Journal of Environmental Management 287 (2021) 112277

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

Review

Afforestation, reforestation and new challenges from COVID-19: Thirty-three recommendations to support civil society organizations (CSOs)

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ARTICLE INFO

Keywords:
Deforestation and forest degradation
Real-time forest monitoring and management
Sustainable development goals (SDGs)
Planting trees with drones
International non-governmental organizations (INGOs)
Impacts of COVID-19 on forests

ABSTRACT

Afforestation/reforestation (A/R) programs spearheaded by Civil Society Organizations (CSOs) play a significant role in reaching global climate policy targets and helping low-income nations meet the United Nations (UN) Sustainable Development Goals (SDGs). However, these organizations face unprecedented challenges due to the COVID-19 pandemic. Consequently, these challenges affect their ability to address issues associated with deforestation and forest degradation in a timely manner. We discuss the influence COVID-19 can have on previous, present and future A/R initiatives, in particular, the ones led by International Non-governmental Organizations (INGOs). We provide thirty-three recommendations for exploring underlying deforestation patterns and optimizing forest policy reforms to support forest cover expansion during the pandemic. The recommendations are classified into four groups - i) curbing deforestation and improving A/R, ii) protecting the environment and mitigating climate change, iii) enhancing socio-economic conditions, and iv) amending policy and law enforcement practices.

1. Introduction

The Kyoto Protocol attributes afforestation to the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land (UNFCCC, 2006). In contrast, reforestation, in general, refers to the process of replanting trees in areas depleted of forests, mostly due to deforestation. Afforestation/reforestation (A/R) is mentioned in Target 15.2 of United Nations Sustainable Development Goals (UN SDGs) #15 (Life on land), which states that "By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and substantially increase afforestation and reforestation globally" (UN General

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https://doi.org/10.1016/j.jenvman.2021.112277
Received 15 November 2020; Received in revised form 22 January 2021; Accepted 22 February 2021
Available online 9 March 2021

Assembly, 2015). SDG #15 has direct and indirect relationships with various other SDGs such as SDG #2 (Zero Hunger), SDG #6 (Clean Water and Sanitation), SDG #13 (Climate Action), SDG #10 (Reduced Inequalities), and SDG #12 (Responsible Consumption and Production), and can thus help support developing and least developed countries (LDCs) to achieve parallel UN SDGs (Baumgartner, 2019). In particular, the UN SDG #13 - which urges nations to take action for combating climate change and its impacts - faces a copious number of impediments in low-income countries as a major proportion of the population here utilize forests for their livelihoods (FAO, 2015).

An average of 1.6 billion people depend on forests for subsistence, livelihoods, employment, and income generation, while between 60 million and 200 million indigenous people are almost wholly dependent on forests (Chao, 2012). With large populations relying on forests for survival, A/R programs are crucial for managing forests and thereby can contribute to the fight against global warming and help increase climate resilience. Climate change, in turn, exacerbates existing inequalities and disproportionately affects marginalized communities and countries with limited human and technological resources (Islam and Winkel, 2017; UNCTAD, 2018). Further, it can result in generating negative feedback loops as individuals will often be forced to place additional pressure on forests to sustain their livelihoods. In this regard, the continuing reduction in forest area - which has declined (in terms of percent of land) from 1990 (33.72%) to 2016 (31.93%) - in low and middle-income countries merits urgent attention (World Bank, 2016).

Local and international development agencies play a key role in combating deforestation and climate change, which are closely interlinked and interconnected to A/R operations (World Bank, 2015). Given the existing tribulations associated with environmental destruction, economic crisis, poverty, and inequality in developing and LDCs, Civil Society Organizations (CSOs) play a vital role as they channel international development aid and philanthropic agencies to targeted relief and conservation operations (Tomlinson, 2013). CSOs comprise a wide sphere of organizations varying from non-formal, small, community-based, and non-governmental organizations to large-scale, high-profile, International Non-governmental Organizations (INGOs) functioning through local partners across different countries, independent of direct government management (Tomlinson, 2013). Their presence is especially visible and required in the A/R sector operations and advertently support SDGs by conceiving site-specific programs tailored to the common public. In fact, SDGs emphasize the importance of utilizing CSOs to advance the goals in countries that have limited resources and administration capabilities (NGO Major Group, 2017).

Improved forest management can play an important role in curbing the spread of zoonotic diseases. Previous estimates show that 60% of all infectious diseases in humans are zoonotic, which result due to the transmission of pathogens from animals (UNEP, 2016). When natural habitats such as forests are deforested and degraded, it leads to a reduction in buffer zones that segregate humans from animals, thereby increasing the probability of the spread of zoonotic pathogens between different species of animals as well as between animals and humans (Bloomfield et al., 2020; UN DESA, 2020; Brancalion et al., 2020). This pathogen transmission to humans can be through direct animal attack or through increased bushmeat hunting, wet markets, poaching, illegal wildlife trade, or the enhanced pathogen hosting capability of wild animals, all of which are indirectly promoted due to forest fragmentation (Plowright et al., 2020; Aguirre et al., 2020; Wolfe et al., 2005; Banerjee et al., 2020). In a similar manner, multiple studies, focusing on various parts of Africa such as Uganda and Côte d'Ivoire, have investigated and underscored how the loss of tropical forests had elevated the risk of physical interactions between people and wild primates and the viruses they carry (Mossoun et al., 2015; Wolfe et al., 2005; Bloomfield et al., 2020; Goldberg et al., 2008). Although there is no significant evidence that deforestation is a major cause behind COVID-19, we cannot overlook the impact of clearing forests on the proliferation of zoonotic diseases. Proper forest management planning and reasonable decisions need to be taken and should be integrated with the research on zoonotic pathogen transmission for minimizing future disease spreads.

Given the importance of A/R programs in terms of achieving UN SDGs and minimizing the chance of future zoonotic diseases, alternative monitoring methods and policy paradigms need to be introduced without significant delays to address the unprecedented challenges for conservation agencies to conduct A/R tasks emerged during COVID-19 pandemic time, especially in developing and LDCs. Herein, we provide thirty-three scalable intervention strategies and/or policy recommendations that could help CSOs administer efficiently and maintain their forest cover enhancement programs during the era of COVID-19 and future similar disasters. The recommendations are further classified into four groups for ease of understanding and implementation: i) curbing deforestation and improving A/R (sections 3.1 to 3.8), ii) protecting the environment and mitigating climate change (sections 3.9 to 3.14), iii) enhancing socio-economic conditions (sections 3.15 to 3.25) and iv) amending policy and law enforcement practices (sections 3.26 to 3.33).

2. Emerging challenges to A/R due to COVID-19

COVID-19 is a disease caused by a novel coronavirus. It was first reported in China in December 2019 (WHO, 2020a). Although researchers are grappling with data limitations to tally the pandemic statistics, it can be stated that the provisional deaths are over 1.9 million, and positive COVID-19 cases have been accounted for in around 215 countries and territories (WHO, 2020b; WHO, 2020c). Without proper and timely support, COVID-19 can sow havoc in developing, and LDCs - which are finding it hard to respond due to limited resources, weak ground-level emergency relief mechanisms, lack of well-qualified practitioners, clouded policy jurisdictions and financial crisis - and their economic growth has been negatively affected (Brancalion et al., 2020).

Current global pandemic has also given rise to both direct (e.g.: increased pressure on forested lands for agricultural production, reduced labor for recycling plastic wastes) and indirect (e.g.: increased medical and food wastes that can affect soil and water quality, xenophobia that hinders effective communication of INGOs with locals) environmental challenges as countries close down their borders, impose nationwide lockdowns, and repatriate citizens (Zambrano-Monserrate et al., 2020; Fox et al., 2020). There have also been reports of the positive impacts COVID-19 is having on the environment such as increased air quality, healthier aquatic life and cleaner beaches though their long-term significance is yet to be justified (Khan et al., 2020; Lokhandwala and Gautam, 2020).

