

## Impacts on biodiversity and ecosystem services and the Emergence of Infectious Diseases (EID): a “one health” approach on Brazilian agriculture governance

*Impactos sobre a biodiversidade e os serviços ecossistêmicos e A Emergência de Doenças Infecciosas (EID): uma abordagem “uma saúde” na governança agrícola brasileira*

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**Abstract:** The ecosystem services are the benefits that people obtain of the ecosystems and biodiversity. They are currently “invisible” to the market and to the agricultural public policies in force in Brazil. The objective of this paper is to demonstrate the importance of these services in the containment of pandemics, and thus to include them in the decision-making processes of the Brazilian agricultural sector. The “one health” approach will allow us to evaluate the relevance of biodiversity and ecosystem services for agricultural governance and policies. Brazil has seven major biomes: Amazon, Cerrado, Atlantic Forest, Caatinga, Pantanal, Pampa and the coastal/marine biome. They harbour exuberant biodiversity but have been converted rapidly into agricultural and livestock production areas. In total, 500,000 km<sup>2</sup> of Brazilian ecosystems were lost between 2000 and 2018, an area the size of Spain. With the expansion of the agricultural frontier over ecosystems, important ecosystem services have been lost, and among those are health risk regulation services, in particular infectious disease regulation services. In addition to the losses in terms of Natural Capital, the degradation of ecosystems favors the emergence of infectious diseases (EID), including zoonoses with pandemic potential. Climate change, biodiversity loss and the collapse of ecosystem services, coupled with an increasingly vulnerable population are the primary drivers of EIDs. Amazon deforestation can therefore cause a “perfect storm” as it provides the link between the factors necessary for the emergence of infectious diseases that can threaten global health. It is urgent to include biodiversity and ecosystem services in the accounting of Brazilian agriculture governance in order to avoid new pandemics and losses in the Natural Capital.

**Keywords:** one health; ecosystem services; biodiversity; agriculture governance; Amazon deforestation; Emerging Infectious Diseases.

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**Resumo:** Os serviços ecossistêmicos são os benefícios que as pessoas obtêm dos ecossistemas e da biodiversidade. Eles são atualmente “invisíveis” ao mercado e às políticas públicas agrícolas em vigor no Brasil. O objetivo deste trabalho é demonstrar a importância destes serviços na contenção de pandemias e, portanto, incluí-los nos processos de tomada de decisão do setor agrícola brasileiro. A abordagem “one health” permite avaliar a relevância da biodiversidade e dos serviços ecossistêmicos para a governança e para as políticas agrícolas. O Brasil tem sete grandes biomas: Amazônia, Cerrado, Mata Atlântica, Caatinga, Pantanal, Pampa e o bioma marinho/costeiro. Eles abrigam uma biodiversidade exuberante, mas foram rapidamente convertidos em áreas de produção agrícola e pecuária. No total, 500.000 km<sup>2</sup> de ecossistemas brasileiros foram perdidos entre 2000 e 2018, uma área com o tamanho da Espanha. Com a expansão da fronteira agrícola sobre os ecossistemas, importantes serviços ecossistêmicos são perdidos, e entre estes estão os serviços de regulação de riscos à saúde, em particular os serviços de regulação de doenças infecciosas. Além das perdas em termos de Capital Natural, a degradação dos ecossistemas favorece a emergência de doenças infecciosas (EID), incluindo zoonoses com potencial pandêmico. As mudanças no clima, a perda da biodiversidade e o colapso dos serviços ecossistêmicos, juntamente com uma população cada vez mais vulnerável, são os principais fatores dos EIDs. O desmatamento da Amazônia pode, portanto, causar uma “tempestade perfeita”, pois proporciona a ligação entre os fatores necessários para o surgimento de doenças infecciosas que podem ameaçar a saúde global. É urgente incluir a biodiversidade e os serviços ecossistêmicos na contabilidade e na governança da agricultura brasileira para evitar novas pandemias e perdas no Capital Natural.

**Palavras-chave:** “one health”; serviços ecossistêmicos; biodiversidade; governança da agricultura; desmatamento da Amazônia; Emergência de Doenças Infecciosas.

## Introduction

The increase in the price of food has pushed up the value of commodities such as soybeans and beef. Brazil depends heavily on agricultural exports. In the present scenario of an economic crisis coupled with a very serious health crisis, the environmental issue has been neglected in favor of increasing agricultural production. The losses in terms of Natural Capital, including ecosystem services and biodiversity, are not accounted for in this equation, which only considers short-term monetary gains. In this context, health risk regulation services, in particular infectious disease regulation services, can be the example for the paradigm shift, since they clearly demonstrate the damage that can result from the degradation of ecosystems and biodiversity. In fact, Emerging Infectious Disease (EID) with potential pandemic consequences are resulting from land cover and land use changes, particularly deforestation and degradation of ecosystem and habitats. Biodiversity extinction rates are too related to the emergence of zoonosis with pandemic potential. Notwithstanding the cost related to ecosystem services losses

