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Measuring Sustainability Indicators for Community Forest Management: A trial run on two case studies in Quintana Roo, Mexico

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Table of Contents

List of Tables

List of Figures

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Summary

Natural forests and the livelihoods of people are intrinsically linked all over the world, and a sizeable portion of the world's forests are under some level of community-based management. Community Forest Management refers to a variety of forest uses partially or entirely decided and performed by several or all members of a community. Multiple actors in and outside of academia have championed CFM as a sustainable approach to land management and resource use, but the forms CFM can take are so diverse that the label is no guarantee of sustainability. The expanding body of scientific literature exploring the sustainability of CFM efforts has a bias towards environmental aspects, relatively lacking on the number of studies addressing the social and particularly the economic dimensions of sustainability. Given that measuring sustainability is a challenging task, a variety of methods for doing it have become popular, one of them being the use of indicators. This study set out to apply, for the first time, one such indicators tool developed by The Nature Conservancy with two *ejidos* in Quintana Roo, Mexico. The specific aims of the work were to measure the baseline of the indicators in the communities and complement these results with an identification of the main challenges to sustainable CFM that the *ejidos* faced. Through this, the links reported in the literature between pre-existing socioeconomic conditions and sustainability in forest management were supported, and an array of empirical tools were identified that could contribute to simplify and maintain the monitoring in the long run and tweak the indicators to render them more informative and useful.

Key words: CBFM, CPR, tropical forest, enabling conditions.

1. Introduction

1.1. Context of the study

Natural forests and the livelihoods of people are intrinsically linked all over the world. This is partially because of the widespread presence and richness of forests resources and partially owing to thousands of years of social and biological co-evolution. This correlation seems to be particularly strong in rural regions, where the absence of alternative paths keep people in close dependence to their surrounding natural resources (Parrotta et al., 2016; Pretzsch, 2014).

Stemming from this strong association, and despite historical trends towards centralization of forest management (Pretzsch, 2014), a sizeable portion of the world's forests are under some level of community-based management (White & Martin, 2002).

Community Forest Management (CFM) refers to a variety of uses of forest partly or entirely decided and performed by several or all members of a community. It can take widely diverse forms depending of the nature and uses of the forest, the bundles of rights the community has in regard to ownership and use of the land, the mechanisms put in place for decision-making, the objectives of the management, the geopolitical context, among other aspects (Agrawal et al., 2008); but both ecological soundness and community well-being tend to be common guidelines.

Multiple actors in and outside of academia have championed CFM as a sustainable approach to land management and resource use (Murali et al., 2006; Porter-Bolland et al., 2012; Salam et al., 2006; Torres-Rojo et al., 2016). The general rationale poses that actively involving forest-dependent societies in forest management can utilize traditional and other sources of knowledge to integrate nature into their livelihoods, reduce economic precarity and strengthen the communities' relationship with themselves and with nature; in turn, the drive to continue this management to younger generations would lead to a more ecologically sound and future-oriented use of forest resources (Bas Arts & de Koning, 2017; Charnley & Poe, 2007). All of the previously stated elements fit into modern conceptions of sustainable development, described by Kates et al. (2005) as having "a core set of guiding principles and values, based on the Brundtland Commission's standard definition to meet the needs, now and in the future, for human, economic and social development within the restraints of the life support systems of the planet".

There is an expanding body of scientific literature exploring the sustainability of CFM efforts. In general, environmental aspects of sustainability are the most widely analyzed, with a relatively

smaller quantity of studies addressing the social and particularly the economic dimensions of sustainability of community forestry (e.g. García-Amado et al., 2012; Hajjar et al., 2016; Macqueen, 2010).

The sustainable thriving of a CFM system is a multifactorial matter. There is evidence backing up that factors range from the composition of forests to human population density, the strength of their social networks and their collective experiences (Alatorre et al., 2021; Arts & de Koning, 2017; Baggio et al., 2016; Ordonez et al., 2018).

The theoretically simplest way to determine if a CFM effort is carried out sustainably is to see it endure the passage of time. However, often this is not a feasible way of measuring sustainability (Janssen et al., 2007). In most cases, there isn't a lot of data available about the specifics of CFM efforts in the past and in-depth longitudinal studies to acquire such data are time consuming and resource intensive, which makes them rare. An alternative that has been used for measuring sustainability in a comprehensive and relatively resource-efficient way are indicators.

The FAO's working definition of criteria and indicators for sustainable forest management states that indicators are "parameters which can be measured and correspond to a particular criterion" and criteria "define the essential elements against which sustainability is assessed, with due consideration paid to the productive, protective, and social roles of forests and forest ecosystems". Indicators, thus, can be tools to measure and monitor forests and forest-related activities in quantitative, qualitative and descriptive ways and reflect the values of the people involved in defining the criteria they are based on (FAO, 2015).

Indicators possess multiple advantages as instruments for the assessment of sustainability. They make possible a systematic approach, which gives the people employing them the ability to compare results over time or between different cases (Linser et al., 2018). Additionally, they have the potential to synthesize multiple sustainability-related attributes into a few representative measurable variables (Hagan & Whitman, 2006) and enable an ordered division of the multiple facets of sustainability, making what may seem as an overwhelmingly complex task more approachable (Gough et al., 2008; Kates et al., 2005). The atomization of indicator sets renders them customizable for particular cases with specific characteristics (Raison et al., 2001). This adaptability goes further, as the optimal values for indicators can be adjusted depending on the goals of each specific case of forest management (Linser et al., 2018).

In some instances, it is important to collect complementary information that gives hints as to why some indicators are not near the optimum stage so strategies can be designed to obtain better results in the future. This critical approach can provide information better reflecting the evolving goals, institutions, and policies around the community forest management (Garcia & Lescuyer, 2008; Linser et al., 2018).

1.2. Problem statement

There is a literature gap and a strategic area of opportunity for communities in Mexico regarding monitoring of sustainable community forest management that integrates the different dimensions of sustainability. This work aims to add to the body of literature regarding sustainability indicators of community forest management, by performing the first application of a newly developed monitoring tool and compiling information that empowers the involved communities to design adequate strategies to achieve their sustainable forest management goals.

1.3. Objectives

General Objective

To measure and complement sustainability indicators of CFM practices in two case studies in Quintana Roo, Mexico.

Specific Objectives

- To measure the baseline of The Nature Conservancy-developed Sustainability Indicators of two *ejidos* chosen as case studies, i.e. Candelaria II and Noh Bec.
- To explore and record the challenges that the *ejidos* face to fulfill their goals relating to sustainable CFM.

2. Theoretical background

This chapter provides background information to frame this research effort. Along the thesis, the focus is on the specific manifestations of sustainability within CFM. Thus, we begin with a brief description of sustainability's implications when applied to forestry. Next, we give an overview of the generalities of CFM, making emphasis on its reported benefits and challenges. Following, and responding to the great variety of CFM modalities globally, we spend some time describing the CFM panorama in the country of Mexico, to give necessary context regarding the location of the case studies. Finally, the last two sections compile a list of relevant elements and considerations pulled from the available bibliography regarding the sustainability of forest management and its measurement with indicators, with a strong emphasis on CFM.

2.1. Sustainability in Forestry

The very concept of sustainability as it is tirelessly used nowadays has its origins in forestry. In 1713, a Saxon public official by the name of Hans Carl von Carlowitz used for the first time the german term for sustainability (*Nachhaltigkeit*) in his work *Silvicultura oeconomica*, where he criticized the devastating and short-sighted practices of forest exploitation at the time that were resulting in forest overuse and degradation. He was a big proponent of conservation, and the sustained growing and use of wood resources. It's been argued that his recommendations were also the beginning of a scientific approach to forestry (Schmithüsen, 2013).

Our current conception of sustainability, of course, goes beyond the environmental realm and extends, broadly, into the social and economic realms. It has, in fact, become so broad that currently the best bets for a useful definition lay on aggregate descriptions (those that resemble more a list of elements than a succinct sentence) (Kates et al., 2005).

Despite its transformations, the idea of sustainability is still of great relevance in the field of forestry, where it comes with its own set of particularities. Some notions that are specifically important for sustainability in forestry stem from its unavoidable and stationary link to land. The relevance of indigenous or local people's relationship to forests, the complexities of land tenure and other rights, and its slow-growth, long-term nature which results in a big commitment by the people involved with sometimes underwhelming short-term results. These special considerations are central to formal and informal discussions on the subject of sustainability as it applies to forests and the people associated with them (Pretzsch, 2014; Schmithüsen, 2013).

2.2. A general overview of Community Forest Management

It is estimated that around one third of people globally depend on forests for their livelihoods (communities living in or adjacent to forests, smallholders, forest workers, and indigenous cultures). They depend on forests in the form of income generation stemming from timber or NTFP exploitation, or other involvement in forest-product value chains, as well as well as in the form of household consumption of forest products for shelter, food, animal fodder, energy, medicine, etc (FAO & UNEP, 2020). Community Forest Management is, in its many manifestations, one of the prominent mechanisms used to avoid forest degradation and provide sustenance to forest-dependent people and to better forest governance (Burivalova et al., 2016).

Calculating an exact figure regarding how much of the world's forests is managed by communities is a challenging task, and a variety of methods have resulted in a few different estimates. For example, a review made in collaboration with FAO presents assessments for forest area with management rights held by indigenous peoples and other communities ranging from 200 to 513 million hectares (Gilmour, 2016).

2.2.1. Highpoints and pitfalls: two sides of the Community Forest Management coin

When analyzing their sustainability, it should be noted that CFM efforts are not a new thing, and that some communities around the world have managed to live with and from forests for generations before the concept of sustainability became commonplace or even existed. Some examples of this have been described for American, Asian, African, European and Pacific Islands societies (Gadgil & Berkes, 1991; Parrotta & Trosper, 2012; Pretzsch, 2014; Sigrist, 2004).

The evidence suggests that current CFM offers a wider arrange of benefits compared to forest management by public and private entities (Baynes et al., 2015; Ginsburg & Keene, 2020). Some of the advantages that CFM poses in comparison with other modalities of forest management stem from the communities' capacity to employ small scale temporal and spatial information acquired through lived experience and informal knowledge transfer made possible by the close-knit nature of groups (Baynes et al., 2015; R. Hajjar et al., 2021).

Furthermore, under CFM there have been reports of a diminishing of illegal activities affecting forest health (Carig, 2018; Forest Trends, 2013) and high values of environmental indicators such as forest cover and biodiversity (E. A. Ellis et al., 2017; Gilmour, 2016; R. Hajjar & Oldekop, 2018). Additionally, there is evidence supporting the claim that the implementation of CFM can create

more secure sources and higher income for households (Antinori & Bray, 2005; Cubbage et al., 2015; Gilmour, 2016; R. Hajjar et al., 2021).

Even with all its reported benefits, CFM is a multifactorial and distinctly context-sensitive approach of which results can vary widely. There are reports of some failures in the ecological and economic spheres. In a study to assess the potential symbiotic relationship between CFM and REDD+, it was found that in some cases, CFM efforts resulted in no changes or increases to deforestation (Pelletier et al., 2016). A different work analyzed the economic sustainability of some Mexican Community Forest Enterprises (CFEs). The authors found that, the profit margin of this enterprises can be quite low. This means that, even if a CFE is currently competitive, that is constantly threatened by a change of preference of the buyers from national to foreign timber (Cubbage et al., 2015).

In a review study that included social, economic and environmental aspects, it was found that, by far, the most commonly lacking aspect in CFM seems to be the social aspect (R. Hajjar et al., 2021). With their increasing recognition and popularity as a virtuous scheme for forest management, CFM has been imposed in a top-down manner in a multitude of contexts. The institutions that perform this, often NGOs or governments motivated by international trends or pressure, can fail to accurately represent the needs of the communities (Pelletier et al., 2016). Because of their inception, the prevalence in time of this imposed CFM can be low, failing once the external supports fades out when short or medium-term projects are finished (Ferraro & Agrawal, 2021). Additionally, in instances in which NGOs are the donors and the local government is not involved, institutionalization of even positive changes is unlikely, which threatens the sustainability of this type of management (Gilmour, 2016)

There have been reports of CFM conditions facilitating corruption in decision making bodies, which can result in perpetuation and exacerbation of power imbalances (Sundström, 2016), and there is evidence that the formalization of CFM in policy (as is the case in Mexico, as well as several other Latin American nations) can come with drawbacks, such as the increase of the barrier for entry with unrealistic requisites that push some communities to operate outside the legal framework (R. Hajjar et al., 2021)

2.3. The panorama of Community Forest Management in Mexico

2.3.1. History of Forestry and Community Forest Management in Mexico

In Mexico, CFM has been an important use of land for centuries. There is evidence of several ways of CFM performed by native civilizations since before there was contact between Europe and America. For example, Larson and Sarukhan (2001) describe a system common in Nahuatl populations in Mesoamerica, where the territorial units (*altepetl*) encompassed different types of land ownership, where sizeable groups of people could subsist off a swath of land, but the management and decision making was reserved for a few governing or elite military individuals. Another instance is the Maya land use strategy of *T'olché* which involved leaving large swaths of land unused so it could recover from previous exploitation and act as a protective barrier for the actively managed land (Ferré, 2001).

