Time to see the forest for the trees: protecting forests could prevent future pandemics and help preserve a common planetary future

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June24, 2020

Abstract

The COVID-19 pandemic and increased rates of documented Emerging Infectious Diseases (EIDs) in human populations over the last century have drawn attention on understanding pathogens spill over to humans and their zoonotic origin. In this paper we argue that we need to change the thinking about the fundamental cause of zoonoses. Our premise is that deforestation is the primary cause of EIDs events and that, to prevent future pandemics, it needs to be addressed without further delays. Therefore, we review recent trends of proximate and underlying determinants of deforestation, forest degradation and related biodiversity losses while seeking to clarify their links to the determinants of EIDs events. Acknowledging the magnitude of the challenge, we propose responses to stop global deforestation from a trans-disciplinary, intersectoral perspective led by indigenous people.

While we envisage that stopping deforestation is the most important approach with long term direct and indirect effects on human, animal and plants health, providing climate changes mitigation and preventing otherwise difficult to predict EID events, we argue that such an initiative may usefully be complemented by reducing contacts between humans and wildlife animals and regulating rather than banning markets where wild animals are sold alive.

Finally, we discuss transformative changes to improve planetary-wide forests preservation, soil, plants, animal, and human protection, together with a further understanding of EIDs transmission dynamics, public health veterinary and human disease surveillance, for improved global collective preparedness and action for the management of zoonotic EIDs.

Introduction

An extinction wave of megafauna occurred during the intercontinental and large islands spread of human hunters and gatherers between around 42,000 and 25,000 years ago. It was possibly associated with the introduction of infectious diseases [1], although hunting and the use of fire by humans to clear vegetation and forest might also have played a role [2]. Extinction concerned not just animals but also plants, forests, and all that we do not see, in the soil or in the oceans. We now realize that human encroachment into the planetary environment, house of billions of life components, dates far back. At the origin of human species, humans savoured the taste of fruits without realizing that they might depend on fruit bearing trees. During the

Palaeolithic period, it is likely that exchanges of potentially infectious agents occurred between wild animals and humans, such as brucellosis, leptospirosis and arboviruses carried by primates e.g. yellow fever [1,3]. Another more recent extinction wave, witness to the farmers spread, started some 12,000 years ago whereas the most recent one, caused by industrial activity, started less than 200 years ago. Lessons from history show that 'If we knew how many species we've already eradicated, we might be more motivated to protect those that still survive' [2].

Following 50 years of repeated warning calls about consequences of human encroachment on its environment, starting with the Club of Rome Report "Limits to growth" in 1972[4], we continue to see widespread destruction of forests and their related biodiversity. Yet, as large parts of humankind start suffocating from temperature rises, face water stress or scarcity and witness air and sea pollution, it is our hypothesis that the primary cause of Emerging Infectious Diseases (EIDs), the systematic human-driven deforestation and encroachment into these complex ecosystems, continues to be largely underestimated. Recent research work on EIDs events show the impact of deforestation on the emergence of new pathogens [5], which emergence is difficult to predict if we merely rely on epidemiologic surveillance. 60.3% of EIDs are caused by zoonotic pathogens, i.e. pathogens which have a non-human animal source and the large majority of those "zoonoses" (71.8%) originate in wildlife. They represent the most significant, growing threat to global health of all EIDs. Wildlife animals often live in primary forests with a high density in tropical rainforests and human destruction followed by exploitation of these forests drive wildlife out of their natural environment, thereby facilitating contacts between animals and humans [5].

A growing body of evidence is linking recent EID events to deforestation. Ebola outbreaks in Central and West Africa were found to be linked to recent deforestation events, specially to deforestation of closed forests of a specific range of tree heights [6]. Another example is provided by the Nipah virus, which emerged as a consequence of forest habitat loss of pteropid fruit bats[7] and caused major economic damage. Geographical expansion of Japanese encephalitis virus in Southeast Asia has also been associated with increasing irrigated rice production which increases the density of *Culex* vectors and with farming of potentially viremic pigs [8]. Furthermore, the indirect effect of deforestation playing a key role in climate change, also involves important changes on the pandemic potential of some pathogens, as illustrated by the Aedes vector expansion that global warming causes, enlarging the potential of transmission of vector borne diseases to other geographic areas, such as dengue, zika, chikungunya or yellow fever [9]. Other endemic diseases such as malaria have been found to be associated with land use changes, such as agricultural expansion and forest fragmentation [10].

