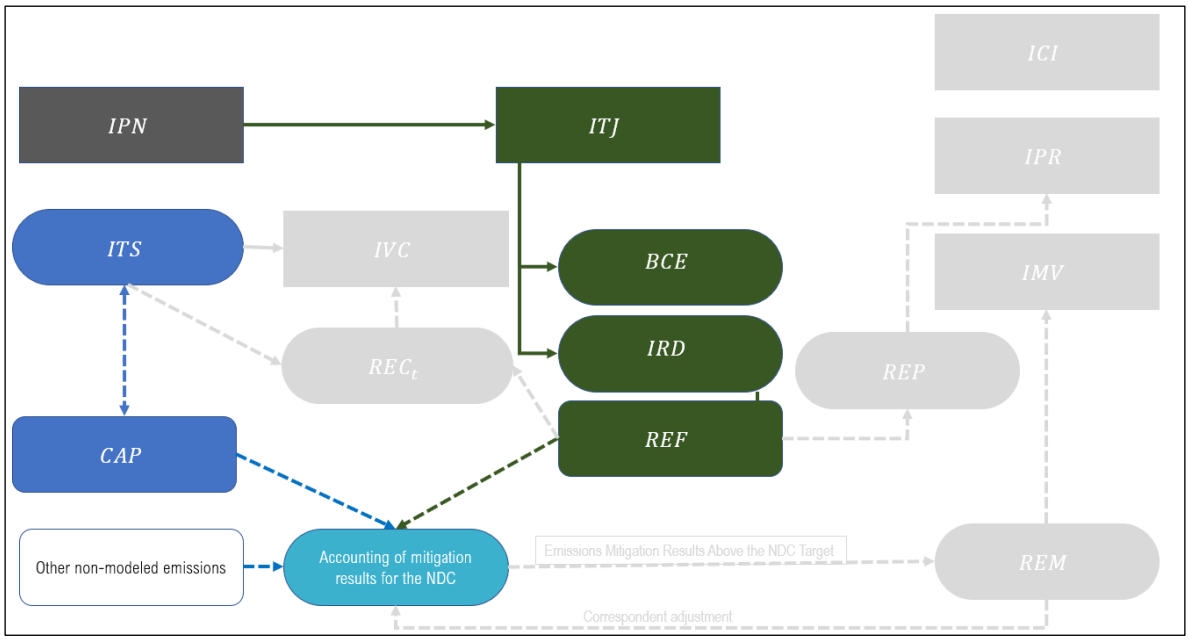
The fourth scenario also uses the same initial conditions of national budget revenues and contemplates the interaction between the ETS, result-based payments and international transfers.

5.2 Results

5.2.1 Scenario 1 (neither ETS nor International Results-based payments)

The first scenario does not include resources from the ETS or international sources and could be characterized as shown in the following figure:

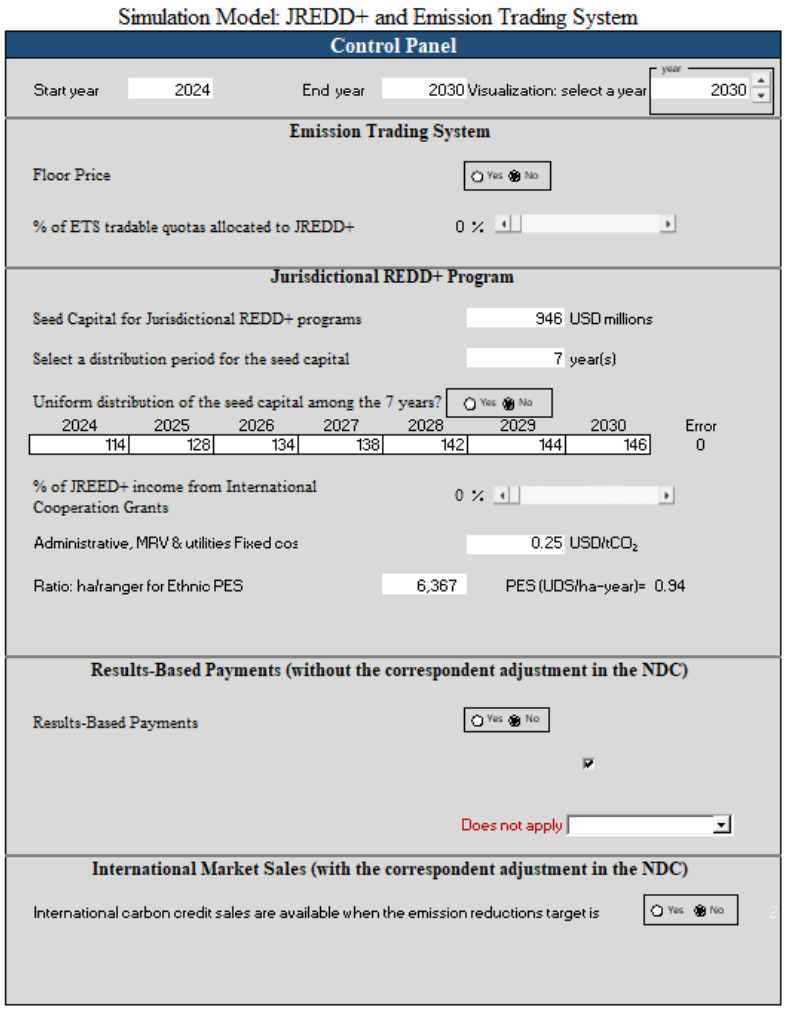
Figure 11 - Components of the model in scenario 1



Note: elements not included in this scenario are shown in gray.
Source: Developed by Uniandes-EDF-CEMR

The following figure presents the model control panel showing the parameters selected for scenario 1. Notice that it was necessary to consider an amount of US$ 946 million from the national budget distributed over the seven years of the simulation.

Figure 12 - Parameters for scenario 1



Source: Developed by Uniandes-EDF-CEMR

With these parameters, the following results are found in terms of projected emissions both in the 'Business as Usual' case and with the intervention of the JREDD+ Program. Projected emissions for the energy and industry sectors are included, as well as the cap trajectory representing the emissions obtained by the ETS. Although this scenario shows the emissions trajectory of the sectors covered by the ETS, it does not take into account revenues from the ETS for the JREDD+ program.

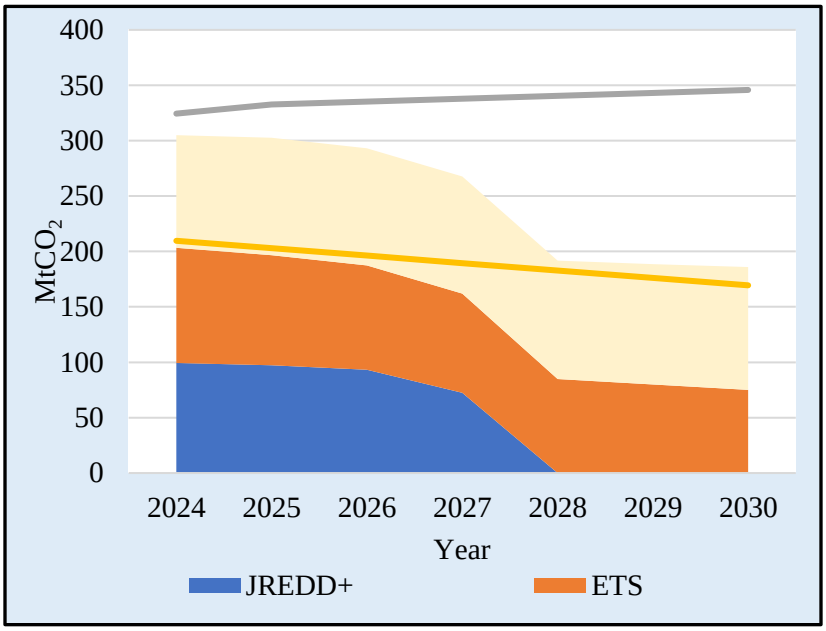
Table 3 - GHG emissions with and without intervention, for scenario 1

Carbon Emissions: BAU vs Intervention Mechanisms								
$MtCO_2$								
	Deforestation		Regulated Sectors: Energy & Industry		Total Emissions		Others: non-simulated	
Year	BAU	JREDD+	BAU	ETS	BAU	NDC	BAU	Remaning
2024	106.1	55.2	116.7	103.9	324.4	209.6	101.6	50.5
2025	105.7	46.6	121.0	99.1	332.7	202.9	106.0	57.2
2026	104.4	41.7	125.5	94.3	335.3	196.2	105.5	60.2
2027	102.2	37.2	129.9	89.5	337.9	189.5	105.8	62.8
2028	99.3	31.9	134.3	84.7	340.6	182.8	106.9	66.2
2029	95.8	27.3	138.8	79.9	343.2	176.1	108.6	69.0
2030	91.9	22.1	143.2	75.1	345.8	169.4	110.7	72.2

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

The figure below accumulates the emissions and compares them to the expected pathway to meet the total NDC.

Figure 13 - Projected emissions from scenario 1



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

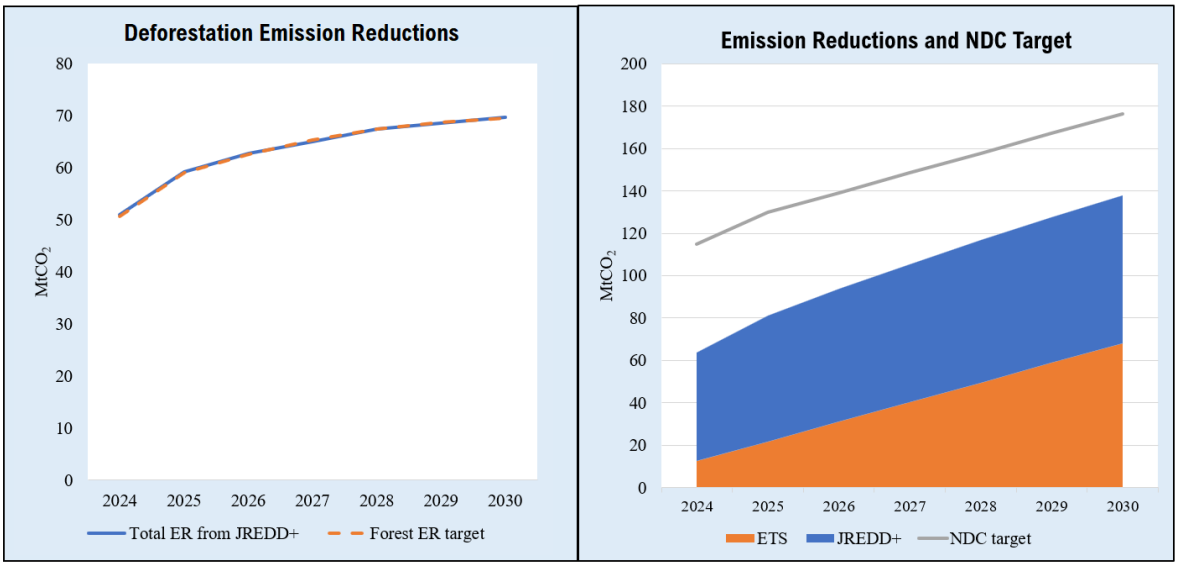
Table 4 is a derivation of the previous one as it counts the reductions made by each instrument and allows comparing the sum of the reductions achieved with the ETS and JREDD+ with the trajectory of the national NDC, and by difference it could be estimated the minimum level of reductions required by the non-modeled sectors (livestock, waste, etc.)

