BRAZIL NEEDS TO MONITOR ITS TROPICAL REGENERATION

REMOTE MONITORING SYSTEM IS TECHNOLOGICALLY FEASIBLE, BUT NEEDS PUBLIC POLICY SUPPORT

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The Challenge

Expanding its environmental policy to include the promotion and protection of tropical forest regeneration would be a strategic and timely decision for Brazil. Restoring ecosystems is key to strengthening conservation measures and improving ecosystem services and can generate significant environmental and financial gains. Brazil is in a unique position to contribute to this effort since it holds vast amounts of degraded and deforested lands in tropical regions. But **secondary vegetation—that which grows in previously deforested areas—is in a completely vulnerable position**. Currently, areas of regeneration are not detected by any official system that monitors tropical forest cover, which means that the country lacks access to essential data for policy design and implementation in the areas of conservation and sustainable development.

Brazil needs systematic, regular, and frequent monitoring of secondary vegetation to spur tropical forest regeneration and strengthen its protection. The main obstacle to achieving this has nothing to do with technology. The country has access to the technology and technical expertise needed to monitor secondary vegetation. But building systems that monitor regeneration will depend on lawmakers understanding how important it is to protect this vegetation, and above all, how relatively simple it would be for the country to implement systems to do so.

This paper offers recommendations on how to move forward in developing remote systems to monitor secondary vegetation.

Policy Recommendations

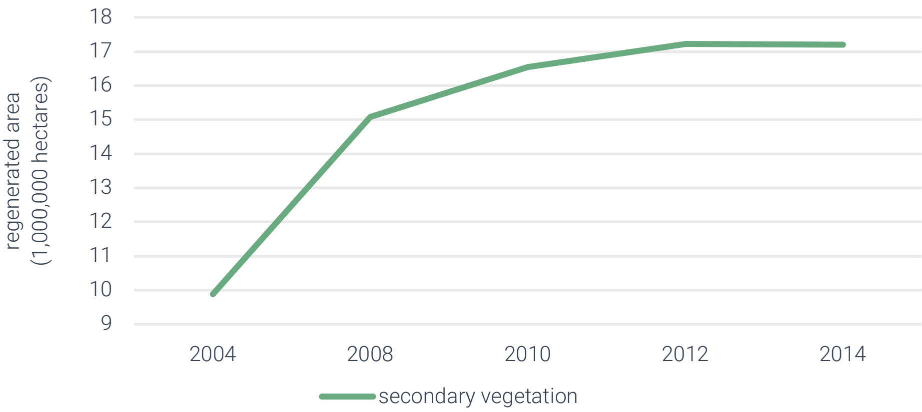
1. **Establish clear criteria for classifying secondary vegetation in remote sensing imagery.**
2. **Develop two complementary systems to ensure monitoring of secondary vegetation in the short, medium, and long term.**
3. **Use existing remote sensing imagery to build a preliminary model of the systems.**
4. **Develop and maintain a careful communication strategy with policymakers and the general public.**

WHAT'S THE ISSUE?

What problem are we trying to solve? Why is this important?

The Brazilian Amazon holds vast amounts of secondary vegetation, that is, vegetation growing in previously deforested areas. In 2014—the last year for which official data exists on forest cover and land use in deforested areas throughout the Amazon—more than 17 million hectares showed signs of tropical forest regeneration (INPE and Embrapa, 2016). This is equivalent to nearly a quarter of all prior Amazonian deforestation. It was not merely a question of past regeneration, but rather of an ongoing phenomenon. Between 2004 and 2014, the amount of land covered by secondary vegetation increased by more than 70%. Figure 1 illustrates this growth.

Figure 1: Extent of Secondary Vegetation in the Brazilian Legal Amazon, 2004 – 2014.



