


Opinion

Public Policies and Social Actions to Prevent the Loss of the Chiquitano Dry Forest

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Abstract: Despite more than two decades of efforts made to prevent the loss of the Chiquitano Dry Forest on the Bolivian side, deforestation and forest fragmentation driven by agricultural expansion, uncontrolled settlement and forest fires have continued putting its ecological integrity at high risk. Currently, this unique forest is severely vulnerable and under considerable pressure, which should generate worldwide attention and concern, considering its importance in terms of biodiversity and climate. In this opinion piece, we address the approach of policies and social actions to reverse the situation using the experiences of locals.

Keywords: deforestation; Tropical Dry Forests; agriculture; wildfires; public policies



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1. Introduction

Forests, especially humid tropical forests such as the Amazon, have been iconic symbols and a priority for conservation at the global level for decades. But, in the process, other highly threatened ecosystems, such as Tropical Dry Forests (TDFs) have been underestimated and undervalued [1]. TDFs cover one million km² globally, but more than half (54.2%) are found in South America [2,3]. TDFs are being lost at an accelerating rate due to agricultural expansion [4]. They are highly fragile ecosystems adapted to complex climatic variability due to water scarcity [5], which makes them vulnerable to fire and land use change [4]. In South America, some of these TDFs, such as the Chiquitano Dry Forest (CDF, Figure 1), the Cerrado, and the Chaco, constitute the main deforestation hotspots caused by agricultural expansion [6]. For this reason, the TDFs of South America were declared a conservation priority by the IUCN at the World Conservation Congress in Marseille in 2021 (Resolution 006) [7].

The CDF, with a cover extent of 23 Mha distributed between Brazil and Bolivia [8], representing 27.5% of the TDFs of the Americas [3], has its largest extension in the Bolivian lowlands (76% of the total area), specifically between the transition of the Amazon rainforests, the dry forests of the Chaco [9] and the Cerrado, in the department of Santa Cruz. However, on the Brazilian side (covering 24%), this ecoregion is generally considered part of the Cerrado [10]. In addition, some classifications show that the CDF extends into the north of Paraguay [11]. Despite being located next to the Chaco and Cerrado ecoregions, the CDF is not floristically related to either of them, and there is evidence that it is more closely related to the adjacent Pantanal, and the seasonal forests of the Argentine piedmont and the low-lying Paraguay-Paraná area [12].

The region harbors a rich cultural heritage made up of indigenous (Chiquitano, Guarayo, and Ayoreo) peoples, as well as settlers from the indigenous populations of western Bolivia (Quechua and Aymara), Creoles and Mennonite settlers [9]. We estimate that between the two countries, there are about 3 million people living in the CDF (Chiquitano Forest Conservation Foundation; FCBC, unpublished data).



Figure 1. The ChiQuitano Dry Forest, one of the largest and best conserved Tropical Dry Forests in the Americas. The Noel Kempff Mercado National Park, declared as a World Heritage Site by UNESCO. Photo: Claudia Belaunde/FCBC.

The climate of this area is warm sub-humid tropical with a rainy period in summer and dry weather in winter, with little average annual thermal variability [11]. The region is characterized by scattered low elevation hills in the southern and eastern sector, which do not exceed 1250 m [11]. The vegetation consists of a closed-canopy deciduous to semi-deciduous forest about 15 m tall, and in some sites individual trees that can reach 35 m in height and 120 cm in diameter. This forest intersects as a scattered mosaic of rock outcrops, shrublands, wetlands and savanna formations [9,13], particularly with Cerrado formations.

