



Analysis of the deforestation of the Peruvian Amazon: Madre de Dios

Análisis de la deforestación de la Amazonia peruana: Madre de Dios

Análise do desmatamento da Amazônia peruana: Madre de Dios

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REVIEW ARTICLE

KEYWORDS

Deforestation, logging, illegal mining, agricultural activity, Peruvian Amazon.

ABSTRACT. The objective of this article was to systematize the evidence of deforestation and determine the main factors of forest loss in the department of Madre de Dios, Peru. A search was carried out for scientific research related to "deforestation", "Peruvian Amazon deforestation", "deforestation Madre de Dios". Scientific articles published in a database of indexed journals were analyzed. A descriptive, non-experimental study design was chosen. For data collection, the document analysis technique was applied. Based on the evidence, it is concluded that the areas of most significant deforestation are concentrated in the southern Amazon, mainly in Madre de Dios. In addition, the main factors of forest loss are illegal mining and mostly illegal agricultural activities; within these two activities, illegal mining is the cause of the highest percentage. Negative aspects such as the loss of biodiversity also prevail, contributing to climate change.

PALABRAS CLAVE

Deforestación, tala, minería ilegal, actividad agrícola, amazonia peruana.

RESUMEN. Este artículo tuvo por objetivo sistematizar las evidencias de la deforestación y determinar los principales factores de pérdida de bosques en el en el departamento de Madre de Dios, Perú. Se realizó una búsqueda de investigaciones científicas relacionadas a "deforestación", "deforestación amazonia peruana", "deforestación Madre de Dios". Se analizaron artículos científicos publicados en base de datos de revistas indizadas. Se optó por un diseño de estudio no experimental, descriptivo. Para la recolección de datos se aplicó la técnica de análisis de documentos. A partir de las evidencias se concluye que, en la Amazonía sur, principalmente en Madre de Dios, se concentran los puntos de mayor desbosque. Además, los principales factores de pérdida de los bosques son la minería ilegal y actividades agropecuarias en su mayoría ilegales, dentro de estas dos actividades la minería ilegal es la causante de mayor porcentaje. También

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prevalecen los aspectos negativos como la pérdida de biodiversidad, contribuyéndose al cambio climático.

PALAVRAS-CHAVE

Desmatamento, extração madeireira, mineração ilegal, atividade agrícola, Amazônia peruana

RESUMO. O objetivo deste artigo foi sistematizar as evidências de desmatamento e determinar os principais fatores de perda florestal no departamento de Madre de Dios, Peru. Foi feita uma busca por pesquisas científicas relacionadas a "desmatamento", "desmatamento na Amazônia peruana", desmatamento Madre de Dios ". Foram analisados artigos científicos publicados em bases de dados de periódicos indexados. Foi escolhido um desenho de estudo descritivo e não experimental. Para a coleta de dados, foi aplicada a técnica de análise de documentos. Com base nas evidências, conclui-se que, no sul da Amazônia, principalmente em Madre de Dios, concentram-se as áreas de maior desmatamento. Além disso, os principais fatores de perda florestal são a mineração ilegal e as atividades agrícolas, em sua maioria ilegais, dentro dessas duas atividades, a mineração ilegal é a causa do maior percentual. Aspectos negativos como a perda da biodiversidade também prevalecem, contribuindo para as mudanças climáticas.

1. INTRODUCTION

The Food and Agriculture Organization of the United Nations (FAO) defines deforestation as transforming the forest into other land uses. It consists of a permanent change in land use, either from a forest to another, or the disappearance of forest cover below 10% (GreenFacts, 2012). Deforestation is an activity that generally borders on illegality; the leading cause is indiscriminate logging for various purposes that leads to the loss of immense tracts of tropical forests but also causes the loss of human habitat and the biodiversity of animals and animals native fauna (Dioses, 2013).

The deforestation process of the Amazon rainforest area of Peru and the socioeconomic development has been characterized by presenting clearly identified periods that go from hunting and fishing of our native Amazonian inhabitants to the exploitation of rubber in the 19th century. The economic and demographic growth of the 20th century with a high presence of forestry, agricultural and mining extractive activities have caused the loss of essential extensions of tropical forests, the causes of which are mainly found in policies oriented towards the exploitation of uncontrolled natural resources (Walsh, 2007).