With colonization, the introduction of ideas and systems originating from vastly different civilizations resulted in a paradigm shift in forest management (Pretzsch, 2014). Continuing with the first example, at the beginning of Spanish-Nahuatl interaction a conflict arose from the different ways the two parts perceived the natural ecosystems. The Spanish perceived them as idle lands and mere sources of wood for mining operations. On the other hand, their incursions to obtain timber resources were considered illegal by the local people, because they saw the lands as their patrimony that should be carefully managed in order to sustain access to a variety of goods. These substantial disagreements in perception, together with the eventual Spanish domination of Mesoamerican territory, resulted in a change from a multi-purpose focused management to one fixated on timber extraction (Larson & Sarukhan, 2001).

Control of the territory's forests was held by the Spanish crown for three centuries and, after independence from Spain (in 1821), that power went to the Mexican state. During around one century more social discontent grew, as only around 1% of managed land was owned by indigenous people, despite them constituting most of the population and workforce in these areas (Otero, 1989). This struggle was one of the pillars of the Mexican Revolution war (which erupted in 1910), and it led to its famous motto (attributed to Emiliano Zapata): "*La tierra es de quien la trabaja*" (commonly translated as "land belongs to those who work it with their hands"). The agrarian reforms pushed for in this war resulted in policies that legally recognized communal ownership of land by locals in the form of *ejidos* and *comunidades agrarias* (Bray et al., 2005).

Since the conception of these reforms, a more modern interpretation of CFM in the country began been gradually consolidating.

After a few years of the implementation of communal ownership of the land, from the 1920s to the 1970s, the vast majority of logging in Mexican forests was carried out by external contractors. In 1926 a new Forest Law, motivated partly by conservationist thinking, limited contracts to one-year periods (a system called *rentismo* in Mexico), but it ended up backfiring as it prompted a maximization of extraction in the allotted time and an eventual over-exploitation of more than 38% of the country's forests (Bray et al., 2005; Klooster, 1996). In addition to this, the communities often had little to no knowledge of the volumes extracted and the prices at which the wood was sold. Contracts were exploitative, and corruption in community leaderships was commonplace. In the year 1940 the Forest Law was updated again, as the government decided that both *rentismo* and subsistence use were the main causes of forest degradation and thus, long-term concessions, similar to pre-Revolution times, were reinstated. The owning communities only had two options: to sell to concessionaries or to not use their forest at all. They received a fixed payment determined and managed by the agrarian institution, and their access to this payment was conditioned upon them agreeing to present and execute investment plans approved by the state (Bray et al., 2005).

Despite the increasing social discontent, a good thing that came out of the concessionary era was that there was a significant upgrade in forest infrastructure and extraction capabilities, which allowed the communities who owned the land to obtain a deeper understanding of the value of their resources and the importance of deciding its fate. During the 70s and extending into the 80s, organized groups of communal landowners from different regions of the country fought to establish further reforms that allowed them to have more control over the management of their lands. The regional alliances' pressure provoked an effort from the government to motivate the communities' active involvement in the forest sector. During these decades the concept of Community Forest Enterprise (CFE) developed, and it was supported by the state with financial aid and technical advice. Some CFEs became profitable, strengthened traditional organizational structures and managed to developed systems against illegal logging, forest fires, and plague species (Bray et al., 2005).

In the late 80s and early 90s, at the same time as community forestry was beginning to be significantly promoted, the country joined the General Agreement on Tariffs and Trade and the

North American Free Trade Agreement. Consequently, CFEs began competing against low-cost imported timber, instead of operating under a closed national market. By the early 90s, CFM went back to not being considered important for the forestry sector and once again lost institutional support (Bray et al., 2005).

In 1994, a new cabinet-level Secretariat of Environment, Natural Resources and Fishing (SEMARNAP for its acronym in Spanish) was created and took charge of forests. This signified considerable changes in comparison to previous administrations when forests were under the control of the agrarian authority. The newly created entity looked through a more environmentally responsible lens when it came to forest policy. It implemented conservationist policies such as the declaration of around 30 Biosphere Reserves during its 6 years of existence. Paradoxically, its laser-focus on strict conservation combined with the government's weak enforcement capacity led to significant land-cover change and a rise in illegal logging. The SEMARNAP also had some integrative initiatives, such as the PROCYMAF, a greatly successful and innovative program that centered community forestry highlighting both its environmental and its socioeconomic aspects. One of its main goals was to strengthen the social capital in CFM efforts, and it was probably the most enduring and successful effort stemming from the combined initiative and determination of organized communal landowners and government agencies working closely in a non-reductive, long-term envisioning manner (Segura-Warnholtz, 2014).

In the 2000s CONAFOR, a government institution specifically focused on forests, was created, hierarchically below the newly redefined SEMARNAT. This nationally unprecedented effort allowed for a better administrative coordination and better continuity of important forest-related programs (Bray et al., 2005)

Since the beginning of the 2000s, the forest sector in Mexico has amassed a valuable body of knowledge and experience in successful cooperation between public programs and rural communities. The program previously known as PROCYMAF evolved into the Program for the Development of Community Forestry (PDFC in Spanish) and now survives to some extent in the form of the Community Forest management and Value Chains component of the Program for the Support of Sustainable Forest Development, but the successors have never reached the levels of success that PROCYMAF reached (Bray et al., 2005; Segura-Warnholtz, 2014). At the same time, we have seen a reduction in the importance of the forestry sector in the national economy, despite increasing local demand of forest products. Administrative and technical obstacles make it

so it's very hard for CFEs to compete with nearby markets, such as the Chilean one. A big section of the communal landowners of the country live in extreme poverty, mainly in zones with precarious social and natural capitals, with frequent conflict manifestations (Segura-Warnholtz, 2014). The current administration has drastically reduced the budgets of most environmental-related efforts, and the forest sector is not the exception (CONAFOR, 2021).

2.3.2. Current state of Community Forest Management in Mexico

In the recent decades, Mexico has been gaining recognition as an example where institutionalized CFM has demonstrated to be a beneficial use of the land, with the capacity to foster ecosystem conservation, economically viable forest enterprises, creation of vast and resilient social networks, and other benefits to quality of life (Bray, 2013).

There are two types of state-recognized communal land ownership in Mexico: the *ejido* and the *comunidad agraria*. Their main difference is historical, because *comunidades agrarias* were defined as an effort of land restitution to indigenous communities with an ancestral relation to the territory. They are often not divided into plots and cannot be sold. *Ejidos*, on the other hand, pertained land assignation regardless of the ethnic background of the owner. This doesn't mean that *ejido* members do not belong to indigenous groups, only that it is not a requirement. *Ejidos* are allowed to be partially divided into plots, and these can be assigned to individual *ejido* members. Both categories are included in the wider category of agrarian nucleus. In this thesis the term agrarian nucleus and the general term community will be used interchangeably when referring to land ownership in Mexico (Bray & Merino-Pérez, 2002; Morett-Sánchez & Cosío-Ruiz, 2017).

According to CONAFOR's last report on the state of the forest sector, the goal of CFM in Mexico is to "execute actions for the *ejidos* and *comunidades agrarias* related to forest management with a territorial and biocultural focus, under the principles of sustainability, equity and inclusion, to strengthen local governance and its technical, organizational, associative, planification and business abilities" (CONAFOR, 2021)

Around 100 million hectares or 51% of Mexico's territory is communal property. Out of 31,785 agrarian nuclei, only 2,361 carry out forest management, contributing to 70% of national forest production. To better strategize its work, the CONAFOR has made a classification of agrarian nuclei in terms of their level of appropriation of the productive process. The types are: potential

producers (Type I), producers that sell standing forest (Type II, 1,644 communities), producers that sell logs and other forest raw materials (Type III, 1,073 communities), producers that sell forest products with primary transformation (Type IV, 176 communities) and producers that sell further transformed forest products (Type V, 50 communities) (CONAFOR, 2021).

There exists a set of formal institutions for CFM in order to get government support. An important aspect of it is the need of the approval of a sustainable management plan by the national forest institution. These plans need to be approved by a technical advisor (a forest engineer or related professional) included in an official list made available by CONAFOR (*Reglas de Operación Del Programa Apoyos Para El Desarrollo Forestal Sustentable 2021*, 2020).

Communities that are interested or currently involved in CFM throughout the country face a complex series of challenges: a low level of coordination among policy, a myriad of bureaucratic hurdles, a high economic barrier for entry, technical advisors taking advantage of the fact that communities need their signature in order to access government resources, extremely unbalanced competition with other national markets (e.g. that derived from the NAFTA, that with the Chilean market), unbalanced distribution of benefits within the communities, organized crime and fiscal obligations not differentiating between CFEs and other forest enterprises, when they deal with a completely different set of extra requirements (Hernández, 2020; Madrid & Hernández, 2021; Skutsch et al., 2018).

2.4. Enabling conditions for sustainable and successful Community Forest Management

A sizeable portion of the literature regarding the longevity and sustainability of CFM adopts the format of enabling conditions. The diverse range of enabling conditions reported appear to be necessary or important requirements for the success of community-based management.

Some elements that have been found to aid in the success and projected sustainability of CFM are a high density and value of species of commercial interest making the effort profitable; the existence of technical support and funds provided by NGOs, government and other external intermediaries that pave the way for human and financial capital that suffices to go through barriers of entry; secure forest rights that allow for long-term plans to be made; good internal governance that cultivates a streamlined decision making process and a tight and trusting social network; a higher land area to communal landowner ratio to avoid competition for resources; the

community's first-hand experience of the negative impacts of forest degradation and the positive impacts of CFM in order to sustain motivation; and a proximity to other communities with management plans to facilitate knowledge exchange and witness examples of success (Alatorre et al., 2021; Arts & de Koning, 2017; Baynes et al., 2015; R. Hajjar et al., 2021; Ordonez et al., 2018; White & Martin, 2002).

Also found to be useful for identifying factors underpinning the success of different Common Pool Resources (CPR) systems are Elinor Ostrom's (2009) eight design principles for robust and enduring CPR management, which focus on institutional aspects of communal governance. In a meta-analysis, it was found that a combination of almost all the design principles seemed to be present in most of the successful forestry systems included in the study. They found that, in the cases where the natural resource is static (e.g. forests), monitoring (principles 4A and 4B) became more important for success (Baggio et al., 2016).

Table 1. Ostrom's design principles expanded by Cox et al. (2010), as used by Baggio et al. (2016)

Clearly defined social boundaries (1A)	Monitoring the monitors (4B)
Clearly defined biophysical boundaries (1B)	Graduated sanctions (5)
Congruence between local conditions and rules (2A)	Conflict resolution mechanisms (6)
Investment/extraction proportionality (2B)	Rights to organize (7)
Collective choice arrangements (3)	Nestedness (8)
Monitoring (4A)	

2.5. Important considerations for forest management sustainability indicators

2.5.1. Indicators for Sustainable Forest Management

The need for Sustainable Forest Management (SFM) indicators to exist has been actively addressed since the 1990s, after 1992's Earth Summit. Since then, around 170 countries have been involved in developing and measuring SFM trough Criteria and Indicators (C&I) and its value has perhaps increased in the eyes of the scientific community. A review effort and expert survey identified six important benefits that this multi-decade effort has catalyzed and highlighted the importance of involvement of more sectors in the development of C&I (Table 2; Linser et al., 2018).

Table 2. Interlinked impact domains of C&I international efforts, as identified by Linser et al. (2018)

Impact Domains
1. Enhanced discourse and understanding of SFM
2. Shaped and focused engagement of science in SFM
3. Improved monitoring and reporting on SFM to facilitate transparency and evidence-based decision making
4. Strengthened forest management practices
5. Facilitated assessment of progress towards SFM goals
6. Improved forest-related dialogue and communication

Sustainability is a complex subject and thus, developing indicators for measuring it comes with a variety of challenges. First comes the multitude of attempts that have been made to define and measure indicators, and how it's common to not have much overlap between them. As a response to this conundrum, and effort was made to identify converging world-wide indicators for sustainable forest management, including three diverse sources. The resulting seven C&I identified are listed in Table 3 (McDonald & Lane, 2004).