While CSOs play an essential role in A/R and sustainable forest management globally, local community support is instrumental to accomplish the aforementioned tasks. For example, community-based forest management initiatives in Nepal and Bangladesh and participatory forest management initiatives in Ethiopia were successful because they had high levels of local support (Tesfaye, 2017; Farouque et al., 2017; Anup, 2017). Consequently, greater involvement from local communities is required (FAO, 2016), and participatory assessments of communities' local needs, customs, culture, socio-economic structures, and social relations should be undertaken on a regular basis. However, COVID-19 has created new formidable barriers as many A/R professionals are being infected from COVID-19 and immense amounts of money and resources from responder agencies have been mobilized toward massive health emergency assistance.

The new restrictions due to COVID-19 have altered the organizational workflows of several A/R organizations, thereby limiting their intra and inter-institutional interactions and community involvement. This can have direct repercussions on the efficiency of CSOs' operations, conservation activities, and response to coming natural disturbances (Cardil and de-Miguel, 2020). In this context, repatriation has also affected CSOs' programs, as many international staff members have been called back to their home countries, causing increased dependency on remote management (Nicaise, 2020). In the face of the pandemic, the

changing perspective of locals towards foreigners/individuals from outside the community - who are often treated as potential carriers of COVID-19 pathogen - threaten the success rates of INGOs operations. Reports of xenophobia and discrimination against foreigners and immigrants with regard to the COVID-19 pandemic has been recorded in various Asian and African countries (e.g., Vietnam, Myanmar, Malaysia, South Africa, Ethiopia) and several other nations across the globe (York, 2020; Humphrey and Pham, 2020; Reuters, 2020).

With regard to A/R and other forest recovery-related initiatives, some of the major threats accelerated by COVID-19 are as follows:

- A spike in deforestation has been recorded in various regions of the globe during the pandemic (Daly, 2020). In Peru, deforestation has surpassed previous levels of 2018 since April 15, 2020 (López-Feldman et al., 2020). Simultaneously, in Amazon, deforestation has continued to rise as per Brazil's national space research institute INPE's deforestation monitoring system DETER (Butler, 2020), even during the COVID-19 pandemic. For instance, between August 2019 and May 2020, Brazil has experienced a 72% deforestation increase compared to the previous year (Escobar, 2020). In a similar vein, more than 22,000 deforestation alerts have been registered by GLAD (Global Land Analysis and Discovery laboratory at the University of Maryland) in the Prey Lang Wildlife Refuge in Cambodia during the fourth week of April itself (Nachemson, 2020). Additionally, it should be borne in mind that an increase in deforestation can aggravate the spread of zoonotic diseases and amplify the chances of pandemics in the future (Bloomfield, 2020).
- One of the conspicuous and immediate effects can be seen in the form of policy changes in response to the COVID-19 pandemic (budget cuts, transfer of environmental funds to other sectors, placing forest programs on hold due to travel restrictions, lax policy enforcements, and easing of environmental regulations) which are affecting forest conservation and management operations significantly. For example, in Latin America, countries such as Mexico and Ecuador have announced cuts that are directly impacting ministries enforcing environmental regulations and fighting climate change (López-Feldman et al., 2020). In Indonesia, the government has started to revitalize 165,000 ha of abandoned peatland landscape into food-estates to fulfill the national food security gap (Government of Indonesia, 2020). The decision is in contradiction with the previous policy on peatlands restoration to meet national emissions reduction targets and puts the carbon-rich ecosystem at risk. While it's hard to predict how long the current pandemic will last, the recent dynamics of environmental regulations will certainly affect the long-term national and global environment-related policies and climate change mitigation targets.
- Recent studies have shown that the return of migrant workers can also place more pressure on forested lands and lead to unrestrained forest conversion (Fox et al., 2020a). With migrants returning to their home countries/villages, there will be a plunge in income levels and a rise in agricultural needs, which might heighten the risks of illegal logging (Chakraborty and Maity, 2020; Fox et al., 2020a, 2020b). Moreover, rural households are observed to address income shocks through solicitation of additional resources from forests, thereby further increasing dependency and pressure on forest lands (Angelsen et al., 2014).
- Another consequence of the COVID-19 pandemic is the disruption in human resources (Corlett et al., 2020). As a result, many activities associated with forest monitoring and afforestation are affected, and the pitfalls will be soon visible in the form of increased unattended forest fires, pest infestation, agriculture/plantation expansion, invasive plant growth, overgrazing/husbandry needs, and illegal logging/mining (Amador-Jiménez, 2020; Farand, 2020; WWF, 2020). The increased mortality rates, medical issues, and health concerns add more constraints to this labor shortage. As practitioners are infected with viruses or called back to their home countries, this creates an unprecedented delay for field-related training and in-situ data collection (Corlett et al., 2020).
- Simultaneously, burgeoning usage of medical products - such as disposable masks, due to increased health concerns - are contributing to escalating pollution levels. Plastic, water, and soil pollution, from inappropriate waste disposal (especially from the disposal of obliterated medical products) and recycling, can also be perceived as a byproduct of limited labor and at the same time be detrimental to the environment (Kulkarni and Anantharama, 2020; You et al., 2020; A. L. P. Silva et al., 2020; Zambrano-Monserrate et al., 2020; Adelodun et al., 2020). For example, in the Soko Islands, Hong Kong based environmental non-governmental organization OceansAsia, discovered stacks of thrown away single-use masks washed up on a 100-m beach shoreline stretch (Mukhopadhyay, 2020). This trend of elevated marine-litter is visible on a global scale, and this non-biodegradable debris can cause detrimental consequences for coastal and marine ecosystems such as mangroves (Suyadi and Manullang, 2020; Canning-Clode et al., 2020). In terms of air pollutants, although in the first few months after COVID-19-based lock-down began, the air quality increased (Sharma et al., 2020) due to reduced transportation and industrial work, the pollution levels have been observed to bounce back (The Economist, 2020). All these pollution related issues will soon permeate into the A/R sector and adversely affect the forest conservation endeavors - either through direct impact on water table and forest soils or indirectly in the form of reduced workforce due to respiratory concerns.
- Conservation efforts supported by the ecotourism sector are also enduring a major consequence as the income source from tourism will be unavailable due to COVID-19 induced travel restrictions (Cherkaoui et al., 2020). The concept of ecotourism, which originated in the 1980s alongside the prospects of sustainable development, is a way to streamline tourism revenues into conservation and development programs (Stronza et al., 2019). And due to COVID-19, the tourism industries which are closely knitted with nature - such as in the countries of Costa Rica and India - are facing long-term shutdowns, and this can have detrimental effects on the corresponding ecosystem and related environmental-friendly incentives and make it difficult to quantify the nexus of social-economic-environmental changes expected through eco-tourism (Shah, 2020; Wunder, 1999).
- The COVID-19 pandemic and the subsequent economic downturn has the potential to influence both existing and previous efforts of A/R programs equally as it can lead to more forests being cleared and thereby nullifying years of hard work. Future operations and effectiveness of forest conservation programs are at stake as the aforementioned issue can translate into a shortage of timber supply, land degradation, monoculture/loss of tree diversity (which will make the forests more vulnerable to climate change), loss of biodiversity/habitats, respiratory illness for foresters, inequality, and poverty (from corruption, land grab, community conflicts, short-term gains, etc.). Moreover, the fragmentation of forests leads to an increase in the spread of zoonotic diseases and related infections as it amplifies the human-wildlife interactions (Bloomfield, 2020). For example, there was a strong geographical relationship between the Ebola virus outbreak – a zoonotic disease type transmitted through fruit bats - occurrence and forest loss and fragmentation in several regions of West and Central Africa (Olivero et al., 2020; Rulli et al., 2017).

In essence, all the aforementioned challenges can have direct and/or indirect consequences on the economy, governmental policies, parameters influencing climate change and achieving sustainability targets for several nations. It is time to address these contemporary challenges through advanced and time-specific forest management strategies and policy amendments. Fig. 1 encapsulates the major issues we are currently facing and the repercussions they can precipitate.