In the case of Peru, deforestation is bordering 9.5 million hectares of forests, equivalent to almost three times the size of the entire Lima region, which means that more than 15% of the country's total forests have been deforested, and economic losses currently reach 60 billion dollars. The situation is aggravated when knowing that each year approximately 150 thousand hectares of forests are lost, the equivalent of ten times the surface of the entire constitutional province of Callao (Marapi, 2013).

Deforestation in the Peruvian Amazon is considered as the loss of immense areas of forests or forest mass, generated by human activity, through the timber forest industry fed by the illegal indiscriminate logging, by migratory agriculture, expansion of lands for agricultural use, commercial use of charcoal firewood, road construction, etc. situation that generates ecological imbalance, loss of biodiversity and increased global warming (National Institute of Statistics and Informatics [INEI], 2011).

- Geographical scope

Peru maintains the tenth position in the world ranking of areas with the highest forest density. More than half of the country, approximately 260,000 square miles (673,109 km²), is covered by forests. Only Brazil has a larger

area of Amazonian tropical forest; this makes Peru one of the ten countries with the most incredible diversity globally, with more than 330,000 people who depend directly on national forests for their subsistence and many more who rely on it. of the many ecosystem products and services provided by these forests (Smith & Schwartz, 2015).

The department of Madre de Dios has an area of 8,475,908 hectares covered with tropical forest (6.6% of the national territory), where about 100,000 inhabitants live. Figure 1 shows that the department is located in the low jungle, south of the Amazon. It borders the neighboring countries of Bolivia and Brazil and has three large provinces: Tahuamanu, Manu, and Tambopata. The altitude of the Department of Madre de Dios is below 500 meters above sea level (Regional Government of Madre de Dios, 2020).

Figure 1

Location of the Madre de Dios area



Fuente: Google Earth

Madre de Dios is considered one of the areas with high biodiversity on the planet (Catenazzi et al., 2013). It has high levels of endemisms, reporting 218 species of mammals, 123 reptiles, 124 amphibians, 260 fish, and 852 birds. Paradoxically, there are socially and economically depressed populations in these affluent areas, such as the rural population, mainly due to ignorance of technological alternatives that promote their development.

Deforestation is one of the main threats to biodiversity due to the selective and constant extraction of all types of wood causing its depletion. 20% of the deforested areas are used for agricultural activities; the remaining 80% are abandoned and in the process of natural regeneration (Vera, 2014). Between the years 2000-2011, in Madre de Dios, a deforestation rate of 6203.6 ha/year was reported, reducing the forest area from 7'789 824.2 ha to 7'721 584.5 ha in the same period (Regional Government of Madre de Dios, 2015).

Factors of deforestation in the Peruvian Amazon

According to a study by the Seasonal Center for Strategic Approaches (CEPLAN), migratory agriculture, illegal logging, illegal mining, and drug trafficking are the most critical factors that contribute to deforestation (Alarcón et al., 2016).

➤ Andean migratory agriculture

Migratory agriculture is defined as the set of techniques used by farmers who only have basic tillage instruments, who cannot invest any capital in labor, and whose essential purpose is to produce food for themselves (Dourojeanni, 2016).

According to relevant information produced by the FAO, migratory agriculture has been called the custom of cultivating scattered clearings in the natural vegetation reserve (forest or wooded meadow) and abandoning them as soon as the soil is depleted, impoverished, or degraded. According to this system, families raise the villages and also emigrate in search of new fertile lands (Dioses, 2013).

➤ Illegal logging

According to the Natural Resources and Wildlife Supervision Agency– OSINFOR (2017) illegal logging is one of the problems that Peru has been facing. About the forestry sector, and in general, illegal logging is concentrated in timber species of high commercial value such as caoba, cedro and cumala.