Table 3. Converging C&I among the Montreal Process, European Union and International Tropical Timber Organization (McDonald & Lane, 2004)

Criteria and Indicators
Conservation of biological diversity
Maintenance of the productive capacity of forests ecosystems
Maintenance of forest ecosystem health
Conservation and maintenance of soil and water resources
Maintenance of forest contribution to global carbon cycles
Maintenance and enhancement of long-term multiple social and economic benefits
Legal, institutional, and economic framework for forest management

In an effort to create a database of standard sustainability indicators for forest management that are useful in a wide variety of cases, Gough and colleagues (2008) identified that there are some indicator gaps, mostly in the social and cultural areas. They also conclude that there must be a trade-off between participation and efficiency of the monitoring process in order to make recurrent monitoring and readjustment a real possibility. It is important to keep in mind particular considerations for each of the elements that conform sustainability.

An European study about governance indicators found a mixture of fact- and perception-based indicators struck a desirable balance between comprehensive and realistic. It also highlighted the importance of reducing the amount of indicators through elimination or condensation of redundant or low informative indicators (Secco et al., 2014).

Another good reference in the social realm is a study with the goal of developing indicators for human wellbeing elements in a first nations territory in Canada. It highlights the importance of site-tailored participatory approaches to define the relevant social attributes to measure in a particular case. It also calls attention the value of including diverse sectors of the population with the purpose of getting a more integral look into the nuances of the case (Gilani et al., 2018).

For the environmental element of sustainability, a study about selecting biodiversity indicators in the US concluded that the main challenges in choosing this type of indicators are not technical or scientific, but stem from the procedure in which they are selected. They claim that in order for indicators to be successful, they need to have social legitimacy, and this is done by having a transparent, open and clear selection process that includes a variety of forest stakeholders. They add that the role of scientists and decision-makers should be in aiding the selection of the right indicators for the goals decided by the stakeholders, based on scientific soundness and feasibility (Hagan & Whitman, 2006).

To assess economic sustainability of Type III and IV CFEs, a study carried out in Mexico measured things like growth rate, species composition, production levels, costs and revenues, harvesting intensity, growth and yield, etc. They found that most of the studied CFEs could sustain their rate of extraction in the long run and made a profit in the national market. (Cubbage et al., 2015).

2.5.2. Indicators for Sustainable Community Forest Management

The previous case brings to the forefront the emerging challenges that come with measuring sustainability indicators of CFM systems in particular. Regarding this, a study identified biophysical

conditions, institutional arrangements within communities, and characteristics of the user-group to be appropriate indicators of the communities that may need focused assistance to overcome adverse starting conditions (R. Hajjar et al., 2021).

In CFM instances, researchers seem to agree that the main challenge is not in creating or selecting good indicators, but in operationalizing them (McDonald & Lane, 2004). A study on CFM in the tropics focuses on the proven significance of truly empowering the community so they continue the monitoring efforts once the inciting agency has ceased collaboration with them. It's not only well-designed indicators that are necessary, but proper interest, involvement, and accountability within the community to reach sustainability goals. It poses that formal indicators might not be the best strategy for communities to self-regulate their sustainable practices, and that a better path could be to integrate the formal indicators into the more informal traditional monitoring systems at place in the communities (Garcia & Lescuyer, 2008).

A study from Nepal further explores the follow-up to setting indicators in CFM. After the thorough and lengthy process of participatory indicator design made in collaboration with scientists and decision-makers, the new forest management practices were never implemented because of people in power (inside and outside the community) who benefitted from the continuance of the status quo. This process is, unfortunately, not uncommon and it concretely brings to light that context is extremely important when attempting to move towards sustainability (Khadka & Vacik, 2012).

3. Methodology

3.1. Context of the study area

3.1.1. Historical context of Community Forest Management in the state of Quintana Roo

Mexico is a very biophysically and culturally diverse country, and for this reason it is not realistic to assume that the same conditions apply to any and all CFM efforts carried out throughout the territory. Each region comes with its own context and the Yucatan Peninsula, in which Quintana Roo is embedded, is no exception.

The Yucatan Peninsula (YP) hosts part of the selva Maya, a sizeable and important continuous mass of tropical forest, with rather homogeneous environmental characteristics (Primack et al., 1998) and a rich cultural background, as well as a history of forest management at varying intensities (Velasco & Velázquez Torres, 2019).

Community Forest Management (CFM) is carried out in around 70 million hectares of land in the YP, and institutions at the local, national and international level promote it as a strategy with both environmental and social development advantages (Edward A. Ellis et al., 2017a, 2019).

Forest exploitation has been an important part of the economic activity in the region since at least the sixteenth century, with the exploitation boom of *palo de tinte* (*Haemotoxylum campechianum*) and, after its substitution with synthetic dyes, of precious woods and rubber. Given the fact that the region's forests were perceived as an important source of income, there is a history of territorial dispute since the year 1902, when the Federal Territory of Quintana Roo was declared by the then president, Porfirio Díaz, to protect the resources to be exploited by the English colonizers who were in the neighboring Belize and in collaboration with the Maya people that sparsely inhabited the land (Edward A. Ellis et al., 2015; Velasco & Velázquez Torres, 2019).

After the declaration of Quintana Roo as a federal territory, the previously Maya land was divided among a group of concessionaires. Exploitation continued to be mainly through concessions to big companies for a few decades. However, this prosperity was fragile. Between 1920 (when timber exploitation reached its peak) and 1940, hundreds of extraction camps and population centers were abandoned and plundered in response to the lowering demand for rubber, which the USA (the main buyer) stopped consuming because of their economic recession, only to revive with the Second World War (Carías Vega, 2019).

Coinciding with the previously described abandonment, *ejido* formation in the region began to take place. Their management power was limited, as the state only allowed them to clear forest in a small area at the center of the *ejido*, while the remaining land had to be managed for conservation. At the same time, several *ejidos* were included in the concession land assigned to internal and external forestry enterprises and didn't receive a fair share of the benefits, but remained involved because of lack of alternatives (Carías Vega, 2019; Edward A. Ellis et al., 2015).

In 1955, hurricane Janet hit the region and the beginnings of an effort to exploit the forest in a sustainable way were halted in favor of utilizing the fallen or damaged timber resulting from the natural disaster. After reaping those benefits, instead of reforestation of the land, the strategy was to clear more forest and favor agricultural colonization from other states with high population pressure. This colonization process continued, partly so that in 1974 Quintana Roo could officially be declared as a state (Carías Vega, 2019).

In the early 80s, the last remaining concessions ended among great social discontent about their practices, and the forestry related policy of the state was rethought in order to prioritize conservation of the remaining forests and favor organization of communal landowners. The changes of this time included the establishment of permanently forested areas in all *ejidos*, a policy active to this day (Carías Vega, 2019).

In 1992, there was a major reform in the agrarian policy regime which strived for efficiency and a more liberal economic approach. This change, which happened at a constitutional level, involved legalizing leasing and sales of *ejido* lands and encouraging partnerships with external investors, as well as relaxing state control over *ejido* affairs. An important consequence of this reform was the emergence of work groups within *ejidos*, that could extract a timber volume established by the *ejido*'s General Assembly, and the creation of subcommunal enterprises. Other effects will be discussed further in the next section (Carías Vega, 2019; Edward A. Ellis et al., 2015).

3.1.2. Challenges that Community Forest Management faces in Quintana Roo

Although both the social and ecological aspects are regularly cited as justification for supporting this land-use strategy in Quintana Roo, there are important gaps in the literature regarding this. The ecological benefits (DiGiano et al., 2013; Edward A. Ellis et al., 2017a, 2019; Levy-Tacher et al., 2019; Porter-Bolland et al., 2012) are much better documented in scientific literature than the social ones (R. F. Hajjar et al., 2012; Torres-Rojo et al., 2019).

It is commonplace in CFEs in Quintana Roo to distribute the profit among the members of the *ejido*. This is a practice that has persisted since the rubber-tapping era of forest management, but it currently affects the *ejidos*' capacity to reinvest into their productive infrastructure and maintenance (Carías Vega, 2019; Cubbage et al., 2015; R. Hajjar et al., 2016).

As a result of the 1992 reform, there have been issues of privatization and appropriation of *ejido* land in the Peninsula. According to a report by the CCMSS (Mexican Civil Council for Sustainable Forestry), since the reform and until may of 2019, 192,000 ha of previously communal land became private and another 355,304 ha were divided into plots and appropriated by individual actors coming from *ejidos*, the government and external companies (Torres-Mazuera et al., 2021).

The dispossession of lands is done in legal and extralegal ways, with the participation of a complex network of actors that are interested in obtaining these valuable lands for making sizeable profits reselling. This network has been called by some people in the community forest sector as an

"agrarian mafia" and has only recently begun to be investigated by journalists and civil associations, by keeping track of administrative irregularities and civil society whistleblowing to newspapers. In the state of Quintana Roo most of the privatization post-reform is linked to surfaces larger than 10,000 ha in moments that correlate with periods of touristic and urban development (Torres-Mazuera et al., 2021).

Quintana Roo is under constant threat of deforestation because of the precarious conditions in which a big part of the rural communities live. Some major deforestation threats are forest fires, livestock production, mechanized agriculture and urban development related to tourism (Edward A. Ellis et al., 2017b).

As a result of its history, the *ejidos* of the state are mostly owned by communities that have less than half a century of history with their land, although there are also several *ejidos* conformed by Maya people that secured legal ownership of sections of their ancestral land (Carías Vega, 2019; Velasco & Velázquez Torres, 2019).

Despite the many challenges it still faces, in 2015 the state held 80% of its territory as forested land (Edward A. Ellis et al., 2015). It has been found that *ejidos* that practice CFM have a positive effect in this land cover statistic, showing a significantly lower proportion and lower overall rates of deforestation compared to *ejidos* with different land uses (Edward A. Ellis et al., 2017b).

3.2. Description of case studies

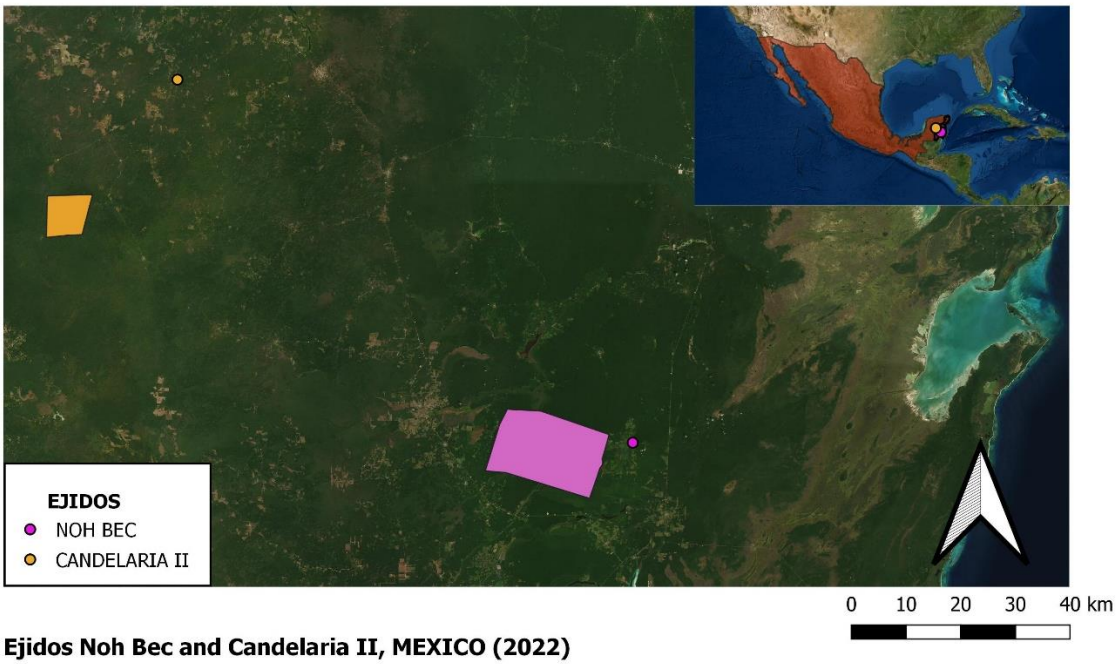

Figure 1. Map showing the location of the state of Quintana Roo in Mexico and close-up on the region of the study that includes the polygon of communal ownership for each *ejido* (colored areas) and the location of the towns where the *ejido* members live (colored dots) [Courtesy of Andrés Roldán]

3.2.1. Ejido Candelaria II

This *ejido* is in the municipality of José Maria Morelos, near the borders with Campeche and Yucatán (the other two states in the Yucatán Peninsula). It borders national land assigned as the Area for Protection of Flora and Fauna Balaan Kax.

The *ejido* was funded in 1991 and is composed of 106 members, most of whom are descendants of Maya people and are bilingual (Maya and Spanish) (Avilés González et al., 2021). They live with their families in the town of Candelaria (population c. 1500), which is located around 40 km away from their communal land (see Fig.1).