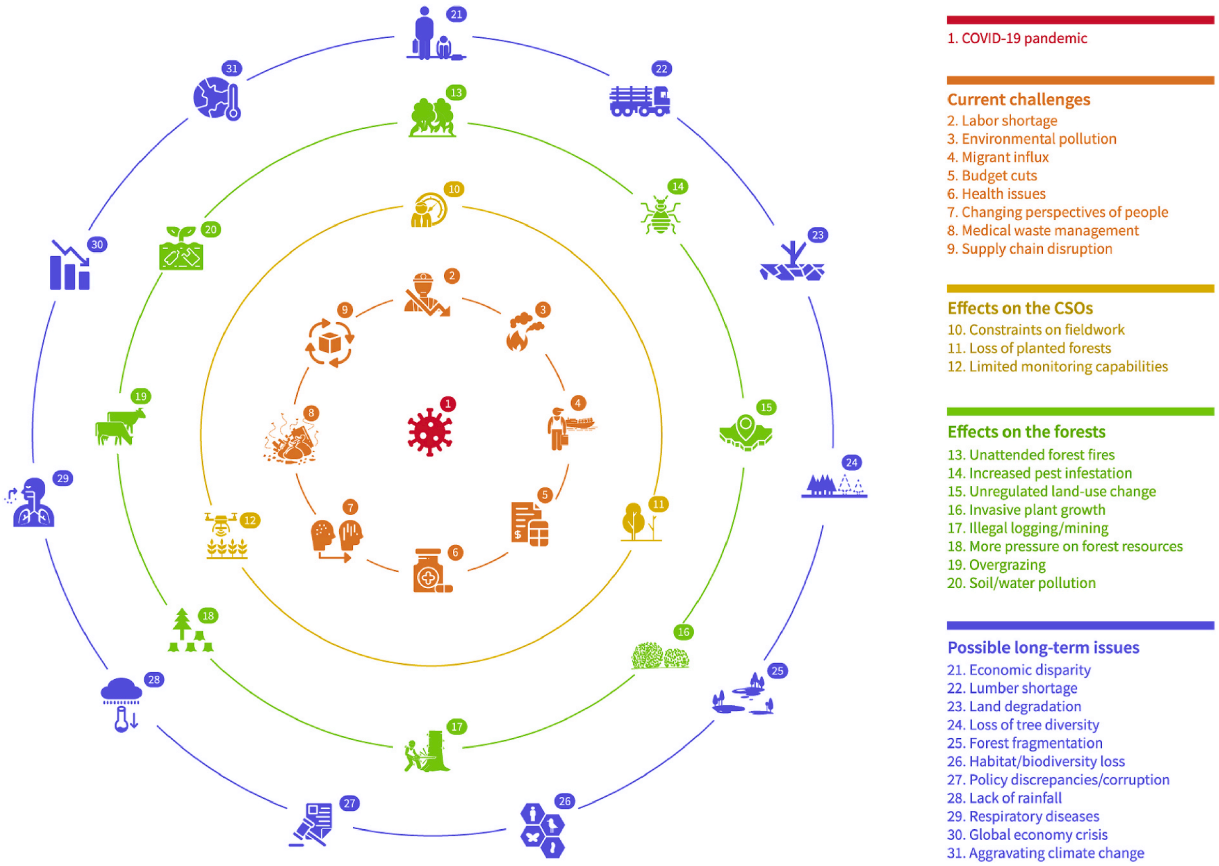

Fig. 1. Interactions between COVID-19 and the A/R sector.

3. Recommendations for performance enhancement of CSOs

Curbing deforestation and improving A/R:

3.1. Monitoring spatio-temporal fluctuations in deforestation using satellite data

CSOs should utilize satellite remote sensing data extensively and identify areas where major hikes/decreases in deforestation are occurring during the COVID-19. In 2020, a 77 percent increase in forest loss alerts compared to the average from 2017 to 2019 has been reported by GLAD, a worldwide warning system for loss in forest cover (Gross et al., 2020). Given the budget limitations and restricted travel during COVID-19, these early indications of forest loss can enable law enforcement officers to allocate resources to the right locations in a timely manner. Understanding how forest loss patterns are changing over time and during different phases of lockdowns will allow authorities to look into forest management specifics and thereby identify exigent issues and underlying patterns for upgrading region-specific policies. Also, whenever possible, CSOs can be mobilized to collect local-level aerial data, for confirming the changes observed from satellite imagery and isolating COVID-19 induced impacts. Further research in the satellite remote sensing sector is encouraged as this can help to pinpoint the exact causes leading to deforestation; for instance, discern between cases of illegal logging induced deforestation and forest cover loss due to increased unattended forest fires.

3.2. Uninterrupted surveilling on illegal logging activities

Measures should be taken to reduce illegal logging and support communities to curb such activities during times of disasters and emergencies. It is advised that such measures are not intermittent and are practiced without interruptions. Support should take the form of sensitization programs to build awareness around the damages of deforestation and the effects illegal logging can have on ecosystems. Moreover, local communities' capacity should be built in terms of identifying, tracking, and reporting illegal logging activities in their surroundings to the proper authorities. It is crucial to increase the capacity of high-risk areas as there have been reports of an exponential increase in illegal extraction of forest resources during the first month of lockdown. For instance, WWF (World Wide Fund for Nature) Nepal mentioned an increase of 227 percent of illegal logging in the country during the first month of lockdown, compared to the previous month (Gross et al., 2020). Therefore, we recommend that CSOs should focus on developing and introducing tools and technologies to increase stakeholders' capacity to monitor and report illegal logging activities on a near-real-time basis.

3.3. Tracking the emergence of newly fragmented forests

COVID-19 emphasizes the necessity of monitoring the ecological dynamics of fragmented forests as they constitute hotspots (edge regions) exhibiting high-levels of human-wildlife interaction and species biodiversity (Turner et al., 2003). The spillover of the physical extent of interfacial areas in fragmented forest critically influences the transmission of zoonotic diseases to people living nearby these habitat edges (Bloomfield et al., 2020). Thus, tracking fragmented forests and evaluating the interaction between them and humans through monitoring programs is crucial for the prevention of emerging threats to health and understanding the dimension of forest derived infections in detail

(Bloomfield et al., 2020; Guégan et al., 2020). We suggest that such monitoring be integrated with A/R programs and accounted for when prioritizing planting sites; this will in turn contribute towards the stability of various landscape-scale processes such as forest fire occurrences, ecosystem dynamics, biodiversity, carbon cycle, arable land productivity and environment quality (Jackson and Fahrig 2013; Lewis 2006; Silva Junio et al., 2018; Abdullahi et al., 2015; Kumar et al., 2018).

3.4. Transitioning from on-site to remote community participation

COVID-19 induced further limitations on mobility requiring CSOs to transition away from in-person assessments to utilizing remote monitoring technologies. The transition to remote sensing, such as satellite imagery, and phone applications - that have low data demands for information transfer and data collection via photos, videos, surveys, etc., for rural communities - should be made available through an increased proliferation of citizen science projects. These tools need to be coupled with capacity building training for both community members and external stakeholders. Firstly, it is recommended that community members be trained as community extension workers that can engage in participatory evaluation, as they can contribute to the achievement of programs and the resolution of problems so that timely measures can be taken to ensure success (Jain and Polman, 2003). Secondly, external actors should be introduced to online training platforms that can help develop a community of experts that can actively collect, monitor, and analyze data. Online data analysis platforms can cater to a higher volume of volunteers around the world to meet the needs of A/R programs by producing data more efficiently and effectively than individual experts or agencies can. In countries with limited economic budgets, focus should be first placed on allocating CSO and donor funds for delivering publicly available training platforms and technological resources for educating people and promoting environmental awareness.