➤ Illegal mining

Informal and illegal mining is the biggest mining environmental problem in the country today (Anto, 2019). It is an economic activity that consists of the exploitation of metallic minerals (such as gold) and non-metallic minerals (clay, marbles, among others), without control or social or environmental regulation on the part of the Peruvian State (Ministerio del Ambiente, 2013). This activity increases over the years, causing ecological damage such as deforestation and generating various criminal figures. An emblematic example is the city of Madre de Dios, where citizens work in illegal mining (Clavo, 2015).

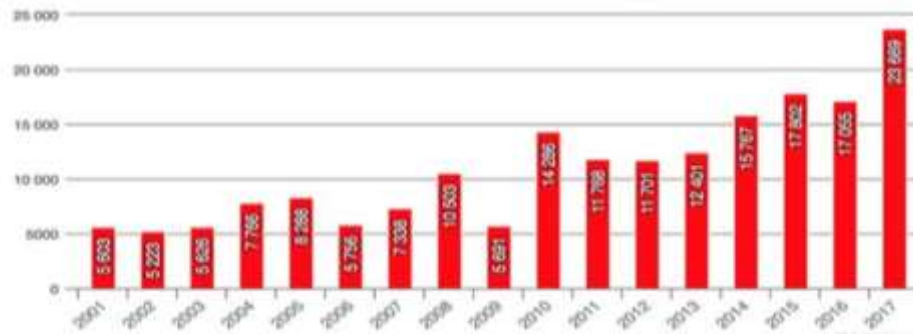
Deforestation in Madre de Dios

The department of Madre de Dios is currently facing severe deforestation and degradation of its forests, due both to the construction of the Interoceanic Highway and the growing increase in alluvial gold mining activities, mostly ilegal (Chavez et al., 2012).

In Madre de Dios, forests abound, which are vulnerable, since by the hand of man there are constructions, artificial environments, extraction of raw materials, such as wood, wild fruits, and minerals. Likewise, due to the extraction of gold, forests are cut down, which has been increasing illegally in this part of the region (Maulana, 2017).

Figure 2

Forest Loss -Madre de Dios



Source: Mongabay Latam

Figure 3

Deforestation by gold mining



Note. With the construction of the Interoceanic Highway, deforestation by gold mining took off more than 400%, according to Araújo et al. (2021). | Source: Maulana, 2017.

It is difficult to perceive from the Interoceanic Highway the environmental crime that is committed in La Pampa, the area located between kilometers 98 and 115 of the road above where gold mining has been concentrated in Madre de Dios (Maulana, 2017).

Between the years 2000-2011, in Madre de Dios, a deforestation rate of 6,203.6 ha/year was reported, reducing the forest area from 7'789,824.2 ha to 7'721,584.5 ha in the same period (Gobierno Regional de Madre de Dios, 2015) .

Illegal mining, for example, has been the leading cause of deforestation in the Madre de Dios region to triple. In 2008, the annual deforestation rate was just over 2,000 hectares, which increased considerably to more than

6,000 hectares in 2012 (Marapi, 2013). In recent years, high gold prices have fueled the uncontrolled growth of illegal and artisanal mining in areas such as Madre de Dios (Alvarado, 2014). Illegal mining is conceived as responsible for the loss of around 10,000 hectares in 2017. It also generates environmental pollution due to the use of uncontrolled chemical inputs in the district of Tambopata- La Pampa- Madre de Dios (Acosta, 2019).

Alarcón et al. (2016) in their research work "Deforestation in the southeast of the Peruvian Amazon between the years 1999 - 2013; Case of the Madre de Dios Region (Puerto Maldonado - Inambari), reported: a deforested area of 55,426 ha, which represents an annual rate of change in coverage of - 0.22% and yearly average Deforestation of 3,246 ha/year. They find that the advance of alluvial gold mining, influenced by the paving of the interoceanic road and the rise in the price of gold, is the primary agent of Deforestation, and to a lesser extent, the expansion of the agricultural frontier, cattle ranching, and forestry activity.