The income level of the *ejido* is low and the town has a few important infrastructural shortcomings: the health service is severely understaffed and underequipped which results in people having to attend private practices. There is also no phone service, and most people use WiFi to communicate with people outside the community. Finally, Candelaria is not well

connected through roads to neighboring towns or the ejido's property (Avilés González et al., 2021).

The *ejido* land is composed of mainly medium subdeciduous tropical forest in a patchwork of slightly hilly and flat land. The tree species of commercial interest present in the land are tzalam (*Lysiloma latisiliquum*), chicozapote (*Manilkara zapota*), chechén (*Metopium brownie*), jabín (*Piscidia piscipula*) and viga (*Caesalipinia platyloba*) (Avilés González et al., 2021).

Most of the town's inhabitants have agriculture as their main source of income and are often the subject of predatory middlemen to reach markets. Apiculture is also an alternative source of income for some inhabitants (Avilés González et al., 2021).

The *ejido* had an approved forest management plan once before and it currently has one valid since 2018. However, the community has not extracted the allotted annual volume so far because of a combination of internal *ejido* organization issues, pandemic-related hurdles, lack of clients and low volumes of demanded timber. The current committee is determined to start the management during their term if volumes allow to make a profit (personal communication).

In the past they were involved in a government-funded PES scheme, but that program is no longer available to them. They are currently in the process of joining a carbon credits program. These non-extractive uses of the forest are favored by the *ejido* members given that the Mayan tradition regards forests as sacred land and some members of the *ejido* are apprehensive about the real sustainability of a forest management plan focused on timber extraction. A lot of members are worried about the compromised continuation of Mayan traditions and cosmovision as they have seen in their lifetime the loss of their language and ancestral practices such as traditional silviculture methods and the milpa maya (an agroforestry model performed for centuries by Maya communities all throughout the Peninsula) which are believed to be largely responsible for current forest compositions in the region (Avilés González et al., 2021; Gómez Pompa, 1993).

3.2.2. Ejido Noh Bec

Ejido Noh Bec is located in the Felipe Carrillo Puerto municipality. It comprises 24,122 ha of *ejido* land, of which 18,000 ha are forested. The *ejido* has 216 members, of which approximately 80 are actively involved. It was originally established in 1936 during the latex boom and has gone through management periods of exploitation by contractors, through concessions and through a national

forest plan (when the community reserve was established). Since 1999, the community decided to acquire a greater degree of control and moved towards a more grassroots CFM approach (del Ángel Santos & Mex Hernández, 2021; Ejido Noh Bec, 2014, 2019).

The town of Noh Bec has around 2100 inhabitants composed of three groups of people of different origin. The *ejido* members of Noh Bec who mostly came from the state of Veracruz, the *ejido* members of Cuauhtémoc who came from Yucatán, Tabasco and other southern states and indigenous migrants from Chiapas of two ethnic backgrounds: Tzotziles and Tzetzales. The Noh Bec town is accessible through paved roads and is nearby (see Fig. 1) and connected by mostly well-maintained dirt roads to Noh Bec's *ejido* lands. All basic services are available and more can be reached in the close-by small city of Felipe Carrillo Puerto (*Ejido* Noh Bec, 2014).

The *ejido* lands contain medium, low, and floodable tropical forests in mostly flat land. They host important volumes of high value precious woods such as mahogany (caoba, *Swietenia macrophylla*) and other topical woods of commercial interest such as chicozapote (*Manilkara zapota*), tzalam (*Lysiloma latisiliquum)*, jabín (*Piscidia piscipula)*, chactekok (*Sickingia salvadorensis*), chacteviga (*Caesalpinia platyloba*), katalox (*Swartzia cubensis*), sac chacá (*Dendropanax arboreus*), chacá rojo (*Bursera simaruba*), amapola (*Pseudobombax ellipticum*), negrito (*Simarouba glauca*) and ciricote (*Cordia dodecandra*) (*Ejido* Noh Bec, 2014).

The main economic activity is silviculture. Most families in the *ejido* depend on the management of the forest either because members are employed in forestry activities or because of the redistribution of profit that the *ejido* makes amongst its members. The *ejido* has two sawmills and most of their timber is commercialized as sawn wood. They have had carpentries in the past, although they are not currently active (del Ángel Santos & Mex Hernández, 2021; *Ejido* Noh Bec, 2019).

They were the first Mexican *ejido* to become FSC certified and are generally regarded as a successful case of CFM in the Peninsula. They hold the sustainability of their management in high regard, as they are very aware that their land is what they will leave to the younger generations (Ejido Noh Bec, 2014)

In the last decades, another important aspect of their group identity has relied on sharing their knowledge with the surrounding *ejidos* to make good practices more common in the region (del Ángel Santos & Mex Hernández, 2021).

3.3. Background preceding this thesis

The selection of this project as the medium through which I wrote my thesis stemmed from my interest in explore the practical aspects of CFM in Mexico and interacting firsthand with people involved in grassroots forestry projects. This stemmed from learning the history of the Mexican modality of communal ownership of land and developing an interest in community-based approaches to forest management. Looking into these topics, I stumbled upon the work of The Nature Conservancy (TNC) in the Yucatán Peninsula. I decided to approach them motivated by the idea that if I wanted to work with people carrying out CFM I had to connect with them through someone with whom they had a pre-existing relationship, combined with the reliability of an NGO with decades of experience working at the intersection of people and ecosystems.

The Nature Conservancy's RITER (Networks for Territorial Innovation, acronym in Spanish) project aims to model the development of capabilities of rural producers in the Yucatán Peninsula. It seeks to serve as a channel to create and exchange knowledge about productive and conservation practices among communities with similar productive goals. Five RITERs have been defined in the region based on productive activities. This work focuses on the Community Forestry RITER (González Delgado et al., 2021; The Nature Conservancy, 2020).

The criteria and indicators for the Community Forestry RITER on which this thesis builds were created to monitor, evaluate and offer feedback to inform the change trajectories of the territories involved in the RITERs. This way, it reflected the values and goals of the communities involved and made sure to uphold the sustainability of management in an area as biologically and socially rich as is the Yucatán Peninsula, all this in the framework of Strong Voices, Active Choices developed by TNC (González Delgado et al., 2021)

This Criteria and Indicators (C&I) list was developed through a participatory effort led by TNC Mexico and external consultants during the year 2020. The process spanned approximately eight months and it comprised an iterative cycle of reviews of both the literature and the experiences of successful community forest management in similar contexts. Through interviews with representatives of the communities involved aiming to address knowledge gaps and co-define

well-being and sustainability, and consultations with external experts from civil society organizations and academia with relevant experience to aid in the construction of the monitoring process among other aspects (González Delgado et al., 2021).

The result of the previously described process was a new monitoring tool composed of 55 indicators (18 social, 6 biocultural, 9 economic and 22 environmental) which aimed to be iteratively measured on each of the RITER member communities to record their evolution. Because the Community Forestry RITER is so diverse and because theoretical exercises often fail to predict complexities that can be more easily observed in practice, my task was to perform a trial run of the monitoring tool to obtain the baseline measurements of two of the RITER members while simultaneously provide information that could inform how the tool can be refined to reflect the state and evolution of communities better.

3.4. Description of the indicators used

When assigned my task by TNC I was given the liberty to modify aspects of the tool to adjust to reality and simplify the monitoring (Garcia & Lescuyer, 2008; McDonald & Lane, 2004), while striving to keep as much of the original tool as possible, regarding the value behind the fact that a diverse and knowledgeable group of people worked in building it and as long as the general structure and aims of the tool remained the same (Hagan & Whitman, 2006).

The first modifications I made were done responding purely to the constraints of my thesis project. A few indicators about water quality, soil composition, biodiversity, carbon stock could not be realistically included in the scope of my thesis, because of lack of resources or because of scale. I trust these indicators will be included in future monitoring.

Some indicators were modified for clarity, as I had several communications with TNC to understand what some of the indicators were setting out to measure. This is an important modification because, in the future, it is likely that the monitoring will continue to be carried out by people not involved in the original design process, so the tool must be understandable to knowledgeable newcomers.

In reading the monitoring tool and exploring its goals, I decided to include the methodological addition of a list of the most important challenges a community identifies in the way to get to the CFM they want. This was included with the purpose of providing complimentary information to the indicator values that can empower the community members to prioritize aspects of

sustainability they consider particularly important at a point in time and how to monitor the results of the resulting actions (Garcia & Lescuyer, 2008).

Another methodological modification was made to the original instruction of the creators: instead of establishing one optimal value for indicators valid for all the communities involved in the Silviculture RITER, the optimal values were determined for each of the cases independently. This decision sacrifices comparability in pursuit of maximizing the utility of the tool for each community involved. It was made in response to the realization that there is significant variability among the communities, as exemplified by the two vastly different case studies, and the acknowledgment that measuring them with the same standard would not reflect the full scope of the potential changes that could result of the RITER Project and the communities' drive for a more sustainable management in their individual conditions. The advantages of tailoring monitoring tool to the characteristics of a site have been reported in the literature (Gilani et al., 2018).

Thus, we decided that through a normalization process, a Likert scale from 0 to 5 was to be set by the person monitoring the indicators, utilizing the local community's goals as a guide for the optimal value of each indicator, and the 0 the absence of the attribute measured. The intermediate values are to be decided by the person monitoring using information acquired in the field and through literature review and/or expert consultations.

The previous structural and methodological changes were decided before the fieldwork. During the fieldwork I realized some indicators could be better measured if they were subdivided into more specific units. After the fieldwork, I rearranged some of the C&I to better reflect what was observed in the field. The working version of the tool includes 18 social indicators, six biocultural indicators, ten economic indicators and 21 environmental indicators. I assigned identification codes to make referring to the list more manageable. The final list is presented in Annex A.

3.5. Data collection

The collection of data occurred in three stages carried out over the course of two weeks. The first two were carried out in the field, and the third one was completed remotely. The stages were (1) determination of optimal values for the indicators, (2) measuring of the current state of the indicators, and (3) recording of the current most significant challenges to the communities' sustainable CFM. At all three stages of the data collection for this thesis, the community members

involved were a mixed bag of people who had taken a part in the original process of indicator definition and people who were not involved.

3.5.1. Indicators

The indicators list (Annex A) was adapted into a questionnaire (Annex B) that served as a guide to both stages 1 and 2.

The data for stage 1 was collected through small (four people plus the moderator) roundtable discussions with diverse people from the communities, such as RITER Project liaisons, members of the *ejido* committee and people who actively work in the forest. For each pertinent indicator, the members of the roundtable were asked to discuss and propose what would be the ideal value of the indicator according to the current situation and the ejido's current goals. These discussions were complemented with other information available (statistical data, TNC reports, academic publications) on the occasions when a consensus couldn't be reached. The data from this stage was used to set the maximum value (5) and the intermediate values in the indicators' Likert scale.

The data for stage 2 was collected through semi-structured interviews. The people interviewed in this stage had some overlap with the ones included in stage 1, but in some cases were different because of specific information needs and time availability of the people involved. The main purpose of these interviews was to acquire qualitative data that could be transformed into values in the Likert scales of the pertinent indicators and represent the current state of the studied communities' forest management.

3.5.2. Challenges

Finally, stage 3 included the available people from the previous stages and consisted of asking the participants remotely (via internet messaging and a call) which were the three main challenges they identified the *ejido* faces in the way to their sustainable CFM goals. The information from this was compared with what was mentioned in the interviews in stages 1 and 2 to develop with a comprehensive list of each community's challenges.

3.6. Data Analysis

3.6.1. Indicators

The data obtained was analyzed comparing it with the literature and with the experiences of the communities for the normalization process, where 0 was set as the absolute absence of an

attribute and 5 was the optimal state of said attribute. This process was carried out before round 2 of interviews. During this process, the indicators that did not apply to each case were eliminated.

The next step was to first assign the community's current state of the attribute a place in the scale and then proceed to determine the rest of the values using the three existing data points data points.

An arithmetic mean was obtained for each dimension of sustainability, as well as a global average.

3.6.2. Main challenges

After a complete listing of the challenges mentioned by the interviewees, an effort was made to determine if the data could be simplified into concrete challenging areas.

The three challenges mentioned the most were deemed the main challenges. Additionally, the rest of the challenges named by interviewees in this stage were also included as "other important challenges" to keep in mind moving forward.

The main challenges were associated with one or several of the dimensions of sustainability and specifically to the indicators that could better reflect the evolution regarding these issues.

4. Results

This result section is divided by case study, first Candelaria II and then Noh Bec. Each ejido's section includes the results relating to the first and second specific objectives (the measuring of indicators and the identification of main challenges, respectively).