***Source:** Climate Policy Initiative / PUC-Rio (2020), with data from TerraClass Amazônia / Inpe and Embrapa.*

But despite its scale and this recent expansion, **tropical forest regeneration remains invisible to the official systems that monitor the Brazilian Amazon**. [1] Since Brazil has not renewed the TerraClass project—which monitored secondary vegetation in the Amazon between 2000 and 2014—it lacks access to systematic, regular, and up-to-date information on the extent of secondary vegetation in its largest biome. The country is thus unable to observe medium and long-term trends in losses or gains to regenerated areas. This severely limits its ability to monitor and verify both its own progress toward meeting international reforestation goals, and rural property owners' compliance with Forest Code restoration requirements. It is also unable to detect secondary vegetation removal in the short term, which prevents environmental authorities from effectively responding to violations and crimes affecting this type of vegetation. These limitations suggest that as long as regeneration remains invisible to

[1] Even though secondary vegetation mechanisms already exist in the Brazilian Amazon developed and sustained by third sector and civil society organizations, like unoficial systems/initiatives. This, however, does not eliminate the need for the brazilian government to have its own official system that guarantees methodological consistency between the official data refering to the Amazon monitoring vegetation.

monitoring systems, it will not receive the attention it deserves from policy actions on conservation and sustainable development.

Expanding its environmental policy to include the promotion and protection of tropical forest regeneration would be a strategic and timely decision for Brazil. Ecosystem restoration is key to strengthening conservation measures and improving ecosystem services. Restoring 350 million hectares of degraded and deforested areas worldwide could absorb an estimated 1.7 gigatons of carbon dioxide per year and generate approximately US $170 billion in liquid assets from water resource protection, increased agricultural production, and forest products (IUCN and Winrock International, 2017). Brazil is in a unique position to contribute to this effort since it holds vast amounts of degraded and deforested lands in tropical regions. But systematic, regular, and frequent monitoring of secondary vegetation is needed to spur tropical forest regeneration and strengthen its protection. This is an important step for Brazil to take toward meeting its environmental commitments to reducing greenhouse gas emissions as well as improving the quality of human life on a local and global scale.

WHAT'S THE CONTEXT?

What is the relevant background on this issue?

Over the last several decades, tropical conservation policy in Brazil has typically focused on containing pressures related to primary forest loss rather than promoting or protecting regenerated areas. This focus arose out of necessity, not from a lack of vision or public policy planning. In the mid-2000s, when the total cleared primary forest in the Brazilian Amazon amounted to over 62 million hectares, primary forest loss reached a pace of 2.7 million hectares per year (INPE, 2019). **This steep rate of annual forest loss was largely responsible for the elevated share of the country's greenhouse gas emissions caused by the forestry sector and land-use changes during that time period—estimated at between 70% and 80% (MCTI, 2013; SEEG, 2020).** In the first half of the decade, Brazil cleared more tropical forest than any other country, in both absolute and relative terms (Hansen et al., 2008).