Therefore, we put forward the wider view that working in full respect of the natural richness of ecosystems is likely to play a key role in decreasing the occurrence of EIDs while bringing about considerable benefits for a joint human, animal and plant planetary future. The current pandemic of SARS-CoV-2 highlights the limitations of biotechnology, epidemiological surveillance from precarious health systems and post-hoc backstop measures, as they act as poorly prepared firefighters and divert efforts to focus on the fundamental cause of EIDs. While various coronaviruses have been studied in bats for some years [11], the human pathogen, SARS CoV-2, was unknown before causing the current pandemic, independently of how intensively bats' viruses had been studied.

The paper focuses mainly on tropical primary forests defined as naturally regenerated forests of native tree species, where ecological processes are not significantly disturbed [12] In these forest some trees take a full century to reach maturity. We examine recent trends of proximate-direct drivers and underlying-indirect drivers of deforestation, forest degradation and their related biodiversity losses and discuss avenues to halt deforestation on a global scale.

Patterns of Deforestation, forest degradation and their determinants

In 1994, the United Nations Framework Convention on Climate Change (UNFCCC) came into force as a binding treaty, following the Rio de Janeiro Conference in 1992 [13] . The objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere. Starting in 2005, one UN specialized agency (FAO) and two UN programmes, (UNEP and UNDP) created the UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries which evolved later with the REDD+ option, a voluntary climate change mitigation approach where the "+" refers to the role of conservation, sustainable management of forests and enhancement of forest carbon stocks [14]. To define intervention strategies to achieve forest protection, it is useful to separate various categories of deforestation and forest degradation, together with their direct causes and underlying determinants [15].

The first deforestation pattern comprises large scale commercial, commodity driven agriculture - often covering thousands of hectares - and using pesticides and fertilizers destroying the natural cycles of nutrients regeneration; this pattern is highly prevalent in Asia but also in South America and less so in Africa. In South America, deforestation takes place mostly to ensure pasture where cattle is raised for meat to feed humankind, while in Africa deforestation allows mining activities, recently tagged with accompanying ecological and social impact assessments that attempt to mitigate a little the devastation (Figure 1). These activities are often preceded by clear-cut logging for commercial sale of timber or pulp, leading to a situation where no trees or nutrients are left. Moreover, hydrologic cycles are durably modified as evaporation increases dramatically with the disappearance of forest canopy. Most importantly, such processes lead to "permanent land use change" because, following deforestation, they do not allow any regrowth before a minimum of half to a full century [16]. The critical underlying determinant of these processes is the economic model based on the export of commodities, national and international demand for agricultural products (food and biofuels), wood products and minerals [15]. This translates into fast, delocalized profit for a few individuals heading large corporations, sometimes buying their way with governments and national regulators, and partaking in often poorly resourced local land tenure and ecological protection governance (Table 1).

Second, a significant, although not the largest contributor to forest degradation, is small scale farmers families' agricultural activities encroaching on forests (usually a few acres) to be distinguished from large scale commercial activities involving the destruction of up to several thousands of square kms of forest. Small scale agriculture usually involves "slashing and burning" trees for crop cultivation, charcoal preparation, small trees growth e.g. banana or papaya, depending on traditions and small-scale cattle pastures. Parts of the smaller trees,

usually from secondary growth, can also be used for small wood collection and transport as fuel for cooking (Figure 2). However, after a few years rain, most of the nutrients held in the burnt trees or the soil are washed away. Farmers then abandon the original plot to further encroach into the forest with the same process [16], henceforth defined as "shifting agriculture" in this paper. This allows some regrowth of plants and trees in the abandoned areas - a process called natural regeneration or "rewilding" that may take up to four decades. The critical underlying determinants of these processes are poverty and population growth [15]. Sometimes, after extensive deforestation, extreme poverty is combined with slave labour for women (Figure 2), severe child undernutrition or chronic malnutrition and high mortality rates, as in Kivu in 1983, Zaire (now DRC) (Table 1).