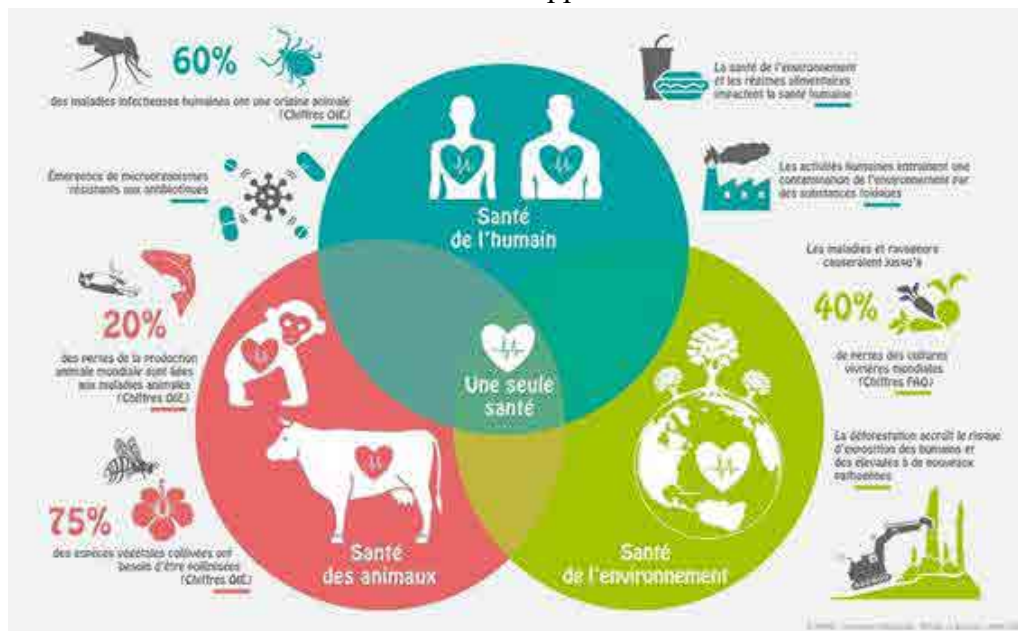
and biodiversity extinctions are not assessed and accounting in the commercial balance of the commodities trade or even in the investment decisions. Land cover and land use change can impact ecosystem services related to the avoidance of new pests and disease. Consistent research demonstrates the relation between deforestation and the EID. In hotspots areas – such Amazonia – the impact of deforestation on the ecosystem services related with avoidance of new pandemics increase the risk of raise of EID, mainly zoonosis. Deforestation in the Amazon is extremely concerning because it can provide the link between the needed factors to favor EIDs. Notwithstanding, deforestation is growing and accelerating in the Brazilian Amazon, particularly facilitated by the ongoing flexibilization of environmental law. This flexibilization, added to the weakness of environmental institutions and surveillance, signals an incentive for deforestation and illegal occupation of public lands. To understand how all these factors can lead to the emergence of new diseases with pandemic potential, it is necessary to perceive that human health, animal health, and ecosystem health are “one health” connected. The “one health” approach, therefore, allows a more precise analysis of the impacts on the environment and the consequences for human well-being. Based on the “one health” approach, the objectives of this paper are: (i) to highlight the importance of biodiversity and ecosystem services to avoid EIDs; (ii) to correlate the loss of biodiversity and ecosystem services with EIDs; (iii) demonstrate that changes in land cover and land use in the Amazon can lead to the emergence of diseases with pandemic potential; (iv) contextualize the advance of the agricultural frontier in the Amazon through deforestation of public lands; (v) warn of the threat to global health caused by this form of agricultural governance in the Amazon. (vi) propose the inclusion of ecosystem services and biodiversity in decision-making on land cover and land use change in the governance of agriculture in Brazil.

## 1. “One health” approach

According to the US Centers of Disease Control and Prevention (2022), “One Health is an approach that recognizes that the health of people is closely connected to the health of animals and our shared environment.” Although this approach is not new (begins in the 2000’s), “it has become more important in recent years” as “many factors have changed the interactions between people, animals, plants, and our environment.” (CDC, 2022). Understanding human, animal, and ecosystem health as a connected “health” allows for a more precise analysis of the impacts on the environment and the consequences for human well-being. The One Health concept, therefore, means looking at health “at the interface between the health of animals, humans, and their environment at local, national, and global scales

(...)” and thus allows “to find solutions that address both health and environmental issues.” (INRAE, 2022) The main issues concerning this approach include vector-borne diseases, environmental contamination, antimicrobial resistance, food security and safety and zoonotic diseases. So, cooperation between different areas is the key to the “one health” approach. The US CDC (2022), for example, uses this approach “by involving experts in human, animal, environmental health, and other relevant disciplines and sectors in monitoring and controlling public health threats and to learn about how diseases spread among people, animals, plants, and the environment.” The “One Health” approach can contribute to making a more accurate appraisal of land use and land cover changes in relation to the emergence of infectious diseases.

