Investigaciones Geográficas • Instituto de Geografía • UNAM
eISSN: 2448-7279 • DOI: https://doi.org/10.14350/rig.60620 • ARTICLES
Issue 109 • December • 2022 • e60620
www.investigacionesgeograficas.unam.mx

Landscape Approach to Support Regional Action in Communal Forest Management: the Case of the Mixteca Alta, Oaxaca, Mexico

Enfoque de paisaje para apoyar el manejo forestal sostenible en la región Mixteca Alta, Oaxaca, México

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Received: 18/08/2022. Accepted: 10/10/2022. Published: 29/11/2021.

Abstract. Forest landscape structure comprises a mosaic of natural and human-modified units, which when well depicted, may help to plan and implement forest management policies, which commonly assume territorial homogeneity. Usually, forest policies lack the use of spatial tools that can help scale up conservation program in heterogeneous forested landscapes. This paper applied a conceptual-methodological framework as baseline to guide regional strategies and scale-up community collective action based on local forestry ejidos and communities. The study case was conducted in the Mixteca Alta, a forestry region in Oaxaca, Mexico, where common property prevails. Zoning was made based on biophysical, social, and forest management criteria. A total of 97 communities were surveyed and the region was disaggregated into five zones based on precipitation, watersheds, community forest management experience and level of regional collective action. Each zone was recognized as having different forestry potentials and intervention needs, ranging from restoration to timber and non-timber product management. This zoning proved the potential to guide forest projects and promote joint regional forest development. The potential use of landscape zoning was discussed in the light of the current need for scale-up forest policies.

Keywords: Community-based forest management, community-based forest enterprises, landscape units, collective action

Resumen. La estructura del paisaje forestal abarca un mosaico de unidades naturales y modificadas por el hombre, que bien representadas pueden ayudar a planificar e implementar políticas de gestión forestal, que comúnmente asumen la homogeneidad territorial. Por lo general, las políticas forestales carecen del uso de herramientas espaciales que

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puedan ayudar a ampliar el programa de conservación en paisajes forestales heterogéneos. En este trabajo se aplicó un marco conceptual-metodológico como línea de base para orientar las estrategias regionales y escalar la acción colectiva comunitaria basada en los ejidos y comunidades forestales locales. El caso de estudio se realizó en la Mixteca Alta, una región forestal de Oaxaca, México, donde prevalece la propiedad comunal. La zonificación se hizo con base en criterios biofísicos, sociales y de manejo forestal. Se encuestó a un total de 97 comunidades y se desagregó la región en cinco zonas en función de las precipitaciones, las cuencas hidrográficas, la experiencia en gestión forestal comunitaria y el nivel de acción colectiva regional. Se reconoció que cada zona tenía diferentes potenciales forestales y necesidades de intervención, que van desde la restauración hasta la gestión de productos madereros y no madereros. Esta zonificación demostró su potencial para orientar los proyectos forestales y promover el desarrollo forestal regional conjunto. El uso potencial de la zonificación del paisaje se debatió a la luz de la necesidad actual de ampliar las políticas forestales.

Palabras clave: manejo forestal comunitario, empresas forestales comunitarias, unidades de paisaje, acción colectiva.

INTRODUCTION

In conjunction with global phenomena such as climate change, humans depending upon forest resources are concerned about the impacts of deforestation trends and forest degradation (Alcamo, 2003; Agarwala *et al.*, 2014). Most forests are inhabited globally. Currently, 350 million people depend directly on forestry areas, and 700 million are estimated to benefit indirectly from forest ecosystem goods and services (Richards, 2008; RRI, 2008). Mainly, where forests commonly operate as social-ecological systems (Berkes *et al.*, 2000; Bettinger *et al.*, 2016; Fischer, 2018). Forest community management has proved to counterweight current forest loss and facilitate collective governance of forest resources (Gibson *et al.*, 2000; Klooster & Masera, 2000; Velázquez *et al.*, 2001; Ostrom, 2005; Bray *et al.*, 2005; Bray 2020).

Forest management is embedded in spatial contexts, commonly distinguished by natural-anthropogenic heterogeneity, which needs to be incorporated into new forest policy approaches that face contemporary challenges. The shifts in models that back the new forestry policies around the world have been able to transit from specific purpose management (timber production) to multi-management purposes to reach sustainability and climate change mitigation. Thus, holistic strategies need to emerge, be inclusive and integrate, the forest inhabitants' identities as well as their biophysical context (Alcamo, 2003; Primdahl *et al.*, 2013) with participatory (involvement stakeholders) and adaptive (continuous adjustments) principles (Raum & Potter, 2015).