Table 4 - Emission reductions and performance accounting under scenario 1

Emission Reductions by Mechanism								
MtCO2								
Year	ETS Payments	Results-Based Payments	JREDD+	Correspondent Adjustment	JREDD+ after adjustment	ETS	JREDD+ & ETS	NDC target
2024	0.0	0.0	50.9	0.0	50.9	12.7	63.6	114.8
2025	0.0	0.0	59.1	0.0	59.1	21.9	81.0	129.8
2026	0.0	0.0	62.7	0.0	62.7	31.1	93.8	139.1
2027	0.0	0.0	65.0	0.0	65.0	40.4	105.4	148.4
2028	0.0	0.0	67.4	0.0	67.4	49.6	117.0	157.7
2029	0.0	0.0	68.6	0.0	68.6	58.9	127.4	167.0
2030	0.0	0.0	69.7	0.0	69.7	68.1	137.9	176.4

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 14 - Projected emissions from scenario 1



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

As can be seen in the figure on the left, the model has been forced to meet the target by allocating as much of the national budget as is required to achieve it, according to the abatement curve which is considered to be time invariant.

The accounting of revenues and expenditures is obvious, since the only source considered in this scenario is the national budget and it is fully executed. First, with the scheduled payment for the ethnic communities and then distributing the rest among projects, implementers (intervention costs), and in incentives for producers and communities (opportunity costs).

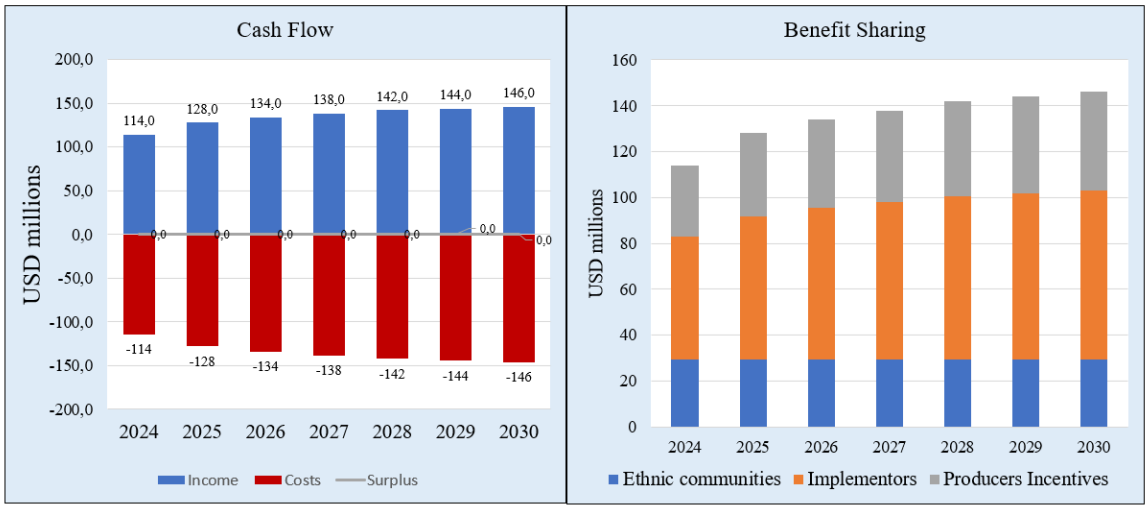
Table 5 - Incomes and expenses of the national JREDD+ program in scenario 1

JREDD+ Income							
USD millions							
	National Revenues		International	Result-based	International	Previous	
Year	Seed Capital	ETS	Cooperation Grants	Payments	credit Sales	Surplus	Total Income
2024	114	0.0	0.0	0.0	0.0	0.0	114.0
2025	128	0.0	0.0	0.0	0.0	0.0	128.0
2026	134	0.0	0.0	0.0	0.0	0.0	134.0
2027	138	0.0	0.0	0.0	0.0	0.0	138.0
2028	142	0.0	0.0	0.0	0.0	0.0	142.0
2029	144	0.0	0.0	0.0	0.0	0.0	144.0
2030	146	0.0	0.0	0.0	0.0	0.0	146.0

JREDD+ Expenses							
USD millions							
Year	Ethnic communities	Implementors	Producers Incentives	Total Cost	Ethnic communities	Implementing Partners	Producers Incentives
2024	29.2	53.5	31.2	114	25.6%	47.0%	27.4%
2025	29.2	62.4	36.4	128	22.8%	48.7%	28.4%
2026	29.2	66.2	38.6	134	21.8%	49.4%	28.8%
2027	29.2	68.7	40.1	138	21.2%	49.8%	29.0%
2028	29.2	71.2	41.6	142	20.6%	50.1%	29.3%
2029	29.2	72.5	42.3	144	20.3%	50.3%	29.4%
2030	29.2	73.7	43.0	146	20.0%	50.5%	29.5%

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 13 - Distribution of income and expenses of the national JREDD+ program in scenario 1



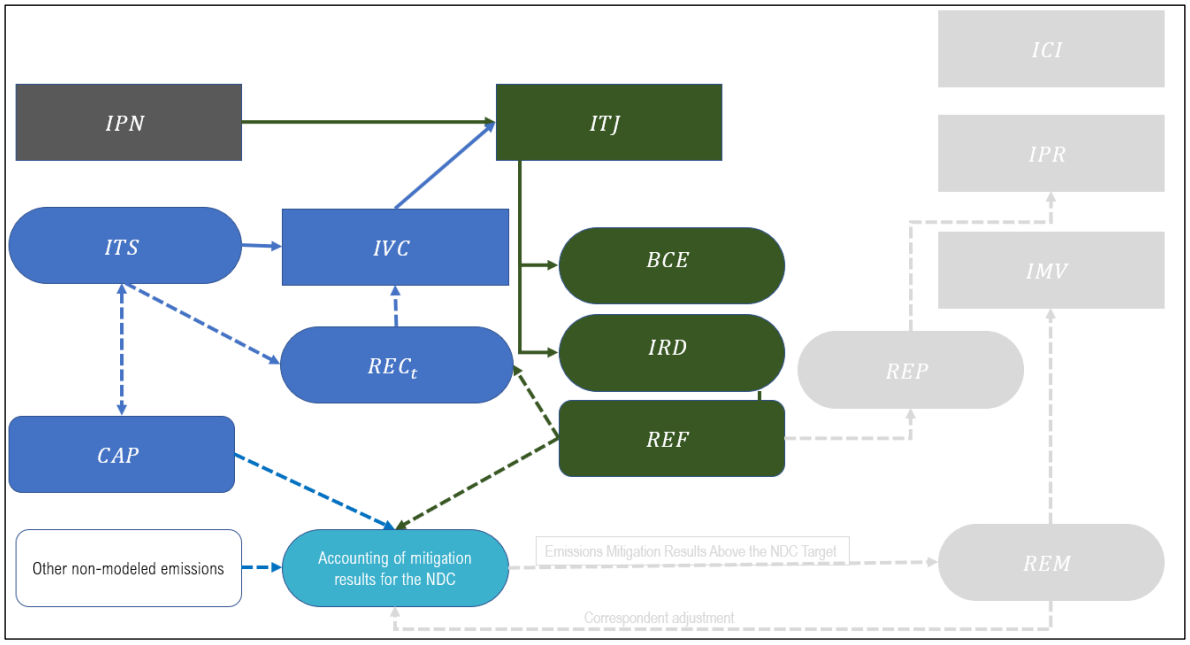
Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

To the extent that the annual flow of costs does not show very large fluctuations but rather a slow growth, the resulting distribution percentages are also relatively stable.

5.2.2 Scenario 2 (ETS only)

The second scenario includes resources from the ETS but not from international sources. In other words, the model calculates the minimum national budget required to achieve the forest conservation goal when additional resources are generated by the ETS. This scenario could be characterized as shown in the following figure:

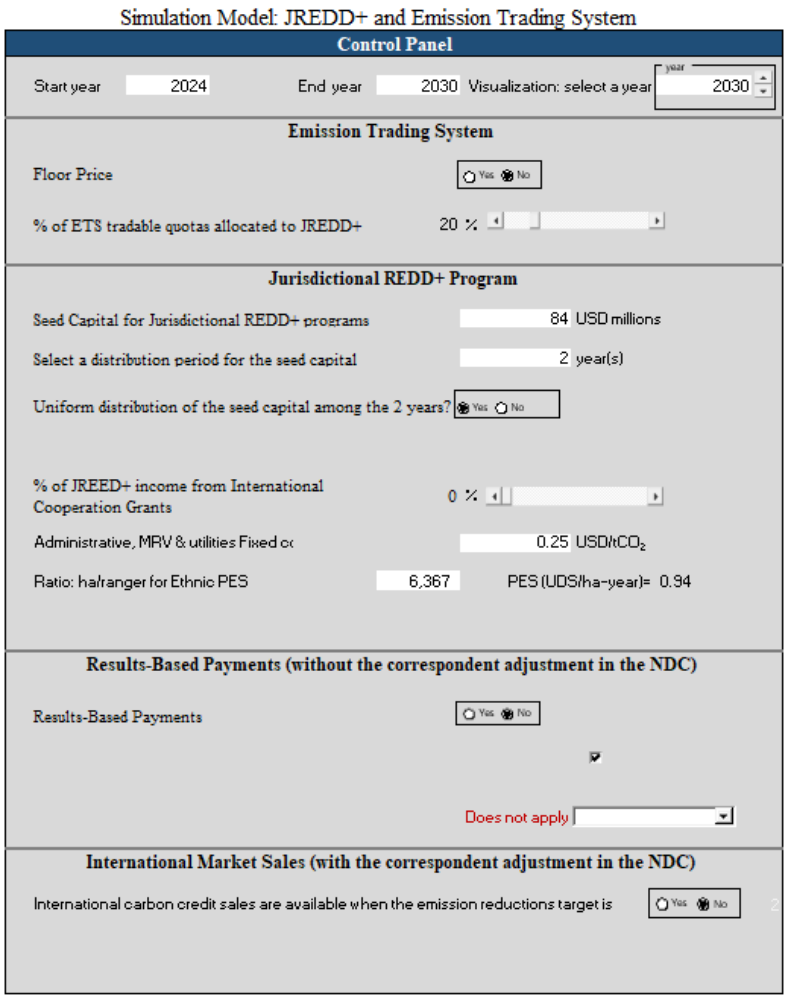
Figure 14 - Components of the model in scenario 2



Note: elements not included in this scenario are shown in gray.
Source: Developed by Uniandes-EDF-CEMR

The following figure presents the model control panel showing the parameters selected for scenario 2. This scenario incorporates possible resource transfers from the ETS and reduces the national budget contribution to the first two years and by the amount needed to meet the 2030 target. In this case, the amount is US$42 million for each of the two years, for a total of US$84 million.