### One Health approach.



Source: INRAE, 2022.

Since animal and plant health, environmental health, and human health are therefore closely linked, impacts on ecosystems and biodiversity can have implications for this “one health”.

## 2. Ecosystem services related with Emerging Infectious Diseases (EID)

Ecosystem services are the benefits that people obtain from the ecosystems (MEA, 2005; TEEB, 2010; UK NEA, 2011; Diaz et al., 2015; EFESI, 2017).

They are essential for the maintenance of human wellbeing and also are the base of the economy. According to the French Assessment of Ecosystems and Ecosystem Services – EFESE (2017), *ecosystem services* are defined as: “Human use of the ecological functions of certain ecosystems, through uses and regulations that govern this use (...)” and thus they can be described “through the benefits that humans derive from their current or future use of various ecosystem functions, while ensuring that these benefits are maintained over time.” MEA (2005) divides these services into four main groups: provision, regulation, support and cultural services.<sup>2</sup> Among the regulation services are the services related with pest and disease control (CICES, 2018). The maintenance of pest and disease control services is central for avoid EID and, therefore, new pandemics. Disturbances to ecosystems and biodiversity associated with these services can trigger the spread of known and controlled diseases or even the emergence of new zoonoses and infectious diseases. The decrease of ecosystem services flows and biodiversity extinction means loss of Natural Capital<sup>3</sup> and, thus, represent economic costs. In very clear terms, the emergence of diseases with pandemic potential is also associated with losses of Natural Capital, with a double impact for the economy (meaning the costs associated with a pandemic itself, plus the costs associated with the loss of Natural Capital). Therefore, understanding the consequences of changes in ecosystems and biodiversity should guide the investment decision-making process. For example, the HM Treasury’s Green Book (2022) recommends that the

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2 “The Millennium Ecosystem Assessment was carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. (...) Approximately 1,360 experts from 95 countries were involved as authors of the assessment reports, as participants in the sub-global assessments, or as members of the Board of Review Editors. (...) The MA deals with the full range of ecosystems—from those relatively undisturbed, such as natural forests, to landscapes with mixed patterns of human use, to ecosystems intensively managed and modified by humans, such as agricultural land and urban areas. Ecosystem services are the benefits people obtain from ecosystems. These include *provisioning services* such as food, water, timber, and fiber; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis,

<sup>3</sup> According to HM Treasury’s Green Book: Appraisal and Evaluation in Central Government (2022) “Natural capital includes certain stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or ‘ecosystem’ services over time. These services, often in combination with other forms of capital (human, produced and social) produce a wide range of benefits.”

degradation of a renewable asset – such ecosystem services – should be assessed and be considered on the investment decisions:

Non-marginal effects such as reaching ecological tipping points might lead to dramatic or irreversible loss in the asset under consideration. This would result in a loss of environmental services and welfare. Cumulative effects of multiple investment decisions upon the underpinning stocks of natural capital should also be considered.

On the other hand, agriculture depends on ecosystem services such as pollination, hydrological cycle, nutrient cycling and pest control. Hence, impacts on ecosystem services can have effects on agriculture, livestock, and human health – since ecosystem, human, and animal health are connected. Land cover and land use changes are the main driver of ecosystem services decline and biodiversity loss. And these changes are linked with the emergence of zoonosis and infectious disease. So, changes in land cover and land use can lead to the loss of ecosystem services and thus increase opportunities for spillover.<sup>4</sup> Ellwanger and Chies (2021) highlights that “understanding the factors that facilitate the transmission of pathogens from wild animals to humans is essential to establish strategies focused on the reduction of the frequency of spillover events.” In this sense, an appraisal of the risks and costs involved with land use and land cover change is necessary before decisions on ecosystem conversion are made.<sup>5</sup> Indeed, in the conceptual framework of the French Assessment of Ecosystems and Ecosystem Services (EFESE, 2017), the regulating services of the biotic environment are divided into the regulation of crop and animal rearing conditions and the regulation of health risks, including the regulation of infectious diseases.<sup>6</sup> The concept of ecosystem services based on the “One Health” approach can contribute decisively to the agriculture governance by demonstrating that health, agriculture, biodiversity, and ecosystems are interconnected.

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<sup>4</sup> According Ellwanger and Chies (2021): “The transmission of pathogens from wild animals to humans is called “zoonotic spillover”. Most human infectious diseases (60-75%) are derived from pathogens that originally circulated in non-human animal species. This demonstrates that spillover has a fundamental role in the emergence of new human infectious diseases.”