A landscape is an area shaped by both natural and sociopolitical elements and processes that owns a multifunctional and heterogeneous structure (Arts *et al.*, 2017; Farina, 2000). This concept of the landscape could be useful to integrate processes and practices in complex environmental, socioeconomic, and institutional contexts (Axelsson *et al.*, 2011; Reed *et al.*, 2015). Additionally, the landscape approach has to recognize the occurrence of natural and human-modified unit mosaics (Farina, 2000; Van der Zee & Zonneveld, 2001; Scherr *et al.*, 2012; Frost *et al.*, 2006; Valverde *et al.*, 2008). These elements can be grouped in landscape units representing homogeneous spaces with a unique physiognomy, structure, and physiography (Zonneveld, 1995).

When analyzing landscape structure, geographic techniques can develop spatial models used to design and apply forest policies. For example, global initiatives like REDD+ need to promote forest management in territories (McCall, 2016; Lazdinis *et al.*, 2019). Although local communities commonly may have the flexibility to adopt top-down forest policies, and some may take advantage of grants, other cases are commonly distinctive in a region with contiguous non-developed communities. Practical and cheap GIS and remote sensing sources may systematically combine biophysical, social, and management attributes to classify regions (Lazdinis *et al.*, 2019), integrate spatial heterogeneity, and generate spatial models. Adopting of these models may help design programs for local conditions instead of assuming homogeneous regional contexts (Varughese & Ostrom, 2001). This paper uses a landscape approach to identify

regional heterogeneity as baseline to guide holistic forestry strategies, that can promote social consensus. The outcomes are derived from the Mixteca Alta region in Oaxaca, Mexico.

Forests context for Mexico

Mexico figures among forestry countries in the world (FAO, 2020) with almost a third of its territory having forested areas (66 million hectares) (Bray, 2020). Common property and collective forest governance are prevalent. Around 17,586 communities live in forested areas, referred to as Mexico's community forests (Torres-Rojo & Amador, 2015; Bray, 2020). However, less than 10% of these communities have developed community-based forest enterprises for timber products, non-timber forest products such as resin extraction and bottled spring water, environmental services and ecotourism (Cubbage et al., 2015, Bray, 2020). Thus, forest community management is seen as a surrogate of sustainable environmental management. Agrarian communities (Ejidos and communities) are not all evenly organized; some need reinforcement of governance, some other technical capabilities. The forest community ecosystem came to be from almost centennial shifts in public agrarian and forestry policies. For many decades, government forest policies have supported forest communities, mainly focusing on timber production, based on annual help for individual communities requesting projects (Torres-Rojo, 2016), expecting all of them to be socially and environmentally even.

MATERIALS AND METHODS

Study area

The Mixteca is an ethnic region of Oaxaca dominated by the Mixtec indigenous group. Based on cultural, productive, and environmental contrasts, the region is divided into Mixteca Baja and Mixteca Alta (Leyva, 2009; Guerrero-Arenas *et al.*, 2010), with neither geographical nor administrative delimitation, but with a clear cultural jurisdiction. We limited our study to common properties in Mixteca Alta, defined as areas above 1800 meters in elevation, hereafter referred to as the Mixteca (Fig. 1). Prevailing climates in the Mixteca are semi-cold sub-humid, warm humid, and warm sub-humid (INEGI, 2010). Temperate pine, oak, and juniper genera-dominated forests are the potential and prevailing vegetation (UMAFOR, 2009).

The Mixteca has a long history of forest use divided into four periods: Pre-Hispanic, Colonial, Independent Mexico, and present-day (post-revolutionary) (Guerrero-Arenas *et al.*, 2010; Díaz-Núñez, 2006). With the introduction of livestock during the 16th century, forest cover loss increased (García, 2002). After four centuries of this practice, in some regions, deforestation and degradation are evident (i.e., the municipalities of the Mixteca Alta Geopark) (García, 2002). According to Hernández-Aguilar *et al.* (2017), in the last decades, around nine communities have successful developed community forest management plans to extract not only timber but also other products such as resin and bottled water. Recently, it has been documented that certain areas within the region have experienced significant forest cover recovery (Lorenzen et al., 2020; Hernández-Aguilar *et al.*, 2021a).

