

# Reflections on the deforestation of the peruvian amazonian forest for agricultural land use, period 2001-2018

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**Abstract.** The present research work is focused on determining the economic valuation of the effect of deforestation of the Peruvian Amazon forests and essentially to warn of the environmental significance; in this sense, the impact of this problem is analyzed in the period 2001-2018. The study was oriented to crops (coffee, cocoa, oil palm, and soybean plantations) developed mainly in deforested forest soils. Such are those that have the most significant impact on drastic changes in soil cover and implicitly in the increase in the release of greenhouse gases. In this research, the economic valuation was carried out by applying the benefit transfer method about reforestation; and carbon; we worked with international market prices.

**Keywords:** Valuation, deforestation, agriculture, Amazon forests.

## 1. Introduction

Peru is the second Latin American country with Amazonian forest and the ninth-largest forest in the world. Peru's forest covers 68,422,585 million hectares, representing 53.2% of the national territory. 2% of the national part made up of the department of Loreto with 35 047 942 hectares (51.2%), Ucayali with 9 336 773 hectares (13.6%), Madre de Dios with 7 905 744 hectares (11.6%), and other departments such as San Martín, Cajamarca and Amazonas represent (26.4%). Thus, 53.9% is forest, 3.2% dry forests, and 0.2% Andean forests, as shown in Table 1.

This forest provides environmental goods (timber, fruits, seeds, honey, medicine), environmental services (water supply, climate regulation, soil erosion regulation, soil formation, natural disaster regulation, scenic beauty, carbon capture, and storage). It is home to native and migrant populations. However, despite their significant importance, in the period 2001-2018, the Amazon rainforests suffered an almost irreparable average cover loss of 126 938.22 hectares per year. This severe environmental damage was caused by deforestation and the implicit effect of releasing 57 million tons of carbon. This also affects diverse ecosystems and reduces wildlife habitats. [1]

Based on official statistics, deforestation has increased by 84.26 % in the analyzed period, as shown in Figure 1, which is explained in the expansion of annual and perennial crops that in minimal part are for the subsistence of the population and most are for commercial purposes to meet the demand of global, national and local markets. In essence, the damage to the forest by deforestation is directly related to farming, agriculture, and cattle ranching. In these activities, the expansion of oil palm, cocoa, coffee, and soybean cultivation stands out; on the other hand, according to, gold mining is another activity that damages the primary forest. In addition, as a consequence of the change of soil uses, the ecosystem has been degraded. Additionally, greenhouse gases and carbon dioxide have been released in an average of 88.82 Mt CO<sub>2</sub> per year, damaging the global environment. [2]

Given the above, it should be noted that the Peruvian Amazon forest is one of the most valuable ecosystems in the world due to the environment and ecosystem services it provides for the benefit of its incredible biodiversity. Consequently, the problem of deforestation in Peru, which reduces the forest below the 10% threshold, is propitiated by the logging of timber species, informal mining, domestic and foreign market demand for export products (coffee, cocoa, palm oil, soybeans, among others), and if doubt by the layout of communication routes for the transport of products. [4]

## 2. Materials and Methods

The analysis of forest loss is of utmost importance, so it is necessary to determine the impact of agriculture on Amazon forest deforestation and the economic valuation of forest loss due to the synergy of economies, such as exponential population growth and its consequences; in this sense, we have worked on the critical area of deforestation and applied internationally accepted valuation techniques.

The scope of the study includes the humid forests of the Peruvian Amazon, located in the areas of most significant deforestation that belong to the departments of Loreto, Ucayali, San Martín, Huanuco, Madre de Dios, Junín, Cuzco, Puno, Amazonas, and Pasco. [5]

The statistical database was based on data from institutional platforms and reports from secondary sources belonging to the Ministry of Environment (MINAM) and the Ministry of Agrarian Development and Irrigation (MIDAGRI), the National Institute of Statistics and Informatics (INEI), indexed journals, books and information disseminated by private institutions linked to forestry, agriculture and the environment. Consequently, data on deforestation in the Amazonian forests for the period under study was obtained from these sources.