3.5. Improving survey and monitoring capabilities with unmanned aerial vehicles

In the past few years, the use of unmanned aerial vehicles (UAVs) and related platforms has become more widely utilized and available, cost-effective, and can be integrated as tools in the forester or land manager's toolbox for myriad survey needs (Mohan et al., 2017). These can potentially be utilized by CSOs for addressing the scalability of A/R on difficult terrain, where rapid response is critical. UAVs are becoming more readily integrated into forest management efforts as a remote sensing tool for real-time and granular assessments of forest conditions. With improvements to user interface (UI), battery technology, and durability of the aircraft, a UAV platform can vastly improve the scale of land monitored by an individual or a small crew. Conventional imagery can be gathered to supplement surveillance needs. These can possibly include compliance, monitoring illegal activity, or other forest operations without the lag time of higher-flying conventional image capture from manned aircraft or satellite systems. LiDAR (light detection and ranging) and multi-spectral imagery collected from a UAV is also more precise and can be employed to estimate tree count, assess forest health, conduct habitat or biometric assessments, and utilized for the prescriptive nature of UAV based seed deployment systems (Mohan et al., 2019; Dalla Corte et al., 2020a, 2020b; Sankey et al. 2017, 2019; Aghai and Manteuffel-Ross, 2020). The capability of these systems is largely dependent on the quality of hobby-grade platforms (drones), hardware (sensor types), and corresponding software that can be acquired at costs that are gradually becoming more palatable to individuals and small entities that can make the investment. Furthermore, the use of UAVs provides a space for field workers and volunteers to develop new skills resulting in new opportunities, boosting the performance of the A/R sector, especially in scenarios where labor shortage and budget cuts are ubiquitous. Introducing scaling technologies like UAVs for afforestation initiatives also require the development and growth of supporting operations at the grassroots levels. These include the collection and processing of seeds, production of seed vessels, and the staffing of commercial crews for UAV based work. Technological advancements present an opportunity to incentivize retention or re-absorption of trained or skilled community members with otherwise no opportunities to contribute to resource management efforts outside of demands for unskilled labor.

3.6. Scaling revegetation efforts with UAVs and seed enablement technology

Nursery capacity is already limited globally (Haase and Davis 2017), and simultaneously, labor shortages and investments in infrastructure for the production of seedlings are likely to be exacerbated by the COVID-19 pandemic. Compounding the present seedling deficit is the need to not only address the posited surges in forest clearing for agro-sylvo-pastoral use and mining but also to counteract catastrophic forest disturbances such as wildfire, cyclones, flooding, and other climate-related impacts to forest health. Whenever new inventory of seeds become available, CSOs should try to make use of UAV systems for revegetation at scale as they can provide more rapid response times which are critical in mitigation of consequences of landscape-level disturbances such as damage to watersheds, state-shift including desertification (Grossnickle and Ivetic 2017; Aghai and Manteuffel-Ross 2020). UAVs can offer CSOs alternative improved scaling and safety measures for A/R operations, especially relevant given the reduced workforces and precautions of human resources due to current COVID-19 restrictions (Amador-Jiménez et al., 2020; Brancalion et al., 2020). UAVs could also facilitate coping with the current and future measures to ensure continuity of afforestation programs where the conventional or even aircraft seed dispersal methods are incompatible and/or costlier. Moreover, many UAV programs and corresponding analytical tools (i.e., software) could be integrated with tree-planting tasks; these include mapping the area to identify optimal seeding locations, implementing desirable prescriptions that meet area management objectives, and monitoring existing vegetation or treatment success following seed deposition events (Fortes, 2017; Kulbacki et al., 2018). Overall, regulatory and technological limitations are significant barriers that need to be overcome, with the support from national agencies, for scaling the implementation of UAVs for seed delivery. Fortunately, commercial entities pioneering in this arena are emerging and providing services, including the delivery of seed using UAVs (Aghai and Manteuffel-Ross 2020).

3.7. Revamping existing operations with regard to supply chains

CSOs should look into developing programs to disseminate the most recent concepts, encourage proper planting, and monitoring of seeds as current supply chains are being disrupted due to COVID-19. These programs can evaluate the entire supply chain and identify areas that are most impacted by new travel regulations and streamline processes for automating operations and skill upgradation wherever possible. For instance, pilot training and adoption of drones to provision resources such as seeds can be done to decrease the amount of human movement and interaction. Moreover, establishing low-cost digital information centers and recruiting local community to staff positions will enable efficient monitoring and resource utilization at all levels of the supply chain. This will offer accountability and ownership to the locals and help source suppliers strategically for achieving the UN SDGs (OECD, 2015). These systems can be further strengthened by incorporating a public-private partnership (PPP) approach, as private companies who are invested monetarily can help ensure a level of ownership and accountability for programs that are providing resources for free. Initiatives such as ITC's Social Forestry Programme in India (a private-sector company) exemplifies and demonstrates that providing

appropriate opportunity and resources to marginalized communities can help reclaim and utilize degraded lands for profitable pulpwood plantations instead of other forested lands (ITC, 2020).

3.8. Investing in early-warning systems

CSOs should consider investing in pathways that allow them to gather near-real-time updates and alerts on forest loss. Though a few platforms committed to the aforementioned task already exist - such as GLAD, DETER-B and ForWarn system - most of them are dependent on optical remote sensing data such as Landsat 8, MODIS, and Sentinel 2 and hence suffer from issues such as cloud cover, the tradeoff between temporal and spatial resolution, small-scale benchmarks (Norman et al., 2013; Finer et al., 2018; Hansen et al., 2016; Diniz et al., 2015). However, for tracking patterns of large-scale events such as forest fires, creating mobile applications incorporating weather satellite data presents a more feasible approach. For instance, Chambers et al. (2019) demonstrated the applicability of GOES data - which takes photos every 5 min - for revealing forest fire hotspots in California during the campfire that happened at Butte County, California in 2019. Despite the above success stories, there is still a need to tap into active sensors such as SAR (synthetic-aperture radar) and LiDAR in several cases such as pest infestation and forest degradation - as the optical remote sensing data doesn't reflect the variations on a timely basis and is in need of detailed historical information of the study area (Tarazona, Y., & Miyasiro-López, 2020; Khodaee et al., 2020). In this regard, strategies that involve a conglomeration of multiple state-of-the-art remotely sensed data such as NISAR, NASA ECOSTRESS, and GEDI would allow the CSOs to perform a more comprehensive analysis of the situation (Dubayah et al., 2014; Fisher et al., 2015; Rosen et al., 2015). And for accomplishing these tasks, we recommend CSOs to collaborate with regional universities and national agencies such as NASA, which has country-level programs. As a result, the inclusion of independent research and technological development channels within CSOs will be very beneficial. Simultaneously, we also recommend CSOs to actively recruit and utilize the potential of student communities from various universities - as interns or part-time employees - who specialize in areas of remote sensing and/or spatial data science.

Protecting the environment and mitigating climate change:

3.9. Explicating interactions with climate change

Impacts of recurring extreme weather events associated with teleconnections such as El Niño should be better understood to separate out the individual contributions of COVID-19 on forest loss. Otherwise, it is highly probable that the impact of COVID-19 can be overestimated, which might have serious repercussions on the performance of predictive models targeted at forest conversion and enhanced carbon sequestration. By teasing out factors that explain and/or exacerbate tree mortality, we are of the opinion that CSOs would be in a better position to quantify the interactions happening between and within various micro-ecosystems and understand how to work to support/combat them. For instance, fire activities in an area that has undergone prolonged droughts in the past might be affected differently by the reduced monitoring efforts compared to areas that experience ample amounts of seasonal rainfall (Cardil et al., 2019). The development of predictive models can assist in understanding how weather and temperature patterns will change across a region and thus support afforestation programs in following proactive prevention measures to limit the deleterious impacts of climate-forest-COVID-19 interactions (Cardil et al., 2020; Xie et al., 2015). In the absence of these, an array of social and economic adversities in the form of abrupt and irrevocable changes in temperature, spatial inequality, weakening of international solidarity, etc. can be triggered in the coming years (Manzanedo and Manning, 2020).