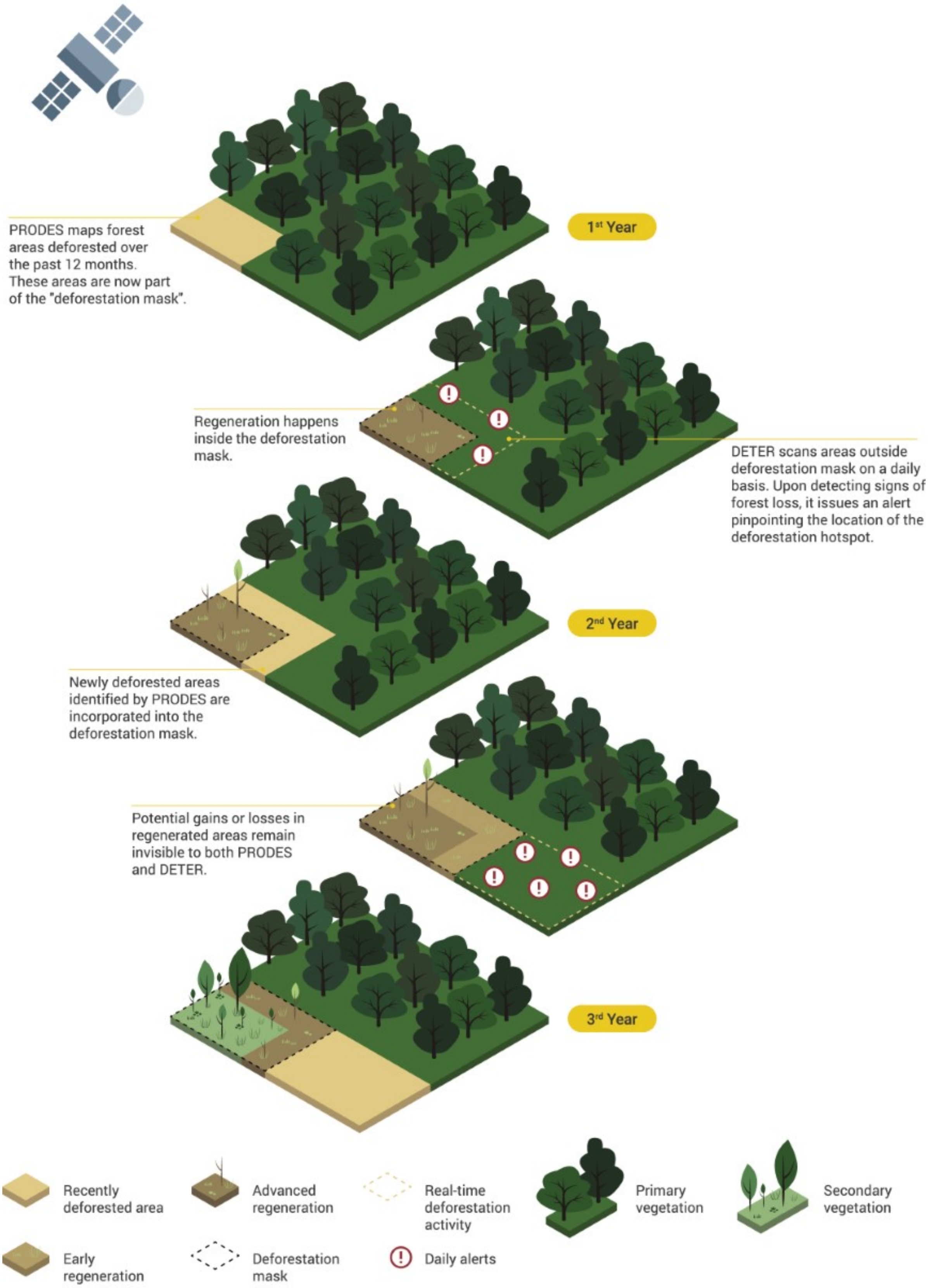
With growing awareness of the role tropical forests play in the global effort to address climate change, combating deforestation became a priority on international policy agendas (Stern, 2008; Burgess et al., 2012). It was in this context, under increasing pressure to control its high rates of forest loss, that Brazil launched its Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm), an ambitious set of strategic conservation measures. This marked a new approach to dealing with tropical deforestation in the Amazon.

Since the overwhelming majority of deforestation in the Amazon was illegal, one of the cornerstones of the PPCDAm was the adoption of satellite monitoring of forests to improve enforcement of environmental laws. The National Institute for Space Research (INPE) developed the System for Real-Time Detection of Deforestation (DETER), which introduced nearly-real-time monitoring of forest loss accompanied by georeferenced deforestation alerts. The Brazilian Institute for the Environment and Renewable Natural Resources (Ibama), the federal authority responsible for investigating and punishing environmental violations, now uses these alerts to target law enforcement activities.