<sup>5</sup> “Appraisal is the process of defining objectives, examining options and weighing up the relevant costs, benefits, risks and uncertainties before a decision is made.” (HM Treasury’s Green Book, 2022)

<sup>6</sup> – Regulation of the biotic environment:

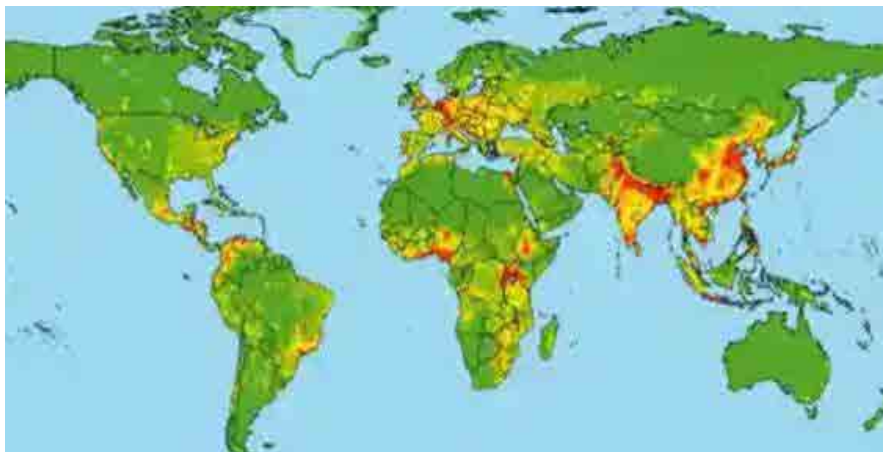
– Regulation of crop and animal rearing conditions: Regulation of weed seeds; Regulation of insect pests in crops; Regulation of animal diseases; Pollination of crops.

– Regulation of health risks: Regulation of infectious diseases; Regulation of dangerous species.

### 3. Land cover and land use changes, ecosystem services collapse and biodiversity loss: a pathway to the Emergence Of Infectious Diseases (EID)

Since the early 2000s, research on One Health approach presents a link between environmental degradation and impacts on human health. Zoonoses and vector-borne diseases are associated with the degradation of ecosystems and biodiversity. Changes in land cover and land use – from forest to agriculture or cattle ranching, for example – increase the spread of known diseases (such as malaria, dengue or yellow fever), as well as increasing the chances of new viruses and bacteria emerging. Jones et al. (2008), state that the emergence infection disease “is thought to be driven largely by socio-economic, environmental and ecological factors.” Analyzing a database of 335 EID events between 1940 and 2004, Jones et al. (2008) found that EID events are mostly zoonoses (60.3% of EIDs), with the majority of these zoonoses (71.8%) originating from wildlife – such as Ebola and severe acute respiratory virus. And the authors warn that these EIDs “are increasing significantly over time.” The results found by Jones et al. (2008) confirm that “EID origins are significantly correlated with socio-economic, environmental and ecological factors, and provide a basis for identifying regions where new EIDs are most likely to originate (emerging disease ‘hotspots’).” In addition, the study revealed “a substantial risk of wildlife zoonotic and vector-borne EIDs originating at lower latitudes where reporting effort is low.” The map below shows the EID events caused by zoonotic pathogens from wildlife in the period 1940-2004:

EID events caused by zoonotic pathogens from wildlife.



Adapted from Jones et al. (2008)

The hotspots for EID events caused by zoonotic wildlife pathogens are shown on the map in red and yellow. These hotspots coincide with densely populated

areas with high environmental degradation. Attention is drawn to hotspots located in tropical forest areas, which coincide with high levels of deforestation, e.g. in sub-Saharan Africa, Southeast Asia and Southeast Brazil. According Jones et al. (2008), this risk map of EID events caused by zoonotic wildlife “suggest that predicted emerging disease hotspots due to zoonotic pathogens from wildlife and vector-borne pathogens are more concentrated in lower-latitude developing countries.” In relation to the hotspots identified in Brazil in the period 1940-2004 analyzed by Jones et al. (2008), it is possible to relate the EIDs to the accelerated degradation of the Atlantic Forest and increase in urban population that occurred in southeastern Brazil in the same period. This same combination of factors is currently occurring in the Amazon. The authors argue that there should be increased surveillance of these zoonoses in areas such as tropical Africa, Latin America, and Asia in order to identify new cases of EID early before large-scale spread. In this regard, Jones et al. (2008) alert that the “Zoonoses from wildlife represent the most significant, growing threat to global health of all EIDs.” In this context, increasing efforts to conserve areas with high biological diversity and reducing anthropogenic impacts on ecosystems “may have added value in reducing the likelihood of future zoonotic disease emergence.” (Jones et al., 2008)

Andreazzi et al. (2020) emphasizes that the “unprecedented rates of biodiversity loss caused by the expansion of anthropogenic activities are major drivers of infectious disease outbreaks (eg, Ebola virus, Nipah virus, arboviruses).” In this sense, Ellwanger and Chies (2020) states that “the loss of biodiversity profoundly alters the dynamics of the infections.” And deforestation is among the main causes of loss of biodiversity. Morand and Lajaunie (2021) are more explicit in stating that “deforestation is a major cause of biodiversity loss with a negative impact on human health.” Therefore, the context of habitat fragmentation, biodiversity erosion and people living close to the forests “creates ideal conditions for the introduction of known and unknown pathogens into the human population.” (Ellwanger and Chies, 2020). At this point it is important to highlight that a growing number of studies are indicating the relationship between deforestation and the emergence of zoonoses. Morand and Lajaunie (2021) find that the increase in outbreaks of zoonotic and vector-borne diseases from 1990 to 2016 is linked to deforestation, especially in tropical countries.<sup>7</sup> According these authors, “the significant associations observed between epidemics and deforestation mostly concerned the countries of the intertropical zone with high forest cover, such as

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<sup>7</sup> Morand and Lajaunie (2021) cite as an example that the increasing prevalence of vector-borne diseases is associated with the conversion of land – including forests – to commercial plantations in Southeast Asia.