3.10. Mediating increased forest fires

The emergence of fires in fragile and/or dry ecosystems - with high levels of accumulated biomass content - can have devastating effects on the surrounding environment. Elevated risks are being experienced due to increasing land surface temperature and climate anomalies that adversely affect the fire resistance capacity of various species (Cardil et al., 2020b; Vilén and Fernandes, 2011). Recently, fire weather seasons have lengthened by 25% across much of the global vegetated surface, with a 100% increase of global fire prone area (Jolly et al., 2015). Therefore, ecologically based fire management, including prescribed burning should be integrated into forest management to reduce the risks of extensive and extreme fires. Integrated fire management concepts can be used to merge ecological, socio-economic, and technical aspects of fire and applied to address fire-related issues (Myers, 2006). However, COVID-19 has complicated fire management activities due to several factors, including strict hygiene and social distancing requirements, reduced staff capacity and support services, difficulties in sharing and receiving resources efficiently, and lack of opportunities for training on risk reduction activities (Stoof et al., 2020). Furthermore, forest governance, including monitoring capacities of public agencies and conservation organizations, has been impacted by COVID-19 lockdowns and shown to be associated with an increase in forest fires in countries such as Colombia (Amador-Jimenez et al., 2020). It should be also noted that increased deforestation has been found to drive forest fire risks and hence both these aspects should be studied in tandem under the light of COVID-19 (Cardil et al., 2020c). We advise that CSOs be proactive in adapting wildfire response plans and develop guidance on best practices to ensure firefighter safety and be prepared for outbreaks (USDOI, 2020). Strategic use of small Unmanned Aircraft Systems (sUAS) along with other remote sensing platforms, including satellite imagery, would increase efficiency in fighting forest fires.

3.11. Utilizing species database management platforms

Accelerated deforestation and natural habitats degradation increase the chance of human-wildlife interactions and spread of zoonotic diseases (Bloomfield et al., 2020; Brancalion et al., 2020). Recent studies have shown that a wide range of mammals are at great risk of getting infected from coronavirus and by acting as viral reservoirs, they can aggravate the pathogen transmission (Conceicao et al., 2020). Therefore, while developing A/R goals, species (both flora and fauna) database management platforms can be coupled with forest management plans to identify the possible role of intermediate hosts, in addition to the actual zoonotic source and pathway to human population. Researchers, and A/R practitioners can undertake collaborative work for enabling targeted interventions, providing optimal guidance against infections, halting the establishment of new zoonotic reservoirs and developing a research agenda to reduce the risk of similar events occurring in the future. Also, by tracking native species and proliferation of non-native species in areas where A/R programs are conducted, it would be possible to delineate the COVID-19 ramifications on forest habitat diversity and identify tree species that may be in potential danger due to illegal logging and animal trade. CSOs can utilize existing platforms such as the Global Biodiversity Information Facility (GBIF, 2020) in this regard and locate priority areas that need urgent attention. Additionally, CSOs can incorporate technological based data fusion strategies to overcome current knowledge gaps and offer direct and remotely analysis tools to support operations such as automatic classification of forest species, yield estimation with respect to atmospheric carbon concentrations and deciphering animal migratory patterns (Arekhi et al., 2017; Liu et al., 2018; Chiang and Valdez, 2019; Koh and Wich, 2012).

3.12. Gauging tree-planting over forest regrowth

Reforestation is one of the largest Natural Climate Solutions (NCS) pathways for cost-effective global climate mitigation (Griscom et al., 2017). However, reforestation initiatives need to be carefully planned by CSOs in certain situations, as natural regeneration can economically and ecologically be a better option (Cook-Patton et al., 2020; Chazdon et al., 2017). Therefore, recognizing where, when, and how to implement A/R is critical for optimal use of limited resources. Due to COVID-19, we face new challenges, which can be perceived as a function of A/R location: firstly, for countries where proper and adequate field data of the A/R sites is lacking due to travel restrictions, and secondly is that CSOs are limited in their capacity to work in the field due to safety concerns. Therefore, CSOs are recommended to use the most recent data products (including drone-derived metrics) and tools from external platforms - such as the ones associated with the medical sector - to assess how natural forest regrowth compares with reforestation measures, evaluate success rate of tree plantings over time and identify areas with the greatest potential for carbon accumulation per hectare (Cook-Patton et al., 2020; Almeida et al., 2019).

3.13. Improving waste management procedures

Waste management has become a growing concern in many parts of the world during the COVID-19 pandemic (You et al., 2020). Due to the massive increase in medical waste, a shift in waste composition and quantity is observed, which stresses the need for a responsive waste management system (Klemes et al., 2020). Increased plastic consumption, workforce shortages for waste collection and recycling, and waste mismanagement leads to pollution of waterways and land degradation (Klemes et al., 2020; Rajmohan et al., 2019). In the long-term, this would nullify A/R initiatives as the low quality of soil and groundwater systems will create an impetus for large-scale tree mortality (Nagajyoti et al., 2010; Zambrano-Monserrate et al., 2020; A.L.P. Silva et al., 2020; Suyadi and Manulland, 2020). For instance, groundwater contamination can decrease the immunity of trees making them more vulnerable to natural stresses such as short-term droughts (Leblanc and Loehle, 1993). In a similar way, accumulation of heavy metals from solid and medical wastes can eliminate useful soil microorganisms and thereby affect forest ecosystem balance and indirectly delay litter decomposition processes and restrict nutrient availability for plants (Tzvetkova et al., 2016; Kabata-Pendias and Pendias, 1989; ICP Forests and ICP Monitoring, 2002). Therefore, it is suggested that better waste management strategies, especially for areas near afforestation zones, should be conceived and added as one of the primary objectives of CSOs within the forestry sector. A pragmatic way for CSOs to combat the current waste management issues is through the promotion of reusable personal protective equipment (PPE) (Kabir, 2020).

3.14. Structured decision making to optimize resource usage

Making quality decisions could be challenging for CSOs during the COVID-19 pandemic, as resource managers must deal with multiple and often competing objectives, constrained capabilities, and uncertainty. A structured approach can explicitly define objectives, assess management alternatives, and employ analytical tools to recognize and implement adaptive management strategies (Williams et al., 2009). Unlike traditional decision making, incorporating risk tolerance can ensure the safety of staff and the community. Combining modeling and group elicitation processes with a structured decision-making (SDM) framework would enable resource managers to make risk-based decisions in a timely manner (Gregory et al., 2012), especially during the COVID-19 pandemic (Shea et al., 2020). CSOs may have to prioritize management actions while accounting for ecosystem services or other non-biophysical values (Martin et al., 2018). Value of information analysis is another decision-support tool that CSOs can use within an SDM framework to optimize resource usage and prioritize management actions, research, and monitoring (collecting new information) that directly informs action (Buxton et al., 2020).

Enhancing socio-economic conditions:

3.15. Understanding the migration of workers back-and-forth

Due to COVID-19, a lot of people who had migrated to foreign countries/urban regions for employment purposes are returning back. This rise in labor availability, accompanied with reduced employment opportunities, can place additional pressure on forested lands as it is seen as a means for increasing food production as well as a source of livelihood given the absence of remittance income (Fox et al., 2020; de León-Martínez et al., 2020). CSOs should place more emphasis on collecting in-depth data on the inflow and outflow of people from rural areas - and their effects on forest loss and afforestation programs. Moreover, data should be aggregated accordingly to pinpoint areas that are potentially sensitive to deforestation. This information can then be relayed to national and international agencies that work on forestry-based initiatives to identify and evaluate deforestation hotspots. By examining correlation between migration and deforestation, data-driven decisions for efficient allocation of CSO resources and development or re-evaluation of forest economics policies can be made.