Indicator values should not be compared among *ejidos* because they are based on different scales adjusting to the ejido's characteristics and goals. The scales used for each *ejido* are available in Appendices C and D.

Some indicators were taken off the list for each of the *ejidos* because they were not relevant. For example, for Candelaria II, the indicator about involvement in the Sembrando Vida program did not apply because, according to the program's rules, this *ejido* cannot take part in it because of its proximity to the Balaan Kax natural protected area. For Noh Bec the one about management of currents did not apply because they have no such currents in the management area of the forest.

4.1. Candelaria II

In the list of indicators (Table 4), the best performing dimension of sustainability is Biocultural, then Environmental, then Social, and the lowest-performing dimension is Economic. Three out of the four main dimension's averages are in the lower half of possible scores (0 to below 2), and only the Biocultural surpasses this 50% mark. The global average is 1.731.

Only five out of the 52 relevant indicators are in their optimal stage (9.62%). They are B1a, M4a, E1c, E4d, E5a. Out of these, 60% are binary (absence/presence) indicators which can only take the extreme values of the scale (0 or 5) and 60% are part of the Environmental dimension.

Table 4. Candelaria II's relevant indicators and their current values in the established scale.

Dimension of sustainability	Criteria	Indicators	Value
Social (S)	Gender inclusion in forest diversification (S1)	Number of people involved in the diversification of forest management (S1a)	**1**
		Percentage of women included in diversification of forest management (S1b)	**0**

	Diversification of forest management activities for wider inclusion (S2)	Percentage of the forest land for recreational purposes (S2a)	**1**
		Self-sustenance activities carried out by the community (S2b)	**2**
		NTFPs utilized by the community (S2c)	**2**
	Communication and organization with other RITER members for creation of alliances (S3)	Number of current strategic alliances (S3a)	**2**
		Number of projects with allies (S3b)	**2**
	Participation of underrepresented groups in decision-making (S4)	Percentage of women in decision making roles (*ejido*) (S4a)	**0**
		Percentage of people 35 or younger in decision making roles (S4b)	**0**
	Reproduction of successful strategies of forest management through RITER (S5)	Number activities adopted because of involvement in RITER (S5a)	**1**
		Perception of RITER in the community (S5b)	**2**
	Strengthening of *ejido* governance through rules (S6)	Existence of explicit detailed internal rules (S6a)	**3**
	Promotion of forest management activities as decent (digno) sources of income for underrepresented sectors (S7)	Percentage of women employed in forest value chain (S7a)	**0**
		Percentage of people 35 or younger employed in forest value chain (S7b)	**0**
		Number of people benefitted by scholarship programs promoted by the *ejido* (S7c)	**0**
	Capacity of forest jobs to be decent sources of income for all forest workers (S8)	Average wage of forest workers (S8a)	**0**
		Number of *ejido* members involved in forest activities (S8b)	**2**
		Social average	**1.059**

Biocultural (B)	Acknowledgement and conservation of the natural attributes of the region (B1)	Existence of rituals related to forest resources (B1a)	**5**
		Are medicinal plants from the forest used in the community (B1b)	**3**
		Number of medicinal plants in the forest area (B1c)	**3**
		Number of wild animal species used by the community (B1d)	**4**
	Acknowledgement and promotion of biocultural value (B2)	Existence of sites with cultural value (recreational, inspiration, connection, ancestral) (B2a)	**4**
	Passing of knowledge between generations (B3)	Existence of intergenerational transfer of knowledge (B3a)	**3**
		Biocultural average	**3.667**
Economic (M)	Community-wide distribution of benefits of forest management (M1)	Existence of a response plan for emergencies (M1a)	**1**
		Number of emergencies contemplated in the plan (M1b)	**3**
		Existence of a common savings fund (M1c)	**0**
	Promotion of job-creation (M2)	Are entrepreneurial ventures stemming from the forest management incentivized in the community (M2a)	**0**
	Maintenance of economic benefits on the long term (M3)	Volume of production (M3a)	**0**
		Value of production (M3b)	**0**
		Cost-benefit relation (M3c)	**0**
	Creation of long-term forest management plans (M4)	Existence of a current forest management plan (M4a)	**5**
	Technification for better performance of systems (M5)	Number of trainings for forest management (M5a)	**1**

		Types of technologies used for forest management (M5b)	**1**
		Percentages of increase in earnings stemming from implementation of new technologies (M5c)	**0**
		Economic average	**1**
Environmental (E)	Conservation of biodiversity in the areas with forest management (E1)	Number of hectares of community reserve (E1a)	**3**
		Number of plant species included in the management (E1b)	**0**
		Number of key animal species for the management (E1c)	**5**
		Number of high value reforested individuals (E1d)	**0**
		Percentage of survival of reforested high value species (E1e)	**0**
		Existence of flora and fauna monitoring (E1f)	**0**
		Use of monitoring data to adjust forest management plan (E1g)	**0**
	Measurement and certification of ES (E2)	Number of certifications acquired for forest management (incl. Conservation) (E2a)	**0**
	Implementation of good management practices that lower emission of GHG (E3)	Implementation of low impact logging techniques (E3a)	**3**
	Integral management of fire (E4)	Number of active and equipped brigades for fire management (E4a)	**2**
		Number of fires since last monitoring (E4b)	**4**

		Surface (ha) affected by fires since last monitoring (E4c)	**4**
		Percentage of attended fires out of the ones that happened (E4d)	**5**
	Management of temporal currents in management (E5)	Inclusion of temporal currents in management plan (E5a)	**5**
		Number of activities for current management (E5b)	**1**
	Avoiding land-use change in forest area (E6)	Surface (ha) affected by land-use change since last monitoring (E6a)	**3**
	Soil health associated to forest management (E7)	Existence of soil erosion on compaction (E7a)	**4**
		Existence of measures to counteract erosion and compaction (E7b)	**0**
		Environmental average	**2.167**
		GLOBAL AVERAGE	**1.731**

The main challenges (Table 5) were overwhelmingly related to economic aspects, emphasizing basic Enabling Conditions (EC).

Table 5. Important challenges faced by Candelaria II to reach their sustainability goals. The Relevant indicators column lists indicators which can be used to track future changes regarding the listed challenges.

Main challenge	**Category**	**Relevant indicators**
1. Habilitation of path infrastructure, greatest hurdle in the way of sustainable management	Economic, environmental	M3c, M5b, M5c, E3a
2. Productive infrastructure in terms of tools and machinery	Economic	M3c, M5b, M5c
3. Need for forestry-related training to not depend on third parties	Economic	M5a

Other important challenges: Access to fair prices through independence acquired by appropriation of the productive process, no history of forestry (*ejido* members mostly do agriculture), precarious economic situation and lack of prospects put them at risk of cheaply sending plots of land, major disagreements among *ejido* members.

4.2. Noh Bec

In reference to the indicators list (Table 6), the best performing dimension was Biocultural, then Environmental, then Social and the worst performing one was Economic. All the dimension's averages are located in the higher half of the scale (over 2). The global average is 2.830.

There are a total of 13 out of 53 indicators already in optimal stage (24.53%). They are distributed throughout the four dimensions of sustainability, almost half of them in the Environmental dimension.

Table 6. Noh Bec's relevant indicators and their current values in the established scale.

Dimension of sustainability	Criteria	Indicators	Value
Social (S)	Gender inclusion in forest diversification (S1)	Number of people involved in the diversification of forest management (S1a)	**1**
		Percentage of women included in diversification of forest management (S1b)	**1**
	Diversification of forest management activities for wider inclusion (S2)	Percentage of the forest land for recreational purposes (S2a)	**5**
		Self-sustenance activities carried out by the community (S2b)	**5**
		NTFPs utilized by the community (S2c)	**5**
	Communication and organization with other RITER members for creation of alliances (S3)	Number of current strategic alliances (S3a)	**3**
		Number of projects with allies (S3b)	**1**
	Participation of underrepresented groups in decision-making (S4)	Percentage of women in decision making roles (*ejido*) (S4a)	**1**
		Percentage of people 35 or younger in decision making roles (S4b)	**1**

	Reproduction of successful strategies of forest management through RITER (S5)	Number activities adopted because of involvement in RITER (S5a)	**2**
		Perception of RITER in the community (S5b)	**2**
	Strengthening of *ejido* governance through rules (S6)	Existence of explicit detailed internal rules (S6a)	**3**
	Promotion of forest management activities as decent (digno) sources of income for underrepresented sectors (S7)	Percentage of women employed in forest value chain (S7a)	**0**
		Percentage of people 35 or younger employed in forest value chain (S7b)	**4**
		Number of people benefitted by scholarship programs promoted by the *ejido* (S7c)	**0**
	Capacity of forest jobs to be decent sources of income for all forest workers (S8)	Average wage of forest workers (S8a)	**3**
		Number of *ejido* members involved in forest activities (S8b)	**2**
		Social average	**2.294**
Biocultural (B)	Acknowledgement and conservation of the natural attributes of the region (B1)	Existence of rituals related to forest resources (B1a)	**5**
		Are medicinal plants from the forest used in the community (B1b)	**3**
		Number of medicinal plants in the forest area (B1c)	**2**
		Number of wild animal species used by the community (B1d)	**4**
	Acknowledgement and promotion of biocultural value (B2)	Existence of sites with cultural value (recreational, inspiration, connection, ancestral) (B2a)	**3**
	Passing of knowledge between generations (B3)	Existence of intergenerational transfer of knowledge (B3a)	**5**
		Biocultural average	**3.667**
Economic (M)	Community-wide distribution of benefits of	Existence of a response plan for emergencies (M1a)	**1**

	forest management (M1)	Number of emergencies contemplated in the plan (M1b)	**0**
		Existence of a common savings fund (M1c)	**5**
	Promotion of job-creation (M2)	Are entrepreneurial ventures stemming from the forest management incentivized in the community (M2a)	**0**
	Maintenance of economic benefits on the long term (M3)	Volume of production (M3a)	**4**
		Value of production (M3b)	**3**
		Cost-benefit relation (M3c)	**3**
	Creation of long-term forest management plans (M4)	Existence of a current forest management plan (M4a)	**5**
	Technification for better performance of systems (M5)	Number of trainings for forest management (M5a)	**2**
		Types of technologies used for forest management (M5b)	**1**
		Percentages of increase in earnings stemming from implementation of new technologies (M5c)	**0**
		Economic average	**2.182**
Environmental (E)	Conservation of biodiversity in the areas with forest management (E1)	Number of hectares of community reserve (E1a)	**5**
		Number of plant species included in the management (E1b)	**3**
		Number of key animal species for the management (E1c)	**5**
		Number of high value reforested individuals (E1d)	**5**
		Percentage of survival of reforested high value species (E1e)	**4**
		Existence of flora and fauna monitoring (E1f)	**3**

		Use of monitoring data to adjust forest management plan (E1g)	**0**
	Measurement and certification of ES (E2)	Number of certifications acquired for forest management (incl. Conservation) (E2a)	**3**
	Implementation of good management practices that lower emission of GHG (E3)	Implementation of low impact logging techniques (E3a)	**3**
	Integral management of fire (E4)	Number of active and equipped brigades for fire management (E4a)	**2**
		Number of fires since last monitoring (E4b)	**3**
		Surface (ha) affected by fires since last monitoring (E4c)	**0**
		Percentage of attended fires out of the ones that happened (E4d)	**5**
	Avoiding land-use change in forest area (E6)	Surface (ha) affected by land-use change since last monitoring (E6a)	**5**
		Surface (ha) with influence of the Sembrando Vida program (E6b)	**3**
	Soil health associated to forest management (E7)	Existence of soil erosion on compaction (E7a)	**4**
		Existence of measures to counteract erosion and compaction (E7b)	**3**
	Reforestation of management-related clearings (E8)	Surface (ha) of management-derived clearing that have been reforested (E8a)	**5**
		Percentage of survival of reforested individuals in clearings (E8b)	**4**
		Environmental average	**3.421**
		GLOBAL AVERAGE	**2.830**

In the main challenges arena (Table 7), one instance (main challenge 2) of enabling conditions is still being considered one of the most important challenges even in a relatively prosperous and long-lived CFM effort. Main challenges 1 and 3 are more specialized, referencing diversification of forest-related activities, inclusion, and better resource use.

Table 7. Important challenges faced by Noh Bec to reach their sustainability goals. The Relevant indicators column lists indicators which can be used to track future changes regarding the listed challenges.