Brazil, Peru, and Bolivia in South America, Democratic Republic of Congo and Cameroon in Africa, Indonesia, Myanmar and Malaysia in Southeast Asia, among others.”<sup>8</sup> This study reinforces the urgent need for an international governance framework “to ensure the preservation of forests and the ecosystem services they provide, including the regulation of diseases.” In effect, the authors state that

Several studies have as exemplified that multiple factors are responsible of the outbreaks of Ebola in Africa, Nipah or Plasmodium knowlesi in Southeast Asia. Not only the emergence of new diseases, but also epidemics of infectious diseases appear to be linked to deforestation as recently evidenced for malaria epidemics in Brazil. (Morand and Lajaunie, 2021)

The COVID-19 pandemic was a clear example of the neglect of the interface between public health and biodiversity conservation, with serious social and economic consequences. (Andreazzi et al., 2020) Countries with high levels of biodiversity, but high social vulnerability and high levels of environmental degradation, “are prone to pathogen spillover from wildlife to humans (...)” (Andreazzi et al., 2020)<sup>9</sup> From the “one health” approach, it is possible to understand that the land cover and land use changes, added with the increase in human population and livestock, settled in the hotspots of biodiversity, compose a context for the emergence of new zoonotic disease with pandemic potential. Nowadays, Amazon region fit on this context, with the recent high levels of deforestation and land use conversion to cattle ranches and soybeans plantations. Thus, the agriculture pressure over ecosystems constitutes an EID risk in the Amazon region.

#### **4. Land cover and land use changes in the Amazon Region may trigger an increased risk of eids**

Brazil has seven major biomes: Amazon, Cerrado, Atlantic Forest, Caatinga, Pantanal, Pampa and the costal/marine biome. They harbour exuberant biodiversity but have been converted rapidly into agricultural and livestock production areas. For example, the Amazon lost 269,801 km<sup>2</sup> between 2000 and 2018, and the Cerrado lost 152,706 km<sup>2</sup> of its natural composition during this time interval. In total, 500,000 km<sup>2</sup> of Brazilian ecosystems were lost between 2000 and 2018,

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<sup>8</sup> “Altogether deforestation and biodiversity regulation loss favor reservoir and/or vector populations, affect disease transmission dynamics and ultimately lead to increasing human contacts with vectors or reservoirs. Several studies have emphasized the role of forest deforestation in the emergence of zoonotic diseases such as Ebola in Africa.” (Morand and Lajaunie, 2021)

<sup>9</sup> Accordind Andreazzi et al. (2020) “in Brazil, clear warnings are the recent emergence of Oropouche virus, hantaviruses, Sabiá virus, and the re-emergence of Chagas disease and sylvatic yellow fever.”

an area the size of Spain.<sup>10</sup> With the expansion of the agricultural frontier over ecosystems, important ecosystem services have been lost, and among those are *health risk regulation services*, in particular *infectious disease regulation services*. Amazon is one of most biodiverse regions in the world. Notwithstanding, their ecosystems are rapidly converted into cattle ranches and soybeans plantations. These changes in land cover and land use can lead to the collapse of the ecosystem services provided by the forest. Among these services, the collapse of ecosystem services related with pest and disease control are very concerning. Also, the high levels of biodiversity loss caused by deforestation are related to the EID. Ellwanger and Chies (2020) highlights that the “influence of Amazon deforestation on the emergence of infectious diseases is supported by a large amount of consistent data.” Analyzing the potential impact of the Amazon wildfires on vector-borne and zoonotic emerging diseases, Bonilla-Aldana et al. (2019) warns that “Land-use changes can impact infectious disease transmission by increasing spatial overlap between people and wildlife disease reservoirs.”<sup>11</sup> In clear terms:

Studies report that deforestation increases the risk of malaria and probably other vector-transmitted infections. The ecologies of multiple transmissions of vector-borne and zoonotic diseases pose challenges for their control, especially in changing landscapes, even more during such deforestation situations. (Bonilla-Aldana et al., 2019)

Indeed, deforestation can cause a “perfect storm” because “provide the link between a variety of factors involved in the emergence and spread of the infections.” (Ellwanger and Chis, 2020)<sup>12</sup> And the causes of the accelerate of deforestation and the uncontrolled expansion of agriculture in Amazon are well-known: “the ongoing flexibilization of Brazilian environmental laws, the dismantling of environmental institutions, the disregard for scientific evidence, and the attacks

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<sup>10</sup> The data are from the Brazilian Institute of Geography and Statistics (IBGE), produced in the context of the project “Natural Capital Accounting and Valuation of Ecosystem Services – NCAVES”, launched in 2017 by the United Nations Statistics Division – UNSD – and UNEP – with European Union funding.