3.16. Magnifying outreach of educational/environmental awareness activities

Since advocacy and awareness efforts by the youth population and other global partners are canceled, constrained or indefinitely delayed due to COVID-19, CSOs need to help revitalize educational and environmental activities to make them self-sustaining, far-reaching, cost-effective, and updatable remotely. These distance-learning mechanisms can take the form of massive open online courses (MOOCs) (Mazoue, 2013) through the collaboration of CSOs with reputed organizations such as UNEP (UN Environment Programme) as well as with educational institutions that already offer courses related to sustainability and data science. Moreover, these courses will pay dividends for aspiring forestry and climate change professionals, as it will allow them to contribute to a worldwide effort while gaining valuable experience and education related to A/R efforts. These MOOCs need to be provisioned in a way that guarantees prolonged activity and knowledge gain by users. Furthermore, these programs should be facilitated so local communities will engage directly with A/R efforts during emergencies like COVID-19. Therefore, classes need to take into account local cultures and data capabilities (for instance, learning platforms that have low-data requirements should be prioritized for rural communities) and deliver materials that are both relevant and available in local and indigenous languages.

3.17. Creating region-specific intra-network of CSOs

Intra-network of CSOs should be formalized around each working sector to increase collaboration between CSOs and to stay updated on emerging COVID-19 imposed challenges. Working groups within sectors can foster resource sharing in terms of capital, data, and human resources. This will cut down on duplication and overlapping of programs and data collection endeavors and allow to alleviate the impacts of budget cuts and funding limitations faced during the COVID-19 pandemic. Additionally, we urge CSO networks to place further focus on supporting community forest user groups that link forest users from various parts of the country for improved forest management and policy making. In countries such as Nepal, these groups are currently experiencing restrictions on accessing government resources, community gathering and addressing issues associated with decreased timber production and concomitant monetary loss (Basnyat et al., 2020). Support for these groups should be prioritized as they have the capacity to

balance livelihood outcomes and closely monitor forests while CSOs are overseeing projects remotely or projects are being postponed.

3.18. Facilitating communication through technology

As CSOs are being faced with mobility restrictions due to the pandemic, actions need to be taken to overcome communication limitations between local communities and project coordinators, especially in remote locations where there is limited access to the internet and mobile services. Moreover, agencies should build the capacity of individuals to utilize technology to implement, monitor, and report on program sites as it will have a compound effect of contributing to the skills of local communities as well as help cut down on travel costs for agencies to program sites. Some tools to facilitate remote communication and overcome restriction barriers include messaging and video conferencing platforms such as Slack, Skype, and Microsoft Teams, among various others (Microsoft, 2020a, 2020b; Slack, 2020).

3.19. Dismantling stigma around outsiders

With growing concerns regarding the transmission of COVID-19 at the community level, non-native individuals are becoming concerned with 'new visitors' or unrecognized people. Therefore, foreigners, as well as individuals from densely populated urban areas, may find themselves barred entry or stigmatized due to perceptions of outsiders being infected or not trustworthy; these tribulations and xenophobic nature are sometimes associated with the race, age groups as well as the country/region the people are coming from (Villa et al., 2020; Abdelhafiz and Alorabi, 2020; Reny and Barreto, 2020). To combat these perceptions, CSOs in coordination with local governments need to enact awareness/sensitization programs at the local level. Moreover, these programs should include discussions on the importance of ecotourism and its importance in the conservation sector. The discussions are essential as ecotourists indirectly contribute to the protection of areas as a portion of the income generated from them contributes to the forestry sector.

3.20. Creating new job opportunities

Afforestation programs offer opportunities for indigenous and rural communities, which will especially contribute to SDG #1 and #13. These opportunities have been recognized for its employment-generation potential, as the worker training requirements are low, require minimal planning and procurement as well as meet social distancing guidelines (UNDESA, 2020a). Moreover, CSOs should utilize and expand these local employment opportunities to advance their afforestation programs and their fights against climate change by incorporating technology in the form of communication tools, open-source analysis platforms, and monitoring devices such as drones. This will further allow CSOs to be successful while engaging in remote management of programs as well as equip community members with skills that can translate into job and/or recreational opportunities, which utilize much-needed skills in the COVID-19-era such as leadership, social influence, creative thinking, analysis, innovation, reasoning and problem-solving (World Economic Forum, 2020).

3.21. Collaborating with environmental and medical groups

We suggest CSOs collaborate with various COVID-19-relief organizations to educate the general public on the importance of forest conservation. Fragmentation of forests leads to an increase in the spread of zoonotic diseases (Bloomfield et al., 2020), and by supporting afforestation programs, the medical/health sector also benefits indirectly. Simultaneously, CSOs can also join hands with local authorities and governments to sensitize the public of the dangers of illegal hunting and wild animal trade, as it has been shown that populations engaging in these practices have led to the spread, or have been the vector, of diseases such as HIV (consumption of nonhuman primate meat), SARS-associated coronavirus (trading of small carnivores) (Karesh et al., 2005) - and hypothesized as the underlying reasons for COVID-19. New collaborations can help optimize the limited resources for the benefit of people and the environment. Similar way, coalitions can be made with groups fighting for biodiversity conservation and/or climate change as their objectives have major overlaps with the A/R programs.

3.22. Promoting fundraising campaigns

The primary sources of financing for the forest sector vary from official loans, foreign direct governmental loans, technical assistance, public/private sector funding, Foreign Direct Investments (FDI), to donations (Tomaselli, 2006; UNDESA, 2020b). Approximately 60% of bilateral and 90% of multilateral climate financing in 2017 were provisioned in the form of loans (OECD, 2019), implying that recipient countries being coerced to expand their risk to external debt in order to implement climate-based initiatives. The COVID-19 pandemic has further aggravated these circumstances, as most of the national budgets are being allocated for health and medicinal programs. To overcome funding constraints and lowering countries' reliance on loans, CSOs should increase their fundraising efforts from individual donors and organizations. Crowdsourcing platforms can play a vital role in this regard and can help aggregate potential funds from the private sector and general population directly (e.g., gofundme.com, Ketto.org, fueladream.com). Additionally, campaigns can involve education-based fundraising efforts in order to raise awareness and demonstrate the urgency of afforestation and climate-based initiatives for the young generation. Local/regional community organizations, schools and associated resources can also be tapped by the CSOs, to develop young activists who can disseminate information to their networks, become environmental activists and changemakers, and engage in virtual fundraising events through the utilization of social media. Furthermore, friction points within the donation process need to be reduced (such as utilizing donation tools that are simple and not convoluted, as well as that, don't require registration or extensive data entry), and the unique selling point of donating to afforestation programs needs to be highlighted, such as 'personal trees' or 'forests', that are marked with GPS and satellite images for the donor to continuously observe; this will instill a trait of responsible stewardship as well.

3.23. Building volunteer alumni networks and social media groups

COVID-19 has compounded and hastened the gap in knowledge transfer, acquisition, and sharing after experts leave work-posted countries due to the unforeseen repatriation of citizens. Therefore, we recommend CSOs to collectively develop and promote country-specific, open-sourced data-sharing platforms that allow experts, volunteers, and academics to collaborate in developing the knowledge base to further progress afforestation programs through a global approach. The inclusion of experts with in-country specific knowledge will assist in the understanding of socio-cultural aspects that underlie, contribute and/or are the predecessor of satellite gathered images and data. Previous in-country experts can further be involved in data aggregation activities as they can communicate with established networks on the ground - who can contribute to collecting field data from beneath the forest canopy that satellite imagery is unable to detect. Knowledge management experts can properly categorize and disseminate information to relative stakeholders across government, intergovernmental organizations (IGOs), CSOs, and local communities to be incorporated within afforestation initiatives and develop uniformed procedures for all participants. Moreover, these information-sharing platforms can curb the duplication, redundancy, and overlapping of programs by CSOs, IGOs, and government agencies, thus assisting in a targeted, collaborative, and more cost-effective approach to development (OECD, 2003). To reach

and encourage a wider audience to participate in data collection remotely during disasters such as COVID-19, dissemination of volunteer opportunities should be promoted through social media such as Facebook and Linked-in for middle-age and older populations, and Instagram and TikTok for younger audiences. For this purpose, we also urge CSOs to diversify their talent acquisition process and recruit candidates from multidisciplinary backgrounds such as data science and public relation.