Figure 15 - Parameters for scenario 2



Source: Developed by Uniandes-EDF-CEMR

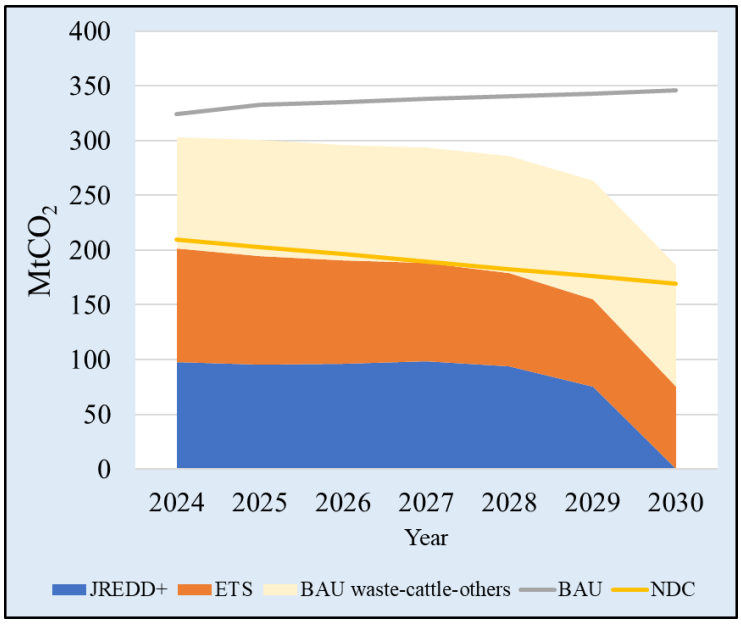
With these parameters, the following results are found in terms of projected emissions in the 'Business as Usual' scenario, as well as in the scenario with the intervention of the JREDD+ Program, including projected emissions for the energy and industry sectors and the cap trajectory, which represents the emissions obtained by the ETS. The incorporation of ETS revenues with the minimum possible contribution from the budget leads to an emissions trajectory that is only slightly lower than the BAU trajectory during the first five years.

Table 6 - GHG emissions with and without intervention, for scenario 2

Carbon Emissions: BAU vs Intervention Mechanisms								
$MtCO_2$								
	Deforestation		Regulated Sectors: Energy & Industry		Total Emissions		Others: non-simulated	
Year	BAU	JREDD+	BAU	ETS	BAU	NDC	BAU	Remaning
2024	106.1	97.6	116.7	103.9	324.4	209.6	101.6	8.1
2025	105.7	95.2	121.0	99.1	332.7	202.9	106.0	8.6
2026	104.4	95.9	125.5	94.3	335.3	196.2	105.5	6.0
2027	102.2	98.4	129.9	89.5	337.9	189.5	105.8	1.6
2028	99.3	93.3	134.3	84.7	340.6	182.8	106.9	4.9
2029	95.8	69.2	138.8	79.9	343.2	176.1	108.6	27.0
2030	91.9	0.0	143.2	75.1	345.8	169.4	110.7	94.3

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 16 - Projected emissions from scenario 2



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

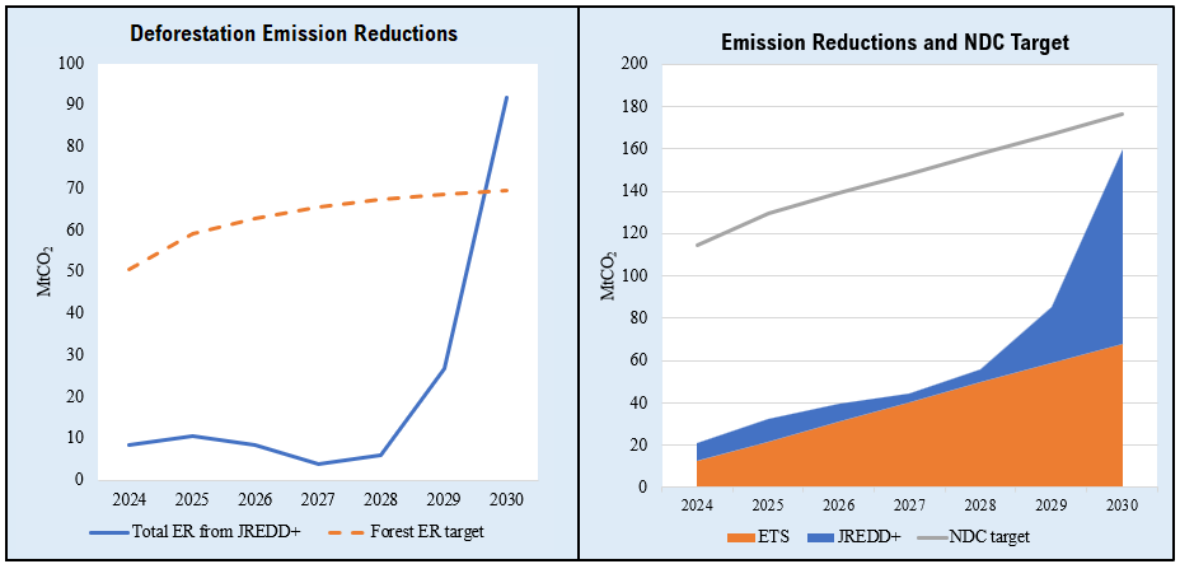
In terms of emissions reductions, the scarcity of resources in this scenario means that during the first few years, resources will only be enough to reduce between 3 and 10 million tCO_{2e}, after honoring commitments to ethnic groups. In 2024, for example, 8.5 million tCO_{2e} would be mitigated and recognized by 2025. With the resources from the national budget plus those obtained from the 8.5 million tCO_{2e} recognized by the ETS, a little more mitigation can be achieved by 2025, reaching 10.5 million tCO_{2e}. In the third year, mitigation drops again to 8.4 million tCO_{2e}, as budget funding is no longer available. And the following year mitigation drops to 3.6 million tCO_{2e}. As the auction price rises from then on, there is a revenue recovery as shown in Table 8.

Table 7 - Emission reductions and performance accounting under scenario 2

Emission Reductions by Mechanism								
MtCO2								
Year	ETS Payments	Results-Based Payments	JREDD+	Correspondent Adjustment	JREDD+ after adjustment	ETS	JREDD+ & ETS	NDC target
2024	0,0	0,0	8,5	0,0	8,5	12,7	21,2	114,8
2025	8,5	0,0	10,5	0,0	10,5	21,9	32,4	129,8
2026	10,5	0,0	8,4	0,0	8,4	31,1	39,6	139,1
2027	8,4	0,0	3,6	0,0	3,6	40,4	44,0	148,4
2028	3,6	0,0	5,2	0,0	5,2	49,6	54,8	157,7
2029	5,2	0,0	20,5	0,0	20,5	58,9	79,4	167,0
2030	15,0	0,0	91,9	0,0	91,9	68,1	160,0	176,4

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 17 - Projected emissions from scenario 2



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

The following chart shows how in the third year the ETS manages to replace the revenues coming from the national budget, then decreases a little and from 2028 onwards grows exponentially due to the increases in allowance prices and the increasing mitigation that can be carried out. This denotes a virtuous circle in the system.

Table 8 - Incomes and expenses of the national JREDD+ program in scenario 2

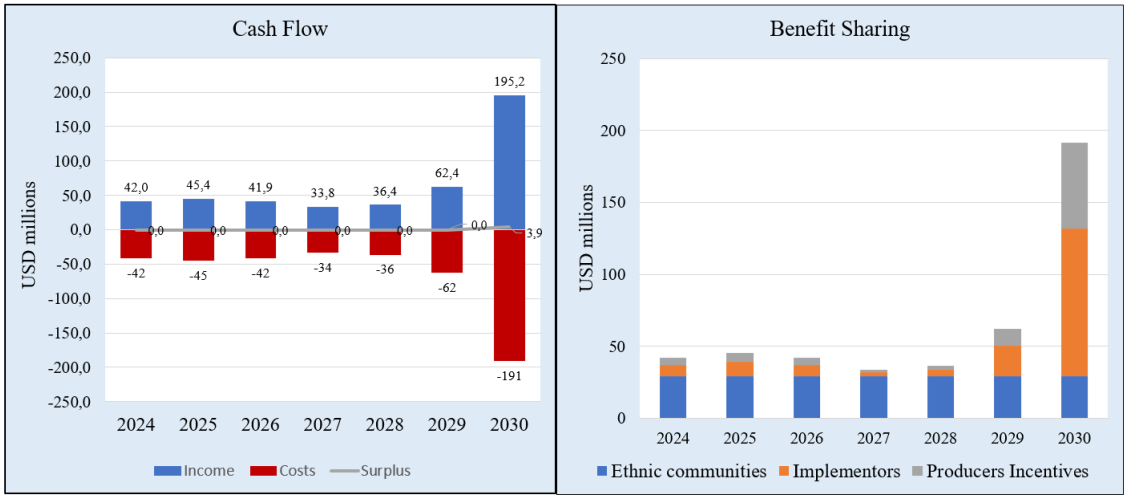
JREDD+ Income							
USD millions							
	National Revenues		International		International		
Year	Seed Capital	ETS	Cooperation Grants	Result-based Payments	credit Sales (Adjustment)	Previous Surplus	Total Income
2024	42	0,0	0,0	0,0	0,0	0,0	42,0
2025	42	3,4	0,0	0,0	0,0	0,0	45,4
2026	0	41,9	0,0	0,0	0,0	0,0	41,9
2027	0	33,8	0,0	0,0	0,0	0,0	33,8
2028	0	36,4	0,0	0,0	0,0	0,0	36,4
2029	0	62,4	0,0	0,0	0,0	0,0	62,4
2030	0	195,2	0,0	0,0	0,0	0,0	195,2

JREDD+ Expenses							
USD millions							
Year	Ethnic communities	Implementors	Producers Incentives	Total Cost	Ethnic communities	Implementing Partners	Producers Incentives
2024	29,2	8,1	4,7	42,0	69,6%	19,2%	11,2%
2025	29,2	10,2	6,0	45,4	64,4%	22,5%	13,1%
2026	29,2	8,0	4,7	41,9	69,7%	19,1%	11,2%
2027	29,2	2,9	1,7	33,8	86,6%	8,5%	5,0%
2028	29,2	4,5	2,6	36,4	80,3%	12,5%	7,3%
2029	29,2	21,0	12,2	62,4	46,8%	33,6%	19,6%
2030	29,2	102,4	59,7	191,4	15,3%	53,5%	31,2%

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In this scenario, revenues and expenses remain balanced, since all revenues are used without generating surpluses. Since payments to ethnic groups have been considered constant, in the first years they represent between 64% and 86%, while in the last year they represent 15%.

Figure 18 - Distribution of income and expenses of the national JREDD+ program in scenario 2

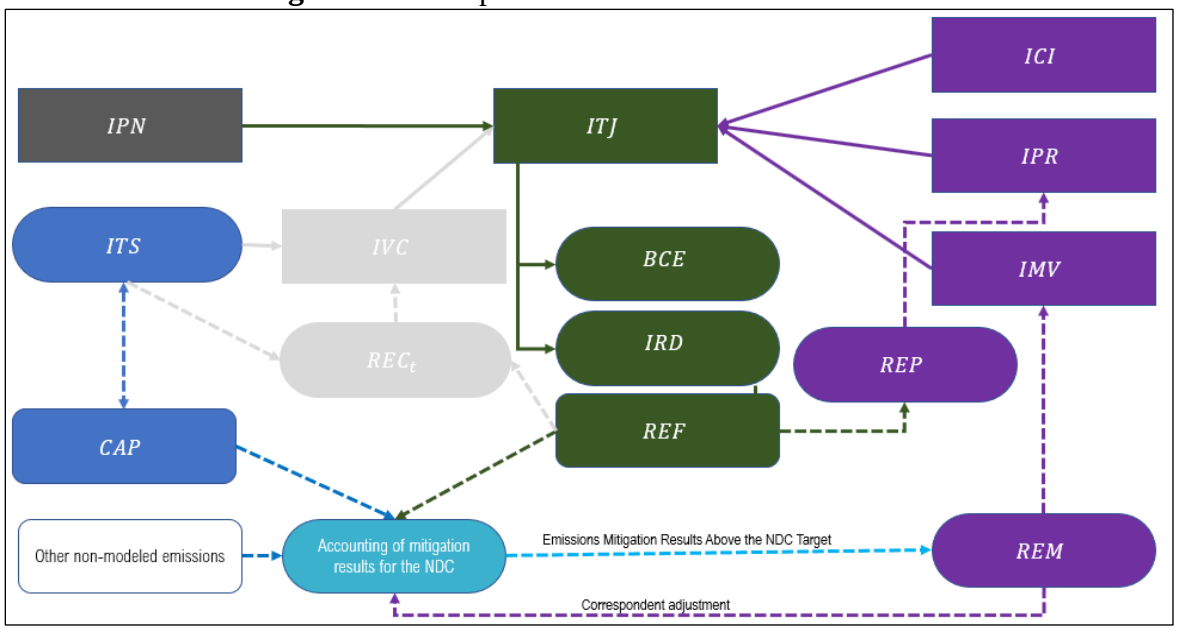


Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

5.2.3 Scenario 3 (International Results-based payments only)

The third scenario includes resources but from international sources such as result-based payments or sales in the voluntary carbon market and excludes revenues from the from the ETS. It could be characterized as shown in the following figure,