Landscape components and units in the Mixteca Alta

Data on physical attributes (basins and annual precipitation) was obtained from the National Institute of Statistics, Geography (INEGI) and field-verified by authors. Vegetation types were generated by classifying an image from the Landsat 8 satellite of 2017, relying on field verification of 80 locations. Social components, such as localities, polygons of communities, and infrastructure (roads and highways), were obtained from INEGI and the National Agrarian Register (RAN, 2017). A filter was established to separate communities with forests from those without them. In this paper, the term forest was regarded a place where the dominant life forms were trees. A community forest was then defined as place dominated by tree life forms harbored by one single agrarian community. Community forests were mapped if the total surface was equal or larger than 400 hectares. Places with trees covering surfaces larger than 5% of forest

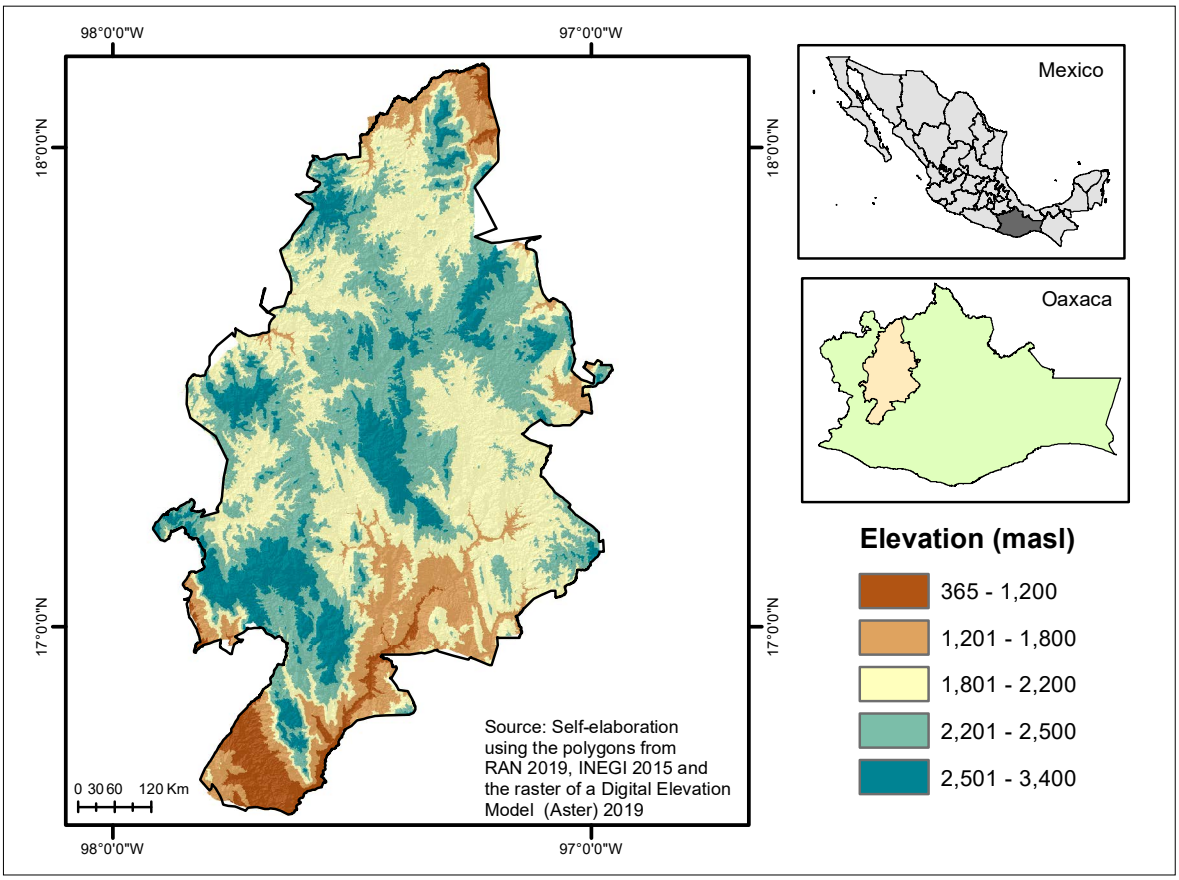


Figure 1. Localization of study area.

cover were classified as forest. Six communities that do not satisfy the criteria were included because they have experience in ecotourist. Local government agencies were consulted to identify forest communities with CFM experience (reforestation, ecotourism, payment for environmental services, resin extraction, and timber logging) in the region. This list of communities was subsequently used to make an intentional sample (open invitation to participate) for the application of interviews. Information was then integrated into vectors to create six thematic maps: basins, precipitation, temperate forest distribution, settlements and roads, community forests, and forest management experiences.