Deforestation rate, to calculate the annual deforestation rate, information from historical data was used to analyze the evolution over time, using the following equation:

$$D = \left( \frac{DF-DI}{DI} \right) 100 \quad (1)$$

$D$  is the deforestation rate;  $DF$  is the area deforested in the final year (2018), and  $DI$  is deforested in the initial year (2001). [3]

Economic valuation method, the economic valuation method applied was the benefit transfer method, based on the relationship between reforestation and the market price for carbon.

To obtain the study's relevant data and information, bibliographic systematization was applied using different normative, bibliographic, and demographic sources institutionally disclosed and related to the survey (norms, books, scientific magazines, theses, etc.). Consequently, the economic valuation method of benefit transfer was used, focused on the transfer of the monetary value of an environmental good (designated study site) to another ecological interest or service (designated intervention site). [6]

The applied method allowed to evaluate the impact of environmental policies when it is not feasible to use direct valuation methods due to budgetary restrictions and time limits; in this sense, the figures derived from the transfer of benefits constitute a first approximation, valuable for decision making, about the benefits or costs to adopt a policy or decision on the severe problem of deforestation. [7]

On the other hand, to use the benefit transfer method, it is necessary to follow the following steps: Identify goods and services to be valued, Compilation and review of source studies, adjustment of the data obtained, and estimation of the values to be transferred, as expressed in the following equation:

$$VA = VR_{(t-1)} \times Tc_{(t-1)} \times IPC_{(t/t-1)} \quad (2)$$

Where:  $VA$  is the updated value,  $VR_{(t-1)}$  is the exchange rate in the year the baseline study was carried out,  $Tc_{(t-1)}$  the year of analysis and  $IPC_{(t/t-1)}$  the consumer price index relating the current period and the period in which the baseline study was carried out.

From the above, the restoration of the areas affected by the removal of forest cover means a cost that the State with the participation of International Organizations focused on the preservation of the environment, must assume, as a policy to preserve the ecosystem not only of the Amazon if not of mother earth if it is required to recover the areas of deforested forest, in that sense it must be transparent in the valuation of environmental damage and restoration for the cost of reforestation; as well as the loss of the environmental good and the service of the accumulated carbon. [8]

To carry out an effective reforestation plan, it is necessary to finance at least the following activities: land preparation, purchase and transport of seedlings, planting, protection of the plantation, and technical advice. [9]

In essence, the methodology used is based on the use of market prices, as this considers the economic value of environmental goods and services that are traded in commercial markets, in which the interaction between producers and consumers defines prices through supply and demand.

## 2.1. Background

The United Nations Framework Convention on Climate Change identified three direct causes that motivate deforestation in the Amazon rainforests: a) migratory agriculture and agricultural expansion, b) illegal extractive activities, and c) the expansion of communication infrastructure, energy and extractive industries. In addition, indirect causes were considered to be related to structural factors, which are difficult to pinpoint. Still, the incidence of deforestation in the Amazon forest can be classified into a) demographic factors, b) economic factors, c) technological factors, d) political/institutional factors, and e) cultural factors. [10]

The Agreement indicated that between 2001 and 2014, 77% of deforestation comprised units smaller than 5 hectares for non-industrial crops. Based on this finding infer that the leading direct causes for deforestation or land-use change in the tropical rainforest are agricultural and livestock activities, which comprise 81 and 93%; which is not specified in the orientation of agriculture, which is not necessarily subsistence, leaving the severe presumption that some are a subset of properties that serve palm oil plants.

Another relevant factor is the illegal mining in Madre de Dios that deforests and damages the soil with mercury, hydroelectric infrastructure projects, hydrocarbon exploitation, lousy logging practices, and unlawful logging causes of the problem under study. Indirect causes are related to infrastructure construction, land tenure problems, and meeting the demand of the domestic and foreign

markets for agricultural products (coffee, cacao, oil palm, meat, among others), mainly due to the lack of compliance with the State's environmental protection measures; additionally, droughts cause migrations from the highlands to the Amazon. In addition, deficiencies cause migrations from the highlands to the Amazon. It cannot be ruled out that legal and financial institutional incentives lead to changes in forest cover towards other uses, especially agriculture and livestock, due to an adequate economic policy of the State. [13]