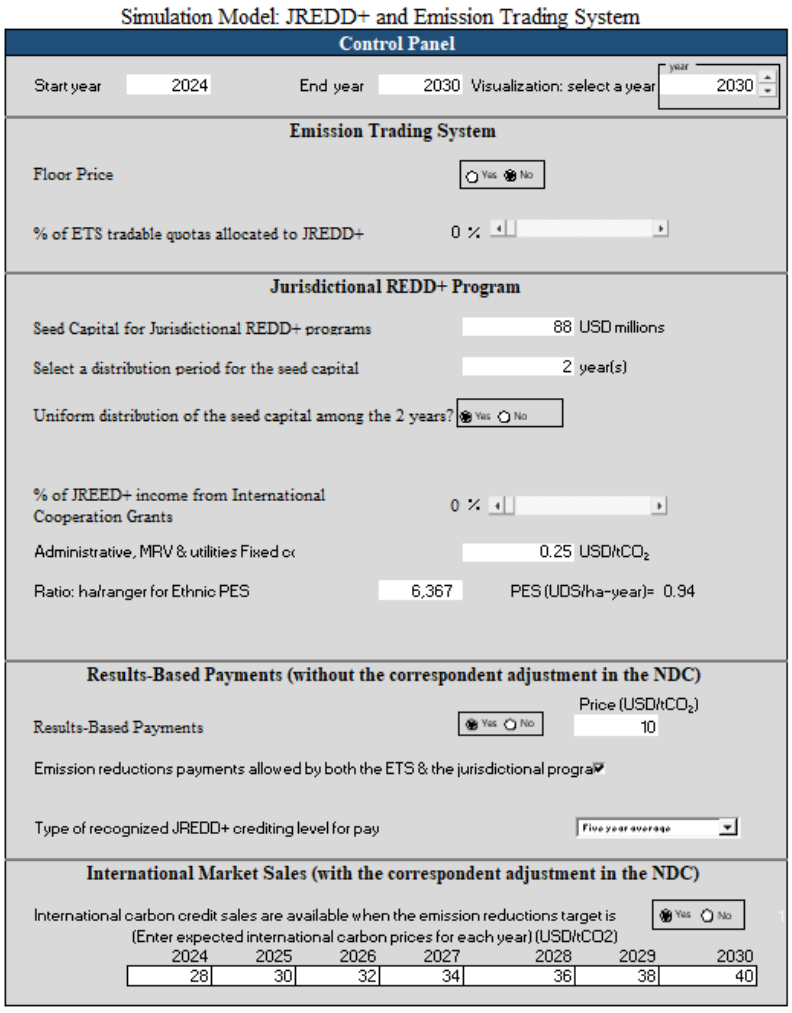
Figure 19 - Components of the model in scenario 3



Note: elements not included in this scenario are shown in gray.
Source: Developed by Uniandes-EDF-CEMR

The following figure presents the model control panel showing the parameters selected for scenario 3. This scenario only considers result-based payments and eventual sales in international voluntary markets, without taking into account the possible transfer of resources from the ETS. The first effect found is that the income from the national budget in the first two years should increase to 88 million.

Figure 20 - Parameters for scenario 3



Source: Developed by Uniandes-EDF-CEMR

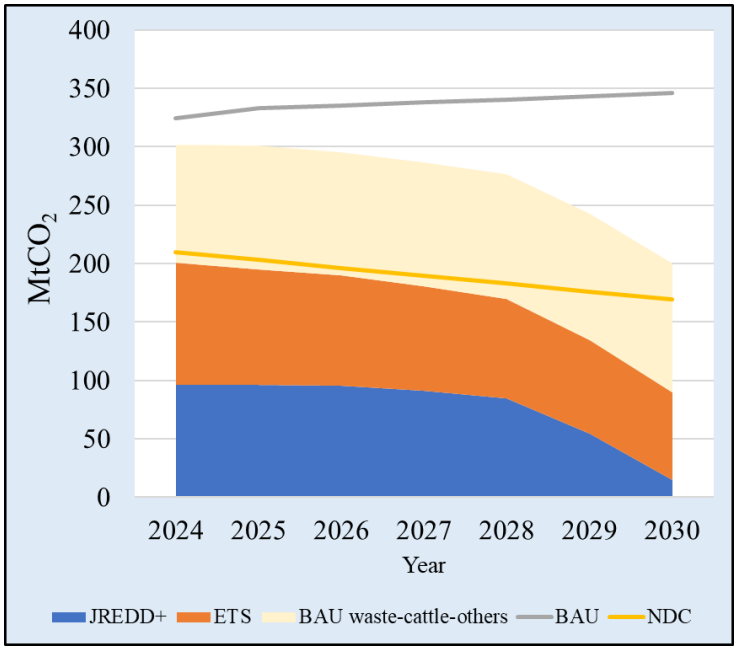
With these parameters, the following results are found in terms of projected emissions in the 'Business as Usual scenario, as well as in the scenario with the intervention of the JREDD+ Program, including projected emissions for the energy and industry sectors and the cap trajectory, which represents the emissions obtained by the ETS. As shown in Figure 21, the trend in emissions is very slow during the first five years as it decreases very little.

Table 9 - GHG emissions with and without intervention, for scenario 3

Carbon Emissions: BAU vs Intervention Mechanisms								
$MtCO_2$								
Year	Deforestation		Regulated Sectors: Energy & Industry		Total Emissions		Others: non-simulated	
	BAU	JREDD+	BAU	ETS	BAU	NDC	BAU	Remaning
2024	106,1	96,5	116,7	103,9	324,4	209,6	101,6	9,2
2025	105,7	96,0	121,0	99,1	332,7	202,9	106,0	7,7
2026	104,4	95,5	125,5	94,3	335,3	196,2	105,5	6,4
2027	102,2	90,9	129,9	89,5	337,9	189,5	105,8	9,1
2028	99,3	84,8	134,3	84,7	340,6	182,8	106,9	13,3
2029	95,8	54,4	138,8	79,9	343,2	176,1	108,6	41,8
2030	91,9	14,4	143,2	75,1	345,8	169,4	110,7	80,0

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 21 - Projected emissions from scenario 3



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

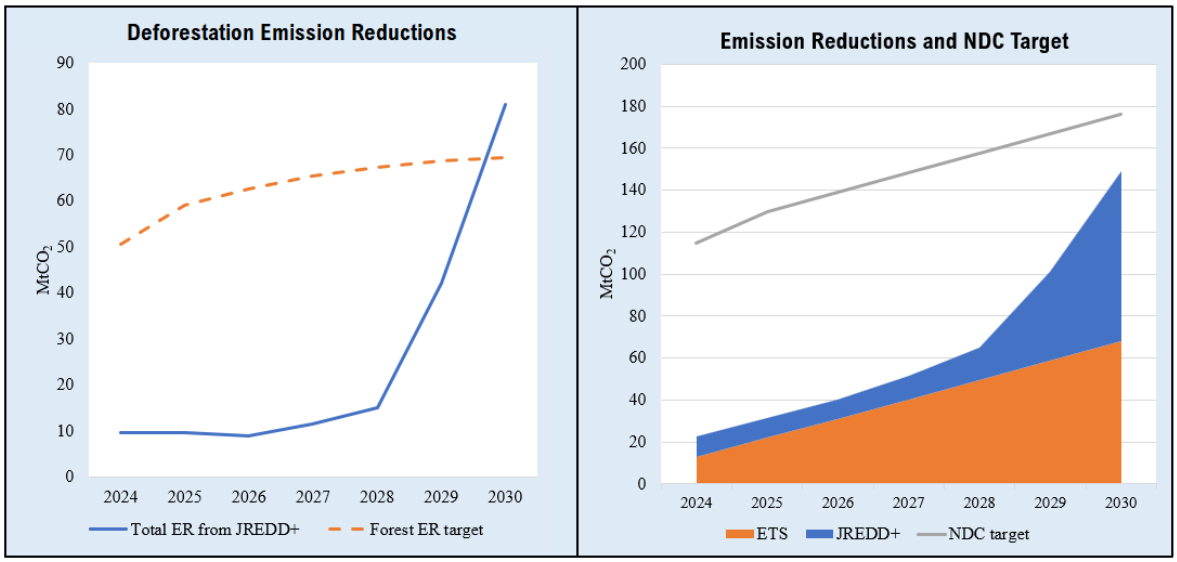
This same result can be seen in the emissions reduction Table 10, where reductions remain between 8.9 and 9.7 million tCO_{2e} during the first three years and then begin to grow, although at a slower rate than in scenario 2. This is because in result-based payment, reductions can only be recognized when the emissions trajectory is lower than the reference level established as an average of the five years prior to the beginning of the result-based payment agreement. Thus, no additional funding is obtained, but only for a proportion of these results.

Table 10 - Emission reductions and performance accounting under scenario 3

Emission Reductions by Mechanism								
MtCO2								
Year	ETS Payments	Results-Based Payments	JREDD+	Correspondent Adjustment	JREDD+ after adjustment	ETS	JREDD+ & ETS	NDC target
2024	0,0	0,0	9,7	0,0	9,7	12,7	22,4	114,8
2025	0,0	4,3	9,7	0,0	9,7	21,9	31,5	129,8
2026	0,0	4,7	8,9	0,0	8,9	31,1	40,0	139,1
2027	0,0	5,2	11,3	0,0	11,3	40,4	51,7	148,4
2028	0,0	9,8	14,5	0,0	14,5	49,6	64,1	157,7
2029	0,0	15,9	41,4	0,0	41,4	58,9	100,3	167,0
2030	0,0	38,4	77,5	0,0	77,5	68,1	145,6	176,4

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 22 - Projected emissions from scenario 3



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

From a flow of funds point of view, it has been assumed that once the results recognition process is completed, the payment process begins, so that the first effective disbursement of result-based payments is seen in 2026. This slows down funding, and therefore the possibility of obtaining additional reductions. However, starting in 2028 the virtuous circle begins to work, but at lower levels than when ETS funding is included. The latter is due to the fact that the price recognized in results-based payments is stable at USD 7/ tCO_{2e}, while the price of the ETS allowance rises to levels close to USD 13.

The distribution of benefits is similar to that of scenario 2.