<sup>11</sup> Bonilla-Aldana et al. (2019) also warns that “previous epidemics like the sizeable yellow fever epidemic, which began in Brazil in 2016 and had as vectors the *Haemagogus leucocelaenus* and *H. janthinomys*, which are wild mosquitoes, have been driven by landscape modifications, with forest fragments running in periurban areas, allowing enough interaction to produce such an epidemic.”

<sup>12</sup> According Ellwanger and Chis (2020), “the association between anthropogenic action in the Amazon rainforest, climate change, alterations in vector dynamics, human migration, genetic changes in pathogens and the poor social and environmental conditions in many Latin-American countries can give rise to the “perfect storm” for the emergence and re-emergence of human infectious diseases in Brazil and other Amazonian countries.”

on conservation organizations (...)" (Andreazzi et al., 2020) And the consequences of this actions are clear:

All such actions represent a major setback in socioenvironmental policies, which opens new fronts for zoonotic emergence and negatively impacts biodiversity and public health, putting millions of people at risk. By threatening wildlife health and compromising the provision of ecosystem services, these actions further aggravate the effects of climate change and outbreaks of zoonotic diseases. (Andreazzi et al., 2020)

The mere possibility of triggering diseases with pandemic potential that threaten global health would be enough to justify stopping deforestation in Amazon region. Nevertheless, the Brazilian government took advantage of the pandemic of COVID-19 crises to approve the flexibilization of environmental legislation that led to the acceleration of deforestation in the Amazon. (Vale et al., 2021)<sup>13</sup> An example of this is the reduction in enforcement operations, even in spite of the growing deforestation: the number of fines was reduced by 40% during the period between January and July of 2020 – “while Amazon deforestation reached 4719 km<sup>2</sup> in the same period – the highest level since the start of monthly deforestation records in 2015.” (Vale et al., 2021)

## **5. Amazon deforestation: a “perfect storm” for global health?**

The growing value of agricultural commodities, animal protein and minerals has urged recent governments and private enterprise to expand production to meet international demand. In light of this, there is a constant and growing expansion of the agricultural frontier over all six Brazilian terrestrial biomes, with the Amazon and the Cerrado being the most rapidly converted. Land fraud (grilagem) and the consequent deforestation and expulsion of traditional communities is a frequent practice. Anyone wishing to “invest” in cattle or soy farms in the Amazon will easily find advertisements of areas for sale with thousands of hectares “ready to produce”. The historic concentration of land ownership not only persists today but has increased exponentially in recent years. According to data from the National Institute of Colonization and Agrarian Reform (INCRA, apud Westin, 2020):

<sup>13</sup> According Vale et al. (2021): “We identified 57 major legislative acts from the current administration that weakened environmental protection in Brazil (...), 49% of which were enacted in the seven months since the onset of the pandemic (...). September 2020 was the month with the highest number of legislative acts published (n = 16). (...). The actions included weakening environmental legislation and institutions, which legalized deforestation in key ecosystems, reduced environmental standards and law enforcement, and enfeebled Protected Areas’ management. The likely consequences of those actions to biodiversity and environmental conservation are yet to be estimated.”

(...) currently, only 0.7% of the properties are larger than 2 thousand hectares (20 km<sup>2</sup>), but together they occupy almost 50% of the Brazilian rural area. On the other hand, 60% of the properties do not reach 25 hectares (0.25 km<sup>2</sup>) and, even so numerous, cover only 5% of the rural territory.

Despite the repeated practice of land fraud (*grilagem*), Brazilian legislation allows the regularization of non-titled occupations. In the state of Pará, for example, reference values for regularization vary from 55 euros to 193 euros per hectare, depending on the location of the property. (Instituto de Terras do Pará, 2021) The illegal appropriation of land is strongly related to deforestation because, according to Socio-environmental Institute (2021), the invaders deforest and fence in order to show that the area “belongs to them”. After deforestation, they allege to the land agency that they have occupied the area for a long time and request regularization, paying the State lower values than those practiced in the real estate market.

With the property title, the *grileiros* sell the “legalized” area for a market price. In this way, the real estate market for agricultural land represents a risk for the forest – long before the sale to soy and cattle producers. The ease that *grileiros* have to legalize invaded public areas “meets a speculative market for terras griladas [fraud lands], now heated by the dismantling of policies to inspect and combat deforestation.” (Oviedo et al., 2021) That is, “those who deforest end up owning the land “ in the Amazon, as Oviedo et al. (2021) explain:

The connection between the invasion of public lands and deforestation reveals the sad reality, where those who deforest end up owning the land, and are benefited by public policies with rules to legitimize and proliferate *latifundia*. However, the retaking of these public lands is never discussed. Thus, deforestation and *grilagem* in the region are not combated by the agencies that have the legal responsibility to do so.