In support of the above, states that the leading cause of Amazon deforestation was and continues to be small-scale agricultural and livestock activities carried out by settlers migrating from the Sierra to the Amazon. They deforest areas of less than five hectares for pastures, take-away crops, and cash crops (coffee, rice, cacao, and coca). Considering that they are not technically assisted, they deforest forests whose soils lose fertility rapidly because they do not have a sufficient layer of fertile soil, so that in a few years, they migrate and deforest new areas, in a recurrent and incessant cycle that causes 80% of the accumulated national deforestation. [12]

An additional reason for the inefficiency of environmental policies is presented in the study. They point out that in 2014, two companies of the Melka Group deforested extensive forest areas in the area of Nueva Requena (Ucayali). Additionally, the company Plantaciones Pucallpa destroyed 13,000 hectares for oil palm cultivation. Also, the company Cacao del Norte SAC has to date cleared some 3,000 hectares in Tamshiyacu (Loreto), trampling the rights of the local population. These actions, unregulated and unsupervised by the state, degrade the forests and reduce their functions as a carbon store and sink; therefore, the forest loses its capacity to produce environmental goods and services and destroys its intrinsic biological diversity economic activities of predatory companies. [11]

On the other hand, 2018 considers that deforestation is often caused by human action. However, this position does not highlight the participation of state authorities in regulating and sanctioning the bad practices that originate the destruction of forest cover, differentiating subsistence from corporate greed. Furthermore, the state must implement an agricultural policy that regulates the use of soils, preferably to serve the small farmer.

### 3. Results

#### 3.1 Deforestation of the Amazon forest

As a reference, for the study period, Peru has 73,280,424 hectares of forest, representing 57.3% of the national territory, of which 53.9% is forest, 3.2% is dry forest, and 0.2% is Andean forest, as described in Table 1. In this regard, the tropical rainforest occupies 94.1% of Peru's total forests and includes aguajales, varillales forest, hill and hillock forest, terrace forest, riparian forest, and paces forest.

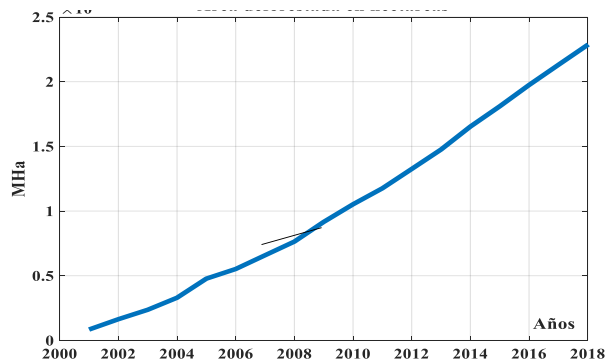
**Table 1:** Area and percentage of natural forest in Peru

Natural forests	AREA		
	Hectareas	% of country	% total forest
Amazonian rainforest (*)	68 962 682	53,9	94,1
Coastal and Andean dry forests	4 107 118	3,2	5,6
Andean relict humid forests	211 625	0,2	0,3
Total	73 280 424	57,3	100,0

**Table 2.** Reforestation Cost

Description	Unit of measure	Quantity
Reforestation Cost (year 2000)	USD*/ Ha	1,300.00
Exchange rate (year 2000) ** Reforestation cost (year 2000)	PEN***/ USD	3.49
Reforestation Cost (year 2000)	PEN/ Ha	4,537.00
CPI - Consumer Price Index (update factor) ****	-	1.67
Cost of Reforestation (year 2020)	PEN/ Ha	7,576.79
Total Area Affected	Ha	2 284 888
Reforestation Cost	PEN	17 312 116,594.50

In the study period, from 2001 to 2018, the loss of Amazon rainforests was 2,284,890 hectares, which is approximately equivalent to the size of the department of Ica. Despite its seriousness, there is no known positive response from the state. Likewise, it is essential to specify that this information includes minor forest losses due to natural causes (winds, landslides, etc.) and anthropogenic causes, i.e., direct human action. Considering the appreciation of, the loss of forests in the Peruvian Amazon during 2018 reached 154 416 hectares, i.e., the equivalent of 216 000 soccer fields. The fact is of utmost gravity because Peruvian forests constitute a vital carbon reserve at the global level. However, under state myopia, forest deforestation is high and increasing, generating 51% of Peru's greenhouse gas (GHG) emissions.