Main challenge	**Category**	**Relevant indicators**
1. Developing a culture of reinvesting profits into equipment for better management practices and higher profit in the long run	Economic	M1c, M3c
2. National policy and bureaucratic hurdles: inefficiency of procedures and national decision making based on incomplete data that does not include the region	Social, economic, environmental	S3a, S3b, M4a, E1b, E1f, E1g
3. Diversification of activities for added value and further inclusion of women and young people	Social, economic	S1a, S1b, S4a, S4b, S7a, S7b, S7c, M2a
Other important challenges: Need of training for acquiring new skills and keeping up to date on existing ones, bettering governance through developing thorough internal rules, synergy of *ejido* members to achieve better quality of life as a community, continuation of the environmentally sustainable practices, marketing the ejido's productive activities.		

5. Discussion

The purpose of this chapter is to frame this thesis' findings within the previously existing knowledge in the field. The first section will explore and interpret the baseline measurements of the indicators for both studied communities guided by the literature about enabling factors for successful CFM. Meanwhile, the second one will focus on how the ejidos' characteristics and context might influence their main challenges on their way to their goals, and how this study's results fit into the existing literature on CFM in the region. Lastly, the third section will talk about the aspects of the indicator tool that make it well suited for its purpose according to research on C&I in sustainable forestry and CFM, whilst giving suggestions around the features that could be improved regarding construction and application.

5.1. State of the communities relative to their sustainable forest management goals

The fact that both the communities included in this round of monitoring are able to decide on goals for years down the line is made possible by the secure ownership of the land enabled by more than a century of advocacy and political will to assign (or devolve) tenure of the land to communities to decide its fate. This is the case for Mexico but not for other regions interested or carrying out CFM (White & Martin, 2002). Hajjar et al. (2021) have found that although the creation of CFM policies can slow down CFM development at first, it is a good strategy for maintaining CFM in the long run.

The overall average score of Candelaria II (1.731; Table 4) indicates a significant gap between the current state of affairs and the ejido's forest management goals. This is expected given the fact that the forest management in the community is still attempting to properly start and is facing a myriad of institutional, socioeconomic and cultural hurdles (Avilés González et al., 2021). The global average of Noh Bec (2.830; Table 6) denotes a promising starting point reflecting the *ejido's* silvicultural tradition and its status as a successful case of CFM in the region, but still a sizeable effort is needed in order to obtain their current goals (Ejido Noh Bec, 2014).

In both *ejidos*, the Economic dimension presented the lowest average. Criteria M1 through M3 are related with economic status of the community members and the profitability of the management. The associated indicators' low scores are likely to have an important negative effect on the success of the CFM effort, as it has been found in comprehensive reviews that the pre-existing socioeconomic characteristics and profit of the management are determinant factors for the success of CFM endeavors (Baynes et al., 2015). This might be particularly the case for Candelaria II (Table 4), which is currently operating on losses. The absence of high-value precious wood such as mahogany and the relatively low volumes of commercial timber species in the ejido's management plan put them at risk of not finding fair price buyers for their product, which poses additional obstacles to the success of silviculture as a successful economic pursue (Ordonez et al., 2018). At least in the short term but possibly further in the future, the *ejido* will not be able to maintain itself with silviculture as their main economic activity, so the fact that they have alternative sources of income that are not as strongly forest-reliant (agriculture and apiculture) is an advantage, and the community could benefit from not neglecting investment and training in any of them (Avilés González et al., 2021). Noh Bec, on the other hand are well nestled into their forest management and have been making decent profits for years. Their backlog of positive

experiences in regard to the use of their forests likely acts as motivation to continue investing resources even when important challenges are faced (Alatorre et al., 2021). They identify their goals as widening their profit margins to be able to reinvest in silviculture technologies and in social welfare of their community. As forest technology breaks down or becomes obsolete, this strive towards renovation in diverse areas is vital to increase the robustness of the CFM (Janssen et al., 2007; Ostrom, 2009)

Economic criterium M5, which is about the trainings received by the *ejido* and the technology used in the forest management, highlights the crucial nature of capacity building and infrastructure (Alatorre et al., 2021; Baynes et al., 2015). Different levels in these aspects can make the difference between having a silvicultural practice or not (as is the case of Candelaria II and their lack of even very basic tools and forest paths) or go from functional but stagnant forest management to one that attracts younger people to get involved and incorporate diverse and fulfilling forest-related activities, enabling the effort's longevity.

The Social dimension was the second most challenging one for both ejidos. For Candelaria II (Table 4) it corresponds to deficiencies in quality of life that go to the most basic needs (such as lack access to health services or decent wages) and thus is heavily associated with economic aspects of the community and infrastructural development for which the government has the responsibility to respond (Avilés González et al., 2021). In fact, Hajjar et al. (2021) found that characteristics of the forest groups could work well as indicators for communities that could benefit from focused assistance to overcome adverse starting condition. For Noh Bec, low Social scores looks like struggling to move away from deeply culturally engrained inequalities (such as serious gaps in the inclusion of women and younger people in the forest activities) even when these subjects have been on the table for years (del Ángel Santos & Mex Hernández, 2021; Ejido Noh Bec, 2014).

For the criteria having to do with inclusion of marginalized sectors of the community (S1, S4, S7) both *ejidos* are far away from their goals, excluding the good score regarding employment of a lot of young people in timber extraction activities for Noh Bec. These aspects should be closely considered, as inclusion of historically underrepresented people in the forest management is considered an enabling factor for success of CFM as it strengthens the social network and makes the effort more robust (Baggio et al., 2016; Baynes et al., 2015). During the interviews it became evident that the inclusion of young people in decision-making roles is a difficult goal under the agrarian law of Mexico, as membership of *ejido* is inheritable. This, especially in cases such as Noh

Bec when the *ejido* was established decades ago, makes it so people under 35 (or even under 50, for that matter) are extremely rare as *ejido* members, and even more so as part of the elected *ejido* committee (the decision-making body) (del Ángel Santos & Mex Hernández, 2021). Through the interviews with Candelaria II, it came out that one of the main motivations for inclusion of women in *ejido*-related projects, even when there are not many women members, are policies for participating on projects by the government or by NGOs. Thus, the large-scale shifting discourse regarding women participation during the last decades (Baynes et al., 2015) might be acting as a positive force towards inclusion in communities where the customary path would have leaned towards non-inclusion, although more in-depth research would be needed to back up this effect.

Another factor measured by the indicators that has been stated to affect CFM positively is the proximity and communication with communities who have adopted management plans successfully (Ordonez et al., 2018). This is measured by Criteria S3 and S5 and is especially linked to the motivations behind the RITER project. Future monitoring will provide more data to explore a link between more knowledge flow and higher success rates.

Criterium S6 was showed to be important for both studied cases. Both have it as one of the elements of their community plan (a production created because of the *ejidos*' involvement in RITER) to develop a more thorough set of internal rules that dictate how the *ejido* will respond in a variety of situations. Such a document can improve internal governance through the streamlining of decision-making and protect the *ejidos* against some challenges that have become important in the recent past, such as the selling of ejido plots to externals since an agrarian reform at the beginning of the 1990s and its resulting complexities. A strong internal governance has been observed to have crucial benefits in CFM efforts (Baggio et al., 2016; Baynes et al., 2015)

Criteria S7 and S8 address elements of forest employment that could make them fairer and thus more attractive to all interested sectors. The development of trust in the ejido enterprise being a fair employer speaks to the importance of tight and trusting social networks for the thriving of CFM (Arts & de Koning, 2017; Baggio et al., 2016).

Biocultural and Environmental are the best scored dimensions for both *ejidos*. These dimensions may feed of each other in the sense that cosmovision or main values captured by the Biocultural indicators can strongly affect the ejido's relationship to the forest and therefore their approach to conservation of the ecosystem, which is reflected in the Environmental dimension. According to review study, positive environmental and resource rights outcomes for community-based forest

management are more likely to occur in tropical or subtropical forests than in other vegetation types (R. Hajjar et al., 2021), perhaps responding to the global interest and political will to conserve these ecosystems. The case studies have vastly different biocultural frameworks and approach their link to the forest in substantially different ways, but both approaches seem to be getting them nearer to their goals and enabling conservation of their forest, without closing it to human intervention. This strategy seems to get positive results in Mexico, relative to conservation strategies with strictly conservationist approaches (Figueroa & Sánchez-Cordero, 2008).

5.2. Challenging aspects of the sustainable forest management of the communities

The main challenges recorded in this study demonstrate starkly the heterogeneity of conditions among the *ejidos* of Quintana Roo and the associated inequalities of access (Skutsch et al., 2018).

For Candelaria II, the main challenges refer to basic infrastructure, tools and know-how. These are not simply attributes that make the CFM more sustainable, but necessary first steps in order to be able to carry out CFM at all. Focusing on overcoming these challenges is paramount to gaining the independence needed to start perceiving profit and social benefits from their silvicultural endeavor. This will come with its own set of trials, given that to jump-start these basic attributes, the *ejido* needs to be well connected with outside actors such as other communities, the government, NGOs and academia. The NGO arena is where Candelaria II has made the most progress so far, starting with joining RITER. The *ejido* is also in the works to join an independent *ejido* alliance. Academia and government actors are harder because there are attitudes in the community of mistrust towards them, and this is not helped by the fact that during the current administration Mexico's governmental forest institution (CONAFOR) has had its budget severely reduced (Madrid & Hernández, 2021). Even so, having links with academic actors especially could feed the community's knowledge of itself and its resources, empowering them to make better informed decisions (Arts & de Koning, 2017).

On the other hand, the main challenges of Noh Bec reflect the worries of a community with an established silviculture practice and a history of external recognition and support (Edward A. Ellis et al., 2015). Its challenges are less straight-forward but better represented in the available literature. One of the main challenges is the need to shift the culture from the redistribution of profits within the ejido members (a common practice that dates back to the gum-tapping days of the Peninsula) in favor of reinvestment of the profits into better machinery and tools to benefit the future forest extraction (Carías Vega, 2019). Policy-imposed bureaucratic hurdles were also

mentioned as one of the main challenges the community faces. Examples of this are tardiness of the CITES process for exportation of timber that has caused Noh Bec and other *ejidos* in the Peninsula important losses (Skutsch et al., 2018) or the fact often mentioned in the field interviews about nation-wide conservation strategies based on population data from other regions that impedes them from using plants that exist in healthy numbers in their region. Lastly, although there is interest in the matter, the community has not managed to incentivize diversification of forest activities to the level that they would like. This is important for the *ejido* because they think of these activities as the ideal spot to employ young people but particularly women. In addition to the clear social benefits, the inclusion of more secondary or tertiary economic activities could bring important streams of revenues to the forest enterprise (Madrid & Hernández, 2021).

5.3. Future monitoring: adequacy and suggestions for the refinement of the tool

The monitoring tool used in this study, as it sets out to fulfill an ambitious task, has advantages and disadvantages.

According to the literature, the diverse participatory approach used to create the list of indicators was a good strategy (Gilani et al., 2018). Including people that have first-hand experiences with the forest management, who make decisions, who are affected by the negative or positive consequences of the management is, of course, vital to represent the specific nuances available only to them (Ponte & Cheyns, 2013; Vandermoere, 2008). The further inclusion of researchers, activists and other external actors helps with putting the local experiences into broader frameworks, getting the chance to see patterns that might not have been evident on a smaller scale (Albuquerque et al., 2014; Nemarundwe & Richards, 2002).

The goal to represent sustainability in an integral way through the inclusion of four dimensions sets this list of C&I apart from most in the area. The over-representation of environmental sustainability in the literature and the comparatively low number of studies addressing socioeconomic sustainability may be due to several methodological hurdles such as the increasing complexity of the issues that can render the analysis less straight-forward and more challenging, the sensitivity of economic and social data that might make it less likely to be disclosed by groups or individuals, , in addition to the fact that “sustainability” is a term much more widely used in the field of Environmental Sciences than in the Social Sciences.

The inclusion of the Biocultural dimension was welcome, as it poses itself as a way to capture some of the values of the community, particularly in association with nature. It seems like a good complement to the Environmental dimension since knowing the state of the ecosystems might not give a full picture about the community's relationship with them, and having information regarding this aspect can help understand the community's action on a deeper level (Janssen et al., 2007; Van Vleet et al., 2016).

The simplifications made to the C&I during this thesis rendered the tool more realistically applicable (Gough et al., 2008). Although informative, some of the original indicators are too resource and time intensive, which is not conducive to continued monitoring. Perhaps a good alternative would be to condense the grand criteria into indicators that can be measured, for example, by the ejido workers during the visits to the forest throughout a longer period of time and without the need to make specific visits (Garcia & Lescuyer, 2008; Secco et al., 2014).

The decision to trade-off comparability for community specificity posed some analysis challenges to this thesis but it will likely result in more useful monitoring data for the communities involved (Gough et al., 2008). Since one of the main goals of RITER is to empower communities, I consider this a sound exchange (The Nature Conservancy, 2020).