The latest studies by the Amazon Scientific Innovation Center confirm that only in 2017 gold mining was responsible for the loss of around 10,000 hectares of forest. Another of the most relevant findings is that, since 1985, this activity has caused the deforestation of more than 95,750 hectares of forest area, the equivalent of one-third of the size of Metropolitan Lima. And that a third of the deforestation recorded in the last 32 years, that is, between 1985 and 2017, is concentrated in the buffer zones of three protected natural areas of Madre de Dios (Araújo et al., 2021; Maulana, 2017)

Barba (2018) in his work "Prospective analysis of the deforestation process in the La Pampa - Guacamayo sector, Tambopata, Madre de Dios, period 1999 to 2030", carried out the analysis and perspective modeling in one of the sectors most impacted by man, by quantifying the change from forest cover to deforestation, to the period 2011-2016 (5 years) with 9,469.71 ha, followed by the period 2016-2030 (14 years) with 12,980.33. Regarding global changes from 1999-2016 and 2016-2030, the latter presents a more excellent conversion of forest to deforestation (23,335.40 ha), contributing to the increase in the agricultural frontier and extraction of gold mining. The quantification of the prospective model to the 2030 period reports that deforestation will increase to 25,091.37 ha, 8,052.08 ha more than 2016 (17 years).

New variables related to deforestation in Madre de Dios

Scientists have studied deforestation in this region for more than three decades and determined that, despite the fall in the price of gold, from the US \$ 1905 an ounce in 2011 to the US \$ 1200 in 2017, illegal activity has not stopped. and they have included new variables related to deforestation as can be seen in figure 4, the various variables in the increase in deforestation in Madre de Dios.

Figure 4

Impact of various variables on the increase in deforestation in Madre de Dios.



Source. Taken from Restoration of areas degraded by gold mining in Madre de Dios. World Wildlife Fund - WWF Peru.

In the case of the Interoceanic Highway, it can be observed that, during the construction period, between 2006 and 2011, the deforestation rate grew by 425%. If in 2006 deforestation was 2010 hectares per year, in 2011 it reached 8,536 hectares per year (Maulana, 2017). Also, the migration of people is another variable.

Mendoza (2012) in his research work, reports that the anthropic activity generated in the forest cover of the mining with 7,178.50 ha is the one that has been causing the most significant impacts on the forests because, in recent years, gold extraction has been It has turned into a fever due to the overvaluation of the ounce of this metal and due to the direct and indirect impacts of the construction of the Interoceanic highway. Then follows the cattle ranch with 4631.49 ha., Secondary forests 9113.22 ha. and agriculture 1,443.15 ha., respectively.

Another variable to highlight in the study on deforestation is "how the type of mining carried out will influence the future regeneration of the soil." The investigation concluded that mining with artifacts such as suction pumps is more dangerous than mining with heavy machinery. 63% of the deforested forest has been caused by the artisanal methodology, while deforestation with machinery represents 37% (Maulana, 2017).

Figure 5

Environmental impacts of Madre de Dios



Source: Ministry of the Environment, 2016.

2. METHODOLOGY

A non-experimental, descriptive, systematic review study design was chosen to analyze the studies, synthesize the scientific information and thus validate the data. For data collection, the document analysis technique was applied.

An exhaustive search of scientific research was carried out, according to criteria, analyzing articles published in indexed journals, using terms related to “Deforestation”, “Peruvian Amazon Deforestation”, Deforestation Madre de Dios”, in the Google Academic database, Scielo, Scopus, Sciencedirect. For this purpose, the scientific articles published from 2007 to 2019 were selected and reviewed.

27 scientific articles were considered, of which five were chosen for the analysis; the criterion was that they think the high level of evidence on the deforestation of the Peruvian Amazon in regards to Madre de Dios, which is summarized in table 1.