**Figure 1.** Deforested area in the period 2001-2018 in hectares.

The cost of reforestation in the jungle is US\$ 1,300 per hectare, published by the National University of the Peruvian Amazon - International Cooperation Office, under the title "Biodiversity as a Source of Opportunity for Bio-business," in Iquitos in 2008. Given this fact, it is necessary to raise public awareness to encourage the state to apply and observe the care of the forest without ignoring the fact that it can be used rationally. [14]

### 3.2 Loss due to carbon dioxide sequestration

For the evaluation of the loss of CO<sub>2</sub> sequestration in forests due to deforestation, the following table was prepared based on the information for the analysis period:

**Table 3.** Economic Valuation of the CO<sub>2</sub> Sequestration Service - Affected Area

	Description	Unit	Quantity
a	Affected Area (2001-2018)	Ha	2 284 888
b	Mass of CO <sub>2</sub> (2001-2018)	Tm/Ha/ Average	87.21
c	Total Mass of CO <sub>2</sub> (2000-2018) (c=axb)	Tm	199 265 082,48
d	Weighted price Tm CO <sub>2</sub> Forest	US\$/Tm	43.26
e	Total CO <sub>2</sub> revenue (e = c x d)	US\$	8 620 207 468.08
f	Exchange Rate (2020)	S/.	3.49
g	Total CO <sub>2</sub> revenue (g = e x f)	S/.	30 084 524 063.60

In addition to the damage of deforestation, the high costs of the loss of carbon dioxide sequestration are undeniable. In the absence of effective policies and measures, it will continue to grow to the country's detriment and humanity. [15]

### 3.3 Deforestation by departments in 2018

This damage was concentrated in the departments of Ucayali, Loreto, Huanuco, Madre de Dios, and San Martin, which together accumulate 73.47 % of total deforestation with 113 622 hectares; in this regard in Table 4 details how in these departments of Peru uncontrolled deforestation grows so that it puts at risk the ecosystem of direct places and indeed to the environmental system of the earth. [16]

**Table 4:** Deforested areas by the department in hectares, 2018

Departments	Forest	2017	%	2018	%	to 2018	%
Amazonas	2831731	8455	5.42	7453	4.82	88279	3.86
Ayacucho	209922	2781	1.78	1744	1.13	15351	0.67
Cajamarca	346762	2222	1.43	1276	0.82	18675	0.82
Cusco	3063940	12181	7.81	9643	6.23	83440	3.65
Huancavelica	17299	19	0.01	18	0.01	1013	0.04
Huánuco	1545972	19236	12.34	16560	10.70	318924	13.96
Junín	1850889	11427	7.33	8497	5.49	151241	6.62
La Libertad	68228	107	0.07	142	0.09	1075	0.05
Loreto	35047942	19082	12.24	26203	16.93	430280	18.83
Madre de Dios	7905744	23669	15.18	23492	15.18	209733	9.18
Pasco	1388278	8090	5.19	5610	3.62	109309	4.78
Piura	41492	465	0.30	60	0.04	3290	0.14
Puno	1423073	5774	3.70	6701	4.33	33294	1.46
San Martín	3344540	12501	8.02	21376	13.81	436512	19.10
Ucayali	9336773	29905	19.18	25991	16.79	384474	16.83
<b>Total</b>	<b>68422585</b>	<b>155914</b>	<b>100.00</b>	<b>154766</b>	<b>100.00</b>	<b>2284899</b>	<b>100.00</b>

According to information reviewed, in the period 2001 - 2018, an average of 126,938 hectares of forests was deforested per year in the Amazon, causing the release of carbon dioxide in an average of 87.21 MTCO<sub>2</sub>e. The primary source of emissions is the destruction of forests for agriculture, pastures, human settlements, mining, and other uses. There are also changes in forest biomass due to the consumption of firewood, timber, forest fires, and monoculture plantations. [17]