When navigating the indicator tool, the structure of scale that should be established for each of them was often hard to determine. In retrospect, I think a useful approach would be to clearly divide the indicators into fact and perception based (Secco et al., 2014). Among the fact-based indicators, there would be set indicators (attributes that don't vary in the region, such as the need of an approved forest management plan for doing CFM in an *ejido* or the living wage) and variable fact-based (e.g. the implementation of low impact logging techniques, which will depend on the available research at the time). Perception-based indicators would be the ones best measured by satisfaction level or level of agreements (several social and biocultural indicators such as the percentage of ejido land dedicated to recreational uses, or the number of strategic alliances). Having the type of indicator clearly stated would have saved time and confusion.

Regarding the set fact-based indicators, I believe these could be grouped into another dimension (Basic Enabling Conditions) that refers to the attributes without which truly sustainable CFM cannot happen (at least not in the context of RITER). They would include the existence of a forest management plan, the avoidance of monetary losses, the avoidance of over exploitation of the forest resources, the presence of basic infrastructure, machinery, and tools. Especially while

compiling the main challenge data, it became evident that a lot of indicators where about making an endeavor *more sustainable*, but there were some attributes whose absence made sustainable CFM an impossibility. The separation of such indicators would be a useful tool to identify particularly vulnerable communities as they set out to sustainably manage their forest (R. Hajjar et al., 2021)

To this I would add that some indicators, particularly those that were binary but non-basic enabling conditions could be inflating the sustainability averages. It would be best to evaluate the need for them, and if the answer is positive, considering condensing them into composite indicators or assign weights to the elements of the list (Secco et al., 2014).

The original C&I list contemplated all the convergences documented by McDonald & Lane (2004; Table 3). However, after the elimination of the very resource extensive indicators, two of them were lost (Conservation and maintenance of soil and water resources and Continuation of the carbon cycle). These important elements of sustainable forest management should be included in the next iteration, but should be included through easier to measure indicators, for the sake of continuation of the monitoring. For this, García & Lescuyer (2008) argue the importance of institutions, genuine interest, and accountability mechanisms on the part of the involved communities to maintain the monitoring going even after the inciting entity finishes their intervention.

6. Conclusion

The Community Forest Management C&I list developed by TNC as part of their RITER program is an ambitious and comprehensive tool with valuable innovations. Its pilot run in two ejidos involved in CFM in the state of Quintana Roo, Mexico provided elements for the simplification and refinement on the tool for easier and prolonged future utilization.

The measuring of the indicators exemplified two different types of ejidos in the Yucatán Peninsula region, with variations in aspects ranging from vegetation type and topography to history and access to public services, reflecting on the indicators' scores in four dimensions (social, biocultural, economic, and environmental).

The indicator values were complemented with a compilation of the main challenges to the sustainable CFM faced by the communities, which provided further insight on the ways in which the *ejido*'s characteristics shape the present and can hopefully give them tools to move forward in an informed and confident way.

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Appendix A. Working list of C&I modified form the version developed by The Nature Conservancy

Dimension of sustainability	Criteria	Indicators
Social (S)	Gender inclusion in forest diversification (S1)	Number of people involved in the diversification of forest management (S1a)
		Percentage of women included in diversification of forest management (S1b)
	Diversification of forest management activities for wider inclusion (S2)	Percentage of the forest land for recreational purposes (S2a)
		Self-sustenance activities carried out by the community (S2b)
		NTFPs utilized by the community (S2c)
	Communication and organization with other RITER members for creation of alliances (S3)	Number of current strategic alliances (S3a)
		Number of projects with allies (S3b)
	Participation of underrepresented groups in decision-making (S4)	Percentage of women in decision making roles (ejido) (S4a)
		Percentage of people 35 or younger in decision making roles (S4b)
	Reproduction of successful strategies of forest management through RITER (S5)	Number activities adopted because of involvement in RITER (S5a)
		Perception of RITER in the community (S5b)
	Strengthening of ejido governance through rules (S6)	Existence of explicit detailed internal rules (S6a)
	Promotion of forest management activities as decent (digno) sources of	Percentage of women employed in forest value chain (S7a)

	income for underrepresented sectors (S7)	Percentage of people 35 or younger employed in forest value chain (S7b)
		Number of people benefitted by scholarship programs promoted by the ejido (S7c)
	Capacity of forest jobs to be decent sources of income for all forest workers (S8)	Average wage of forest workers (S8a)
		Number of ejido members involved in forest activities (S8b)
Biocultural (B)	Acknowledgement and conservation of the natural attributes of the region (B1)	Existence of rituals related to forest resources (B1a)
		Are medicinal plants from the forest used in the community (B1b)
		Number of medicinal plants in the forest area (B1c)
		Number of wild animal species used by the community (B1d)
	Acknowledgement and promotion of biocultural value (B2)	Existence of sites with cultural value (recreational, inspiration, connection, ancestral) (B2a)
	Passing of knowledge between generations (B3)	Existence of intergenerational transfer of knowledge (B3a)
Economic (M)	Community-wide distribution of benefits of forest management (M1)	Existence of a response plan for emergencies (M1a)
		Number of emergencies contemplated in the plan (M1b)
		Existence of a common savings fund (M1c)
	Promotion of job-creation (M2)	Number of entrepreneurial ventures stemming from the forest management (M2a)
	Maintenance of economic benefits on the long term (M3)	Volume and value of production (M3a)
		Cost-benefit relation (M3b)
	Creation of long-term forest management plans (M4)	Existence of a current forest management plan (M4a)

	Technification for better performance of systems (M5)	Number of trainings for forest management (M5a)
		Types of technologies used for forest management (M5b)
		Percentages of increase in earnings stemming from implementation of new technologies (M5c)
Environmental (E)	Conservation of biodiversity in the areas with forest management (E1)	Number of hectares of community reserve (E1a)
		Number of plant species included in the management (E1b)
		Number of key animal species for the management (E1c)
		Number of high value reforested individuals (E1d)
		Percentage of survival of reforested high value species (E1e)
		Existence of flora and fauna monitoring (E1f)
		Use of monitoring data to adjust forest management plan (E1g)
	Measurement and certification of ES (E2)	Number of certifications acquired for forest management (incl. Conservation) (E2a)
	Implementation of good management practices that lower emission of GHG (E3)	Implementation of low impact logging techniques (E3a)
	Integral management of fire (E4)	Number of active and equipped brigades for fire management (E4a)
		Number of fires since last monitoring (E4b)
		Surface (ha) affected by fires since last monitoring (E4c)
		Percentage of attended fires out of the ones that happened (E4d)

	Management of temporal currents in management (E5)	Inclusion of temporal currents in management plan (E5a)
		Number of activities for current management (E5b)
	Avoiding land-use change in forest area (E6)	Surface (ha) affected by land-use change since last monitoring (E6a)
		Surface (ha) with influence of the Sembrando Vida program (E6b)
	Soil health associated to forest management (E7)	Existence of soil erosion on compaction (E7a)
		Existence of measures to counteract erosion and compaction (E7b)
	Reforestation of management-related clearings (E8)	Surface (ha) of management-derived clearing that have been reforested (E8a)
		Percentage of survival of reforested individuals in clearings (E8b)

Appendix B. Data-collection questionnaire

Social indicators

1. How many people are involved in the forest management of the ejido? How many (proportion) are men and women?
2. What percentage of forest land is destined for recreational purposes such as ecotourism?
3. Do people involved in forest production carry out self-subsistence activities related to the forest?
4. Which NTFP are used in the ejido for self-consumption?
5. Does the ejido hold current strategic alliances with civil society organizations/NGOs, other ejidos, members of academia? List them.
6. Does the ejido has ongoing projects with said allies?
7. How many people are involved in the decision-making regarding forest management of the ejido? How many (percentage) are women and how many are below 35 years old?

8. Has the ejido adopted activities because of their involvement in the RITER project? Which ones?
9. How is the RITER project perceived in the community? Is it well known? Is it well accepted?
10. Does the ejido have regulations that include elements such as functions associated with each job title, description of the forest management, sustainable vision of the land, collaborative functions, etc?
11. How many women and young people (35 or younger) are employed in the forest management value chain?
12. Is there a promotion of opportunities by the ejido through scholarships? How many and what's the age of the beneficiaries?
13. How is the distribution of earnings of the forest management carried out? What is the average wage?
14. How many members of the ejido are involved in forestry-related activities?

Biocultural indicators

15. Are there any ritual or traditions related to or that made use of forest resources?
16. Are there any medicinal plants in the managed forest area? Does the community make use of these medicinal plants?
17. Are wild animals used for household consumption? Which species?
18. How many and which are the sites of spiritual, recreational, and ancestral value in the ejido land?
19. Did you acquire your forest management related knowledge from other generations in your community?

Economic indicators

20. Does the ejido have an emergency response plan in terms of forest management? Which emergencies are included in this plan?
21. Has a common saving fund been generated for transformation/machinery/social urgency? What purposes does this fund address?
22. Is individual or collective entrepreneurship relating to the forest management motivated by the ejido? Which ones?
23. What are the volume and value of the forest production? Rate of cost-benefit?

24. Does the ejido have a current forest management plan in force?
25. Have people involved in the forest management received training to improve their technical capabilities? How many and which ones?
26. Which technologies are used in the forest production process?
27. Has the profit from the production gone up as a result of the implementation of new technologies? What percentage of the profit?

Environmental indicators

28. Which area of tree cover is permanently maintained in the ejido's forest land? How many hectares are set as community reserve?
29. Which tree species are used in the forest management?
30. Which are the key fauna species and species of interests for the forest management?
31. Is regeneration of the high value tree species carried out? How many individuals/species/hectare?
32. How do the reforested individuals grow?
33. Is there a monitoring effort for animal and plant species, including the ones commercially exploited?
34. Are the data obtained from this monitoring to make decisions on forest management?
35. Has the ejido obtained certifications for the management of their forest land?
36. How many tons of carbon are stored in the forest management area?
37. Does the ejido implement Reduced Impact Logging techniques? Which ones?
38. Does the ejido have strategies for the integral management of fire? How many active brigades and equipped brigades are there?
39. What surface area has been affected by fires recently? Number of fires, intensity. Are there periodical/seasonal fires?
40. What is the rate of reported to attended fires?
41. Are there temporal water currents on the surface of forest management? Are these considered in the management plan?
42. Which activities are carried out to take care of the currents?
43. How many hectares have undergone land use change in recent years? How many of these used to be forest and currently aren't?
44. How many hectares of ejido forest are part of the Sembrando Vida government program?

45. Does the ejido use machinery that results in compaction or erosion of soil?
46. Are methods applied to avoid or diminish the impact of compaction and erosion?
47. Does the ejido perform reforestation on the clearings opened up after logging?
48. Which percentage of the reforested plants survives?

Appendix C. Indicator scales for Ejido Candelaria II

Dimension of sustainability	Criteria	Indicators	0	1	2	3	4	5
Social (S)	Gender inclusion in forest diversification (S1)	Number of people involved in the diversification of forest management (S1a)	0	<10	<20	<30	<40	40+
		Percentage of women included in diversification of forest management (S1b)	0	2%	5%	10%	20%	>20%
	Diversification of forest management activities for wider inclusion (S2)	Percentage of the forest land for recreational purposes (S2a)	0	<5%	<10%	<15%	<25%	25%+
		Self-sustenance activities carried out by the community (S2b)	none	1	2	3	4	5
		NTFPs utilized by the community (S2c)	none	1	2	3	4	5
	Communication and organization with other RITER members for creation of alliances (S3)	Number of current strategic alliances (S3a)	0	1	2	3	4	5+
		Number of projects with allies (S3b)	0	1	2	3	4	5+
	Participation of underrepresented groups in decision-making	Percentage of women in decision making roles (ejido) (S4a)	0	2%	5%	10%	20%	>20%

	(S4)	Percentage of people 35 or younger in decision making roles (S4b)	0	2%	5%	10%	20%	>20%
	Reproduction of successful strategies of forest management through RITER (S5)	Number activities adopted because of involvement in RITER (S5a)	0	1	2	3	4	5
		Perception of RITER in the community (S5b)	no one knows	only RITER leaders know	RITER leader and some ejido members	leaders, ejido members	leaders, ejido and small portion of community	most people in community know
	Strengthening of ejido governance through rules (S6)	Existence of explicit detailed internal rules (S6a)	no and no interest in developing	no but interested	no but in process	yes but very basic or outdated	yes but details are missing	yes and completely satisfactory
	Promotion of forest management activities as decent (digno) sources of income for underrepresented sectors (S7)	Percentage of women employed in forest value chain (S7a)	0	2%	5%	10%	20%	>20%
		Percentage of people 35 or younger employed in forest value chain (S7b)	0	<50%	50%+	60%+	70%+	80%+
		Number of people benefitted by scholarship programs promoted by the ejido (S7c)	0	1	2	3	4	5
	Capacity of forest jobs to be decent sources of income for all forest workers (S8)	Average wage of forest workers (S8a)	below min wage	MW	MW + 25%	MW + 50%	MW + 75%	2 MW
		Number of ejido members involved in forest activities (S8b)	0	<10	10+	20+	30+	40+