3.24. Setting up COVID-19-screening platforms at field sites

Ensuring a solid response plan set by specialists in coordination with health providers is critical to maintain healthy operations and reduce potential transmission among workers and the public during a pandemic. Incorporation of general health recommendations, promotion of awareness programs, the emphasis of preventative measures, and application of conventional site screening (such as thermal testing) could be conducted as a part of A/R programs to cope with the pandemic situation. CSOs should make sure that preventative equipment, including face masks, surgical gloves, disposable coats, tissues, hand sanitizer, and hygienically disposable trash bags are accessible for all workers at the field sites, and a specific part of the existing funds can be allocated for this. Quality equipment and prompt response preparation could also be crucial in case of any other emergency such as a forest fire - which might be hard to compress, given the limited labor during COVID-19. Additionally, with the latest developments in the COVID-19 vaccine landscape, we recommend CSOs to have their staff vaccinated who directly engage with local communities and provide awareness while organizing community events, once the vaccines are officially available in their respective regions. (WHO, 2021).

3.25. Generating income and building forests through app development

The promotion of A/R efforts through gamification has been growing in popularity and should be capitalized on during COVID-19 induced lockdown measures as populations are currently being restricted to their homes. Gamification is the concept of using game features and techniques during non-gaming situations (Antwi et al., 2018). Moreover, due to the introduction of motivation aspects of gameplay, apps that incorporated these features have improved student engagement. Although the benefits of these tools have been well documented, there has been limited utilization of them within the A/R sector. Public-private-partnerships (PPP) can develop gamified afforestation apps that can be utilized to leverage and raise funds through in-app purchases as well as donations. Furthermore, assistance and evidence can be acquired by PPPs implementing these from previous UN initiatives like Right Runner - a child's right based awareness game (https://www.unicef.org/lac/en/right-runner). Tools and mechanisms can be taken from Right Runner, which can assist in streamlining the creation of the app while including services that provide a medium to raise awareness around the urgency of implementing climate mitigation programs. Further, we also suggest PPP and gamification be utilized to conduct competitions for afforestation programs, where communities and individuals can be rewarded for the number of planted trees as well as the number of living trees in comparison to other communities.

Amending policies and law enforcement practices:

3.26. Tightening regulations on forest conversions

In the tropical regions, commercial agriculture expansion has induced deforestation and forest degradation (Hosonuma et al., 2012). Since COVID-19, there is a high probability of lax sustainable policy implementations which can indirectly embolden not only unregulated land use land cover change but also give rise to illegal mining and logging activities (WWF, 2020; FAO, 2020). It is suggested that small-scale landowners be incentivized to avoid forest conversion, especially in biodiversity hotspots and edge regions of forest landscapes. Additionally, appropriate transparent channels that allow easy integration of smallholders into voluntary certification schemes should also be promoted wherein CSOs, INGOs, and similar organizations can keep an up-to-date track on areas being assigned for crop plantation expansion (Brandi et al., 2015; Meijaard et al., 2017). We also urge CSOs to undertake collaborative endeavors with groups such as Roundtable on Sustainable Palm Oil (RSPO), which help implement global standards for sustainable palm oil production as a means to nullify the negative impact on the environment, wildlife and/or people (Cattau et al., 2016).

3.27. Optimizing timber markets

COVID-19 has negatively impacted the forest and lumber industry, including the global trade and supply chains (Damicis, 2020). Reduced labor, delays, and inefficiencies in production and supply chains and reduced monitoring during the ongoing pandemic have all contributed to increasing the risk of illegal timber harvesting and trade. Keeping the global timber trades legal and sustainable is crucial for post-COVID-19 economic recovery (Hewitt, 2020). CSOs should join hands with local authorities to limit corruption and halt illegal timber trades and supply chain routes that offer opportunistic actors access to national and global markets (FAO, 2020; Brancalion et al., 2020). CSOs can also contribute to the bigger cause by developing remote teaching platforms and online workshops that offer tools and strategies to optimize forest management practices for new and future recruits; for example, talk sessions can focus on explicating the advantages of forest thinning, prolonged rotation, carbon sequestration, and provide information on potential carbon credit markets and the importance of UN SDGs. In short, it should be made clear that afforestation doesn't have to happen at the cost of timber production and/or a country's economy. In tandem, credible forest certification systems such as the Forest Stewardship Council (FSC) can be introduced to avoid the impacts of illegal and unsustainable logging and promote responsible practices throughout the forest products supply chain (WWF, 2020; Rainforest Alliance, 2016).

3.28. Amending labor rights and policies

The COVID-19 pandemic has led to various socio-economic implications and an increase in illegal activities leading to forest degradation (Golar et al., 2020). This chain of events has put forest sector workers at risk of labor rights violations as they are not protected by law, and these discrepancies can further marginalize communities by exposing them to risks such as withholding of wages, deception, hazardous conditions, and child labor (WWF, 2020). The disfranchisement of these causes will further plunge the workers into the vicious circle of poverty. CSOs should utilize their networks both locally and nationally to provide alternative temporary employment opportunities to communities that are deprived of income; this can be done in areas such as medical waste management, which is short of supporting staff (You et al., 2020). Moreover, we encourage CSOs, in collaboration with governments, to conduct awareness programs to sensitize stakeholders of the risks of labor exploitation, illegal supply chains, and corruption. The aforementioned cases have been significantly found to increase during the COVID-19 pandemic (ILO, 2020). Technology to help sellers and buyers accurately trace logged trees should also be introduced among the young population in particular. Finally, there needs to be increased ownership of forests by indigenous communities so they can act as stewards of local forests. Additionally, fast-tracking of law enforcement should be made on a case-by-case basis as one of the major issues faced by countries with high tribal populations such as Papua New Guinea is the outdated policy structures and with COVID-19, meetings for decision-making to update forest policy are facing further delays which can topple the forest sector severely.

3.29. Placing focus on urban tree-planting

Restrictions on gatherings and mobility call for a shift in focus from current large-scale programs to individualized household and government-based urban forestry initiatives. With current projections showing that by 2050, 68% of the world's population will live in urban areas (UNDESA, 2018), it's crucial for CSOs to use opportunities like COVID-19 to develop strategies to increase participation in urban forestry. This could help compensate for the limited largescale in-situ conservation activities resulting from restricted outdoor movement. Moreover, urban forestry can provide a range of ecosystem services, including climate change mitigation, improve air quality, increase well-being, cut the risk of floods and heatwaves, and halt land degradation (Win, 2019). It is imperative to begin the process of urban forestry now, as urban areas continue to grow especially in Asia and Africa (Richards and Belcher, 2020), and will find themselves in a situation where it is too late to incorporate trees within their city planning. Therefore, CSOs should, and easily can work within urban settings with the government as well as citizens as they are stationed in these localities and can utilize different mediums for information dissemination - TV, loudspeaker systems, posters in grocery stores, on public transportation, and local gathering areas. It is particularly effective for city-state countries where areas are limited but with a more urban setting and educated society that value ecosystem services by urban green space (Jaung et al., 2020).