3. RESULTS

Table 1

Studies on the deforestation of the Peruvian Amazon. Madre de Dios

Año	Year	Name of the investigation	Research design	Population and sample	Results	Conclusion
1.Alvarado, L.	2014	Impacts and lessons learned from illegal and informal mining in Madre de Dio	Descriptive	Peruvian Amazon shows Madre de Dios.	Mining activity in the study area was found to have significant impacts on economic growth and employment, but also on deforestation and crime rate.	In recent years, high gold prices have fueled the disorderly growth of illegal and artisanal mining in areas like Madre de Dios.
Año	Year	Name of the investigation	Research design	Population and sample	Results	Conclusion

2. Alarcón et al	2016	Deforestation in the southeast of the Peruvian Amazon between the years 1999 - 2013; Regional case of Madre de Dios	Documentation, verification, and validation procedures allowed evaluating the quality of the information generated and the data reported.	Deforested areas in one of the areas most impacted by man	They show the systematic conversion of forest to deforestation for the year 2008-2011 with 29,478 ha, the most responsible being the advance of alluvial gold mining influenced by the paving of the interoceanic road and the rise in the price of gold.	Alluvial gold mining is the primary agent of deforestation, and to a lesser extent, the expansion of the agricultural frontier, livestock, and forestry
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Año	Year	Name of the investigation	Research design	Population and sample	Results	Conclusion
3.Barba R.	2018	Prospective analysis of the deforestation process in the La Pampa-Guacamayo sector, Tambopata - Madre de Dios, Period 1999 to 2030	Descriptive prospective analysis and modeling. The images involved in this research were acquired from the Landsat 5 TM sensor (1999 and 2011) and Landsat 8 OLI (2016)	Peruvian Amazon population and sample: sector most impacted by man in the Madre de Dios region; La Pampa - Macaw.	The validation of the model shows a level of agreement (kappa index) of 96.20%, and I quantify 25,091.37 ha of deforested areas, of which is 14 years (2016-30). This corresponds to 12,980.33 ha.	Anthropic activity in the La Pampa - Guacamayo sector has increased considerably in the last decade, causing irreparable damage to natural ecosystems.

Año	Year	Name of the investigation	Research design	Population and sample	Results	Conclusion
4.Anto, M	2019	Impact of illegal mining and logging on development and national security	Descriptive	Peruvian Amazon shows: cities affected by deforestation	They report that the impact of illegal and informal mining in the buffer zones of the protected areas of the Tambopata National Reserve, the Bahuaja National Park, and the Amarakaeri Communal Reserve, 31,000 ha of lost forest was found.	One of the main problems of the Amazonian countries is related to illegal mining and indiscriminate logging. Current deforestation crisis due to gold mining in the Peruvian Amazon.

Año	Year	Name of the investigation	Research design	Population and sample	Results	Conclusion
5. Acosta	2020	Illegal mining generates environmental pollution due to uncontrolled chemical inputs in the district of Tambopata- La	Descriptive, relational, transversal and non-experimental type method.	Peruvian Amazon Sample district of Tambopata - La Pampa Region	Managed to identify that the main problems of La Pampa, Tambopata province: (1) Environmental contamination due to misuse of mercury	With Law No. 27308, Conservation and Assessments of Illegal Mining in Fauna, Flora and Waters, there is no compliance



Pampa-Madre de Dios Region.	Madre de Dios	affecting river waters, (2) Child labor with exploitation, Continuous deforestation, and (4) Permanent informality and Illegality of mining activity	with the Environmental Adequacy Program
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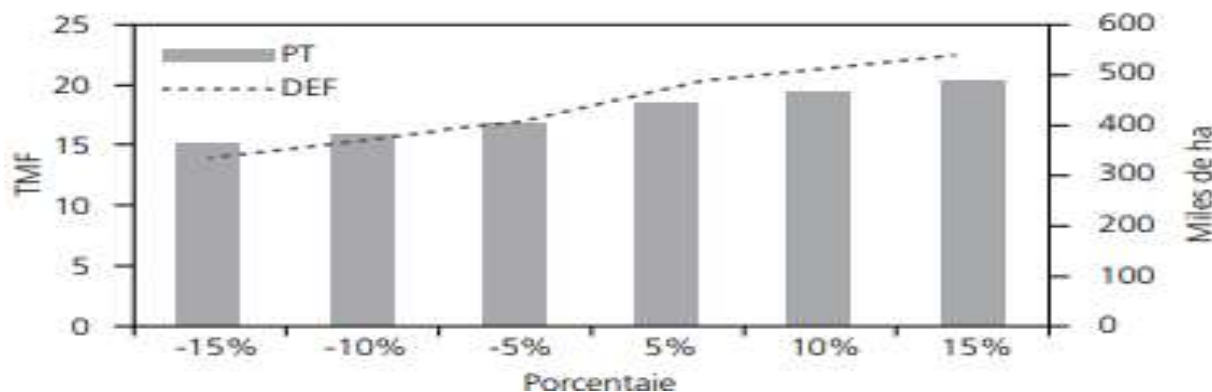
Source: self-made.