Interview information (following subsection) and data from thematic biophysical, infrastructure, and social maps were crossed, and forest communities that shared similarities in four or more attributes were grouped. Data was then integrated into a table composed of the following attributes: (1) precipitation, (2) watershed, (3) percentage of forest surface area, (4) experience in CFM activity, and (5) inter-community collective action. This table labeled the potential landscape units according to similarities in communities. Subsequently, communities were located spatially through a geographical information system software to zone the study area.

Needs, challenges, and strategies to improve community forest management

To document the history, needs, challenges, and regional collective action of community forests in

different Mixteca landscape units, 30 out of 97 Community Boards (*Comisariados*) accepted to participate in an interview. The interviews focused on the involvement of forestry potential, implementation of government programs, and intercommunal organization. Additionally, government officials from the Regional Office of the National Forest Commission (CONAFOR) and the Ministry of the Environment and Natural Resources (SEMARNAT) were interviewed. Furthermore, members of the regional organizations Southern Mixteca Natural Resources Regional Committee (CRRN Mixteca) (operating since 2006) and Project Mixteca (sponsored by the Global Environment Facility, the National Commission of Protected Natural Areas, and the Fund for the Environment of the United Nations since 2013) were also interviewed.

The information helped to define the key landscape attributes local authorities need and to establish forestry strategies to promote CFM and regional collective action. These recommendations were based on the characteristics of landscape units and the analysis of community forest management development. Each recommendation addressed problems and forestry potential in each area of the Mixteca Alta landscape. Local authorities demanded simple and recognizable landscape attributes rather than sophisticated statistical data.

RESULTS

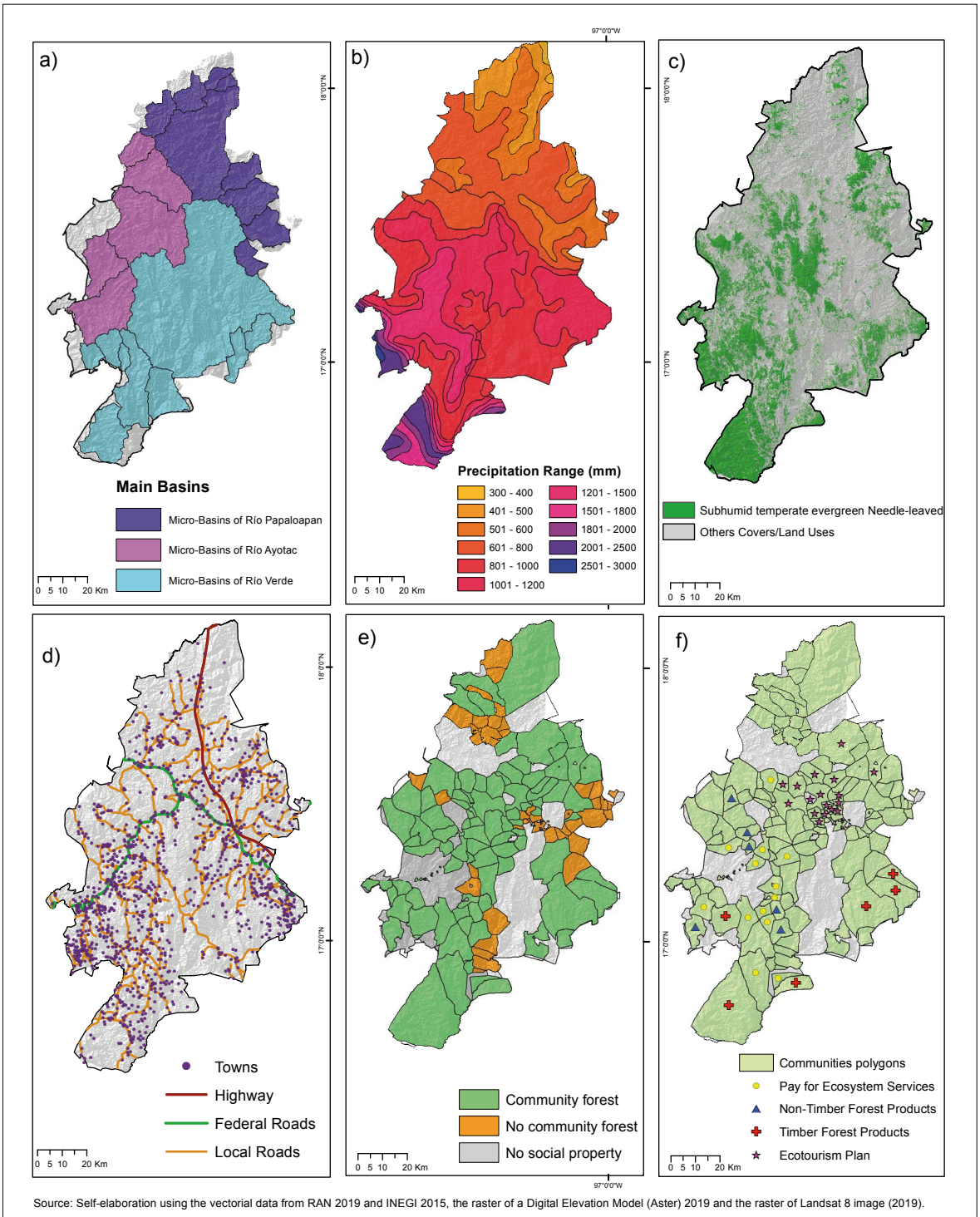
Landscape components and landscape units of the Mixteca Alta