A third pattern includes selective logging, frequently used in Europe, Russia, China and the USA in secondary forests (as opposed to primary rain forests) and often classified as "forestry". Logging is for timber or for the paper industry. The usual time for natural regrowth is around 20 years. However, instead of waiting for natural regrowth, many countries opt for plantations according to the policy of bioenergy with carbon capture and storage. Here, the critical determinant appears to be aimed at growing wood to burn in power stations, then capturing and burying the carbon emissions [17], a financial instrument whose utility the authors of this paper struggle to understand (Table 1).

Finally, fragmentation of forest entails the alteration of habitat configuration, loss of forest area and connectivity, increased isolation of forest patches and greater exposure to human land uses along forest fragment. Perforations, or the introduction of holes into intact forest patches, is one of the chief components of fragmentation. Perforations are often accompanied by the introduction of roads, resulting in a strong decrease of undisturbed core forest habitat area [12](Table 1).

In 2012, commercial agriculture i.e. the first pattern was the dominant proximate cause of deforestation in the majority of "developing" countries (named "Non- Annex I" in the UNFCC agreement), especially in Latin America. Commercial timber extraction and logging activities were the main causes of deforestation and forest degradation in Latin America and (sub)tropical Asia while fuel wood collection and charcoal production were the main forest degradation drivers on the African continent (Table 1).

In 2018, global deforestation patterns were mapped using high-resolution Google Earth imagery and classified drivers of forest loss between 2001 and 2015 [18]. The authors conclude that the overall rate of large-scale commercial commodity-driven deforestation has not declined since 2001. Twenty seven percent of global forest loss was due to deforestation through permanent land use change to produce commodities i.e. for commercial purposes, including beef, soy, palm oil, and wood fibre. Another 26% of loss was attributed to forestry (implying some level of regrowth but loss of original cover), 24% to small scale agriculture and 23% to wildfire. A focus on mega-regions' situations leads to great concern: in Latin America, 64% of tree cover loss was attributable to commodity (e.g. beef, soy, wood) driven deforestation between 2001 and 2015, while in South-East Asia, 61% of tree cover loss was attributable to commodity (palm oil mostly) driven deforestation during the same period.

Among critical determinants of grand scale deforestation and forest degradation, land tenure security (which is related to the characterisation of legal or illegal trade) and purchase or lease of very large areas for periods of up to 99 years in Latin America, Africa and Asia combined with absent or token social participation are the most important. Foreign direct investments are the most discreet while the most important challenge: for example, decades long loans on land the size of small European countries. On such investments, Ethiopia and Ghana are illustrative : in 2012, acquisitions were equivalent to 42.9% of the total area suitable for agriculture in Ethiopia and in Ghana they had reached 61.6% [15]. Poor funding of law enforcement and little experience of inter-sectoral collaboration also contribute.

2018 data from Africa [18] suggest that "small-scale" or shifting agriculture plays a major role (93%) in deforestation. Compared to Latin America and South-East Asia, satellite data appear to reveal relatively less massive logging and commodification of the rainforest in Central Africa. This implies that trees are not yet cut on grand scales to plant palm trees for oil-to end-up in hyper processed food components, spreads or cosmetics, or to breed cattle, thereby contributing to the climate change, obesity, undernutrition "syndemic" where two billion people are overweight, while on the same planet an estimated 800 million people struggle for basic food [19] and, all too often, access to water.

Nevertheless, since the 19th century colonization, trees were cut and replaced by industrial cultures such as bananas using pesticides which durably damage ecosystems and contributing to biodiversity loss. Partly thanks to foreign direct investments in African countries, extensive logging in primary forests is growing fast for widespread timber export of raw construction materials. TM's personal experience in difficult to reach regions spreading from Southern Nigeria, Cameroon, Gabon, Congo, to vast territories in the Democratic Republic of Congo witnessed that logs, at times one single huge log filling a semi-trailer, are exported, illegally or legally - nobody knows, at a pace reaching up to 1500 trailers each day on a single road towards the Atlantic or Indian Ocean coast's mega tankers ports. In Central Africa people say that "A large tree can furnish many houses", but local crafts industry has never been encouraged nor supported.