An important feature of DETER is that **the system was designed to detect only the loss of primary vegetation.** This is in line with the way Brazil has measured tropical deforestation since the end of the 1980s through its Program for Satellite Monitoring of the Brazilian Amazon Rainforest (PRODES). While DETER monitors deforestation and issues alerts in near real-time, PRODES makes more precise maps and measurements of forest loss over the course of a year. Once PRODES identifies an area as deforested, that area is not revisited in the future and becomes part of what is known as the "deforestation mask." The mask represents the cumulative history of deforestation over time. DETER only scans for signs of forest disturbance outside the mask, but, by definition, regeneration occurs in areas that were previously deforested – that is, within the mask. **Since the mask is a blind spot for both PRODES and DETER, any changes to secondary vegetation in the Amazon remain invisible to both systems, and consequently, to Brazilian environmental authorities.** Figure 2 shows the relationship between PRODES, DETER, and regeneration.

The TerraClass project (Almeida et. al. 2016), a joint effort between INPE and EMBRAPA, partially addressed the problem of the invisibility of secondary vegetation in the Amazon by creating biennial maps of land use and cover within the PRODES deforestation mask, with secondary vegetation as one of the categories monitored. But due to a lack of funding for the project, the most recent map is from 2014.

Figure 2: Why is regeneration in the Amazon invisible to forest monitoring systems?



Source: *Climate Policy Initiative/ PUC-Rio (2020).*

How effective is existing public policy?

Brazil is building solid public policy expertise to effectively combat primary forest loss in the Amazon. Studies show that by combining up-to-date technology with innovative policy, the PPCDAm has reduced the annual rate of primary forest loss by over 80% (Hargrave e Kis-Katos, 2013; Assunção et al., 2015; Burgess et al., 2019). Monitoring and enforcement efforts based on DETER alerts have proven particularly effective in reducing deforestation (Assunção et al., 2019b). Satellite monitoring has made it possible to detect forest disturbances more quickly and accurately, significantly improving IBAMA's ability to impose effective penalties on environmental offenders. As the risk of incurring penalties has increased, so have the anticipated costs of engaging in illegal deforestation. DETER remains the primary tool for monitoring the environment in the Amazon.

Despite the proven effectiveness of public policy in controlling the clearing of primary forests, the country has not had an analogous experience with tropical forest regeneration. Indeed, secondary tropical vegetation has been largely absent from Brazilian environmental policy in recent decades. There has been no specific policy effort to promote regeneration, nor any effort to protect existing areas of regrowth in the Amazon. Furthermore, while empirical evidence has documented the vital role forest monitoring has played in the conservation of the Amazon, current monitoring systems do not detect changes to secondary vegetation cover. Therefore, in order to design and implement effective policy actions to drive both forest restoration and protect regrowth, Brazil first needs to observe, monitor, and track secondary vegetation.[2]

HOW CAN BRAZIL SOLVE THIS PROBLEM?

Recommendations and Discussion

Brazil is a pioneer in the development of remote systems to monitor tropical vegetation. PRODES and DETER have been recognized by the international scientific community for their technical accuracy and their contributions to forest conservation (Diniz et al. 2015, Maurano et al. 2019). The country can, and must, use its wealth of experience in developing and updating these systems to implement systematic, regular, and frequent remote monitoring of secondary vegetation in the Amazon.

The main obstacle to achieving this has nothing to do with technology. Brazil has access to the technology and technical expertise needed to monitor secondary vegetation. However,

[2] Assunção et al. (2019a) document an indirect effect of monitoring and enforcement focused on combating primary forest loss: an increase in secondary vegetation in the Amazon between 2004 and 2014. This is the first study to explore the unintended spillover effect that policy aimed at controlling deforestation has had on forest regeneration.

there is no current initiative, neither within nor outside of the government, that addresses this type of monitoring. With a price tag of around US $500 thousand, it would be absolutely feasible (albeit an arduous process) to implement a system for monitoring tropical forest regeneration within a year. The following recommendations suggest ways to meet the primary challenges and take advantage of the opportunities this process presents.