It was possible to show that the points of most significant deforestation are concentrated in the southern Amazon, mainly in Madre de Dios. Among the main factors of the forest loss are illegal mining and agricultural activities to a lesser extent.

Alvarado (2014) states that illegal mining has increased due to the increase in the price of gold. Additionally, figure 6 shows that, given the 5, 10, and 15% increase in gold production, there would be increasingly significant increases in deforestation. In addition, the lower the show, the reforestation would also be reduced.

Figure 6

Impact of mining production on deforestation



PT = producción total de oro; DEF = deforestación; TMF = tonelada métrica fina de oro; ha = hectárea.

Source Alvarado,2014

In the Amazon of the Madre de Dios region concerning the other areas of the country and Latin America, deforestation is caused mainly by alluvial gold mining, added to the accelerated immigration of the Andean region's inhabitants, the rise in gold in the international market, and the inadequate policies of the Peruvian government in land use planning in the period 2002-2010 (Alarcón et al., 2016; Asner et al., 2013).

Acosta (2020) determines that, in the last 15 years, illegal gold extraction (heavy machinery, excavators, front loaders, dump trucks) has disturbed some 7,000 hectares of tropical forests in Huepetuhe, Cachee, Delta Uno, Río Inambari (Reserva bionatural del Manu and Reserva del Bahuja Sonene) in the department of Madre de Dios.

Barba (2019) presents a prospective model that reported 134 163.92 ha of forest and 25 091.37 ha for the deforestation category (table 2). The quantification of the future model to the 2030 period says that deforestation will increase to 25,091.37 ha, 8,052.08 ha more than 2016 (17 years).

Table 2

Prospective report on change of use: forest to deforestation, 2030 period

Years	Lessons	
	Forest (ha)	Deforestation (ha)
2030	134 163,92	25 091,37

Source Barba (2019)

Table 3

Land cover change (Forest -deforestation) in the La Pampa -Guacamayo, Tambopata-Madre de Dios sector

Calculated years	Years	Coverage change			
		Forest persistence (Ha)	Deforestation persistence (ha)	Forest to Deforestation (ha)	Deforestation to vegetation (ha)
1	1999-2011	148 232,00	1 343,21	9 187,51	492,57
2	2011-2016	139 271,09	7 569,58	9 469,71	2 944,91
3	2016-2030	129 251,46	12 111,04	12 980,33	4 912,46

Source Barba R. (2018)

The data produced for the periods 1999, 2011, 2016, and predicted to 2030 confirm that deforestation has advanced and will continue to advance in the area according to Table 3 as India. The forest changed rapidly due to the demographic increase and the appearance of illegal miners, driven by the global financial crisis where the price of gold increased considerably. This trend was growing.