The State of the Word Forests and People 2020 (SOFO) Report defines forest as a combination of tree cover and land use, while some others define forest only in terms of tree cover[12]. This makes comparisons with previous data, including those of Curtis et al. [18] more complex but most importantly, the SOFO report reminds us that more than 60 000 different tree species are known, more than 20 000 of which have been included in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, and more than 8 000 of these are assessed as globally threatened. More than 1 400 tree species are assessed as critically endangered and in urgent need of conservation action while an estimated 880 million people worldwide spend part of their time collecting fuelwood or producing charcoal, many of them women (Figure 2). Human populations' density tends to be low in areas of low-income countries with high forest cover and high forest biodiversity, but poverty rates in these areas tend to be high. Forests also supply water, mitigate climate change and provide habitats for many pollinators, which are essential for sustainable food production. [12].

Another example from Central Africa illustrates rising global inequalities and the widespread arms trade leading to deadly conflicts among traditional nomads and local settled populations. In an immense region spreading from Niger to Lake Chad bordering Nigeria, Chad and Cameroon to the Central African Republic and Darfur region, conflict, climate change, increasingly difficult access to water, combined in a deadly cocktail with dire poverty push various population to seek refuge at the forest fringes. Traditional nomad people are trapped in territories that used to be common land for cattle pastures but have been ransomed for the last 15 years by armed groups with no affiliation. From 2008 onwards, in collaboration with the Government of Cameroon, UNHCR, UNDP and WFP organized the settlement of more than 80, 000 nomad people who had lost their cattle and, for some, their children captured by armed bands for a ransom. For those who did not manage to be part of the settlement plan, encroachment into forest continues with slash and burning techniques for basic survival (TM's experience as UN Resident Coordinator, 2009-2011).

The uncontrolled expansion of intensive commercial agriculture and farming, including millions of hectares for cattle farming, corporate extractive, mining and infrastructure development, powerful market forces organized in monopolies and delocalized where labour is cheap, armed conflicts, systematic avoidance of open debate about the planet's Common Goods and unequal distribution of downstream and upstream gains have led to tipping points that we witness with COVID-19 rapid spread and destabilising power.

Another example of global market forces is provided by the carbon market credits. It was estimated that oil palm plantations generated between USD 6000 and USD 9000 per hectare in 2011 while keeping one hectare of the original forest standing only generated a maximum of less than USD 1000 through carbon credit payment [20].

Pathways to stop deforestations need to be discussed at both global level and locally, establishing a continuum of actions with transparency on the terms of gains 'exchange. A systemic approach looking at the dynamics and terms of global trade helps identifying recurrent patterns. The Centre of gravity of efforts to reduce deforestation needs to be located in the Global South. However, there is little acknowledgement of the underlying causes of deforestation, most of which originate from the Global North "needs". Fragmented interventions continue to attempt addressing national- and local-scale problems rather than the international drivers of deforestation. Systematic resources extraction from the Global South with hardly any information or capabilities being shared between Africa, Asia, Central and South America do not allow for any collaborative efforts beyond national borders. Many indebted governments in the South continue to sell logging or farming concessions from their forests to pay international debt. Borders have become the best allies of global trade and extraction.

People, born in the forest, and living within forests for centuries continue to be extracted from their environment and are "invited" to celebrate their introduction to the "first" world (figure 3). Partake in the "first, civilized" world is the dream of many. Their children, often forcibly, are invited to be separated from their parents to be educated by missionaries of all kinds and taken away from their natural environment. Parents and children continue to witness, full of elusive hope and fully dispossessed from their heritage, the accelerated and lethal process of

forest destruction and the need to move from their shelter. Alcohol and cigarettes are brought as gifts in a tragic history's repetition.

In the search of collaborative avenues to halt deforestation worldwide, some voices have proposed that indigenous people drive the protection processes of what is left of forests [21]. However, while this is fundamental, we posit that such an approach is not sufficient to bring the results that we need to halt deforestation. We propose a wide scale collaborative initiative working with existing and new movements, joining existing efforts, enabling indigenous people to become not only the guardians of their environments, but also the guardians of global planetary health. A collective, well endowed, neutrally supported, and documented movement is required for change to take place rapidly. In a process led by indigenous people, it is critically important to map the state of all the existing forests needing protection [22].
Just like air and water, forest is the planet's Common. Will water continue to be privatized, air continued to be polluted and forests continued to be sold and burnt?