The landscape approach identified patterns for the availability of forest resources and organizational processes for forest management. When identifying and characterizing forest landscape components, it is possible to locate landscape units with different forest potentials based on specific biophysical and social attributes. The Mixteca Alta landscape is a mosaic interconnected by topography, hydrology, and natural vegetation. It presents the interconnection of towns and roads (Fig. 2d) and forestry needs and opportunities. Currently, the common property represents around 78% of the Mixteca Alta (722,732 ha) and comprises 142 community polygons (Fig. 2c). The communities' extension ranged from 65 ha (San Andrés Andua) to 53,000 ha (Tepelmeme). The communities' polygons are included in three hydrographic basins: Atoyac River, Verde River, and Papaloapan River, which include 23 micro-basins within the region (Figure 2a). Temperate forest cover in the Mixteca is estimated to be 297,058 ha (32% of the total surface area), of which 83% is common property (Figure 2c).

Of the 142 communities in the Mixteca Alta, 97 could use the established criteria, including 98% of the surface area of pine-oak forests in common properties of the region (Figure 2e). Forty-three forest communities (≈ 43% of the total area) were found to have experience in CFM for the commercial use of timber (6), water (2), resin (4), ecotourism (18), and hydrological services payment (PES) (13) (Figure 2f).

The 97 communities have a basic set of documents that certify their legal existence (presidential resolution, registration of beneficiaries, and a certified community map). All have communal statutes and carry out annual Assemblies as the maximum authority to determine the use and management actions for forest resources in their territory. A decade ago, community assemblies set rules that contributes to forest conservation: the prohibition of unregulated logging and livestock grazing. More than half of the forest communities with degraded lands have carried out reforestation activities at least every two years. In the early 1990s, reforestations were organized at the initiative of the communities and were usually on a small scale (less than 5 hectares). By the beginning of this century, reforestation had become massive and on larger extensions (up to 50 hectares) due to government programs such as PROCYMAF (community forestry development program). Grazing control through collective norms was present in all interviewed communities. These two factors (reforestation and norms) have contributed to emerging vegetation in the Mixteca. According to community members, this vegetation has increased in the last years, mainly in hilly areas.

Biophysical and social components analysis have helped identify trends and patterns in the



Source: Self-elaboration using the vectorial data from RAN 2019 and INEGI 2015, the raster of a Digital Elevation Model (Aster) 2019 and the raster of Landsat 8 image (2019).

Figure 2. Biophysical and social landscape components in the Mixteca Alta. a) Basins in the Mixteca Alta. b) Precipitation gradient in the Mixteca Alta. c) Distribution of temperate forests in the Mixteca Alta. d) Settlements and roads in the Mixteca Alta. e) Forest communities in the Mixteca Alta. f) Experiences of CFM in the Mixteca Alta.

Mixteca Alta. In the dry zones, remnants of pine-oak and shrub forests predominate harboring species with low timber and non-timber potential. In contrast, more humid zones have species suitable for timber and non-timber (resin extraction), such as *Pinus pseudostrobus*, *Pinus ayacahuite*, and *Pinus oaxacana*. Due to this, experiences in CFM in the Mixteca Alta exist mainly in more humid zones, which have greater availability for commercial-potential species.