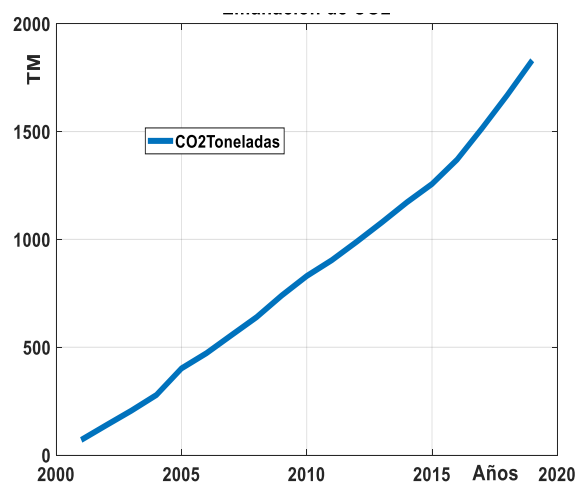
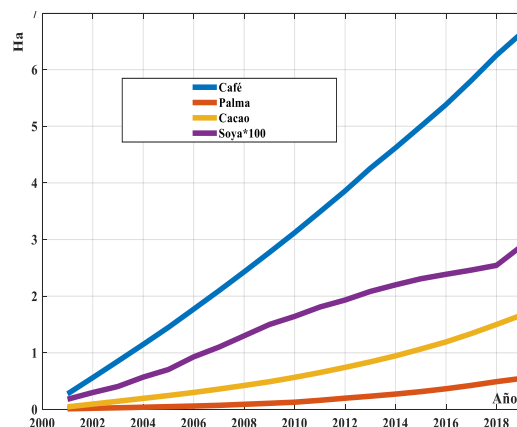
**Figure 2.** Growth of carbon dioxide emissions in metric tons.

Figure 2 noted that forest predators cause invasions of Private Conservation Areas, taking advantage of the permissiveness of the state and the problematic demarcation of these areas.

### 3.4 Deforestation and agricultural expansion in the Amazon region.

The expansion of agriculture for industrial purposes and population growth are direct factors in the accelerated deforestation rates of tropical rainforests due to their extension, natural richness, and high industrial potential. In addition, the lack of control and easy access represents an incentive and attraction for food companies and the Sierra populations.



**Figure 3.** Cultivated areas of agricultural products in hectares

### 3.5. Coffee cultivation

The average area dedicated to this purpose is 348 526 hectares per year for 2001 - 2018. The growth gradient is worrisome for reaching 62.67% in the study period, which leads to affirming that deforestation is severe. The Ministry of Agriculture reported that for 2018, 446 137 hectares were cultivated, and it was the largest crop in 17 regions, 67 provinces, and 338 districts. Despite this situation, there is no knowledge of relevant policies to stop this scourge. [18]

**Table 5.** Economic Valuation of the CO<sub>2</sub> Coffee Growing Service - Area Affected by Coffee Cultivation

Description	Unit	Quantity
a Affected area (2001-2018)	Ha	6 273 466.00
b Mass of CO <sub>2</sub> (2001-2018)	Tm/Ha/Average	87.21
c Total mass of CO <sub>2</sub> (2000-2018) (c=a x b)	Tm	547 108 969.86
d Weighted price Tm CO <sub>2</sub> Bosque	US\$/Tm	43.26
e Total income of CO <sub>2</sub> (e = c x d)	US\$	23 667 934 036.10
f Exchange rate 2020	S/.	3.49
g Total income of CO <sub>2</sub> (g = e x f)	S/.	82 601 089 786.10

Deforesting the forest to orient the soil for agricultural activities is an activity that has been carried out without responsibility for almost all of history. Since the discovery of agriculture and cattle ranching, Greenhouse Gas (GHG) emissions have been increasing, causing soil degradation and biodiversity loss.

Its cultivation is driven by attractive prices and market demand. Therefore, only for this crop, the deforested area, in the period 2001-2018 amounting to 6 273 466 hectares, the economic valuation of the carbon dioxide sequestration service in the coffee area amounts to USD 23 667 934 036.10 considering only the biomass.