So far, there is no updated document describing the biodiversity of the CDF. However, we estimate that between Bolivia and Brazil, there is a rich biodiversity containing more than 3000 species of vascular plants and ca. 1200 vertebrate species (FCBC, unpublished data). Based on the Red List of species [14], in the group of vascular plants there are 144 threatened species (14 Critically Endangered, 56 Endangered, 75 Vulnerable) and one (*Arachis rigonii*) catalogued as Extinct in the Wild (FCBC, unpublished data). Regarding tree species, the CDF lists ca. 246, of which 14 have a high commercial value [15]. Although the CDF has few endemic plants, a high level of endemism [16,17] with ca. 154 species is explained by the presence of scattered relicts of the Cerrado formation (FCBC, unpublished data), especially rocky outcrops. In addition, at least 40 protected areas are distributed totally or partially in the CDF (35 Bolivia, 5 Brazil; FCBC, unpublished data). One of these areas in Bolivia, the Noel Kempff Mercado National Park, was designated as a World Heritage Site by UNESCO.

The CDF is catalogued as one of the largest and best conserved TDFs in the Americas [3], subject to deforestation pressures [15,18], thus it should receive greater attention and concern at the global level, considering its importance in terms of biodiversity and

climate [11]. For more than two decades, the FCBC has been making enormous efforts to prevent the loss of the ecological integrity of the CDF [9]. Some of these efforts include the promotion for the creation of 5 local government protected areas (1.8 Mha); the support for improving management plans of 8 protected areas (9.5 Mha); the identification and creation of private natural heritage reserves in 360 thousand hectares of private properties; the development of forest management plans with forest conservation and sustainable development criteria in 7 municipalities and 3 indigenous lands (15 Mha); the support of 4 value chains for non-timber forest products, which contribute to forest protection and benefit 300 indigenous families; and other activities such as preventing and fighting wildfires, raising public awareness and monitoring, to support policy decision-making. Still, the current trends of forest loss show that more action is needed to prevent the CDF from disappearing.

In this opinion note, we describe and discuss the causes, effects, and consequences of two major human activities in the CDF on the Bolivian side, deforestation and wildfires, as well as the policies and social action to reverse the situation using local experience. We hope that this document will serve as a forum for scientists and practitioners to develop ideas of broad significance to research, policy and conservation practices in this ecoregion.

2. Consequences of Human Pressure in the CDF

Different factors that are putting the CDF at risk have been identified, such as the expansion of mechanized agriculture for agro-industrial production, expansion of grazing lands for large-scale cattle ranching, road infrastructure development, settlements and mining activities [18,19]. Below we describe the two main consequences of these human activities: deforestation and wildfires.

2.1. Deforestation

The CDF plays a key role in people's water security and food production, it provides medicines to local communities. In combination with other tropical ecosystems, it plays a significant role in local and regional climate regulation. However, the CDF is globally one of the regions that has lost most of the area in recent years [6]. Until 2022, accumulated deforestation in the CDF reached 2.8 Mha (FCBC, unpublished data) which represents ca. 39% of the total forest loss recorded in Bolivia (7 Mha) [6]. In fact, in 2021 Bolivia led the chart of primary forest loss in the tropics, after Brazil and the Democratic Republic of Congo [20]. Although the main direct causes of deforestation processes in the CDF are mechanized agriculture, cattle ranching and small-scale agriculture [21], at present, the main drivers are the combined effect of soybean expansion, consolidation of corporate ownership and the increase of degraded soils in productive areas [22]. Some of these activities are linked to land speculation, as they are used to justify land ownership [23].

As a result of deforestation, forest fragmentation is occurring [19,24,25], which represents a landscape-scale problem for the CDF because habitat quality for thousands of plants and animal species is being degraded or locally lost entirely, creating spatial barriers that prevent connectivity between wildlife populations. For instance, one of the key species of conservation concern whose population and habitat is rapidly declining is the jaguar (*Panthera onca*), the largest carnivorous species in the Americas (Figure 2). Due to deforestation and landscape fragmentation in the CDF [26], it is projected that about half of the potential habitat and connectivity corridors for jaguars will be lost over the next 24 years if the necessary conservation actions are not taken [25]. In addition, the impact of deforestation is causing an increase in soil temperature locally. There is a significant relationship between the loss of forest cover and the increase in land surface temperature in the CDF, showing an increasing trend in deforested areas and a difference of +3 °C in relation to areas covered by forests [27]. Additionally, deforestation in combination with meteorological drought events have caused wetlands and reservoirs to lose surface area, as is the case of Laguna Concepción, a Ramsar site with an area of 5000 hectares that completely dried up in 2021 [22].