The landscape components and patterns helped to depict five land units quasi-homogeneous (Table 1; Fig. 3). Zoning focused on the following factors: precipitation, watershed, percentage of forest area, experience with CFM activity, and inter-community collective action. These landscape units are described below:

- *Landscape unit I.* It encompasses forest communities that belong to the basin of the Papaloapan River. It registers the lowest precipitation, the lowest percentage of forest surface, few experiences in CFM, and a null degree of inter-community collective action.
- *Landscape unit II*. This landscape unit includes forest communities in the basin of the Papaloapan river. The forest surface area is 14.5% and the precipitation is higher (800-1000 mm) than in Landscape unit I. The level of inter-community collective action in this

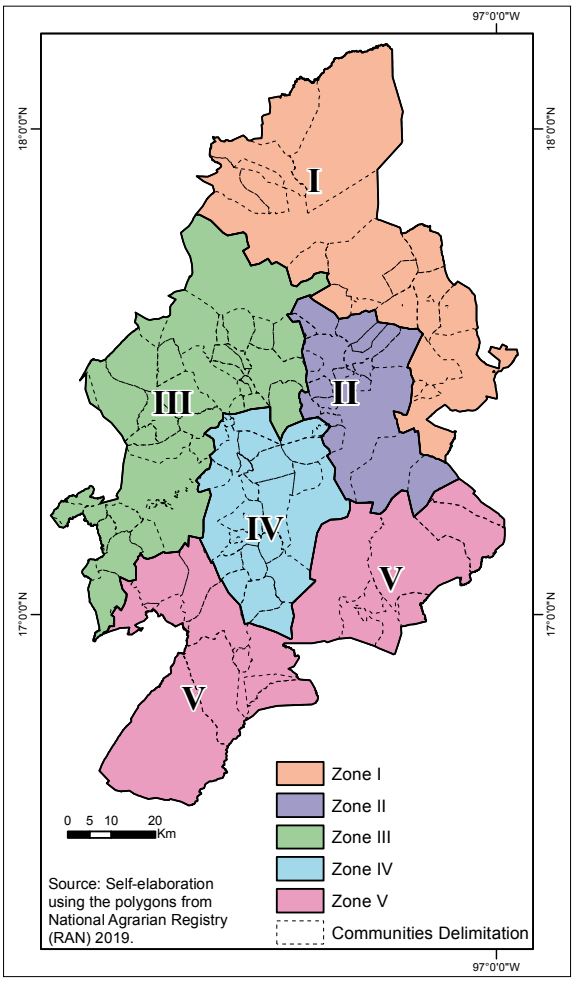


Figure 3. Five landscape units proposed for the Mixteca Alta region, Oaxaca.

Table 1. Characteristics of the proposed landscape units in the Mixteca Alta region, Oaxaca

	Number of communities	Precipitation	Watershed	Percentage of forest surface area (%)	Experience CFM activity (#)	Inter-community collective action*
Landscape unit I	14	300-800 mm	Papaloapan River	14.8	Ecotourism (2)	Null
Landscape unit II	16	800-1000 mm	Verde River	14.5	Ecotourism (13)	Low
Landscape unit III	30	800-1500 mm	Atoyac River	43.8	NTFP and PES (10)	Medium
Landscape unit IV	20	1000-1800 mm	Verde River	36.6	NTFP and PES (9)	Low
Landscape unit V	16	1500-2500 mm	Verde River	42.7	CFE (9)	High

* Participation in local organizations and regional committees (CRRN Mixteca and Mixteca Alta Geopark).

area is high since most of the communities cooperate in ecotourism activities through the project of Mixteca Alta Geopark. Thirteen communities have formed a network of trails that take the tourists to different spots of interest. These communities make agreements regarding the management (promotion, training, research) of the touristic project shared over their territories.

- *Landscape unit III.* It is composed of forest communities within the watershed of the Atoyac River. Due to high precipitation and forest cover, this landscape unit has forest suitability, especially for non-timber forest products (NTFP) production and the PES program. The level of inter-community collective action is medium. Only a third part of the communities participate in the CRRN Mixteca.
- *Landscape unit IV.* This landscape unit is composed of forest communities within the watershed of the Verde River. Biophysical conditions are similar to Landscape unit III. However, fewer communities participate in the CRRN Mixteca.
- *Landscape unit V.* This landscape unit includes forest communities in the Verde River watershed. It has the highest annual average precipitation in Mixteca Alta. They have good inventories of commercial timber species that have allowed six communities to operate a CFE since 1990. The level of collective action amongst them is high: eight communities take part in the CRRN Mixteca.

