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THE LUNGS OF EUROPE AND AMERICA UNDER THREAT: IMPACTS OF DEFORESTATION AND ILLEGAL LOGGING ON ECOLOGICAL AND AGRICULTURAL SUSTAINABILITY IN THE CARPATHIANS AND THE AMAZON-PERU

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Abstract. *The forests of the Carpathians (Romania) and the Peruvian Amazon (Madre de Dios) are critical ecosystems for climate change mitigation, water regulation, and biodiversity, and are fundamental for rural livelihoods. Deforestation and illegal logging have intensified forest degradation, affecting both wildlife and local communities, as highlighted by UNODC (2023), which emphasizes the direct connection between forest loss, food security, and the sustainability of natural resources. Additionally, provide information on deforestation rates, percentage of forest cover loss, and affected area. This study conducts a comparative assessment of both regions through analysis of recent scientific literature (FAO, 2022; Global Forest Watch, 2024; etc.) and satellite data from 2001 to 2024. The results reveal similar patterns of habitat fragmentation, reduction in carbon stocks, and loss of forest cover, driven by agricultural expansion, illegal timber exploitation, and weaknesses in environmental governance. It is crucial to recognize and protect the last remaining "lungs" of Europe and the Americas. Deforestation not only affects local climate, agriculture, and biodiversity, but also intensifies climate change and alters rainfall patterns, impacting other regions of the worldIt is concluded that forest degradation not only threatens biodiversity and ecosystem services but also undermines agricultural productivity, soil fertility, and water availability for local communities. This analysis underscores the need for integrated strategies that combine conservation, community-based management, and international cooperation to ensure the ecological and social resilience of these regions.*

Keywords*: Deforestation, illegal logging, biodiversity, ecological sustainability, agricultural sustainability, Carpathians, Amazon*

INTRODUCTION

Forests contribute significantly to climate regulation by absorbing CO_2 during photosynthesis and incorporating it into woody biomass; on average, each hectare of forest stores approximately 10 tons of this greenhouse gas (NATUREFUND, 2025). They also regulate precipitation by enabling the gradual infiltration of water into the soil and by participating in the water cycle, in which solar energy absorbed by the leaf canopy is converted into water vapor, and soil moisture absorbed through the roots is released into the atmosphere via the leaves. This process, known as evapotranspiration, accounts for roughly 40% of annual rainfall, generating rain clouds and influencing climatic patterns by producing a cooling effect in the atmosphere and regulating cooling periods (SMULEAC AT ALL, 2025). Additionally, forests protect soils from erosion caused by wind and water, thus playing a critical role in maintaining soil fertility. Their root systems further stabilize the soil, reducing the likelihood of landslides or avalanches, decreasing surface runoff, and, once soil absorption capacity is reached, allowing water to percolate through the soil to replenish groundwater supplies (GOMES ET AL., 2019).

In this context, the importance of the Carpathian forests and the Peruvian Amazon for their respective countries and continents becomes evident. Romania possesses one of the largest forested areas in Central and Eastern Europe, with the Carpathian forests covering approximately one-third of its national territory. According to WWF Peru (2022), the

department of Madre de Dios is one of the most biodiverse regions globally, recognized as the biodiversity capital of Peru and spanning more than 700,000 hectares.

However, while both regions have distinct geographical conditions, in recent decades they have shown similarities in the causes and effects of massive deforestation, the process of uncontrolled and often illegal logging of forests. This threatens not only the environment, biodiversity, and ecosystem services, but also agricultural productivity, soil fertility, and water availability for local communities. Therefore, this article compares both locations, evaluating the causes of deforestation, rates of forest cover loss, and agricultural impacts, highlighting the importance of designing more effective strategies to protect one of the last remaining "lungs" of both continents.

MATERIAL AND METHODS

This study employs a comparative approach to analyze changes in forest cover and their associated impacts in two regions: the Carpathians in Romania and the Peruvian Amazon in Madre de Dios (Figure 1). Both areas were selected for their ecological relevance and vulnerability to deforestation and ecosystem degradation.