Figure 2. The Chiquitano Dry Forest is the habitat of the jaguar, the largest feline in the Americas. Deforestation is causing fragmentation and habitat loss of this species. Photo: Camera trap/FCBC.

2.2. Wildfires

In Bolivia, wildfires have impacted a total area of 24 Mha in the last 21 years [28], of which 2.4 Mha were in the CDF area (FCBC, unpublished data). In fact, globally it is among the countries with the highest trend in forest loss due to fire [29]. Although there are indications that some fires originated from lightning [30], every year fire in this region is mainly due to human action [31]. As in many dry forests of the world, fire is used to reduce vegetation, but its mismanagement causes uncontrolled fires that affect natural vegetation. For many local communities in the CDF, fire remains essential as it is the cheapest tool used during *chaqueos* practices (slash-and-burn agriculture to prepare land for planting), mechanized agriculture for commercial purposes and to increase the availability of palatable fodder for livestock. Recent scenarios have shown that uncontrolled fires are more intense by fragmentation processes and severe meteorological droughts [24].

One of the most severe wildfire events recorded in the country's history occurred in 2019 [27,31]. The strong public outrage over these disasters placed wildfires in the public eye, dominating headlines for months. As a result, many people volunteered to fight the flames in the CDF area (Figure 3), several charity events were organized to raise financial support, foreign governments supported efforts with financial resources and equipment to fight the wildfires and to help restore fire-affected areas. This crisis increased urban people's awareness of the existence of the CDF and the importance of preventing further fires. Although many species are adapted to fire by possessing thick, corky bark with relatively slow growth and very high wood densities [9] so vegetation has a high rate of survival and regeneration by resprouting in disturbed areas [32,33], when fires are recurrent and at high intensities, its capacity to recover is unknown. The recurrence of wildfires in the CDF promotes significant structural and floristic changes, such as loss of biomass and ecological change as fire-tolerant tree species become more dominant [34]. While vegetation regenerates naturally, in the following years some of these areas will burn again in a regular cycle [35], causing a series of ecological, economic and social problems, directly affecting the livelihoods of thousands of local communities. In addition, fires affect the habitat and distribution of globally threatened species of conservation concern found in the CDF, including plants, mammals, and birds [25,36,37].



Figure 3. Forest firefighters inspect a burned forest in the Chiquitano Dry Forest area. Many of these areas were burned again in the following years. Photo: Claudia Belaunde/FCBC.

3. Policies and Social Action

In Bolivia, economic reactivation is a high priority for the national government. We are living an uncertain scenario in which the country will cease to receive economic resources from gas exports and will have to encourage the exploitation of minerals and the production and export of soybeans and beef. Furthermore, the country will have to ensure the production of biofuels (e.g., biodiesel, ethanol) [22] to reduce the high cost of subsidies on imported fuels [38]. Indeed, two biodiesel production plants are currently under construction, and one is in the CDF region. This implies an increased demand of feedstock for biofuel production (e.g., soybeans, corn) which might lead to an increased land use change with negative impacts on natural habitats and biodiversity, as has been widely reported in other regions. The existing critical ecological situation in the CDF, it is likely to be further exacerbated with a high environmental cost in the long term, as has happened in other regions.

The lesson learned from this succession of critical environmental events is that we are still not solving the main problems, nor acting in a timely manner. Therefore, effective holistic solutions are needed engaging national and regional policy makers, nature conservation NGO's and other key stakeholders such as indigenous forest communities, soybean farmers and cattle rangers, among others. The following are some recommendations for social policies and actions to improve the situation based on local experience.