Backstop temporary measures: "wet markets", raw bushmeat and health education for the poor

Research on zoonoses of wild origins has focused on "special reservoirs" of animals. We were hoping that systematic epidemiological surveillance would help early detection of primary incidents and allow a swift response in the case of "spill-over" to humans. Early in the current pandemic of SARS CoV-2, coronavirus' genomes identified in potential reservoirs (bats, as a primary host and pangolins as a secondary host) suggest an evolutionary divergence from the human SARS-CoV-2 genome of some 40-70 years [23]. We now realize that the identification of a potential intermediary host from a wild reservoir may take a long time to – or possibly never - be identified [24].

It appears likely that live animal markets where wildlife, birds, domesticated animals, and fish may be found together in one space, nicknamed "wet markets" contributed to SARS CoV-2 emergence, as with previous epidemics of SARS[25]. In 2005, estimates of the importance of wildlife trade [26] in various continents indicated large volumes and hence many people employed in the trade. Unfortunately, larger scale commercialisation, implying organized hunting using forests perforations built by the logging consortia, sometimes blinding animals with lamps at night and using sophisticated weapons has now replaced local hunting performed mostly by indigenous populations who killed a limited number of animals for subsistence.

In 2016, serious concerns have been expressed about extinction of many mammal's species and bans on "wet markets" and illegal trade of wild animals were proposed [27]. This proposal was recently revived to reduce pandemics' risks by the acting executive secretary of the UN Convention on Biological Diversity but she cautioned that "we should … remember you have communities, particularly from low-income rural areas…which are dependent on wild animals to sustain the livelihoods of millions of people…". "So, unless we get alternatives for these communities, there might be a danger of opening up illegal trade in wild animals which currently is already leading us to the brink of extinction for some species" [28].

Unfortunately, banning wildlife markets is likely to increase illegal trade with little local control and enforcement capacity in a context of continued deforestation by powerful industrial and commercial actors and very precarious survival conditions for local inhabitants. To some extent we join the views expressed in a comment published in June 2020 in the Lancet Planetary Health [29]. Alternative options to bans might be more promising and include the regulation of major hubs of the wildlife market networks in different contexts [26] with hygiene rules, keeping different species separate in different markets, protection of market workers, regular closure days and disinfection, and consider selling dead meat if a cold chain exists.

Following the pandemic emergence of HIV in the early 20th century and the epidemic resurgences of Ebola Virus Disease (EVD) in various places including in Kikwit (Zaire, now Democratic Republic of Congo) in 1995, consuming raw bush meat was identified as one of the possible primary trigger of infection chains - and perceived as a cultural transgression that facilitates the transmission of viruses to humans in an increasingly connected world. WHO's websites on preventing EVD and COVID-19 recommend "**reducing the risk of wildlife-to-human transmission** from contact with infected fruit bats, monkeys, apes, forest antelope or porcupines and the consumption of their raw meat…" [30,31].

We contend that structural conditions need to be in place for people to be enabled to change behaviours. To illustrate the enormous challenges of providing contextually appropriate advice before overcoming dire structural living conditions, we use the example of the EVD epidemic in Kikwit in 1995: initial efforts for health education about hygiene and protection brought little comfort as the water supply system of Kikwit General Hospital had collapsed, including in the maternity ward with dozens of deliveries each day. This undoubtedly played a major role in the early human to human spread of the Ebola Virus and it took a while, international mobilization, two carrier planes to bring the material and expertise to drill wells, rehabilitate the water supply and enable the population to wash their hands and clean the maternity ward (TM, personal experience in Kikwit, June 1995).

A piecemeal approach, focusing attention on discrete parts of the complex consequences of human extractive activities out of fragile ecosystems and geared to global trade, is unlikely to tame the enormous tsunami we are facing. Beyond the stark inequalities prevailing in many places where some options are not implementable immediately, fundamental rethinking is required on the current global economic system [32].