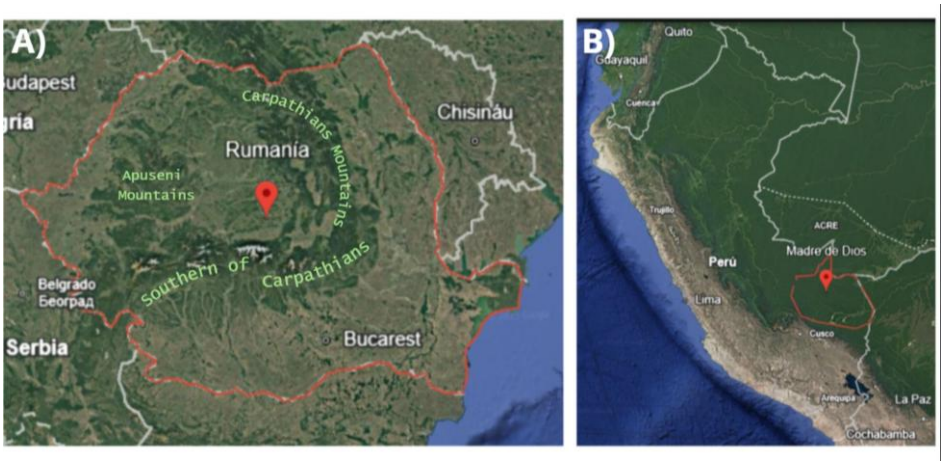

Figure 1. Geographical location of the Carpathian Mountains (Romania) and Madre de Dios (Peru)
Note. A) The Carpathians area of Romania and B) Madre de Dios (Peru). Created by the author using data retrieved from Google earth, 2025.

The information compiled in this study is based on recent literature and reliable environmental monitoring platforms, including reports from FAO (2022), Global Forest Watch (2024), UNODC (2023), as well as documentation from Naturefund, WWF, and satellite-based databases, among others. These sources provide data on forest cover, land use dynamics, and the socio-environmental impacts of deforestation. For both regions, key variables were considered, such as the annual deforestation rate, the percentage of forest cover loss, the extent of degraded areas, the impacts on agricultural activity, and the temporal evolution of these indicators between 2001 and 2024.

The analysis aims to identify common patterns and differences, considering both the magnitude and the temporal progression of deforestation and its associated effects. The results are

organized and presented visually through charts that facilitate the interpretation of observed changes in both regions and allow the establishment of relationships between forest cover loss and ecological and agricultural impacts.

RESULTS AND DISCUSSIONS

According to the reviewed sources, Global Forest Watch (2024) reports that the main drivers of deforestation in both regions include the expansion of agricultural land (in Madre de Dios primarily for cocoa, coffee, and maize; and in Romania generally for wheat, maize, sunflower, and grapes); illegal logging; industrial timber extraction or industrial forestry; forest fires; infrastructure development (such as roads and dams); and illegal mining.

The following graphs show a comparison of the main causes of deforestation (Figure 2), evaluating mining processes, settlement and infrastructure, and permanent agriculture. The latter is the most significant cause in Madre de Dios, with 210 kha, compared to 1.9 kha in the Carpathian Mountains. This indicates that agricultural expansion in the Peruvian Amazon is the primary cause of forest loss, followed by mining and extractive processes, which also have a major impact in Madre de Dios (110 kha). Mariano Castro (2023), director of the United for Forests Program at the Foundation for Conservation and Sustainable Development (FCDS) Peru, reported a 400% increase in illegal miners in La Pampa, which belongs to Madre de Dios (Mongabay, 2023). In contrast, in the Carpathian Mountains, the impact is almost negligible (2 kha). Finally, with respect to settlements and infrastructure, the Carpathians present a relatively higher value (3.4 kha) compared to Madre de Dios (1.7 kha), suggesting that in Romania, urbanization and infrastructure development represent more visible drivers of deforestation than in Madre de Dios.