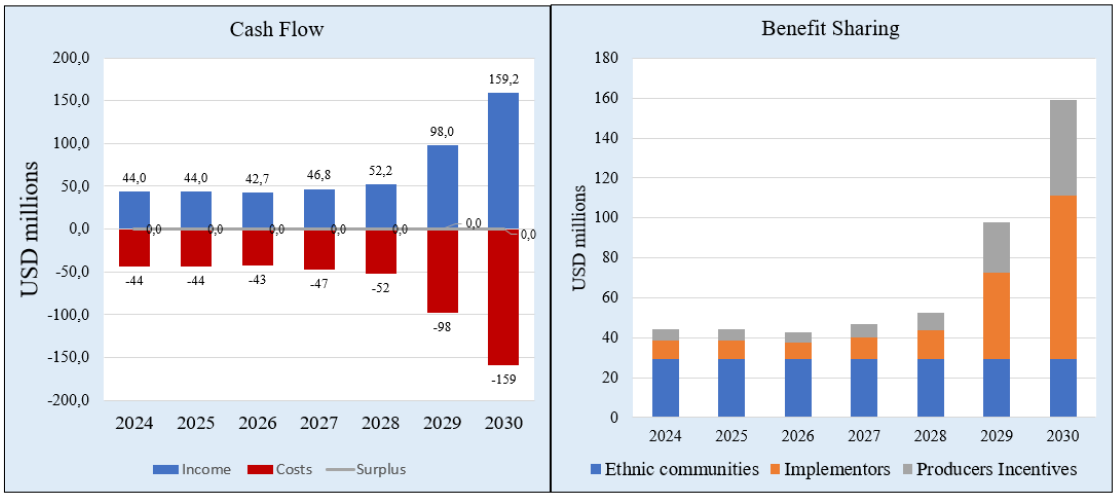
Table 11 - Incomes and expenses of the national JREDD+ program in scenario 3

JREDD+ Income							
USD millions							
	National Revenues		International		International		
Year	Seed Capital	ETS	Cooperation Grants	Result-based Payments	credit Sales (Adjustment)	Previous Surplus	Total Income
2024	44	0,0	0,0	0,0	0,0	0,0	44,0
2025	44	0,0	0,0	0,0	0,0	0,0	44,0
2026	0	0,0	0,0	42,7	0,0	0,0	42,7
2027	0	0,0	0,0	46,8	0,0	0,0	46,8
2028	0	0,0	0,0	52,2	0,0	0,0	52,2
2029	0	0,0	0,0	98,0	0,0	0,0	98,0
2030	0	0,0	0,0	159,2	0,0	0,0	159,2

JREDD+ Expenses							
USD millions							
Year	Ethnic communitie	Implementors	Producers Incentives	Total Cost	Ethnic communities	Implementing Partners	Producers Incentives
2024	29,2	9,3	5,4	44,0	66,5%	21,2%	12,4%
2025	29,2	9,3	5,4	44,0	66,5%	21,2%	12,4%
2026	29,2	8,5	5,0	42,7	68,5%	19,9%	11,6%
2027	29,2	11,1	6,5	46,8	62,5%	23,7%	13,8%
2028	29,2	14,5	8,5	52,2	56,0%	27,8%	16,2%
2029	29,2	43,4	25,3	98,0	29,8%	44,3%	25,9%
2030	29,2	82,0	47,9	159,2	18,4%	51,5%	30,1%

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 23 - Distribution of income and expenses of the national JREDD+ program in scenario 3

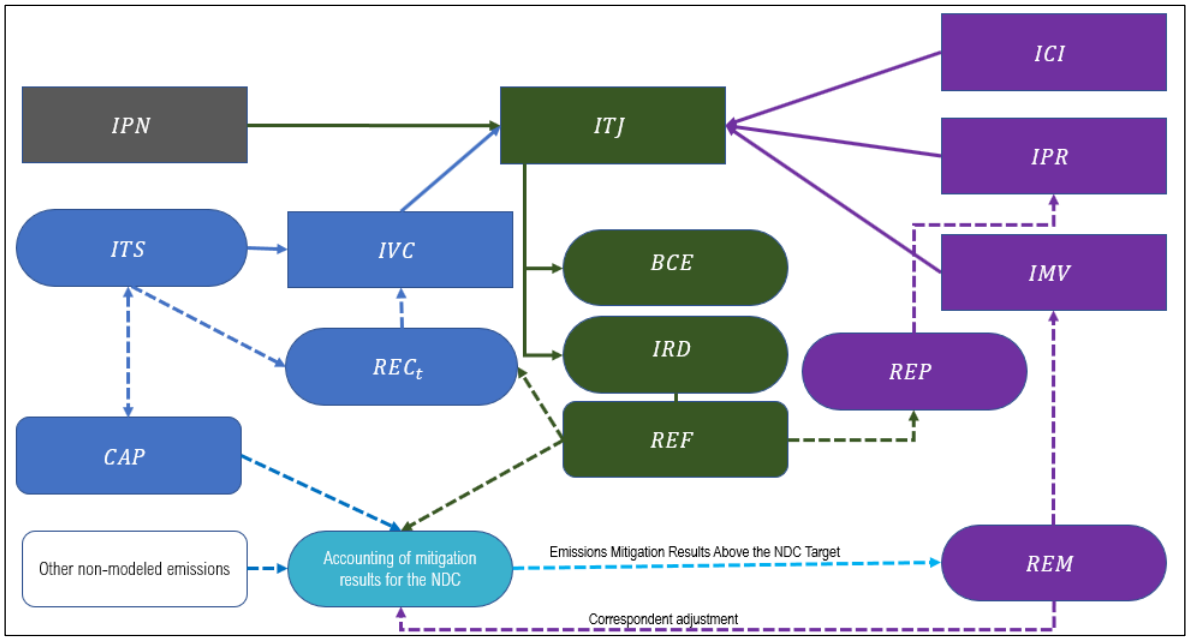


Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

5.2.4 Scenario 4 (both ETS and International Results-based payments)

The fourth scenario includes resources from the ETS, international result-based payments and sales in the voluntary carbon market. It could be characterized as shown in the following figure.

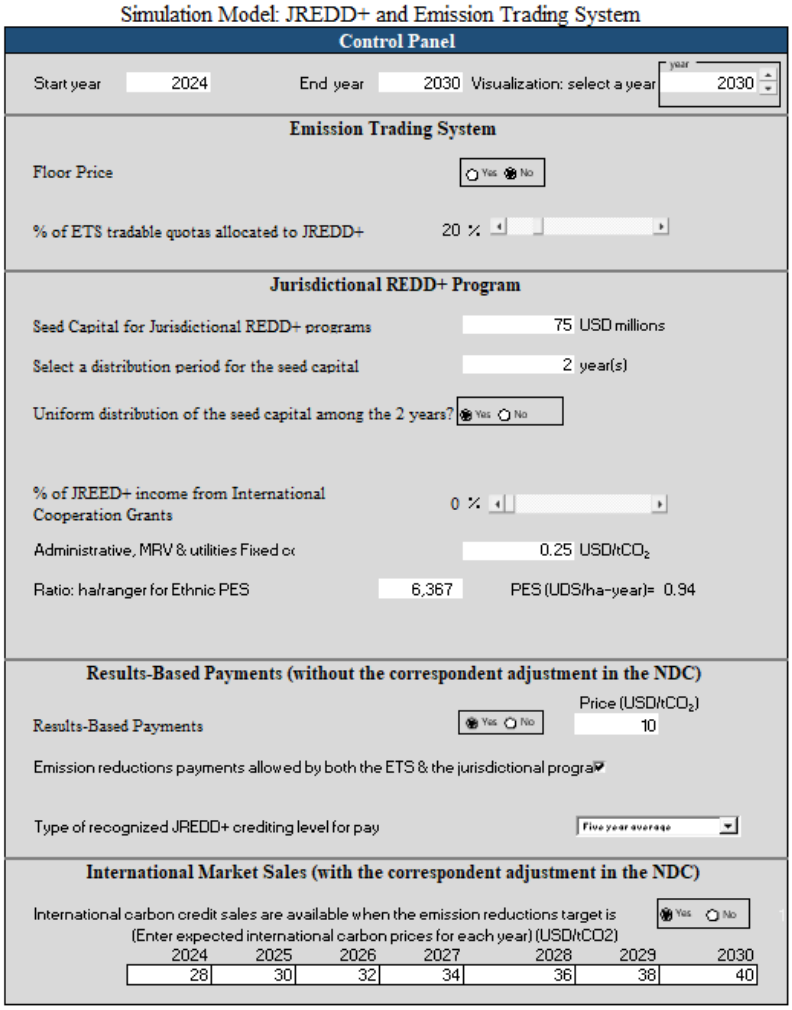
Figure 24 - Components of the model in scenario 3



Note: elements not included in this scenario are shown in gray.
Source: Developed by Uniandes-EDF-CEMR

The following figure shows the control panel of the model showing the selected parameters for scenario 4, which contemplates the joint application of resources from the ETS and the result-based payment mechanisms. In this case, the initial public budget conditions are reduced below the two previous scenarios, requiring US$75 million distributed over the first two years.

Figure 25 - Parameters for scenario 4



Source: Developed by Uniandes-EDF-CEMR

With these parameters, the following results are found in terms of projected emissions in the 'Business as Usual scenario, as well as in the scenario with the intervention of the JREDD+ Program, including projected emissions for the energy and industry sectors and the cap trajectory, which represents the emissions obtained by the ETS.

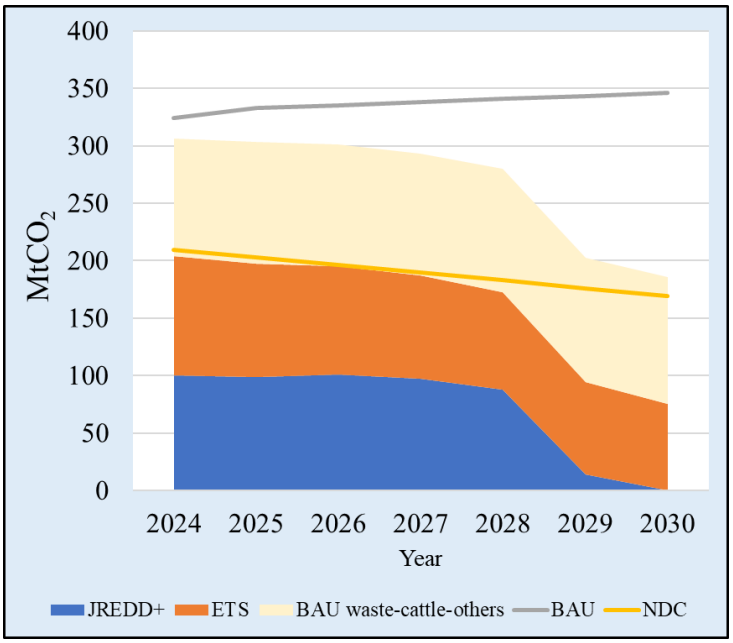
In this case, although emissions remain stable for the first four years, they are drastically reduced after the fifth year, achieving zero deforestation in 2030.

Table 12 - GHG emissions with and without intervention, for scenario 4

Carbon Emissions: BAU vs Intervention Mechanisms								
$MtCO_2$								
	Deforestation		Regulated Sectors: Energy & Industry		Total Emissions		Others: non-simulated	
Year	BAU	JREDD+	BAU	ETS	BAU	NDC	BAU	Remaning
2024	106,1	100,3	116,7	103,9	324,4	209,6	101,6	5,4
2025	105,7	98,5	121,0	99,1	332,7	202,9	106,0	5,3
2026	104,4	101,1	125,5	94,3	335,3	196,2	105,5	0,8
2027	102,2	97,6	129,9	89,5	337,9	189,5	105,8	2,5
2028	99,3	88,1	134,3	84,7	340,6	182,8	106,9	10,0
2029	95,8	14,1	138,8	79,9	343,2	176,1	108,6	82,2
2030	91,9	0,0	143,2	75,1	345,8	169,4	110,7	94,3

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 26 - Projected emissions from scenario 4



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In terms of reductions, these fluctuate between 3.3 and 7.2 million tCO_{2e} during the first four years, due to the lower initial budget. However, as of year 5, reductions grow at a high rate, reaching the maximum possible reductions defined by the BAU projection.