Biocultural (B)	Acknowledgement and conservation of the natural attributes of the region (B1)	Existence of rituals related to forest resources (B1a)	no	NA	NA	NA	NA	yes
		Are medicinal plants from the forest used in the community (B1b)	no	some use	NA	conspicuous use	NA	conspicuous use and catalogued
		Number of medicinal plants in the forest area (B1c)	0	<7	<10	<13	<16	16+
		Number of wild animal species used by the community (B1d)	0	1	2	3	4	5+
	Acknowledgement and promotion of biocultural value (B2)	Existence of sites with cultural value (recreational, inspiration, connection, ancestral) (B2a)	no	1 reason	2 reasons	3 reasons	4 reasons	5+ reasons
	Passing of knowledge between generations (B3)	Existence of intergenerational transfer of knowledge (B3a)	no	yes but insufficient	NA	not fully satisfactory	NA	very satisfactory
Economic (M)	Community-wide distribution of benefits of forest management (M1)	Existence of a response plan for emergencies (M1a)	no	no but intention	NA	yes but details are missing	NA	yes and satisfactory
		Number of emergencies contemplated in the plan (M1b)	0	1	2	3	4	5
		Existence of a common savings fund (M1c)	no	yes but insufficient	NA	yes but aspects are missing	NA	very satisfactory

	Promotion of job-creation (M2)	Are entrepreneurial ventures stemming from the forest management incentivized in the community (M2a)	no	yes but no support	NA	yes and support is available	NA	yes and there are entrepreneurial efforts currently
	Maintenance of economic benefits on the long term (M3)	Volume of production (M3a)	no extraction	<100 m3	<300 m3	<500	<700	<900 and more
		Value of production (M3b)	0	<100,000	<500,000	<1,000,000	<2,000,000	2,000,000+
		Cost-benefit relation (M3c)	Losses	no loss or profit	<500MXN/m3	<750MXN/m3	<1000MXN/m3	1000MXN/m3 +
	Creation of long-term forest management plans (M4)	Existence of a current forest management plan (M4a)	no	NA	NA	NA	NA	yes
	Technification for better performance of systems (M5)	Number of trainings for forest management (M5a)	no training	1	2	3	4	5+
		Types of technologies used for forest management (M5b)	none	1	2	3	4	5+
		Percentages of increase in earnings stemming from implementation of new technologies (M5c)	0	<5%	5%	10%	15%	20%

Environmental (E)	Conservation of biodiversity in the areas with forest management (E1)	Number of hectares of community reserve (E1a)	0	<100	<200	<300	<400	400+
		Number of plant species included in the management (E1b)	0	1	2	3	4	5+
		Number of key animal species for the management (E1c)	0	1	2	3	4	5+
		Number of high value reforested individuals (E1d)	0	NA	1	NA	2	2+
		Percentage of survival of reforested high value species (E1e)	0	<50%	<60%	<70%	<80%	80%+
		Existence of flora and fauna monitoring (E1f)	no	NA	NA	NA	NA	yes
		Use of monitoring data to adjust forest management plan (E1g)	no	NA	NA	NA	Na	yes
	Measurement and certification of ES (E2)	Number of certifications acquired for forest management (incl. Conservation) (E2a)	0	NA	NA	1	NA	2
	Implementation of good management practices that lower emission of GHG (E3)	Implementation of low impact logging techniques (E3a)	no	1	2	3	4	5+

	Integral management of fire (E4)	Number of active and equipped brigades for fire management (E4a)	no fire brigades	starting to form brigades	1 insufficiently equipped	1 fully equipped	2 insufficiently equipped	2 fully equipped
		Number of fires since last monitoring (E4b)	>4	4	3	2	1	0
		Surface (ha) affected by fires since last monitoring (E4c)	500+	250+	125+	60+	30+	<30
		Percentage of attended fires out of the ones that happened (E4d)	0	20%	40%	60%	80%	100%
	Management of temporal currents in management (E5)	Inclusion of temporal currents in management plan (E5a)	no	NA	NA	NA	NA	yes
		Number of activities for current management (E5b)	0	1	2	3	4	5+
	Avoiding land-use change in forest area (E6)	Surface (ha) affected by land-use change since last monitoring (E6a)	More than 100 ha forest loss	<100ha loss	no loss or gain	<25ha gain	<50 ha gain	>50 ha gain
	Soil health associated to forest management (E7)	Existence of soil erosion on compaction (E7a)	strong erosion or compacti on	evident erosion or compaction	moderate erosionor compacton	some observed	non observed	monitored and none observed
		Existence of measures to counteract erosion and compaction (E7b)	none	NA	NA	efficient forest paths	NA	good forest paths plus remote sensing to avoid unnecessary entrance to forest

Appendix D. Indicator scales for Ejido Noh Bec

Dimension of sustainability	Criteria	Indicators	0	1	2	3	4	5
Social (S)	Gender inclusion in forest diversification (S1)	Number of people involved in the diversification of forest management (S1a)	0	<10	<20	<30	<40	<50
		Percentage of women included in diversification of forest management (S1b)	0	10%	20%	40%	60%	80%
	Diversification of forest management activities for wider inclusion (S2)	Percentage of the forest land for recreational purposes (S2a)	0	3%	6%	9%	12%	15%
		Self-sustenance activities carried out by the community (S2b)	none	NA	NA	NA	NA	minimum for game meat
		NTFPs utilized by the community (S2c)	none	1	2	3	4	5+ sources
	Communication and organization with other RITER members for creation of alliances (S3)	Number of current strategic alliances (S3a)	0	1	2	3	4	5
		Number of projects with allies (S3b)	0	<2	<4	<6	<7	<8
	Participation of underrepresented groups in decision-making (S4)	Percentage of women in decision making roles (ejido) (S4a)	0	<10% ejido (E), no council (C)	>10% E, no C **OR** <10% E, yes C	>20% E, no C **OR** >10% E, yes C	>30% E, no C **OR** >20% E, yes C	>40%+ E, no C **OR** >30%E, yes C
		Percentage of people 35 or younger in decision making roles (S4b)	0	1% of E	2%	3%	4%	5%

	Reproduction of successful strategies of forest management through RITER (S5)	Number activities adopted because of involvement in RITER (S5a)	0	1	2	3	4	5+
		Perception of RITER in the community (S5b)	no one knows	only RITER leaders know	RITER leader and some ejido members	leaders, all ejido members	leaders, ejido and small portion of community	most people in community know
	Strengthening of ejido governance through rules (S6)	Existence of explicit detailed internal rules (S6a)	no and no interest in developing	no but interested	no but in process	yes but very basic or outdated	yes but details are missing	yes and completely satisfactory
	Promotion of forest management activities as decent (digno) sources of income for underrepresented sectors (S7)	Percentage of women employed in forest value chain (S7a)	0	2	4	6	8	10
		Percentage of people 35 or younger employed in forest value chain (S7b)	0	20	40	60	80	100%
		Number of people benefitted by scholarship programs promoted by the ejido (S7c)	0	1	2	3	4	5/year
	Capacity of forest jobs to be decent sources of income for all forest workers (S8)	Average wage of forest workers (S8a)	below min wage	MW	MW + 25%	MW + 50%	MW + 75%	2 MW
		Number of ejido members involved in forest activities (S8b)	0	<5%	<15%	<25%	<35%	<45% plus

Biocultural (B)	Acknowledgement and conservation of the natural attributes of the region (B1)	Existence of rituals related to forest resources (B1a)	no	NA	NA	NA	NA	yes
		Are medicinal plants from the forest used in the community (B1b)	no	yes but rarely	NA	yes and common	NA	yes and catalogued
		Number of medicinal plants in the forest area (B1c)	0	3	6	9	12	15+
		Number of wild animal species used by the community (B1d)	0	2	4	6	8	10
	Acknowledgement and promotion of biocultural value (B2)	Existence of sites with cultural value (recreational, inspiration, connection, ancestral) (B2a)	no	1 reason	2 reasons	3 reasons	4 reasons	5+
	Passing of knowledge between generations (B3)	Existence of intergenerational transfer of knowledge (B3a)	no	yes but insufficient	NA	not fully satisfactory	NA	very satisfactory
Economic (M)	Community-wide distribution of benefits of forest management (M1)	Existence of a response plan for emergencies (M1a)	no	no but intention	NA	yes but details are missing	NA	yes and satisfactory
		Number of emergencies contemplated in the plan (M1b)	0	1	2	3	4	5
		Existence of a common savings fund (M1c)	no	NA	NA	NA	NA	yes

	Promotion of job-creation (M2)	Are entrepreneurial ventures stemming from the forest management incentivized in the community (M2a)	no	yes but no support	NA	yes and support is available	NA	yes and there are entrepreneurial efforts currently
	Maintenance of economic benefits on the long term (M3)	Volume of production (M3a)	Extracted more than sustainable plan	<4000	<4500	<5000	<5500	>6000 following plan
		Value of production (M3b)	0	<12million	<13million	<14million	<15million	more than 15million
		Cost-benefit relation (M3c)	Losses	<700MXN/m3 without compromising socio-eco benefits	<800MXN/m3 without compromises	<900MXN/m3 without compromises	<1000MXN/m3 without compromises	>1000MXN/m3 without compromises
	Creation of long-term forest management plans (M4)	Existence of a current forest management plan (M4a)	no	NA	NA	NA	NA	yes
	Technification for better performance of systems (M5)	Number of trainings for forest management (M5a)	no training	some but unsatisfactory	mostly unsatisfactory	moderetaly satisfacory	fairly satifactory	completely satisfactory
		Types of technologies used for forest management (M5b)	none	old extraction machinery, trucks, sawmill, electric saws, recorders for fauna	1+new extraction machinery, +new trucks, +drones, + trap cameras,	Two extra	Three extra	Four extra
		Percentages of increase in earnings stemming from implementation of new technologies (M5c)	0	<5%	5%	10%	15%	20%

Environmental (E)	Conservation of biodiversity in the areas with forest management (E1)	Number of hectares of community reserve (E1a)	0	<150	<350	<550	<750	750
		Number of plant species included in the management (E1b)	0	10 or <	11	12	13	14+
		Number of key animal species for the management (E1c)	0	<3	4	5	6	7+
		Number of high value reforested individuals (E1d)	<10000	<12000	<14000	<16000	<18000	<20,000+
		Percentage of survival of reforested high value species (E1e)	0	<55%	<65%	<75%	<85%	85%+
		Existence of flora and fauna monitoring (E1f)	no	NA	NA	only flora or fauna	NA	Yes to both
		Use of monitoring data to adjust forest management plan (E1g)	no	NA	NA	NA	NA	yes
	Measurement and certification of ES (E2)	Number of certifications acquired for forest management (incl. Conservation) (E2a)	0	NA	NA	1	NA	2
	Implementation of good management practices that lower emission of GHG (E3)	Implementation of low impact logging techniques (E3a)	no	NA	NA	yes but some things missing	NA	yes and satisfactory
	Integral management of fire (E4)	Number of active and equipped brigades for fire management (E4a)	no fire brigades	starting to form brigades	1 insufficiently equipped	1 fully equipped	2 insufficiently equipped	2 fully equipped

		Number of fires since last monitoring (E4b)	>4	4	3	2	1	0
		Surface (ha) affected by fires since last monitoring (E4c)	1000+	500+	250+	125+	60+	<60
		Percentage of attended fires out of the ones that happened (E4d)	0	20%	40%	60%	80%	100%
	Avoiding land-use change in forest area (E6)	Surface (ha) affected by land-use change since last monitoring (E6a)	More than 100 ha forest loss	more than 50 ha forest loss	less than 50 ha forest loss	no change	less than 50 ha forest won	more than 50 ha forest won
		Surface (ha) with influence of the Sembrando Vida program (E6b)	0	less than 25 ha	25 ha +	50 ha +	75 ha +	100 ha +
	Soil health associated to forest management (E7)	Existence of soil erosion on compaction (E7a)	strong erosion or compaction	evident erosion or compaction	moderate erosionor compacton	some observed	non observed	monitored and none observed
		Existence of measures to counteract erosion and compaction (E7b)	none	NA	NA	efficient forest paths	NA	good forest paths plus remote sensing to avoid unnecessary entrance to forest
	Reforestation of management-related clearings (E8)	Surface (ha) of management-derived clearing that have been reforested (E8a)	0	<5	<15	<25	<35	35+
		Percentage of survival of reforested individuals in clearings (E8b)	0	<55%	<65%	<75%	<85%	85%+