Oviedo et al. (2021) show that between 2018 and 2020<sup>14</sup>, the invasion of public lands that could not be occupied (such as indigenous lands, quilombola territories, and conservation units) grew 56%, representing an area of 297,000 km<sup>2</sup>, an area seven times larger than Switzerland. In these areas, deforestation grew 63% between 2018 and 2020, in all states of the Brazilian Amazon – the data were obtained from PRODES/INPE<sup>15</sup> and the Brazilian Forest Service, ImaFlora,

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<sup>14</sup> This period coincides with the election of the Bolsonaro government and the first years of his administration.

<sup>15</sup> “The PRODES project conducts satellite monitoring of clearcut deforestation in the Legal Amazon and has produced, since 1988, annual deforestation rates in the region, which are used by the Brazilian government to establish public policies. The annual rates are estimated from the

IPAM and RAISG. The opening of highways, railroads, or electricity supply further valorizes the irregularly occupied areas, fomenting illegal occupation. With the opening of roads in forest areas, the deforestation known as “fishbone” occurs. The simple announcement of the paving of highways, such as BR-319, heats up the land market, encouraging more invasions.

Junction of the Transamazônica Highway (BR-230) with the BR-163 highway near Santarem (PA), Pará, and its numerous fishbone branches.



(Mongabay, 2020)

As well as the announcement by the Public Authorities of new infrastructure works, the mere processing of Bill No. 510/2021 and Bill No. 2633/2020 – known as the “PLs da grilagem” – are encouraging the invasion of public lands even before the law has been approved.<sup>16</sup> The numbers from PRODES demonstrate

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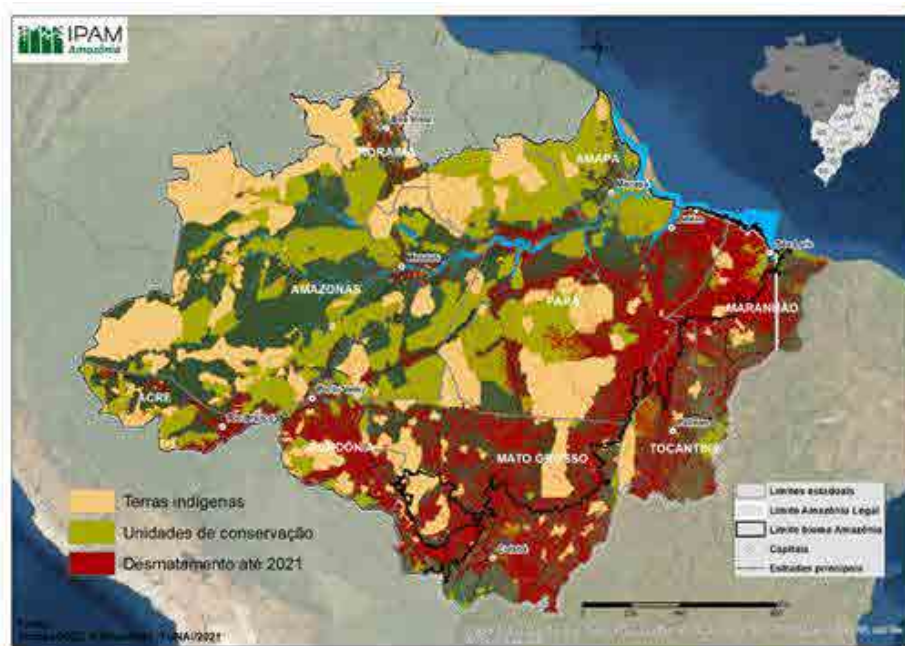
deforestation increments identified in each satellite image covering the Legal Amazon.” Available <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>

<sup>16</sup> “The federal government’s proposal to change the legal frameworks of land tenure regularization was presented by the edition of MP 910, December 10, 2019. PL 2633/2020, which replaced MP 910/2019 and amends articles of Law 11952/2009, promotes a radical change in the legal framework for the occupation of federal public lands. Among these changes, we highlight three especially significant ones: (i) the extension of the time frame for land regularization, (ii) the expansion of the simplified regularization procedure by self-declaration, and (iii) the favoring of medium and large rural producers to the detriment of family farmers, indigenous peoples, and traditional communities.” (Oviedo et al., 2021) It is curious to note the similarities that the PL of Grilagem has with what happened in practice with the promulgation of the Land Law of 1850: it recognized the immense sesmarias of the colonial period, giving amnesty to the grileiros of public

this: between 2018 and 2019, 225,856 hectares were deforested in undesignated public forests (federal and state), which represents a 420% increase compared to the previous period (2017 – 2018). The proposition of this bill is representative of the moment of retrocession of environmental and social policies in Brazil, where “geographical pressures and dynamics that have been exerted, especially in the Amazon and Cerrado biomes, and result in the reduction of the limits of protected areas, increased deforestation, invasion of public lands, and land conflicts.” (Oviedo et al., 2021) All this goes against the Paris Agreement and the COP-26 in Glasgow.