Needs and challenges of the CFM in the Mixteca Alta

Timber production in the Mixteca Alta started in *Landscape unit V* during forest concessions back in the 1970s and 1980s. In the 1990s, 15 forest communities with timber potential embarked on their own community forest enterprise (CFE) and began commercially using their forests. The communities of San Esteban Atatlahuca, Santo Domingo Nuxxa, San Juan Tamazola, San Andres Nuxiño, Santa Catarina Cuanana, and Santa Cruz Itundujía stood out. These CFEs started as small entrepreneurs with local financial resources. They received government financial incentives until the beginning of the 21st century. Several CFEs have operated intermittently due to a lack of investment or failure to renew forest management permits.

Since 1998, forest management of the region has been organized around the CRRN Mixteca, promoted by the Community Forest Development Program (PROCYMAF). The CRRN Mixteca was consolidated in 2006 by obtaining a legal register. It adopted an organizational structure with a board of directors composed of Community Boards as legal representatives of 32 communities of *Landscape units III*, *IV*, and *V*. Currently, it has permanent technical staff that helps coordinate monthly reunions. It also guides program procedures related to the forest sector. In the last ten years, the CRRN Mixteca has become a cross-sectional form of communication and promotion where initiatives such as Project GEF Mixteca and federal agencies (mainly CONAFOR) have promoted programs and activities for non-timber forest products: resin extraction, spring water bottling, ecotourism, and the PES program.

This proposal has been accepted in several forest communities of *Landscape unit III* and *Landscape unit IV* because they represent economic opportunities to improve CFM. Resin production in Mixteca began in 2011 by a Mexican company called *Alen del Norte*. Resin tappers have increased due to the promotion by Project Mixteca of the biological and economic benefits of the extraction. Likewise, this initiative brought funds to build greenhouses for seed genetic improvements. PES resources have allowed several communities to promote of tourist attractions in the landscape, like waterfalls, rivers, archaeological sites, and Dominican temples. Additionally, two communities have initiated the sale of spring water through a bottling business.

The bark beetle pine disease is a present threat in dozens of communities of *Landscape units III*, *IV,* and *V*. This disease is not new in Mixteca. Since 1995, some communities have agreed on joint management to control the plague. Currently, despite the efforts to achieve better management of the forests, the plague continues.

Since 2016, the UNESCO Mixteca Geopark, located in *Landscape unit II,* have contributed to the governance and management of the landscape in the region. The Geopark owns impressive geological features and soil degradation, comprises 41,500 ha, nine municipalities, and 13 communities, and it also promotes geological, biological, historical, and cultural richness. According to interviews with community members, it has strengthened talks about soil restoration and reforestation. It has also promoted ecotourism. The Mixteca Geopark tries to scale local management actions to a regional level. However, it does not have a formal structure (as the CRRN Mixteca has) that can implicate all stakeholders. Although communities of *Landscape unit I* have similar biophysical and social conditions to those of *Landscape unit II*, they were not included in the Geopark project. However, several communities of *Landscape unit I* are a national and worldwide reference in reforestation activities, which they have carried out since the 90s.

Strategies for improving community forest management in the Mixteca Alta

Strategies and actions implemented by government agencies and communities to enhance the CFM within each landscape unit are based on the characteristics, priorities, and needs of each unit.

Landscape unit I and Landscape unit II. Due to the degradation and deforestation, it is advised to continue expanding restoration programs (forest and soil). These activities can involve communities jointly. In the absence of information on forest suitability, technical studies could help communities to identify forest potential. In Landscape unit II, technical advice and business skills development could help organize and promote ecotourism in the Geopark. On the other hand, communities should create a formal regional committee to promote Geopark activities jointly.

Landscape unit III and Landscape unit IV. CONAFOR should focus on generating new management plans for NTFP and strengthening existing ones. Implementing technical studies and strengthening the supply, transformation, and marketing processes is advised. The forest health program should be a priority for these Landscape units, its implementation should be done separately through a community-coordinated group. Additionally, communities should join the CRRN Mixteca to create cooperation, this could help to coordinate logistics collaboration (storage, transport, and sale) of communities that produce NTFP.

Landscape unit V. Communities in this unit must strengthen their supply, transformation, and marketing processes. Forest productive projects would help diversify activities in communities that extract timber. CFM in Landscape unit V could grow if communities form a committee to obtain public and private financing to enforce lawful timber production and diversify forest management (PES, resin extraction, and ecotourism). Joint forest sanitation between communities is also advised.