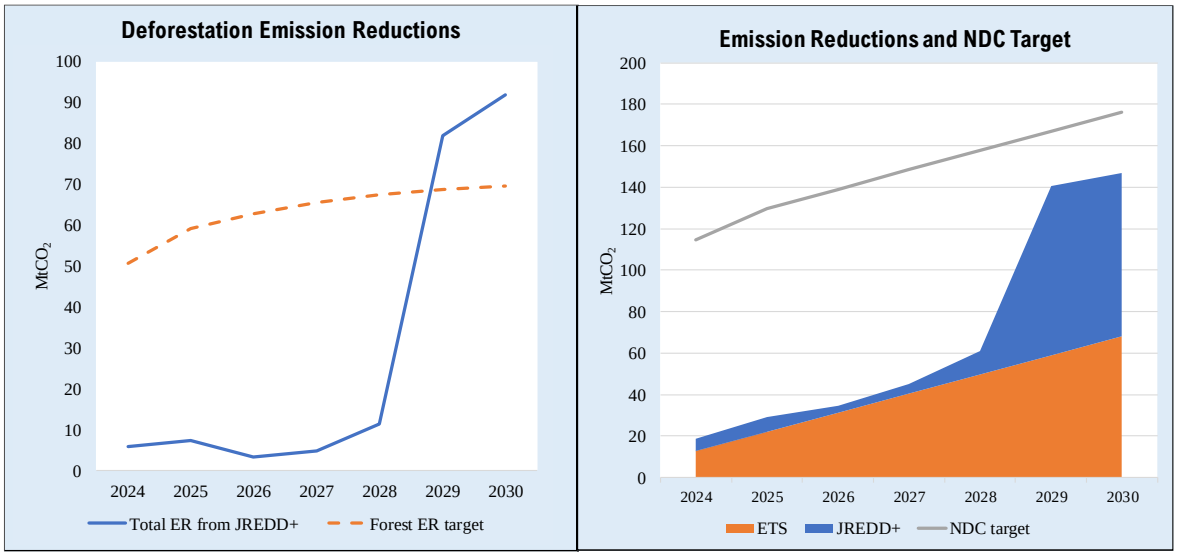
Notice that in this scenario the target is even exceeded with 13.1 million tCO_{2e}.

Table 13 - Emission reductions and performance accounting under scenario 4

Emission Reductions by Mechanism								
MtCO2								
Year	ETS Payments	Results-Based Payments	JREDD+	Correspondent Adjustment	JREDD+ after adjustment	ETS	JREDD+ & ETS	NDC target
2024	0,0	0,0	5,8	0,0	5,8	12,7	18,5	114,8
2025	5,8	0,4	7,2	0,0	7,2	21,9	29,1	129,8
2026	7,2	2,2	3,3	0,0	3,3	31,1	34,4	139,1
2027	3,3	0,0	4,7	0,0	4,7	40,4	45,0	148,4
2028	4,7	3,2	11,2	0,0	11,2	49,6	60,8	157,7
2029	11,2	12,6	81,8	0,0	81,8	58,9	140,6	167,0
2030	15,0	68,7	91,9	-13,1	78,8	68,1	146,9	176,4

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 27 - Projected emissions from scenario 4



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In terms of income, since the initial transfer provided by the national budget is lower in this scenario, it is not possible to offset the absence of such income in year 3. Even so, in the following two years they have been surpassed and by the end of the period they had increased up to fivefold. The results above the target cannot be accounted for in the simulation horizon, but it would be expected that in 2031 significant resources would be received through this channel, given that a growth in international prices is assumed. However a surplus is registered in last simulation year.

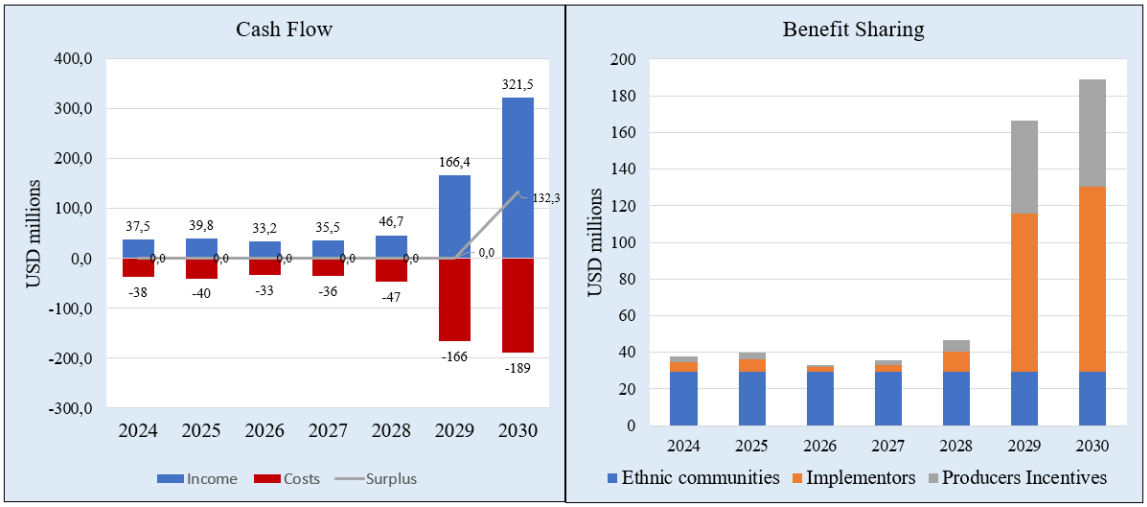
Table 14 - Incomes and expenses of the national JREDD+ program in scenario 4

JREDD+ Income							
USD millions							
Year	National Revenues		International Cooperation Grants	Result-based Payments	International credit Sales (Adjustment)	Previous Surplus	Total Income
	Seed Capital	ETS					
2024	38	0,0	0,0	0,0	0,0	0,0	37,5
2025	38	2,3	0,0	0,0	0,0	0,0	39,8
2026	0	28,8	0,0	4,4	0,0	0,0	33,2
2027	0	13,3	0,0	22,2	0,0	0,0	35,5
2028	0	46,7	0,0	0,0	0,0	0,0	46,7
2029	0	134,7	0,0	31,7	0,0	0,0	166,4
2030	0	195,2	0,0	126,3	0,0	0,0	321,5

JREDD+ Expenses							
USD millions							
Year	Ethnic communities	Implementors	Producers Incentives	Total Cost	Ethnic communities	Implementing Partners	Producers Incentives
2024	29,2	5,2	3,0	37,5	78,0%	13,9%	8,1%
2025	29,2	6,7	3,9	39,8	73,4%	16,8%	9,8%
2026	29,2	2,5	1,5	33,2	88,0%	7,6%	4,4%
2027	29,2	4,0	2,3	35,5	82,3%	11,2%	6,5%
2028	29,2	11,0	6,4	46,7	62,7%	23,6%	13,8%
2029	29,2	86,6	50,6	166,4	17,6%	52,1%	30,4%
2030	29,2	101,0	58,9	189,2	15,5%	53,4%	31,2%

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 28 - Distribution of income and expenses of the national JREDD+ program in scenario 4



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.
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5.3 Comparative Analysis

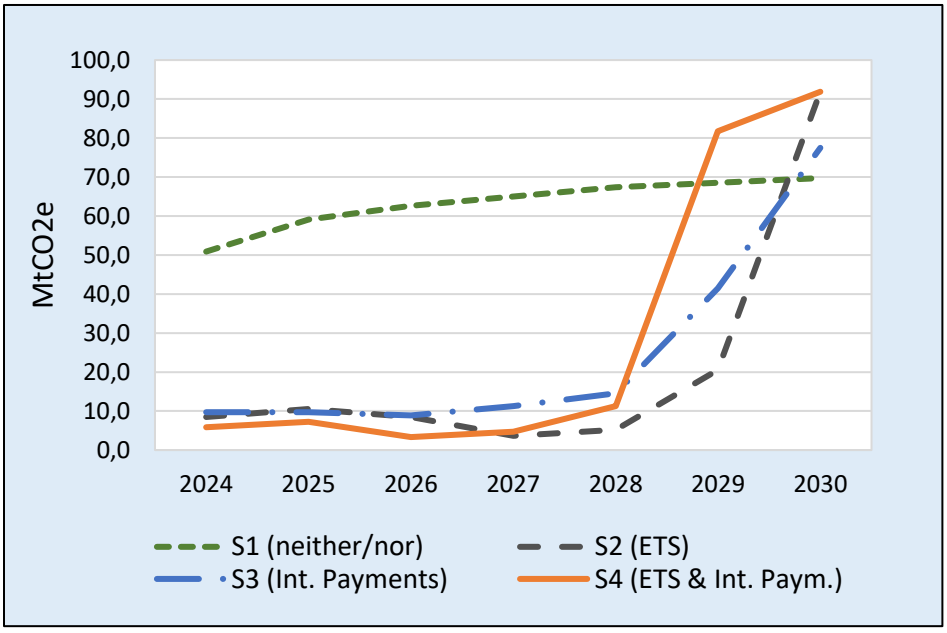
The Table 15 summarizes the results of emissions and reductions for the four simulation scenarios. It is important to note that simulations have been conditioned in all scenarios to find the minimum public budget that results in meeting the AFOLU sector target by 2030. Scenario 1 then coincides, year by year, with the trajectory of the goal. The other three scenarios minimize the contribution of the public budget so that their results in the initial years are very low and exceed the AFOLU target in the last or penultimate year due to income from the ETS or the mechanisms of payments for results. Even in scenarios 2 and 4 it is achieved in the last year to reduce all the projected emissions in the reference level (NREF).

Table 15 – GHG emissions and reductions by scenario (MtCO2)

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Year	Emission	Reduction	Emission	Reduction	Emission	Reduction	Emission	Reduction
2024	55.2	50.9	97.6	8.5	96.5	9.7	100.3	5.8
2025	46.6	59.1	95.2	10.5	96.0	9.7	98.5	7.2
2026	41.7	62.7	95.9	8.4	95.5	8.9	101.1	3.3
2027	37.2	65.0	98.6	3.6	90.9	11.3	97.6	4.7
2028	31.9	67.4	94.1	5.2	84.8	14.5	88.1	11.2
2029	27.3	68.6	75.3	20.5	54.4	41.4	14.1	81.8
2030	22.1	69.7	0.0	91.9	14.4	77.5	0.0	91.9

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Figure 31 – Emission reduction by scenario



Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model

The revenues by source are shown in Table 16.

Table 16 – Financial sources by scenario (million USD)

	Scenario 1	Scenario 2		Scenario 3		Scenario 4		
Year	Seed Capital	Seed Capital	ETS	Seed Capital	Result-based Payments	Seed Capital	ETS	Result-based Payments
2024	114	42	0.0	44	0.0	38	0.0	0.0
2025	128	42	3.4	44	0.0	38	2.3	0.0
2026	134	0	41.9	0	42.7	0	28.8	4.4
2027	138	0	33.8	0	46.8	0	13.3	22.2
2028	142	0	36.4	0	52.2	0	46.7	0.0
2029	144	0	62.4	0	98.0	0	134.7	31.7
2030	146	0	195.2	0	159.2	0	195.2	126.3

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model

Scenario 1 has only one source and it corresponds to the capital provided by the public budget (which we have called seed capital). Scenarios 2 and 3 replace the public source with revenues that depend on the volume of reductions. In scenario 2 they are counted against the FREL and valued at the ETS price, while in scenario 3 they are counted against the ART-TREES reference level (five-year average) and valued at a constant price of US$10. Scenario four assumes that the same reductions financed by the ETS are co-financed by the pay-for-performance scheme, which increases revenues.