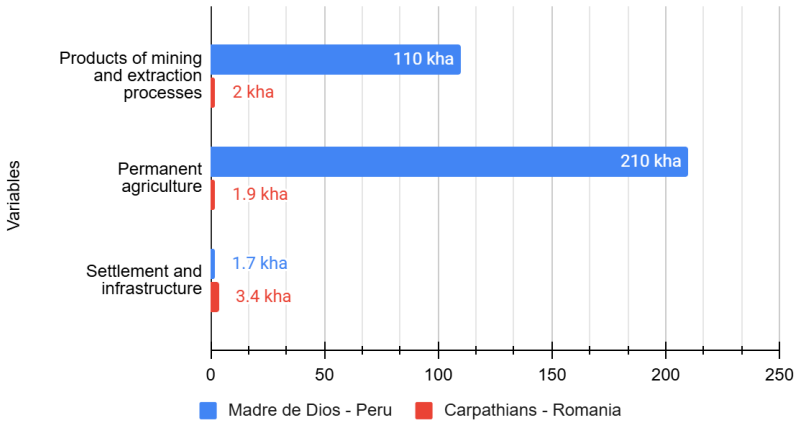

Figure 2. A comparative analysis, in thousand hectares (kha), of the principal drivers of deforestation

Note. The data show that deforestation drivers have a stronger impact in Madre de Dios, predominating the permanent agriculture with 210 kha and the products of mining and extraction processes with 110 kha. Created by the author using data retrieved from Global Forest Watch, 2024.

On the other hand, the causes of temporary deforestation disturbances evaluated from 2001 to 2024 (Figure 3) include logging, forest fires, shifting agriculture, and other natural disturbances. The data shows that in the Carpathian Mountains, deforestation is strongly

associated with logging, possibly both legal and illegal, covering 440,000 hectares, making it the primary cause. In contrast, in Madre de Dios, logging is also significant, with 17,000 hectares affected, but it is not the dominant factor, ranking instead as the third main cause. With regard to landslides, floods, and natural events related to climatic variability such as El Niño, these disturbances have greater impact in Madre de Dios, positioning them as the main temporary cause there, and as the second most important cause in Romania. In the Carpathians, such natural events are more sporadic and occur on a smaller scale, affecting approximately 2,500 hectares.

In third place are forest fires, which are less common in the Carpathian Mountains (1,300 hectares) because they are controlled by the climate and stricter forest management. However, they are much more frequent and impactful in the Peruvian Amazon due to seasonal drought conditions and the use of fire to clear agricultural land, affecting 21,000 hectares and making it the second leading cause of deforestation. According to an interview by RPP with Jesús Flores Puchiri, Director of Monitoring and Evaluation of Natural Resources at MINAM (2024), 98% of forest fires are anthropogenic (caused by human activities) primarily due to a lack of knowledge and the persistence of pre-colonial traditional practices in which many farmers burn their fields in the belief that ash will retain nutrients. Over time, these nutrients are lost, which is reflected in reduced crop yields. Although Peru has penalties established under Article 310 of the Penal Code, including a minimum of four years in prison, no individuals have been sanctioned to date, largely because identifying the responsible party is extremely difficult. Moreover, there are currently no institutions capable of extinguishing forest fires in remote areas that already have a history of recurrent fires, due to the high costs and the long response times required to reach these locations (RPP NOTICIAS, 2024).

Finally, migratory agriculture, which is typical of Amazonian communities, contributes to the temporary loss of forest cover in Madre de Dios with 10,000 hectares, while this practice does not exist in the Carpathians, where agriculture is more intensive and technologically advanced but there are control measures that are respected.