3.1. Valuation of the CDF

The CDF represents a source of multiple resources for subsistence, meeting the needs of different populations, especially the most vulnerable, such as peasant and indigenous communities. This forest has been an important part of the social, cultural, and economic life of the Chiquitania region [11]. In addition, the original inhabitants value this forest because it not only provides timber and firewood, but also a rich variety of non-timber forest products (e.g., fruits, seeds, bark, roots, resins, and oils). However, the increasing international price and demand for soybean and beef [39] are the main challenges to the conservation of the CDF, given that Bolivia is one of the top 10 producers of soybeans

worldwide [40]. Compared to the international price of these commodities, the forest is considered to have almost no commercial value [41]. Governments, businessmen, citizens of the country's cities, and especially those who have always sustained their livelihoods in rural areas, should recognize the value of the CDF so making responsible decisions aimed at maintaining this natural heritage.

An important step towards the conservation of the CDF is that the society and government authorities recognize and value the important role of forests offer by providing a wide range of benefits such as local livelihoods, sustainable development, and adaptation to climate change. Specifically, it is recommended that government authorities review incentive policies to reduce pressure on forests, apply land use regulations at different jurisdictional scales according to land use capacity, and promote the sustainable use of timber and non-timber forest resources under forest certification schemes. This should be done through technical proposals that demonstrate the value of the CDF, its degree of vulnerability to degradation and the impact of climate change on biodiversity and ecological functions.

3.2. Environmental Education and Effective Communication

Perhaps one of the most common actions, but still one of the greatest alternatives for long-term change in society's general behavior is related to environmental education at all levels, particularly from infancy [42]. However, this could be considered a long-term goal, considering the ca. 3 million people living in the region. A coordinated effort to produce high quality and targeted environmental awareness materials for students throughout their school years combined with effective teaching strategies could be one way to ensure civil society's sensitivity to nature [43].

This also includes the production of massive but strategic communication campaigns through popular media using non-technical language or approaches [44], such as presenting the CDF's as high value for eco-tourism or making the environmental services more obvious to public. The success of these last two types of initiatives depends on the communication of different actors and should be approached in coordination with different NGO's and governmental departments. The main target group to be involved in promoting environmental education is the formal education system itself: urban and rural schools and regional and local education authorities. At this level, both content and educational tools (such as Teaching Ecology in the Schoolyard) [45] could be provided in school. Contents should include relevant information on the characteristics, vulnerability, and importance of the CDF and how to transmit them to students.

In turn, the protected area systems (national and subnational) have personnel, although scarce, that have installed capacities to develop nature interpretation activities and non-formal environmental education, as well as to provide information on the characteristics, vulnerability, and importance of the CDF. A program at the level of the CDF region that strengthens local capacities for environmental education is a priority to enhance its impact on both urban and rural populations.

On the other hand, internet access is very limited in areas distant from the main population centers, thus radio is the mean of communication with the greatest coverage in rural areas and therefore is the most effective way to disseminate the value of the forest for the livelihoods of communities and its importance in resilience in the face of climate change. For example, the formation of a platform of radio stations supported by local governments and civil society organizations and articulated with formal education efforts driven by the education system. These messages can be complemented by other media such as television in urban areas and social networks and digital communication.

3.3. Creation, Strengthening and Management of Protected Areas

Protected areas remain the main defense against forest cover loss and the best strategy for maintaining the ecological integrity of forests [46]. Although, the contribution of the National Protected Areas Service (SERNAP) [47] of the national government, the Directorate of Natural Heritage Conservation (DICOPAN) of the departmental government

of Santa Cruz [48] and municipal governments, thought valuable, are not enough to protect this unique ecoregion. On the Bolivian side, 11.8 Mha (72.7%) of the CDF are not legally protected (FCBC, unpublished data). The last two protected areas created in 2021 were those of Bajo Paraguá, in the municipalities of San Ignacio (983,006 ha) and Concepción (154,275 ha). We believe that Bolivia must continue to make progress in expanding, strengthening and managing protected areas. Moreover, the fact that extensive areas are located on private properties necessitates the integration of political conservation between the governmental and the private sector. Recommended future actions are to support the capacity of local people to manage their territories. In this sense, it is imperative that SERNAP and DICOPAN strengthen the processes of elaboration and revision of protected area management plans, both national and subnational, evaluating the degree of implementation through methods based on management effectiveness and using standards such as the IUCN Green List [49] to generate recommendations for continuous management improvement, and seeking incentives for the mobilization of resources from the financial sector to support protected area management.