Table 17 shows that in scenarios 1 and 3 all revenues are spent to achieve the results, while in the scenarios 2 and 4 surpluses are generated because revenues are higher than those strictly necessary to reduce total emissions.

Table 17 – Financial balance by scenario (million USD)

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Year	Total Income	Total Cost	Total Income	Total Cost	Total Income	Total Cost	Total Income	Total Cost
2024	114.0	114.0	42.0	42.0	44.0	44.0	37.5	37.5
2025	128.0	128.0	45.4	45.4	44.0	44.0	39.8	39.8
2026	134.0	134.0	41.9	41.9	42.7	42.7	33.2	33.2
2027	138.0	138.0	33.8	33.8	46.8	46.8	35.5	35.5
2028	142.0	142.0	36.4	36.4	52.2	52.2	46.7	46.7
2029	144.0	144.0	62.4	62.4	98.0	98.0	166.4	166.4
2030	146.0	146.0	195.2	191.4	159.2	159.2	321.5	189.2

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model

5.4 Sensitivity Analysis

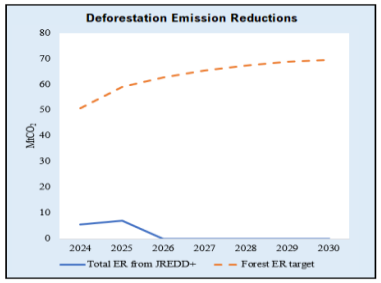
An important aspect to be considered is that the system is very sensitive to the level of initial revenues coming from the national budget. The following set of figures shows that, if in scenario 4 the budget is reduced by US$1 million, going from US$75 million to US$74 million, by the third year neither the ETS nor result-based payments will be able to generate resources to pay for the intervention and the incentives of producers and communities.

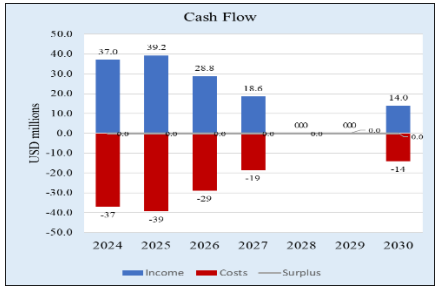
Consequently, no further reductions can be generated to ensure the sustainability of the system.

On the other hand, if the budget is increased from US$75 million to US$76 million, the target trajectory will be exceeded as of 2028, and if it is increased to US$77 million, zero deforestation will be achieved as of 2028. Higher initial levels gradually allow targets to be met earlier and allow for greater accumulation of surpluses.

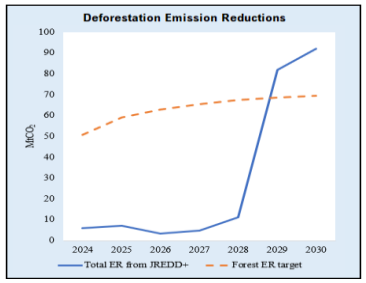
Figure 32 - Sensitivity analysis regarding reductions and cash flows

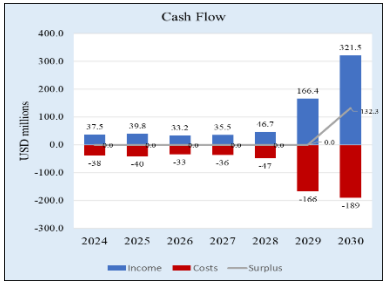
Intial public invesment = **74 million USD**
Net surplus in 2030 = **0 million USD**



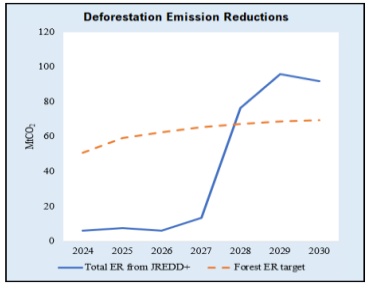


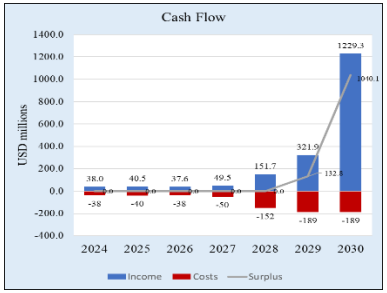
Intial public invesment = **75 million USD**
Net surplus in 2030 = **132,3 million USD**



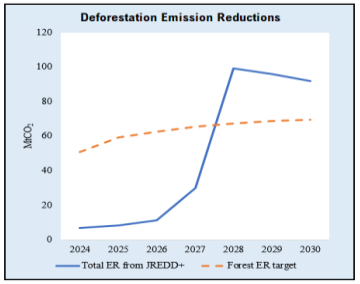


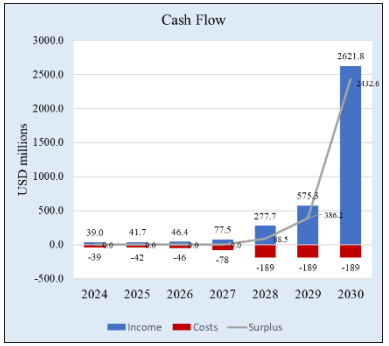
Intial public invesment = **76 million USD**
Net surplus in 2030 = **1040,1 million USD**





Intial public expenditure = **78 million USD**
Net surplus in 2030 = **2432,6 million USD**





7 CONCLUSIONS

For the development of the model presented in this document, multiple financing mechanisms were included that correspond to the integration of a JREDD+ program and an ETS for Colombia. We analyze different financing mechanisms that enable Colombia to achieve its NDC cost-effectively. Relevant constraints were included in this modeling to obtain realistic results given the context of the country's emission reference levels, the NDC emission targets, the mitigation costs of the forestry sector, the abatement costs of the regulated sectors, and the characteristics imposed by the result-based payment programs. In this way, the model optimization process allowed finding relevant results that simulate the emissions reduction trajectory with dependence on the sources of financing and the availability of resources to mitigate emissions. The results obtained are intended to be relevant for the country's decision-making and public policy in order to implement cost-efficient measures and programs that are in accordance with the country's regulatory framework, emissions trajectory, mitigation objectives, standards used by jurisdictional program funders, and international voluntary carbon markets.

Although the simulation possibilities are multiple, this document explores four simulation scenario- We consider scenarios where JREDD+ may be funded by three different sources: the national budged, a national ETS coupled with an offset mechanism that operates at the jurisdictional level and international sources of funding such as the Lowering Emissions by Accelerating Forest Finance (LEAF) Coalition. The analysis is carried out over 7 years, specifically for the 2024 – 2030 period. We calculate the seed funding from the National Budget required to meet the forest goals established in the country´s National Determined Contribution (NDC) under four financing scenarios

When JREDD+ is linked to a national ETS and/or International Results-based Payments such as those offered by the LEAF Coalition, the public funding needed to achieve the NDC deforestation target of 50,000 hectares in 2030 is about ten times lower when compared with the scenario where only Government funding is used. In particular, if external and internal financing instruments are not implemented, the cost of meeting the NDC targets for the forestry sector in terms of public funding are US$900 million in the period 2024 - 2030 years, as opposed to about US$75 million when JREDD+ is linked to complementary funding sources. To the extent that not all transaction costs are considered in this study, e.g. the coordination costs in establishing a JREDD program are not modeled, these results should be interpreted with caution. However, the *relative* funding requirements across scenarios are likely to be unbiased.

The model assumes that JREDD+ programs have designed their operation to ensure efficient emissions mitigation, the incorporation of safeguards, such as environmental education and awareness measures, and the minimization and/or compensation of potential adverse socio-environmental impacts of such interventions. Although the model provides results in terms of emission reductions and economic benefit streams for each of the scenarios considered, it does not ignore the fact that there are other unaccounted effects of these interventions. In addition to the direct benefits of emission reductions on social well-being, the modeling results imply the generation of co-benefits (economic, social and environmental) that

contribute to the development of ethnic communities, local communities and other private land users.

Harnessing funding from the ETS and/or international results-based payments result in large fiscal savings as they both generate a virtuous financial circle: mitigation results in a given year generate financial resources that can then be invested in actions that lead to further mitigation results. It is important to note that the calibrated model is highly sensitive to seed funding from the national Government. This suggests that, if seed funding is large enough. Colombia and its JREDD programs have the potential to generate internationally transferred mitigation outcomes (ITMOs) and benefit from extra revenues in international markets.

The ETS generates greater savings in government funding and it dynamizes the system faster than international result-based payments, due to the stringency of the latter instrument. In the international result-based payments scenario, the base-line used is given by the five-year average forest emissions prior to the payment period. On the other hand, in the national ETS scenario, the base-line is set according to the business-as-usual scenario given by the National Reference Level of Forest Emissions (NREF) which assumes that deforestation will peak in 2025.

The model examines outcomes in terms of emission reductions, as well as funding flows to communities and program implementers. Benefit-sharing payments for ethnic communities require that the implemented funding mechanisms have the capacity to generate sufficient resources to meet these obligations. A stable payment level helps buffer the risks of fluctuations in the income of ethnic communities, but it requires higher initial funding conditions from the national government. If indigenous revenues were a proportion of net income from participating in the corresponding JREDD program, the initial funding requirements would be lower but there would be no guarantee of resources for these communities.

It is important to highlight that the scenarios considered here sought to find the lowest budgetary contribution required from the National Government in order to comply with the goals of the forestry sector, but in all cases, they correspond to the minimum required. Higher initial government funding may also be warranted given the ancillary socio-economic and environmental benefits generated by a well-designed JREDD+ program. At COP27 in Sharm El Sheikh, the Colombian government pledged to create a fund to protect the Amazon. A JREDD+ approach can be an effective way to managed these resources while leveraging international finance.