Table 4

Evolution of forest losses due to deforestation from 2000 to 2014

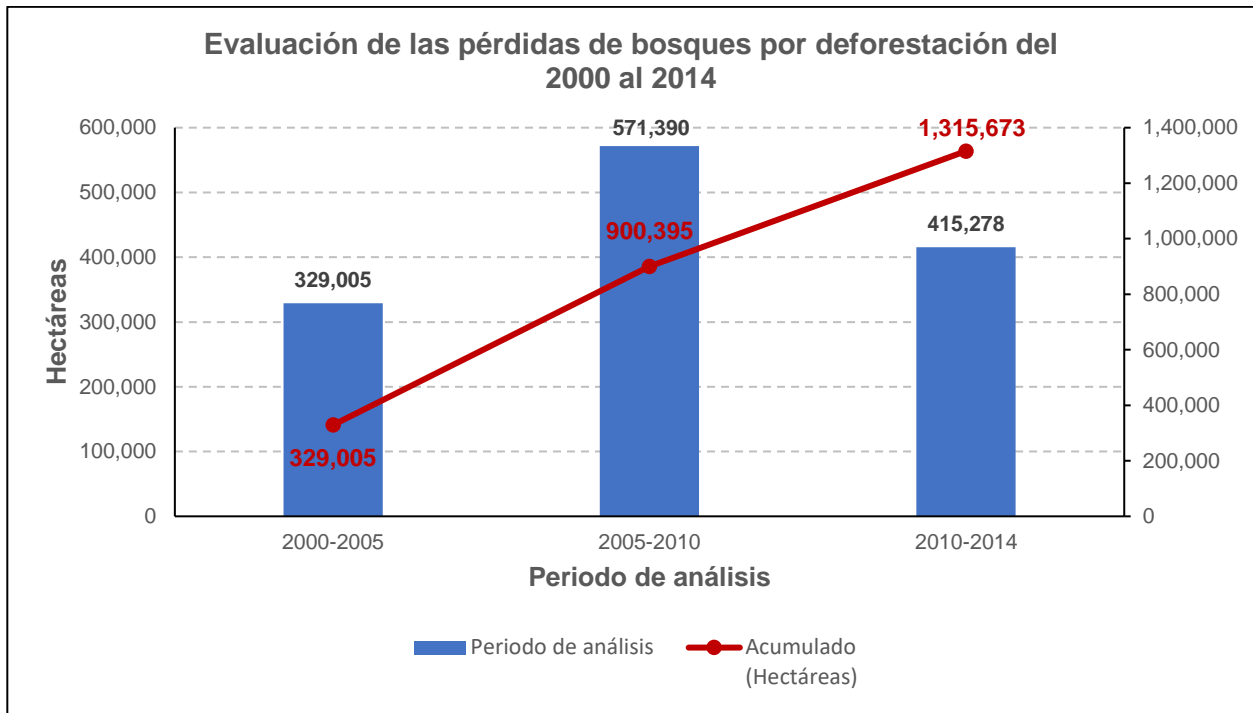
Analysis period	Forest losses due to deforestation (Hectares)	Accumulated (Hectares)
2000-2005	329,005	329,005
2005-2010	571,390	900,395
2010-2014	415,278	1,315,673

Source: Forest Mapping and Conservation Monitoring Unit - PNCBMCC, 2015



Figure 7

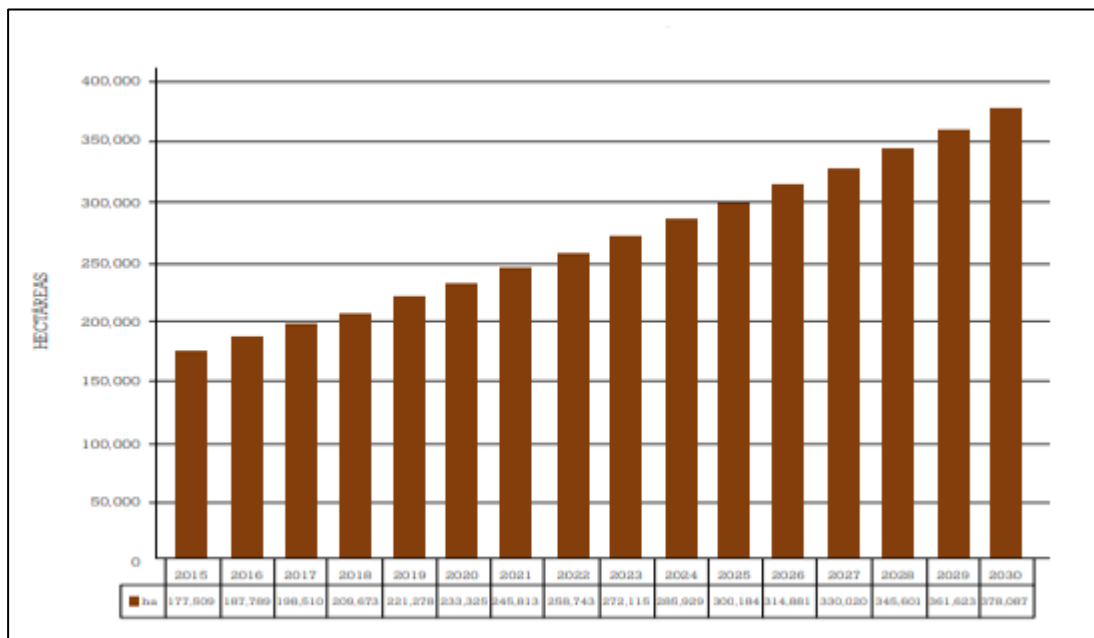
Evolution of forest losses due to deforestation from 2000 to 2014