**Table 6.** Reforestation Cost

Description	Unit	Quantity
Reforestation Cost (year 2000)	Usd*/ Ha	1,300.00
Exchange rate (year 2000) ** Reforestation cost (year 2000)	Pen***/ Usd	3.49
Reforestation Cost (year 2000)	Pen/ Ha	4,537.00
CPI - Consumer Price Index (update factor) ****	-	1.67
Cost of Reforestation (year 2020)	Pen/ Ha	7,576.79
Total Area Affected	Ha	6 273 466.00
Reforestation Cost	Pen	47 532 734,454.10

**Table 7.** Reforestation cost of affected area Oil palm cultivation

Description	Unit	Quantity
Coste de reforestación (año 2000)	Usd*/ Ha	1,300.00
Tipo de cambio (año 2000) ** Coste de reforestación (año 2000)	Pen***/ Usd	3.49
Coste de reforestación (año 2000)	Pen/ Ha	4,537.00
IPC - Índice de precios al consumo (factor de actualización) ****	-	1.67
Coste de Reforestación (año 2020)	Pen/ Ha	7,576.79
Superficie total afectada	Ha	490 521
Coste de reforestación	Pen	3 716 574,607.59

Repopulating the depredated forest and recovering its soils implies reforesting with native species to conserve and restore its integrity to stop the biodiversity damage crisis and mitigate climate change. The approach is oriented to achieve the objectives of sustainable development. From the international point of view, these activities will contribute to mitigating GHG emissions and will be in harmony with the criteria of the 2030 schedule regarding sustainable development goals. Although its value amounts to USD 13,619,694,686, this activity would be a simple way to reduce poverty in the deforested departments, considering that they are part of Peru's most economically depressed area. [19]

### 3.6. Oil palm cultivation

The area of cultivation of this species is virtually developed on soils resulting from the deforestation of the Amazon forest, which is why it is precarious for the environment than the average area dedicated in the period 2001 - 2018 reached 27 251 ha/year (with a severe growth of 490.81 % in this period). In this sense, considers that the accelerated expansion of this activity in the last decade is due to the development of large-scale projects of the oil industry derived from oil.

Palm for industrial use, sustained by farmers with plots of 5 hectares dedicated to monoculture. Points out that they have caused the loss of forest heritage and wildlife. In addition to the above, there is an increase in environmental contamination due to inadequate management of chemical inputs used to produce these crops and situations of conflict over the possession and ownership of private land and indigenous territories.

In recent years, the growth of oil palm monoculture is very accelerated; what is serious is the fictitious legality derived from the action of some companies that buy this product. In other words, deforestation is not attributable to subsistence but to the underground promotion of large industry, whose growth is directly related to the loss of forests in the Amazon, specifically in the departments of Ucayali, San Martin, Loreto, and Huanuco in the period 2001-2018 with a degree of deforestation of 490,521 hectares. Consequently, it is warned that if the depredation of the Amazon forest by this activity is not promptly controlled, deforestation will increase in the coming years. [20]

A policy hypothesis for forest restoration is to work with mixed species in which native species predominate to "rehabilitate autogenous ecological processes that enable species populations to reorganize themselves and establish functional, viable, resilient communities appropriate to changing conditions while providing essential ecosystem services" as stated by FAO Unasylva. This hypothesis is supported by the fact that native species require many years for their development. [21]

**Table 8.** Economic Value of the CO2 Sequestration Service - Area Affected by Oil Palm Cultivation

Description	Unit	Quantity
a Affected Area (2001-2018)	Ha	490 521.00
b Mass of CO2 (2001-2018)	Tm/Ha/Promedio	87.21
c Total Mass of CO2 (2000-2018) (c=a x b)	Tm	42 784 441.11
d Weighted price Tm CO2 Forest	US\$/Tm	43.26
e Total CO2 revenue (e = c x d)	US\$	1 850 854 922.41
f Exchange Rate (2020)	S/.	3.49
g Total CO2 revenue (g = e x f)	S/.	6 459 483 679.24

Economic Value of the Loss of Ecosystem Service of CO<sub>2</sub> Sequestration, forests as systems in environmental services allows the storage and capture of carbon dioxide, which is related to the anatomical structure of the soil where it accumulates in the root, stem, branches, leaves, flowers, and fruits, thus contributing to the carbon cycle ratified. Consequently, considering that the area affected by deforestation and oil palm cultivation is 490 521 hectares, the economic valuation of the carbon dioxide sequestration service in the area of this crop amounts to USD 1 850 854 922.41.