The Indigenous Lands, the Conservation Units and the non-allocated public areas form a true buffer zone against the advance of the agricultural frontier in the southern and southeastern Amazon region known as the “arc of deforestation”, as can be seen in the map below:

Deforestation until 2021 and the public lands.



(IMAZON, 2022)

Besides forming a “buffer zone”, the Indigenous Lands and Conservation Units can contribute greatly to the restoration of the biome, since many of the degraded areas are located adjacent to them. (Burgel and Altmann, 2022) These lands and allowing only the large landowners to “regularize” their possessions. All in favor of the producers of commodities for export.

areas are, therefore, strategic to avoid a tipping point in the Amazon biome. Nobre and Lovejoy (2020) warn that the tipping point in the Amazon forest may occur when the biome loses more than 20% of its area, which, according to the authors, is close to occurring:

Current deforestation is substantial and frightening: 17% in the entire Amazon basin and about 20% in the Brazilian Amazon. There are already ominous signs in nature. Dry seasons in Amazon regions are already warmer and longer. Mortality rates of wet-climate species are increasing, while dry-climate species are showing resilience. The increasing frequency of unprecedented droughts in 2005, 2010 and 2015/16 is signaling that the tipping point is near.

These public areas are therefore strategic to contain the advance of the agricultural frontier into the forest and prevent the tipping point of the Amazon, which would have catastrophic regional impacts (in relation to the hydrological cycle) and global consequences (because of climate).

Even though the 1988 Federal Constitution represents a paradigm shift in relation to property rights and environment protection, Brazil has not been able to change a reality of centuries of appropriation and destructive use of the environment. Land distribution in the country is extremely unequal. On the large properties, the use of the soil is mainly directed to the production of commodities and cattle. Many of these large properties do not respect the environment and the rights of native peoples and traditional communities are systematically violated – all for the sake of private profit. This profit, therefore, is generated from great collective damage. And it is obtained from two sources that are linked to exports: the production of commodities and the “production” of land for the production of agricultural commodities. (Burgel and Altmann, 2022)

There is a significant portion of landowners who are seeking a less environmentally degrading production through the use of advanced technology and preservation of sensitive ecosystems, thereby achieving productivity gains in increasingly smaller areas. In fact, the invasion of public lands, with the consequent slash and burn of the forest for the expansion of the agricultural frontier, is a persistent reality – reproducing the modus operandi of land use and occupation carried out in Brazil for 500 years. A significant part of the occupied areas are public areas (indigenous lands; protected environmental areas; public forests). The acquisition of property rights over these invaded areas through fraudulent documents is a recurrent practice, known as “grilagem”. Thousands of square kilometers are illegally appropriated and deforested every year. The native peoples who live in these areas are forcibly expelled. The “grileiros” deforest these areas and prepare them to be sold to investors, rural producers who run ranches of

thousands of hectares of soy, cattle, palm oil, and other export products. (Burgel and Altmann, 2022)

## Conclusions

In the post-pandemic future, deforestation – whether “legal” or “illegal” – cannot be accepted. Not only because of decarbonization and sustainability issues, but also for avoid the risk of new pandemics. In other words, no deforestation can be tolerated. Both “legally” deforested areas and those illegally invaded are today producing soy, cattle, cocoa, sugar... commodities which are exported without calculating the value of the lost forests and biodiversity, of the traditional communities dispossessed of their lands. The current federal government is committed to the approval of Bills PL no. 510/2021 and PL no. 2633/2020 – known as the “Bill of Grilagem”, which will “legalize” the invasions that occurred until 2018. Even before it comes into effect, the Bill of Grilagem is already causing record deforestation, by encouraging the grileiros who hope to have ownership of the land they are deforesting today. The situation is likely to get even worse with the approval of these bills.

Looking at the demand side, the value of products imported by the rich countries of the global North does not reflect the costs of deforestation. Thus biodiversity, ethnic groups and cultures are lost. And lives, human and non-human. Analyzing the whole chain, importing countries finance the destruction of forests and native peoples – and benefit from commodity prices that do not take into account what is happening in Brazil. And those who profit are a select few.

The “one health” approach paints a picture of the complex factors that could lead to the next pandemic: habitat degradation, collapse of ecosystem services, extinction of biodiversity, human and livestock population growth advancing on ecosystems. All this is done for the sake of immediate profit, because the costs in terms of Natural Capital and EID risks – and even of a new pandemic – are not accounted for. The agricultural value chains must internalize these costs, since the production of commodities in hotspots of EID represent a risk to global health. In view of this “perfect storm” that is currently forming in the Amazon, the region therefore represents a global health risk.

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