Continued hopes for EIDs surveillance and pandemic prevention

Viruses are particularly threatening to humans because they are the most frequently identified pathogen in Emerging Infectious diseases (EIDs) events and among the top 7 prioritized agents for future EID events in the WHO R&D Blueprint [33]. This is due to evolutionary characteristics, that allow viruses, specially RNA viruses, to tolerate large amounts of genetic variability and therefore easily adapt to different hosts without losing viability. Human exploitation and destruction of forests drive wildlife out of their natural environment facilitating contacts between animals and humans [5]. Systematic research over the last 30 years has identified several animal vertebrate species, mostly mammals, wild such as primates, bats, civets, forest antelopes, rodents, racoon dogs and recently, pangolins [34] and

birds as potential primary sources of infections by various pathogens for humankind. Animals domesticated by humankind before or during the agricultural revolution e.g. dogs, pigs, horses, sheep, goats, cattle, or poultry can also be primary or intermediary hosts for the transmission of viruses and other pathogens to humans [35]. Poverty, overcrowded habitat and promiscuity with domesticated animals may enhance pathogens' transmission events (Figure 4).

Identifying specific wild animal groups which would have a greater propensity to harbour viruses transmissible to humankind, possibly via intermediary hosts, has appeared an appealing approach to organize viral surveillance among such animals for the last three decades. Earlier this year, Johnson et al used a multi-variable modelling approach to evaluate disparities in zoonotic virus richness among threatened species, using the International Union for Conservation of Nature (IUCN) red list and found that those 53 most threatened species with severe habitat loss and exploitation were predicted to host over two times as many zoonotic viruses [36]. This analysis supports the so called "dilution" hypothesis whereby a high biodiversity of animal species would provide a high number of "non-competent" species to "harbour" pathogens and act as reservoirs suggested by work on West Nile fever and haemorrhagic fever caused by Hantavirus [37]. Animal population declines would therefore facilitate virus spill-over to humans. A further study on West Nile fever in the USA showed that the prevalence of the disease in humans was negatively correlated with bird's species richness [38,39]. Another study indicated that viruses with high host plasticity were more likely to amplify viral spill-over by secondary human-to-human transmission and have broader geographic spread, i.e. have a higher pandemic potential [40]. These results contribute to point out that there is no time to lose to radically change the ways humankind continues to encroach, exploit the global ecosystem, and perpetuate the extinction of animal species.

However, a metanalysis on the studies to test the "dilution" effect found no statistical significance of the association and concluded that the effect of biodiversity on local transmission of an infectious disease was unlikely to be predictable because such event depends on webs of local conditions [41], indicating also that it is difficult to predict which species to focus on for epidemiological surveillance of spill over events. In a similar approach, Mollentze and Streicker created a large data set from the literature of reservoir host-virus associations with records describing their histories of human infection and tested whether special reservoirs of zoonoses exist. They found that more species-rich reservoir groups host more virus species and a larger number of zoonotic species, suggesting that "viral zoonotic risk is homogenous among taxonomic orders of mammalian and avian reservoir hosts". The analysis found no evidence that intrinsic or ecological differences among animal groups increases the number of viruses they maintain or the likelihood that any given virus is zoonotic. The authors conclude that basing surveillance and research aiming to identify high-risk viruses on the assumption that some taxonomic orders of hosts are disproportionate sources of zoonoses risks missing important zoonotic viruses [42].

Nevertheless, a wide consensus has so far recommended strengthening health systems worldwide and enhancing increased epidemiological surveillance on wild, domesticated animals and humans [43], nowadays possibly supported by genomics and geographical

computerized tracking. The International Health Regulation [44], a binding international treaty, ratified by virtually all countries on the planet is the instrument to achieve such surveillance. These recommendations are part of the agenda to control epidemics and demand continuous systematic investments in human health preventive and care systems in the zones where transmission is likely to happen. Unfortunately, investments have been very slow to come and Jones and collaborators [5] remind us that disease spill-over is probably vastly under-reported, especially in regions where people have limited access to health care while a comment by Holmes and collaborators pointed out that the resurgence of Ebola virus disease (EVD) in Mbandaka and surroundings, Democratic Republic of the Congo in 2018, "is a stark reminder that no amount of DNA sequencing can tell us when or where the next virus outbreak will appear" [24]. Just a few weeks later, a severe EVD epidemic started in North Kivu and Ituri provinces, DRC.

Already in 2015 Chen and Takemi underlined that growing inequalities in the terms of exchange between various sub-continents, the failure to share the benefits of global economic growth required a comprehensive, transformational approach of all societies- in the northern and the southern hemispheres- to enable each part of the world to share a common vision of prevention, preparedness and care [43]. That same year, the report of The Rockefeller Foundation- Lancet Commission on planetary health identified the "imagination challenge" to enable humankind to change the current economic model that has led to extract and produce while creating an increasing gap of social inequalities [45].
Bedford et al have also proposed a "new twenty-first century science for effective epidemic response" which involves transdisciplinary approaches well beyond the silos we have been trained to follow [46].