### 3.7. The cocoa crop

The average harvested area for the period 2001 - 2018 was 83 368 hectares per year, with a growth of approximately 251 %, presumably linked to deforestation activity in the most representative areas of the Amazon forest, according to information from the Ministry of Agriculture, which confirms that cocoa plantations are located in 16 regions, highlighting the San Martin and Loreto regions with 37.5% of the area at the national level. The deforested areas replaced by this crop are with irreversible problems caused by industrial cocoa companies, in which it is confirmed that most of the deforestation was carried out by the company Tamshi S. A. C, with the aggravating factor that could be within the framework of the law. [22]

**Table 9.** Reforestation Cost

Description	Unit of measure	Quantity
Reforestation Cost (year 2000)	Usd*/ Ha	1,300.00
Exchange rate (year 2000) ** Reforestation cost (year 2000)	Pen***/ Usd	3.49
Reforestation Cost (year 2000)	Pen/ Ha	4,537.00
CPI - Consumer Price Index (update factor) *****	-	1.67
Cost of Reforestation (year 2020)	Pen/ Ha	7,576.79
Total Area Affected	Ha	1 500 632
Reforestation Cost	Pen	11 369 973,531.20

Forest deforestation and losses due to carbon dioxide capture this aspect were fundamental for the awareness of the problem of global climate change that took place at the Earth Summit in Rio de Janeiro in June 1992; additionally, it should be noted that more than one hundred and fifty countries certified the United Nations Framework Convention on Climate Change, which refers to stabilizing greenhouse gas concentrations in the atmosphere at a level that curbs all dangerous anthropogenic disturbances of the climate system. It is therefore worrying that, in our country, after so many years, deforestation continues to be allowed to use the soil for cocoa plantations, which is reflected in the period 2001-2018, in which 1,500,632 hectares were cultivated. [23]

**Table 10.** Economic Value of CO<sub>2</sub> Sequestration Service - Affected Area

Description	Unit	Quantity
a Affected Area (2001-2018)	Ha	1 500 632
b Mass of CO <sub>2</sub> (2001-2018)	Tm/Ha/Promedio	87.21
c Total Mass of CO <sub>2</sub> (2000-2018) (c=axb)	Tm	130 870 116,72
d Weighted price Tm CO <sub>2</sub> Forest	US\$/Tm	43.26
e Total CO <sub>2</sub> revenue (e = c x d)	US\$	5 661 441 249.30
f Exchange Rate (2020)	S/.	3.49
g Total CO <sub>2</sub> revenue (g = e x f)	S/.	19 758 429 960.00

### 3.8. Soybean cultivation

In 2001 - 2018 the area dedicated to soybean cultivation was 25,431 hectares and an average of 1,413 hectares per year with an average negative growth of 53.97%, with a reforestation cost of 55 million US dollars.



**Table 11.** Reforestation cost per area affected by soybean cultivation.

Description	Unit of Measurement	Quantity
Reforestation Cost (year 2000)	Usd*/ Ha	1,300.00
Exchange rate (year 2000) ** Reforestation cost (year 2000)	Pen***/ Usd	3.49
Reforestation Cost (year 2000)	Pen/ Ha	4,537.00
CPI - Consumer Price Index (update factor) ****	-	1.67
Cost of Reforestation (year 2020)	Pen/ Ha	7,576.79
Total Area Affected	Ha	25 431
Reforestation Cost	Pen	192 685,346.49

The information on the decrease of deforestation for this crop in Peru seems encouraging; however, a look at the continent illustrates a very worrying reality in Argentina, wherein the last 25 years, about 5 million hectares of native forests have been deforested for the cultivation of transgenic soybeans, with the same severe effects on the environment that this study deals with.

To sustain the environment, the recovery of the Amazon forests is becoming more crucial every day to pursue ecological restoration. This includes the necessary repair of biological diversity. Furthermore, the essential effect is to recover ecosystem services that allow storing and capturing carbon dioxide. [15]

This is detailed in the following table:

It is prudent to point out that, despite having Ministries and authorities, deforestation of the Amazon forest in Peru continues to be a scourge that is not on the agenda of the governments in power; warning that this crop represents a source of GHG emissions whose economic value amounts to USD 95,943,650.68. [17]