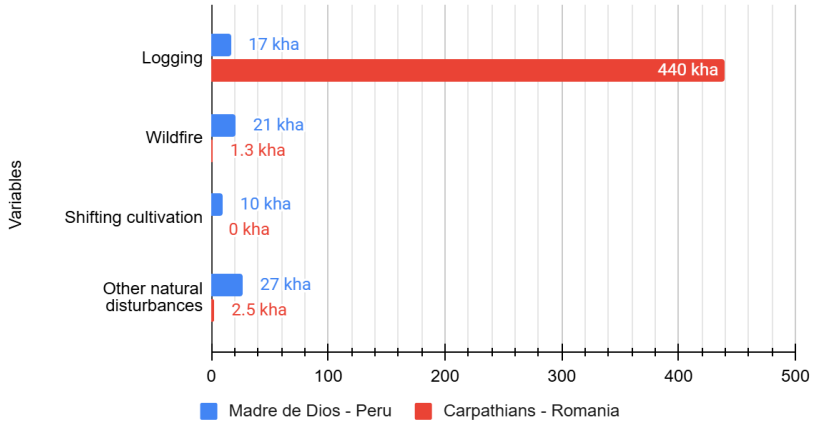

Figure 3. A comparative analysis, in thousand hectares (kha), of drivers of temporary disturbances of deforestation

Note. The data show that deforestation drivers of temporary disturbances have a stronger impact in Rumania, predominating the logging with 440 kha. Created by the author using data retrieved from Global Forest Watch, 2024.

Likewise, all of this is reflected in the variables compared:

- ***Deforestation rate and percentage (%) of forest cover loss***

The Carpathian region in Romania covers an area of approximately 66,303 km² (6,630,300 hectares), of which more than 450,000 hectares of forest have been lost in the last 24 years (Figure 4). Organizations such as Greenpeace indicate that around three hectares of forest are illegally logged every hour in Romania, equivalent to about 20 million cubic meters of timber per year, a quantity comparable to that legally harvested in the country's forests. The annual percentage of forest cover loss is estimated at approximately 6%, with the most affected areas located in the north, particularly in the counties of Maramureș and Suceava, around Borșa, Câmpulung Moldovenesc, and Vatra Dornei; in the mountains, the impacts extend toward Bistrița, Harghita, and Covasna; in the south, effects are observed in Rucăr, the Făgăraș Mountains, and the sub-Carpathian regions; in the east, near Petroșani and Cugir in the Șureanu, Lotru, and Parâng massifs; and in the Apuseni Mountains, particularly in Cluj and Bihor, affecting the forests of Gilău and Muntele Mare.

Figure 4. Tree cover loss in Romania to 2001-2024
Note. Global forest watch, 2024.

In comparison, the Madre de Dios region of Peru covers an area of 85,183 km² (8,518,300 hectares), of which it was estimated that between 2001 and 2024 (Figure 5), approximately 400,000 hectares of primary forest were lost, equivalent to 4.7% of the region's total forest cover during this period (GFW, 2024; GEOBOSQUE, 2024). The most impacted areas include primarily the Mining Corridor, where the greatest loss of forest cover is concentrated, as well as the areas adjacent to the Tambopata National Reserve, the Bahuaja Sonene National Park, and the Amarakaeri Communal Reserve. Several Indigenous communities have also been severely affected; among them, Barranco Chico is the most impacted, followed by San José de Karene, Tres Islas, Kotsimba, Puerto Luz, and Boca Inambari. According to data from the Monitoring of the Andes Amazon Program - MAAP (2023), between 2021 and 2023, these communities lost 3406 hectares of forest exclusively due to illegal mining, which has increased significantly in recent years as mentioned above.

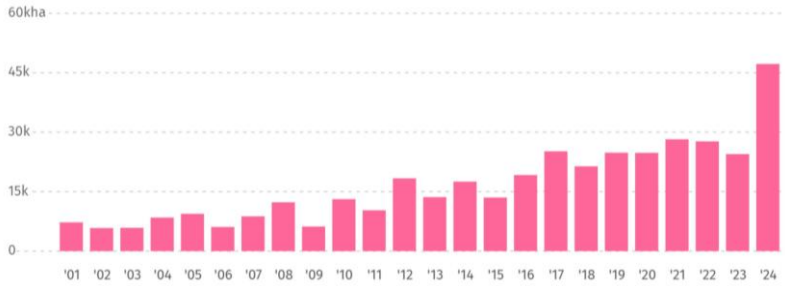

Figure 5. Loss of tree cover in Madre de Dios, Peru to 2001-2024
Note. Global forest watch, 2024.