Conclusion

The first step is to stop the massacre of what is left of primary forest today rather than tomorrow, using a wide scale collaborative initiative working with existing and new movements, joining existing efforts, enabling indigenous people to become not only the guardians of their environments, but also the guardians of global planetary health.

While there is a need to dramatically "review fiscal policies and regulatory frameworks to strengthen and enforce environmental regulations" to start with [12], we propose that a collective, well endowed, neutrally supported, and documented movement is required for change to take place rapidly. One way to approach both global and local governance as well as funding issues of such initiative to protect forests would be to take stock of experiences from the last decades' global initiatives but to root the center of gravity at the local level with a governance structure and system including majority votes for indigenous people from all continents, active presence of countries with primary forests, FAO, UNEP, WHO, UNDP, UNHCR, WFP and local / global NGOs, while considering the usefulness of G20 structures.

Rather than conquering nature, initially for survival and now for an elusive economic growth, we now understand that diversity, richness, synergy and cooperation may be fundamental determinants of mutual survival and healthy lives, one cooperating with each other in our common environment reflecting the dynamics of primary forests. Here, we question the

argument, used by large corporations, commercial lobbies, many governments but also by many actors of global health, that the onus of societal change for any ecological transition, relies on individual behaviours rather than on collaborative, systemic approaches. If a few individuals among billions change behaviours, everything continues the same. Individuals having "opted out" are at best likely to end-up impoverished and excluded. By fragmenting humankind in singular hungry identities, we end up living in a world of seven billion planets, instead of one.

We also contend that the focus on the interactions between animals and humans to stem the continuous emergence of infectious diseases is to narrow a path to address the health of humankind, animals, plants and the planet as a whole.

In support of the IPBES 2019 Report's recommendation for a system-wide recognition that global level economic, technological and social factors be radically reviewed[47], we wish to add the ethical perspective in considering common values and goals, to promote responsibilities across all sectors. Albert Einstein reminded us: "The world we have created is a product of our thinking. It cannot be changed without changing our thinking" (Cited by[48])

Author contributions

TM proposed the idea to AA in March 2020, both authors agreed on the paper concept and TM prepared a first draft. Both authors worked jointly to full completion of the paper.

The authors wish to acknowledge the thoughtful comments on the penultimate draft version of this Review and Perspective paper from Professor Themis Bowcock, Department of Physics at Liverpool University, UK as well as those from Dr Alexander Khot, London, UK.

Funding

TM's exclusive funding source was a fraction of his salary at IHMT-UNL. Global Health and Tropical Medicine is funded by Fundação para a Ciência e Tecnologia (FCT) (UID/04413/2020).

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FIGURES

Figure 1: Iron mining project in tropical rain forest, Mbalam, Cameroon. Photo Thierry Mertens, 2009

Figure 2: Women carrying wood “fuel” for cooking, Kivu, Zaire. Photo Thierry Mertens, 1983

Figure 3: Autochtonous women celebrating the inauguration of a tubewell handle pump, Cameroon. Photo Thierry Mertens, 2010.

Figure 4: Poverty and promiscuity with domesticated animals in an urban slum of around 20000 people, India. Photo Thierry Mertens, 2007.

TABLES

Table 1 – Tentative description of putative patterns and determinants of deforestation worldwide (TM and AA, 18 June 2020)

Cause of deforestation	Underlying Determinants	Impact	Regions where it is more important
Large scale commercial - industrial agriculture	Export of primary commodities, including cattle meat and soy National and international economic demand for agricultural products (food and biofuels), wood products and minerals Profit of large corporations	Permanent land use change. Hardly any tree regrowth before 50 years.	Latin America Subtropical Asia
Small scale agriculture	Mining and logging activities for timber export Poverty Population growth	Shifting agriculture 40 years until some forest secondary regrowth	Africa Latin America
Selective logging and forestry	Paper industry and pulp products	Up to 20 years for regrowth	Russia, EU, USA, Canada, China
Wildfires	Climate change Slash and burning	Highly dependent on the extent of wildfires	Global