The involvement of the private business sector under the umbrella of Corporate Social Responsibility, through the Santa Cruz chambers of commerce (CAINCO, Chamber of Industry and Commerce) [50] could be an option for this. In addition, not only could the monitoring capacities be improved but also equipment for the park rangers could be provided. The protected areas management committees should continue to be strengthened, because they play a key role in the defense of protected areas and natural resources. NGOs can contribute to the empowerment of local society by helping in decision-making in the management of protected areas by strengthening management committees and promoting networks of different committees in the CDF region thus generating interexchange of experiences [51] and lessons learned so establishing defenses against the threats of encroachment, deforestation, poaching, mining, among others.

3.4. Sustainable Production

Besides expanding protected areas, we urgently need to find and promote productive alternatives that reaching economic targets while minimizing environmental damage. When the CDF's are replaced by agriculture, there is a rapid loss of nutrients and productive capacity, thus organic, mineral or synthetic fertilizers must be applied, or rotation practices implemented [52]. To reverse this, the development of livestock and sustainable agriculture practices, and territorial management models at landscape scale such as agroforestry and silvopastoral systems are proposed. In recent years, the FCBC has made great progress in the implementation of sustainable livestock practices in the CDF with remarkable results [52]. These initiatives have been shown to be able to provide a greater number of ecosystem services in 12 livestock properties, through the diversification of forage plants with the introduction of legumes, the implementation of Voisin Rational Grazing (VRP), the restriction of the use of pesticides that damage soil microfauna (e.g., Dung Beetles) and the establishment of agroforestry systems that provide shade for livestock, food in the dry season and make available nectar and pollen for bees [51]. These approaches are currently being replicated in other areas of the CDF. Other potential initiatives include increasing productivity and efficient use of resources in already occupied agricultural lands along with promoting habitat corridors in frontier areas, in order to promote landscape connectivity and multifunctionality.

The agricultural sector, both commercial and community-based, is the main beneficiary of these innovations in sustainable food production practices, including Bolivian Association of CREA Groups (Rural Agricultural Experimentation Consortiums) [53] and other key stakeholders such as the Federation of cattle rangers in Santa Cruz (FEGASACRUZ) and the organization of soybean farmers in Santa Cruz (ANAPO) [54]. To achieve this, a fundamental step is the development of adequate land management plans, which technically define the areas destined for production as well as the forest areas that must be protected to ensure the provision of ecosystem services, especially water, and areas for the

sustainable use of timber and non-timber forest products as complementary sources of economic income that will not only contribute to the improvement of the livelihoods of local communities but serve to maintain the forest ecosystem services.

The Bolivian Land and Forestry Authority (ABT) must strengthen its monitoring capacity in both the design and implementation phases of these land use plans and improve regulations and criteria for the safeguarding of conservation easements, such as forest blocks that protect water sources and biodiversity. In turn, the departmental government of Santa Cruz and the municipal governments should review and adjust their PLUS (Land Use Plan of the Department of Santa Cruz, Supreme Decree 24124) with the purpose of promoting ecological connectivity in the landscape, prioritizing biological corridors within the CDF and related ecosystems (Amazonian, Chaco and Pantanal), over the next 25 years at least.