1. Establish clear criteria for classifying secondary vegetation in remote sensing imagery.

In remote sensing systems, categories of ground cover are identified by classifying the areas observed in images obtained by optical sensors. An area’s transition from one category to another can be detected by comparing older images with more recent ones. Thus phenomena marked by an abrupt change in category are easier to detect. This is the case with clearcut primary tropical forest, when an area of forest that had never previously been cleared loses all or nearly all of its biomass. The PRODES system was developed to detect precisely this type of forest loss; the remote sensing technology available at the end of the 1980s could already detect transitions from dense forest to clearcut forest despite the considerably lower resolution of sensors at the time.

Although remote sensing technology has evolved considerably since then, detecting forest restoration is inherently more complex. Regeneration is a gradual phenomenon in which ground cover changes slowly over time. To be detected, secondary vegetation has to accumulate enough biomass to become visible and distinguishable in remote sensing imagery. Even in tropical ecosystems, this process can take decades as the vegetation moves through the different stages of secondary forest growth (Alves et al., 1997; Aide et al., 2000; Guariguata e Ostertag, 2001; Chazdon, 2008). It would also be important to simultaneously monitor various incidences of secondary vegetation in order to track changes to the biomass. This would allow for a proper correlation between the age of vegetation and the accumulated biomass.

Thus, to ensure consistency and accuracy in detecting forest regeneration, clear criteria must be established that defines what is considered secondary vegetation. The literature on remote sensing shows that it is possible to monitor secondary vegetation in tropical forests (Almeida et al. 2010). Tropical vegetation is characterized by a high density of biomass above ground, and rapid growth (under favorable conditions), which makes it easier to detect secondary vegetation. Indeed, it is already possible to identify areas in the beginning stages of regeneration using images captured by sensors with medium resolution. The focus on tropical vegetation is appropriate for a monitoring system in the Amazon since it’s the predominant vegetation in the region.

It is also important to establish the moment at which secondary vegetation may be classified as such for the record. This could be based on stages of growth and/or continuity. The patterns observed in remote sensing imagery vary throughout the different growth stages of an area undergoing restoration; for example, the quantity of biomass and the density of the canopy vary as a function of the original plant life forms. Moreover, it could be determined how long a particular area has been covered with secondary vegetation. This measure of vegetation continuity serves as an indicator of its "age," which is also associated with its stage of growth.

Establishing a clear line based on these criteria would help eliminate time-series noise in monitoring secondary vegetation and would confer greater stability and consistency on the data collected. Field work should be very helpful in defining criteria specific to the Brazilian Amazon, contributing to the characterization of secondary vegetation growth stages and age, and helping to link these to patterns observed in the satellite imagery.

2. Develop two complementary systems to ensure monitoring of secondary vegetation in the short, medium, and long term.

Secondary vegetation monitoring should be carried out in light of the two systems that currently monitor primary forest loss in the Amazon. PRODES generates more precise, higher-resolution data, but less often (yearly), while DETER generates somewhat less-accurate, lower-resolution data, but more often (daily). PRODES and DETER complement each other since they serve different purposes. PRODES aims to measure annual primary forest loss and allows for the tracking of deforestation trends from year to year. Meanwhile, DETER detects evidence of recent forest cover changes in order to signal active deforestation or degradation hotspots, which helps focus environmental law enforcement efforts.

The same approach could be applied to monitoring secondary vegetation. To keep up with its international goals and forest restoration commitments under the Forest Code, Brazil needs data on medium and long-term gains and losses in regenerated areas. And this data needs to be spatially explicit, so that a specific regeneration history can be constructed for each area. But the protection of secondary vegetation depends upon the country's ability to observe damage to this vegetation and respond in time – that is, in the short term. A system of alerts signaling losses to secondary vegetation would help focus law enforcement actions, allowing environmental authorities to punish offenders who currently operate undetected. Brazil's experience using enforcement as a strategy for combating primary forest loss demonstrates that strengthening command-and-control policies helps curb environmental crime. This rationale can be extended to secondary vegetation clearing: faced with an increase in the anticipated costs of cutting down secondary vegetation, potential offenders will stop clearing forests because the costs of engaging in deforestation outweigh the benefits.