**Table 12.** Economic Value of CO2 Sequestration Service - Affected Area

Description	Unit	Quantity
a Affected Area (2001-2018)	Ha	25 431.00
b Mass of CO2 (2001-2018)	Tm/Ha/Average	87.21
c Total Mass of CO2 (2000-2018) (c=a x b)	Tm	2 217 837,51
d Weighted price Tm CO2 Forest	US\$/Tm	43.26
e Total CO2 revenue (e = c x d)	US\$	95 943 650.68
f Exchange Rate (2020)	S/.	3.49
g Total CO2 revenue (g = e x f)	S/.	334 843 340.87

### 3.9. Summary of the costs of Amazonian forest deforestation in Peru

The total accumulated area dedicated to coffee, cocoa, oil palm, and soybean crops in the areas where the consequences of primary forest deforestation are present, in the period 2001-2018, amounts to 8 290 050 hectares, of which 75.67% of the total area is dedicated to coffee cultivation, followed by cocoa cultivation with 18.10%, oil palm 5.925% and soybean 0.31%. [8]

**Table 13.** Total deforestation, reforestation costs, and carbon dioxide value.

Products	Surface en Ha.	Value CO2	Reforestation value
Deforestation	2 284 888	8 620 207 468.08	4 960 461 861
Coffee	6 273 466	23 667 934 036.10	13 619 694 686
Palm	4 90 521	1 850 854 922.41	1 064 921 091
Cocoa	1 500 632	5 661 441 249.30	3 257 872 072
Soybeans	25 431	95 943 650.68	55 210 701
Total	8 290 050	31 276 173 858.49	17 997 698 550

In recent years, the orientation towards the industrial cultivation of coffee and cocoa has been motivated by high international prices and, in particular, by having access to low land prices through forest deforestation. [11]

As shown in Table 13, the total accumulated area covered by coffee, cocoa, oil palm, and soybean crops in 2001-2018 is 8,290,050 hectares. In this regard, the total economic value of the cultivated areas of coffee, cocoa, oil palm, and soybean in the deforested forests is USD 49 273 872 408.49, of which 63.47% corresponds to the economic value of CO<sub>2</sub> and the difference to the estimated investment to reforest the deforested area.

#### 4. Discussions

On average, the loss of Amazon rainforests between 2001 and 2018 was 126 938 hectares per year; however, between 2014 and 2018, there was an average increase of 161 874 hectares per year.

In this work, it was determined that the loss of Amazon forests by direct factors of deforestation is oriented to the substitution of soils for commercial agricultural uses oriented to export products, totally unrelated to the subsistence of the local people. In this regard, the Ministry of Environment reported that forest loss due to agricultural expansion and extractive activities in 2001-2016 was 1 974 209 hectares, increasing by 2018 to 2 284 889 hectares (15.69 %). What is worrying is that the Peruvian state has not established sanctioning policies for predatory companies. Even more so, no practical norms have been shown to prevent the depredation of the increasingly threatened forest. In addition to these activities, the opening of trails mainly for timber extraction due to deforestation becomes a severe risk factor for the forest and the cultural clashes that these activities cause. [21]

A severe reflection leads us to argue that the change in land use and the degradation of primary forests constitute a severe threat to biodiversity due to the release of greenhouse gases. These gases harm climate change and the life of beings on earth. Consequently, preserving the primary forest is not a matter of nations; because of its relevance, it is a matter of humanity.

#### 5. Conclusions

The analysis of the increase in the agricultural area implies establishing a direct relationship with the deforested area of the Amazon forests. This pernicious activity has been caused by the precarious legal norms and the lack of adequate regulations for state officials who have acted contrary to the spirit of the law and life. It is also clear that these activities have favored the entry of companies that, in response to market demand for the products studied, have depredated the forests, degrading the environment in general and destroying the habitat of native populations, with the presumed complicity of those in charge of the state and the permissiveness of the law.

Considering that 2,284,888 hectares of Amazon forest have been deforested during the study period, the reforestation costs amount to USD 4,960,461,861. In addition, it is appropriate to conclude that the economic value of the environmental damage amounts to USD 4,960,461,861 for the loss of carbon in the Amazon forests, obtained through the market price method.

Finally, the most significant damage caused by the deforestation of the Amazon forest is the more substantial increase in the emanation of greenhouse gases and its consequent impact on climate change of the earth, so that given this reality, deforestation should be a matter of international policy and not officials whose sinopia before the law and life have allowed this severe damage to the environment.

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