3.30. Championing carbon credit systems

It is recommended that the promotion and development of a 'UN Carbon Offset Platform' like program be prioritized amongst CSOs to engage more local leaders, small-scale forest owners, industrial investors and government officials in the fight against escalated illegal logging and forest conversion happening during the COVID-19 pandemic phase (Roise et al., 2016; Hou et al., 2019; Freedman and Keith, 1996). Previous studies have shown that carbon credit platforms can provide long-term funding for communities, help fund micro-enterprises for income generation opportunities and subsequently reduce community dependence on forest-based products (Holmes et al., 2008). Therefore, this framework will help add the much-needed funding to afforestation initiatives during COVID-19 while offsetting CO_2 emissions. For this policy tool to be prosperous, governments, corporations, and CSOs can develop a working group to best utilize funds as well as honor the carbon credits across geographical borders while avoiding previously experienced loopholes and legal issues that have bogged programs down before. Additionally, new pathways utilizing smart web-based geospatial decision support systems can be improvised to tap into a circular economy to integrate soil restoration with carbon sequestration as this can address the disruption of the global food supply chain and nutritional insecurity arising from COVID-19 pandemic (Lal et al., 2020).

3.31. Supporting indigenous communities

Indigenous communities are invaluable in protecting intact forest landscapes, decelerating the rate of deforestation, and mitigating the risks of climate change globally (Fa et al., 2020). Through Traditional Ecological Knowledge (TEK), existing indigenous practices, and cultural heritage, these communities help promote the protection and sustainable utilization of ecosystem resources (Martin et al., 2010; Berkes et al., 1994). Indigenous people manage or have tenure rights over at least ~38 million km^2 throughout the world, representing over a quarter of the world's land surface (Garnet et al., 2018). In the face of the COVID-19 pandemic, indigenous people across the globe have been exposed to a wide range of risks and challenges. These include travel restrictions for nomadic and pastoralist communities across frontiers, disruption of domestic economies, related local supply chains and livelihood, the encroachment of traditional lands, increase in rights-based issues and discrimination within the communities, acceleration in the loss of native languages, lack of access to clean water, education, health services and information related to the pandemic (UNESCO, 2020a; UNESCO, 2020b; UNESCO, 2020c; UNESCO, 2020d). In this regard, it is evident that in such circumstances, intermediaries such NGOs, CSOs, and other international agencies play an important role in implementing ground-level policy changes and provide support mechanisms to respond to the challenges created and aggravated by the pandemic. These can be enacted in the form of provision of resources - human capital, monetary support, or communication tools - or by government policy reforms led by CSOs, especially through indigenous community participation. By enabling the implementation of policies to protect forests, facilitating access over ownership rights to indigenous communities, supporting livelihood and local economy, promoting sustainable use of resources, skill development, dissemination of information and knowledge transfer relevant to the pandemic, CSOs can empower native people to oversee the utilization and management of forests and natural ecosystems more efficiently. For example, in Mexico and Africa, UNESCO has partnered with various local and international organizations to implement COVID-19 response programs, disseminate vital information, help recognize indigenous people's rights and cultural heritage, and to overcome the aforementioned challenges (UNESCO, 2020c; UNESCO, 2020d). This is essential to meet various SDGs, including SDG #4 (Social cohesion and community resilience).

3.32. Securing long-term funding

CSOs in LDCs and developing countries often lack the necessary long-term funding to adequately meet the demands of A/R programs and stifle the advancements of deforestation and climate change. With the current funding levels, CSOs are forced to implement piecemeal approaches that result in protected areas (national parks and wildlife reserves) but fail to ensure the longevity of programs and the biodiversity of the protected areas. Moreover, short term funding results in incomplete views of the necessary conditions for habitats to be protected and ultimately are described as efforts to, "hold off disaster," and "live to fight another day" (Linden et al., 2012). If afforestation programs are to be successful, it will be imperative for CSOs to secure consistently, earmarked and long-term funding in order to properly plan and envision future objectives and goals; retain funds during disasters like COVID-19 - that call for the reallocation of funds to other sectors; and be resilient in their operations during humanitarian disasters that restrict programmatic operations. Therefore, CSOs must work with potential donors (such as IGOs) to increase funding opportunities from short-term (one to two year) to long term programs (five-plus years). Additionally, CSOs can advocate for long term funding pools to be filled through the addition of carbon taxes within countries, as mentioned in Section 3.30. We also recommend that CSOs, academics, and governments work together to develop and incorporate long term afforestation visions for high-risk areas corresponding to national strategic plans for countries where COVID-19 cases have pivoted; similar measures have proven to be effective in suppressing deforestation in developing countries such as Costa Rica and Columbia (Barbier and Troëng, 2020).

3.33. Transitioning to renewable energy with caution

There is a substantial need to channel energy sources for domestic consumption from forest-based products to renewable resources. As of 2017, over 2 billion people, both in urban and rural areas, relied on wood for their primary energy needs, especially in developing countries where 90% of fuelwood being used globally is consumed for cooking and heating purposes (UNDESA, 2017). Although the use of natural resources is high, and CSOs should assist in the transition to renewable energy sources, special measures and caution should be taken while doing so. For example, often forest lands are cleared for the construction of solar farms, which can result in CO_2 emissions as high as 36 g CO_2

kWh−1 (Turney and Fthenakis, 2011), displace carbon from above and below-ground pools and release it back into the atmosphere (Hernandez et al., 2014). Transitioning to hydropower produces similar issues, as significant areas of forests and ecosystems need to be cleared or drastically changed to allow for infrastructure to be built. India's ambitious hydropower project showcases this, as it was rejected twice by the environment ministry's forest advisory committee, who stated that the ecological, environmental, and social costs of the destruction of forests would far outweigh the benefits likely to accrue from the project (Aggarwal, 2019). These examples shed light on the issues faced with the implementation of renewable energy sources, and therefore call for innovative solutions by CSOs in regard to new energy sources (such as biofuels or harnessing plant energy, environmental impact assessments, and local micro-based energy productions). Finally, CSOs need to focus on making these renewable energy source initiatives self-sustainable and long-lasting through capacity building training for communities, so they can effectively repair, connect new houses to the power grid, and make minor adjustments to equipment to improve energy outputs. Thus, self-reliance and sustainability are the need of the hour across energy sectors, especially in times of emergencies/pandemics like COVID-19 when communication, human resources, and mobility is limited.

4. Conclusion

The global COVID-19 pandemic has put afforestation, reforestation, and related forest recovery initiatives at the crossroads due to the constraints imposed on available human resources, financial aid, waste management protocols, supply chain functionalities and individual perceptions of foreigners. The influence of COVID-19 needs to be identified, tracked, and quantified on an accurate, comprehensive, and continuous basis over time for optimizing resource allocations, policy reforms, and forest conservation endeavors. The major threats to the forest sector resulting from the pandemic were found to be unregulated deforestation, policy changes, decreasing stringency in environmental laws, laxity in enforcing environmental regulations, limited monitoring at ground level, reduction of labor force participation, the return of migrant workers, and increasing pollution levels among others.

This review work provides recommendations cross-cutting various domains to support Civil Society Organizations and encapsulate four different but interconnected spheres that merit immediate attention: i) curbing deforestation and improving A/R, ii) protecting the environment and mitigating climate change, iii) enhancing socio-economic conditions and amending policy and iv) law enforcement practices. Remotely sensed data - especially the use of UAVs and open-source satellite platforms - and advanced database management systems, along with extended dependable local community networks, are proposed as pathways for keeping deforestation under control during the pandemic. Notwithstanding the vital role of CSOs in the afforestation and reforestation realms, there should be support, involvement, and reciprocity from government agencies, local authorities, and citizens of respective nations in a timely manner for translating our takeaways into the administration domains in a more explicit and efficient manner. Only through this conglomeration, we would be able to tackle unforeseen adversities to forest cover enhancement programs that can arise from interactions of the pandemic with transforming anthropogenic perspectives, resource shortages and global environmental shifts.

Ethical approval and consent to participate

Not applicable.

Availability of supporting data

Not applicable.

External funding

Not applicable.

Credit author statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors are grateful to the UN Volunteering program (https://www.onlinevolunteering.org/en/opportunities), the Morobe Development Foundation (Papua New Guinea), UNDP Papua New Guinea as well as to the following people for their contribution with reviewing and/or editing the draft versions of the manuscript: Ricardo Martínez Prentice of Estonian University of Life Sciences and Aurelie Shapiro of WWF Germany.

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