3. Build preliminary models of the systems using existing remote sensing imagery

The PRODES and DETER systems currently use images from sensors aboard LANDSAT/OLI satellites (spatial resolution: 20-30 m) and CBERS/WFI satellites (spatial resolution: 64 m). Not only are records of these images already available in INPE archives, but access to future images from these satellites has already been granted to the systems that monitor primary forest loss. These images would be clear enough to construct a preliminary model of systems to monitor secondary vegetation. The annual higher-resolution images could be used to construct a baseline for secondary vegetation, and the more-frequent, lower-resolution images could be used to identify recent losses. Making use of images already stored in the archives, or that are already earmarked for other projects, would reduce the cost of developing a system to monitor regeneration.

But any remote monitoring system based on optical sensor images has a serious limitation: it is not possible to identify land cover or land use when the image contains a visual obstruction. Clouds are the most common type of obstruction in the Amazon. They make it difficult to identify primary forest loss, and even more difficult to detect secondary vegetation, which is inherently more complex. This does not make it impossible to monitor regeneration, but it means that adaptations must be made to ensure consistency and reliability. A possible solution would be to adopt less frequent monitoring in the short-term system – to bundle data in trimesters, for example. The best images from a given time period could thus be selected, which would increase the chances of finding an unobstructed image of a particular area.

4. Develop and maintain a careful communication strategy with policymakers and the general public.

The systems that monitor primary forest loss in the Amazon are already fairly well known in Brazil. In addition to technical support, the development of new systems to monitor secondary vegetation will require a meticulous public information campaign, in the public and private spheres, explaining how to interpret the new data.

In particular, despite the similarities of the proposed systems for monitoring secondary vegetation to the ones that already exist for primary forest loss, it is important to emphasize that combining data on primary and secondary forest loss is not recommended. Primary forests are inherently different from secondary forests, and thus deforestation in each type of forest carries different implications for policy design and implementation. Moreover, Brazil must preserve the comparability of its historical data on primary forest loss in the Amazon. The systems for monitoring secondary vegetation can—and should—use the experience gained from systems that monitor primary forest loss, but the data generated by the new systems should be clearly recorded and communicated as specific to secondary vegetation.

It is important, therefore, to outline a dissemination strategy that a) shares data on gains and losses to secondary vegetation and b) carefully explains the nuances inherent to a phenomenon as complex as tropical regeneration. These explanations should be made in plain, accessible language, to familiarize the general public with the subject of secondary vegetation.

CONCLUSION

The world faces an urgent need for action that mitigates the adverse effects of climate change and supports sustainable development. Since forest growth captures carbon and improves human well-being, the restoration and protection of natural ecosystems—particularly tropical forests—play an important role in that effort. The increase in international initiatives supporting vegetation recovery, such as the Bonn Challenge and the UNFCCC's Intended Nationally Determined Contributions, demonstrate the international community's interest in calling attention to ecosystem restoration.

In this context, **it is critical that Brazil act now to strengthen protection of its secondary vegetation**. This will require the development of systems of remote monitoring that can detect variations in secondary vegetation in the short term for purposes of law enforcement, and in the medium to long term for purposes of measurement. This is the only way it will be possible to incorporate tropical forest regeneration into conservation and sustainable development policy.

Such systems are technologically feasible, but their development depends on solid support from public policymakers, and especially a commitment to guaranteeing technical and financial resources. **By making a firm commitment to promoting and protecting tropical regeneration, the country would protect a valuable national heritage and take steps toward regaining its position as a global leader on climate action.**

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