Finally, when comparing the loss of tree cover between both regions, it is evident that both Romania and Madre de Dios have experienced significant reductions in their forested areas during the period 2001-2024. These data demonstrate that, although the contexts present different forest dynamics, one mainly associated with illegal logging and the other with agriculture and the expansion of extractive activities (illegal mining), the environmental impacts are comparable in magnitude and urgency.

- ***Agricultural Impacts***

In general, deforestation causes harm not only in the areas where it occurs but also in surrounding regions, generating alterations in the hydrological regime (droughts and floods), global and local climate change (reduced humidity and higher temperatures), heatwaves; and the loss of biodiversity, including essential pollinators and the balance of the ecosystem. These impacts negatively affect activities such as agriculture, primarily through soil erosion and desertification.

In both countries, deforestation has repercussions for agriculture. In Peru, in the short term, deforestation provides land for farming, but in the long term, the soil degrades rapidly due to humus loss and erosion, impacting traditional crops. During periods of heavy rainfall (December to February), landslides are more frequent in deforested areas. In Romania, particularly in the Carpathians (characterized by mountainous and hilly regions) deforestation reduces soil water retention, exposing crops during drought periods (in the European summer months of June to August and the autumn months of September to November). The forests that once protected against wind and flooding are gone, leaving these areas exposed to extreme weather events and local climate change, which negatively affect agricultural productivity and biodiversity.

For example, according to the article by AGERPRES (2025), the heatwave has generated edaphic drought during this European summer, damaging agricultural crops (wheat, corn, sunflower, and grapes) with losses ranging from 4% to 100% in the county of Timiș; therefore, the average yields obtained were lower than expected. In Peruvian agriculture this year, according to a press release from *La República* (2025), 20,000 hectares have been damaged, causing crop losses due to unpredictable rainfall, mudslides, landslides, droughts, reduced productivity of crops such as potatoes, quinoa, corn, Amazonian fruits, loss of agricultural land, and soil salinization. Economically, this represents a loss exceeding S/140 million, considering an investment of S/7,000 per hectare.

These impacts lead us to consider that it's not just about cutting down or felling trees, but that it affects everything we have and that surrounds us sooner or later, whether human activities or natural resources like rain. For instance, it has been demonstrated that air masses passing through

regions with higher vegetation density produce twice as much rainfall as air masses crossing areas with lower vegetation density, due to evapotranspiration, which contributes to intensifying terrestrial rainfall and reducing surface air temperature (PONTES ET AL., 2022; YANG, Y. ET AL., 2023). Conversely, forest fires, which are one of the causes of temporary deforestation in both countries (one more than the other), generate dense smoke that reduces the proportion of raindrops in clouds, delaying the onset of precipitation from 1.5 kilometers above the cloud base (ANDREAE, M. O. ET AL., 2004).

These are examples of the consequences that compromise long-term soil fertility and increase the sensitivity of agricultural crops, allowing us to recognize—based on the results presented in this article—that an activity such as deforestation and its underlying causes generate high vulnerability to extreme weather events (droughts and floods), which affect multiple sectors. For example, in the economic sector, Romania loses 6 billion euros annually due to illegal logging, according to European estimates cited by the Romanian State in the National Recovery and Resilience Plan (PNRR), whereas Peru loses approximately USD 250 million, according to figures from the Regional Government of Loreto. Both figures reflect losses derived solely from logging, excluding the economic losses associated with agricultural crops that did not achieve adequate yields due to hydrological and climatic factors.

CONCLUSIONS

Deforestation in the Carpathian Mountains and the Peruvian Amazon severely impacts ecosystems, climate, biodiversity, and agriculture. Although land clearing may provide short-term agricultural benefits, the continuous loss of forest cover leads to water scarcity, soil degradation, erosion, salinization, and reduced yields of strategic crops, thereby increasing the vulnerability of communities to droughts, floods, and heatwaves.In Romania, deforestation is primarily due to settlements, industrial infrastructure, and logging linked to the forestry economy, whereas in Madre de Dios it is multifactorial, influenced by fires, shifting cultivation, and natural events. These differences highlight the need for conservation strategies tailored to each region: control and monitoring of logging in the Carpathians, and integrated fire management, restoration, and sustainable agriculture in Madre de Dios.