Source: Forest Mapping and Conservation Monitoring Unit - PNCBMCC, 2015

Figure 8

Potential loss of the forest by 2030



Source: Forest Mapping and Conservation Monitoring Unit PNCBMCC.2015

4. DISCUSSION

This work showed that one of the main problems of the Amazonian countries is deforestation and that in Peru, Madre de Dios is the one with the most significant deforestation. The most important factors that contribute to the loss of the Amazon forest, also known as deforestation, are those generated by human activity, illegal logging for commercial use of forest species of high economic value; the expansion of land for agricultural use; the construction of roads, which together with illegal mining and drug trafficking, are what generate ecological imbalance and irreversible damage to the forest habitat. These findings are related to those found by Alarcón et al. (2016), who point out that alluvial gold mining is the primary agent of deforestation and, to a lesser extent, agriculture and livestock..

Asner et al. (2013) and Alarcón et al. (2016) in their studies coincide that in the Amazon region of Madre de Dios, deforestation is caused mainly by alluvial gold mining, added to the accelerated immigration of the inhabitants of the Andean region, the rise of gold in the international market and the inadequate policies of the Peruvian government in land use planning. Likewise, Barba (2019) shows us that the quantification of the prospective model to the 2030 period reports that deforestation will increase to 25 091.37 ha, 8 052.08 ha more, concerning 2016 and determines that anthropic activity in the sector La Pampa - Guacamayo has risen considerably in the last decade, causing irreparable damage to natural ecosystems.

Faced with the problem of deforestation and degradation, there must be an intersectoral commitment to articulate intersectoral and multilevel policies. In addition, it is necessary to have financing to fulfill environmental obligations and avoid adverse impacts in the respective regions to address the causes of deforestation directly.

5. CONCLUSIONS

The analysis shows that the Peruvian Amazon is currently facing severe deforestation and degradation of its forests. The factors that cause deforestation in the Peruvian Amazon are those generated by human activity, such as illegal logging for commercial use, the expansion of agricultural land, illegal mining, and drug trafficking.

In the southern Amazon, mainly in Madre de Dios, the areas of most significant deforestation are concentrated. Therefore, one of the main problems of the department of Madre de Dios is deforestation. The leading causes of forest loss in Madre de Dios, according to the studies, are related to illegal mining, which is the main factor and, to a lesser extent, the expansion of the agricultural frontier, cattle ranching, and forestry. In 2017, the most significant historical extension of forest loss due to gold mining was registered 9,860 ha, representing 38% of the total deforestation for Madre de Dios and 6.9% of the total deforestation of the country written in that year. Most of the deforestation by gold mining (63% or 60,200 ha) results from mining that uses artisanal technologies, while deforestation with heavy machinery represents 37% (35,550 ha) of the total deforestation by gold mining.

The decentralization of forestry functions to the Regional Governments in the period 2012-2018 did not represent an advance in the management of rescue and fire fighting services, considering the deficiencies of execution and operation; and controls and reviews in its processes. Nevertheless, the objective of the strategy designed by the Ministry of the Environment, through the fulfillment of its goals by 2021, is to eradicate 100% deforestation. Furthermore, it is proposed to reduce the rate of deforestation of primary forests by promoting their conservation and sustainable use.

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