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APPENDIX A. RESULTS FROM A REGIONALIZATION OF MODEL

A.1 Scenario 1 (neither ETS nor International Results-based payments)

In scenario 1, mitigation is financed exclusively by contributions from the national budget. There is no revenue from the ETS, nor from payments for results or international carbon markets (JREDD). According to **¡Error! No se encuentra el origen de la referencia.**, emission reductions and abatement costs by jurisdiction would be as follows:

Table A.1.1 - JREDD+ emission reductions by jurisdiction in scenario 1 (MtCO2)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	48,69	0,69	0,05	1,45	0,00	50,88
2025	56,94	0,69	0,05	1,45	0,00	59,13
2026	60,47	0,69	0,05	1,45	0,00	62,66
2027	62,83	0,69	0,05	1,45	0,00	65,02
2028	65,18	0,69	0,05	1,45	0,00	67,37
2029	66,36	0,69	0,05	1,45	0,00	68,55
2030	67,54	0,69	0,05	1,45	0,00	69,73

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Table A.1.2 - JREDD+ abatement costs by jurisdiction in Scenario 1 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	82,59	0,99	0,02	1,16	0,00	84,76
2025	96,59	0,99	0,02	1,16	0,00	98,76
2026	102,59	0,99	0,02	1,16	0,00	104,76
2027	106,59	0,99	0,02	1,16	0,00	108,76
2028	110,59	0,99	0,02	1,16	0,00	112,76
2029	112,59	0,99	0,02	1,16	0,00	114,76
2030	114,59	0,99	0,02	1,16	0,00	116,76

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In addition, costs associated with revenue for ethnic communities would be as follows:

Table A.1.3 - Revenue of ethnic communities by jurisdiction in scenario 1 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	20,00	2,63	5,73	0,25	0,64	29,24
2025	20,00	2,63	5,73	0,25	0,64	29,24
2026	20,00	2,63	5,73	0,25	0,64	29,24
2027	20,00	2,63	5,73	0,25	0,64	29,24
2028	20,00	2,63	5,73	0,25	0,64	29,24
2029	20,00	2,63	5,73	0,25	0,64	29,24
2030	20,00	2,63	5,73	0,25	0,64	29,24

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Finally, the annual revenue available in this scenario are presented below:

Table A.1.4 - Total revenue by jurisdiction in scenario 1 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	102,59	3,62	5,75	1,40	0,64	114,00
2025	116,59	3,62	5,75	1,40	0,64	128,00
2026	122,59	3,62	5,75	1,40	0,64	134,00
2027	126,59	3,62	5,75	1,40	0,64	138,00
2028	130,59	3,62	5,75	1,40	0,64	142,00
2029	132,59	3,62	5,75	1,40	0,64	144,00
2030	134,59	3,62	5,75	1,40	0,64	146,00

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In this scenario, results indicate that the emissions reduction strategy focuses on controlling deforestation in the Amazon (reduction of 67.54 MtCO2) and is complemented by small contributions from silvopastoral systems (SSP) in the Pacific, Caribbean, Amazon and Orinoco jurisdictions (reduction of 2.54 MtCO2). The Andean jurisdiction would only participate in the budget through the payments made to the indigenous communities.

A.2 Scenario 2 (ETS only)

In scenario 2, contributions coming from the national budget are substantially reduced, since resources from the ETS are available. Payments for results or international carbon markets (JREDD+) are not considered. According to **¡Error! No se encuentra el origen de la r eferencia.** and the annual available revenue in this scenario, the emission reductions and the regional distribution of the budget would be as follows:

Table A.2.1 - JREDD+ emission reductions by jurisdiction in scenario 2 (MtCO2)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	6.29	0.69	0.05	1.45	0.00	8.48
2025	8.29	0.69	0.05	1.45	0.00	10.48
2026	6.25	0.69	0.05	1.45	0.00	8.44
2027	1.45	0.69	0.05	1.45	0.00	3.64
2028	3.01	0.69	0.05	1.45	0.00	5.20
2029	18.33	0.69	0.05	1.45	0.00	20.52
2030	83.05	0.69	1.17	6.05	0.90	91.87

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Table A.2.2 - JREDD+ abatement costs by jurisdiction in Scenario 2 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	10.59	0.99	0.02	1.16	0.00	12.76
2025	13.98	0.99	0.02	1.16	0.00	16.15
2026	10.52	0.99	0.02	1.16	0.00	12.69
2027	2.37	0.99	0.02	1.16	0.00	4.54
2028	5.02	0.99	0.02	1.16	0.00	7.19
2029	31.03	0.99	0.02	1.16	0.00	33.20
2030	140.94	0.99	2.78	14.47	2.94	162.13

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In addition, costs associated with revenue for ethnic communities would be as follows:

Table A.2.3 - Revenue of ethnic communities by jurisdiction in scenario 2 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	20,00	2,63	5,73	0,25	0,64	29,24
2025	20,00	2,63	5,73	0,25	0,64	29,24
2026	20,00	2,63	5,73	0,25	0,64	29,24
2027	20,00	2,63	5,73	0,25	0,64	29,24
2028	20,00	2,63	5,73	0,25	0,64	29,24
2029	20,00	2,63	5,73	0,25	0,64	29,24
2030	20,00	2,63	5,73	0,25	0,64	29,24

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Finally, the annual revenue available in this scenario are presented below:

Table A.2.4 - Total revenue by jurisdiction in scenario 2 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	30.59	3.62	5.75	1.40	0.64	42.00
2025	33.98	3.62	5.75	1.40	0.64	45.39
2026	30.52	3.62	5.75	1.40	0.64	41.93
2027	22.37	3.62	5.75	1.40	0.64	33.78
2028	25.02	3.62	5.75	1.40	0.64	36.43
2029	51.03	3.62	5.75	1.40	0.64	62.44
2030	160.94	3.62	8.51	14.72	3.59	191.37

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In this scenario, the national budget necessary to generate results —recognizable by the ETS— is reduced, thus generating resources to finance activities in order to reduce emissions

from deforestation. As identified through the analysis of the program at the national level, reductions are very low in the early years. Subsequently, ETS resources allow accumulating reductions to meet and exceed the target in the last two years. In this case, the contribution in terms of reducing deforestation in the Amazon is significant but not as high as in scenario 1. On the other hand, the participation of silvopastoral systems in emission reductions increases, and the Andean jurisdiction remains without active participation during most of the period, beyond the contribution to ethnic communities. However, in the last year of the simulation this jurisdiction participates with Andean SSPs and deforestation reduction activities. In addition, the Pacific and Caribbean jurisdictions also managed to implement more measures for restoration and avoided deforestation, respectively. This increases their contribution in the last year and therefore also increases their revenue at the sub-program level.

A.3 Scenario 3 (International Results-based payments only)

In scenario 3, mitigation activities are financed by payments for results or international carbon markets, but there are no ETS resource flows. As a result, contributions from the national budget for the JREDD+ are reduced. According to **¡Error! No se encuentra el o rigen de la referencia.** and the annual available revenue in this scenario, the emission reductions and the regional distribution of the budget would be as follows:

Table A.3.1 - JREDD+ emission reductions by jurisdiction MtCO2 in scenario 3

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	7,47	0,69	0,05	1,45	0,00	9,66
2025	7,47	0,69	0,05	1,45	0,00	9,66
2026	6,69	0,69	0,05	1,45	0,00	8,88
2027	9,10	0,69	0,05	1,45	0,00	11,29
2028	12,32	0,69	0,05	1,45	0,00	14,52
2029	39,25	0,69	0,05	1,45	0,00	41,44
2030	75,29	0,69	0,05	1,45	0,00	77,48

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Table A.3.2 - JREDD+ abatement costs by jurisdiction in scenario 3 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	12,59	0,99	0,02	1,16	0,00	14,76
2025	12,59	0,99	0,02	1,16	0,00	14,76
2026	11,27	0,99	0,02	1,16	0,00	13,44
2027	15,35	0,99	0,02	1,16	0,00	17,52
2028	20,83	0,99	0,02	1,16	0,00	23,00
2029	66,55	0,99	0,02	1,16	0,00	68,72
2030	127,75	0,99	0,02	1,16	0,00	129,92

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In addition, costs associated with revenue for ethnic communities would be as follows:

Table A.3.3 - Revenue of ethnic communities by jurisdiction in scenario 3 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	20,00	2,63	5,73	0,25	0,64	29,24
2025	20,00	2,63	5,73	0,25	0,64	29,24
2026	20,00	2,63	5,73	0,25	0,64	29,24
2027	20,00	2,63	5,73	0,25	0,64	29,24
2028	20,00	2,63	5,73	0,25	0,64	29,24
2029	20,00	2,63	5,73	0,25	0,64	29,24
2030	20,00	2,63	5,73	0,25	0,64	29,24

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Finally, the annual revenue available in this scenario are presented below:

Table A.3.4 - Total revenue by jurisdiction in scenario 3 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	32,59	3,62	5,75	1,40	0,64	44,00
2025	32,59	3,62	5,75	1,40	0,64	44,00
2026	31,26	3,62	5,75	1,40	0,64	42,68
2027	35,35	3,62	5,75	1,40	0,64	46,76
2028	40,83	3,62	5,75	1,40	0,64	52,24
2029	86,55	3,62	5,75	1,40	0,64	97,96
2030	147,75	3,62	5,75	1,40	0,64	159,16

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

This scenario is similar to the previous one, since compliance with the emissions reduction target occurs in recent years when sufficient revenues are consolidated to implement various abatement measures within the different regional sub-programs. However, in this case, the significant growth in reductions begins in 2027 (four years before the end of the simulation period). Likewise, during the last year, avoided deforestation contributions in the Amazon are lower than in scenario 2. The Andean jurisdiction does not generate emission reductions, and the other jurisdictions contribute to mitigation with the implementation of SSP, as in scenarios 1 and 2.

A.4 Scenario 4 (ETS & International Results-based payments)

In scenario 4, all three sources of financing are combined: national budget, ETS and payments for results or international carbon markets. In this way, national budget contributions are minimized, and ETS funding streams and payments for results or international carbon markets increase the capacity to implement mitigation measures, making it possible to achieve emission reduction targets in less time. According to **¡Error! No se encuentra el origen de la referencia.** and the annual available revenue in this scenario (**¡Error! No se encuentra el origen de la referencia.**), the emission reductions and the regional distribution of the budget would be as follows:

Table A.4.1 - JREDD+ emission reductions by jurisdiction MtCO2 in scenario 4

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	3.64	0.69	0.05	1.45	0.00	5.83
2025	5.02	0.69	0.05	1.45	0.00	7.21
2026	1.13	0.69	0.05	1.45	0.00	3.32
2027	2.47	0.69	0.05	1.45	0.00	4.67
2028	9.03	0.69	0.05	1.45	0.00	11.23
2029	79.57	0.69	0.05	1.45	0.00	81.76
2030	83.05	0.69	1.17	6.05	0.30	91.27

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Table A.4.2 - JREDD+ abatement costs by jurisdiction in scenario 4 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	6.09	0.99	0.02	1.16	0.00	8.26
2025	8.42	0.99	0.02	1.16	0.00	10.59
2026	1.82	0.99	0.02	1.16	0.00	3.99
2027	4.11	0.99	0.02	1.16	0.00	6.28
2028	15.24	0.99	0.02	1.16	0.00	17.41
2029	135.02	0.99	0.02	1.16	0.00	137.19
2030	140.94	0.99	2.78	14.47	0.74	159.92

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In addition, costs associated with revenue for ethnic communities would be as follows:

Table A.4.3 - Revenue of ethnic communities by jurisdiction in scenario 4 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	20,00	2,63	5,73	0,25	0,64	29,24
2025	20,00	2,63	5,73	0,25	0,64	29,24
2026	20,00	2,63	5,73	0,25	0,64	29,24
2027	20,00	2,63	5,73	0,25	0,64	29,24
2028	20,00	2,63	5,73	0,25	0,64	29,24
2029	20,00	2,63	5,73	0,25	0,64	29,24
2030	20,00	2,63	5,73	0,25	0,64	29,24

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

Finally, the annual revenue available in this scenario are presented below:

Table A.4.4 - Total revenue by jurisdiction in scenario 4 (USD millions)

Year	Amazon	Orinoquia	Pacific	Caribbean	Andean	Total
2024	26.09	3.62	5.75	1.40	0.64	37.50

2025	28.42	3.62	5.75	1.40	0.64	39.83
2026	21.82	3.62	5.75	1.40	0.64	33.23
2027	24.10	3.62	5.75	1.40	0.64	35.51
2028	35.24	3.62	5.75	1.40	0.64	46.65
2029	155.01	3.62	5.75	1.40	0.64	166.43
2030	160.94	3.62	8.51	14.72	1.38	189.16

Source: Developed by Uniandes-EDF-CEMR based on the financial simulation model.

In this scenario, all potential abatement measures can be used to reduce emissions due to deforestation in all juGrisdictions. Thanks to this, emission reduction results increase and revenues increase, especially from the year 2028 onwards. It is assumed that the surpluses presented in scenario 4 remain at the national level while regional revenues are only those necessary to cover expenses.