3.5. Reviewing and Reformulating Public Policies

National public policies need to be reviewed, reformulated and made consistent [55]. While some Bolivian laws guarantee forest conservation (Forestry Law 1700), others encourage forest destruction (Law 1171, Law 741) [22,56]. On several occasions, amnesty laws (e.g., Law 337) have been enacted to pardon illegal deforestation [21,22,57]. These laws have been used to subvert other existing regulations such as the PLUS and Law 1700 that aim to regulate the sustainable use and protection of forests [21]. In this sense, the PLUS needs to be used in territorial planning by public institutions, in land distribution by the INRA (National Agrarian Reform Institute) and for land clearing authorization by the ABT.

The reformulation of these regulations will help to prevent the unnecessary loss of thousands of hectares of forest and promote the connectivity of the landscape. Specifically, the central government of Bolivia through its competent ministries (Ministry of Environment and Water and the Ministry of Rural Development and Lands) should review the criteria established for the Economic and Social Function of the lands (FES in Spanish) [21], so that modifications to these criteria proposed to the legislative bodies not only productivity criteria, such as agricultural and livestock activities [58] but also the conservation of biodiversity and the maintenance of the carbon stock, as part of the fulfillment of this FES.

Likewise, based on Bolivia's Framework Law on Autonomies and Decentralization (Law No. 031/2010), subnational governments can establish specific regulations to consider the natural capital of the territory, private business and community, as sustenance to maintain the coverage and integrity of forests in CDF and be recognized as an environmental dimension in the fulfillment of the FES.

3.6. Restoration of Deforested and Degraded Areas

Restoration of deforested and fire-degraded ecosystems in the CDF is a high priority and one of the greatest environmental challenges, as much effort is needed to reconnect impacted forest fragments and influence current land use trends [59]. Depending on the state of degradation of an ecosystem, as well as the time, effort and financial investment needed, a number of restoration management approaches could be undertaken, ranging from assisted restoration to natural regeneration [60]. In the department of Santa Cruz the areas categorized as high priority for assisted forest restoration were those areas impacted by fires covering an area of 81,670 ha [61], of which 26.4% are located in the CDF (FCBC, unpublished data). Other restoration prioritization analyses have been conducted using a watershed approach [62]. Although assisted restoration action could enrich the forests by planting native species of high value to local communities, the process remains highly costly, even more so if one considers that the burned area of the CDF is 2.4 Mha. For this reason, it is necessary to identify and evaluate alternatives that are feasible, and effective [59]. Natural regeneration remains one of the best options for the restoration of the CDF at a larger scale [35].

The success of restoration in the CDF will depend on the implementation of a participatory, coordinated and collaborative plan with the integration of national and subnational government sectors, in which local communities can have productive development alterna-

tives to improve their economic income. The restoration process must consider the threats of wildfires, deforestation and land use changes. In this sense, strategies must be proposed so that the restored sites do not burn again [61]. In addition, actions must be implemented to ensure natural regeneration [28]. Throughout this process, it is important to use remote sensing tools and modern machine learning techniques to monitor the restored landscape [59].

4. Final Considerations

Currently, the CDF provides fundamental environmental services for culturally diverse human communities that are settled in the territory and whose activity, as indicated in this piece, generates different impacts on the natural system. These functions are being altered due to deforestation, degradation and the gradual increase in the severity of wildfires caused by human activity and climate change, which, in the absence of effective action by the competent authorities, continues unabated despite worrying projections in terms of increased temperatures, deforestation and drought.

In this context, the CDF needs effective global and national commitments for its governance and socioeconomic well-beings as it is under considerable pressure and at this critical time. Given that an extension of the CDF is present in Brazil, efforts should be made to achieve close coordination with local stakeholders and decision makers in this country to jointly address problems and solutions in this ecoregion.

We are at a crucial moment in which it is strategic to link environmental knowledge with public policy and land management actions related to: the valuation of the forest through sustainable productive initiatives, effective functioning of protected areas, strengthening of management capacity and community responses, communication campaigns with a social marketing approach, understanding the response capacity of the natural system to anthropic impact, cost-effective restoration action, involvement of medium and large-scale productive actors, all without losing sight of the potential of local participation and the legitimacy of community decisions.

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