For this reason, to mitigate these impacts, comprehensive measures are proposed that, in the case of Romania, improve forest control and management by developing monitoring tools and platforms like Geobosques in Peru, focused on the Carpathian Mountains and forested areas individually, not just collectively. Additional strategies include continuing to strengthen environmental legislation and enforcing penalties for illegal logging; implementing monitoring systems using drones, cameras, and satellites, which are still in the process of being consolidated in this country; promoting environmental education in schools, universities, and local communities; supporting ecological organizations and reforestation projects; and encouraging responsible wood consumption and recycling.

However, before implementing these measures, it is essential to guarantee greater transparency and availability of information from the State and the entities responsible for the care of the Carpathians. Currently, much of the data remains in the hands of these entities, limiting public access and reducing citizen participation. This lack of information means that many people in Romania are unaware of the magnitude of the problem and assume that protection depends solely on the State. To foster active participation in conservation, it is essential to disseminate up-to-date data on the state of the Carpathians, deforestation levels, and ongoing management actions. Without this access, monitoring platforms, environmental education, community projects, and responsible consumption choices are limited, as citizens

lack the necessary knowledge to become consciously and committedly involved. Therefore, a genuine transparency policy is not an optional component—it is the minimum requirement to raise awareness, mitigate impacts, and ensure the long-term conservation of the Carpathians and their surrounding ecosystems.

Regarding Peru, strategies are proposed to improve integrated fire management, restoration, and sustainable agriculture in Madre de Dios. The Peruvian Ministry of the Environment (MINAM) suggests continuing to study fire patterns in areas prone to extreme wildfires, as this is key to understanding how ecosystems might be affected by these disturbances in a world facing climate change (FERNÁNDEZ-GUISURAGA, 2023; QUESADA-ROMÁN & VARGAS-SANABRIA, 2022). Furthermore, it is recommended that they provide information on the months and locations where conditions are favorable for fires in certain areas and conduct frequent, on-site monitoring during those periods to mitigate fires and enforce the law against those responsible. The long-term effectiveness also depends on the proper implementation of coordination between different levels of government and its coherence with local socio-economic conditions where combining law enforcement with economic incentives, strengthening institutional capacities and applying fire management strategies adapted to the cultural context can be a key piece to achieve sustained reductions in the incidence of forest fires (Requia et al., 2025).

Regarding restoration, at the international level, mechanisms such as REDD+, implemented in the Amarakaeri Communal Reserve through the Amazonian Indigenous REDD+ pilot (RIA), contribute to recognizing forest ecosystem services and promoting sustainable practices (WWF Peru, 2022). The combination of conservation and restoration is essential, as natural recovery processes are slow and require active support to mitigate the consequences of forest degradation. Finally, in the area of sustainable agriculture, this opens the door to collaborative work and a better understanding of how countries like Romania, with its high agricultural activity and emerging economies, and others, respect areas designated for cultivation, how their cultures and traditions influence this, how they raise awareness among the population, and what the State and individuals themselves are doing to understand the importance of forests and their relationship with the soil. Likewise, replacing land-burning practices with the production of biochar from crop residues, reducing intensive tillage, implementing crop rotation to avoid the need for migration, and promoting that each farmer seeks to learn more about the type of soil they have to accurately determine its nutrient needs, among other strategies, are recommended (BHULLAR, G. S., & BHULLAR, N. K., 2013).

Overall, it is crucial to recognize and protect the last remaining "lungs" of Europe and the Americas. Deforestation not only affects local climate, agriculture, and biodiversity, but also intensifies climate change and alters rainfall patterns, impacting other regions of the world. Implementing these measures allows us to protect and restore these areas, which strengthen ecosystems, ensure resources such as water and fertile soil, and contribute to the well-being of both the planet and local communities, fostering the active participation of present and future generations.

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