DISCUSSION

Practical use of the landscape approach

Land planning has become a central spatial component for different management fields that may conduct sustainable development (Van der Zee & Zonneveld, 2001; Metternicht, 2018; Simensen, *et al.*, 2018). The landscape approach makes it possible to distinguish the continuity/discontinuity of the territories with forest potential (Reed *et al.*, 2015). This paper is an additional prove that landscape approach can guide collective public policies, which may scale-up for consolidate the CFM. This effect had been exhibited with synchronic of dozens of community forest management in almost homogeneous landscapes in the Sierra Norte in Oaxaca and in the Maya zone in central Quintana Roo, among other regions in Mexico (Bray, 2020). The spatial model of five landscape units for the Mixteca Alta (Figure 3) disentangled part of the spatial complexity using of biophysical, social, and forest management attributes. This landscape analysis helped to recognize a spatial structure not documented until now. Identified landscape units can be helpful to:

1. To contextualize forests and forestry lands within a connected biophysical-social space.

2. To integrate antecedents of community forest management.
3. To recognize natural connections among communities' polygons, like in micro-watersheds.
4. To recognize connections among communities that integrate organization, and critical areas with social conflicts or forest plagues.

These five landscape units can be a spatial referent to recognize specific needs and opportunities for forest management (Table 1) in the prevalent context of common property in the Mixteca Alta. Although current Mexican forest policies are aimed at supporting common property (Bray, 2020), unfortunately, national intervention strategies from CONAFOR are still based on the spatial framework of geopolitical units (states, geopolitical or biocultural regions, and sub-regions). On the other hand, at the local scale, projects promoted by governmental agencies remain restricted to community borders. Thus, any forestry program achievement is reported as a success based on the individual properties or communities performance; however they fail to prospect a systematical success by scaling up to the forestry landscape level.

Adopting a landscape analysis based on biophysical, social, and forest management attributes differs from two spatial-political planning tools used in Mexico (Bray & Velazquez, 2009). On one hand, it is different form ecological land planning (Rosete-Vergés, 2006; Tubío-Sánchez *et al.*, 2013), which is already a mandate by law and exists at the national, state, and municipal levels, but the local geopolitical borders rarely are coincident with the community forest management scale. While the mandatory forest management plans, which include a formal land use zoning needed for the commercial harvesting of forest products as established in the 2003 Forest Law, that emerged from practice and was adopted by the government for community forests in the 90s (Chapela & Lara, 1996). Thus, the zoning in the forest management plans include a division of community territories into: 1) conservation areas, 2) forest production areas, 3) forest restoration areas, and 4) other uses, mainly agriculture and village areas (Bray & Duran, 2014), but that zones commonly lack of continuity beyond the community borders. As a result, this landscape analysis is finer-grained and participatory by zoning land into communities and focusing on the "collective vision of their whole territory and prospected for a future based on taking advantage of their resources" (Bray, 2020), without strategies for scale up to the forested landscaped. These land planning instruments place restrictions on forest-ecological and productive goals because they use arbitrary borders (based on administration and land tenure) instead of natural or socio-ecological borders. Official ecological land planning presents low potential because regional and municipality boundaries reduce possibilities for forest management across the landscapes (Meffe *et al.*, 2002). While forest management and community land planning are restricted in the community polygons, anyone can overpass actions when biophysical and functional borders exist. However, the landscape units recognized in the Mixteca Alta region could include both natural and administrative boundaries and still have the flexibility to include current annual forest programs, which focus on grants for individual communities at a local scale and address both specific forest management goals and regional development.

Implications of landscape zonning

The experiences of CFM in the Mixteca Alta have emerged in different periods and have developed at different rates. Timber harvesting was predominant during the last century due to forest policies with diversification strategies (Bray, 2020). However, at the beginning of this century, new types of forest harvesting, and conservation programs have been included here and in other parts of Mexico (Bray *et al.*, 2003; Bray *et al.*, 2005). Diversification in forest management activities is linked to national strategies that promote social forestry in the country (Torres-Rojo *et al.*, 2016), although this is done with individualized assistance.

When compared with other regions of Oaxaca and Mexico, the Mixteca Alta presents a low contribution to national commercial production (Merino, 2004), even though a third of its surface area is covered by forest and its community forest companies have been operating for more than 20

years. Historically, different government entities have considered the Mixteca a region of high forest degradation and soil erosion, thus slowing the development of community forest management (Plancarte, 2019; Hernández-Aguilar et al., 2021b). This situation has led to the wrong perception that the entire region has no commercial potential and that only reforestation and soil restoration projects are needed. This paper documented that the Mixteca Alta has biophysical and social conditions not only for timber production but also for products such as resin or bottled spring water, as well as for ecotourism activities.

Forest collective management and decision-making at the scale of communities is the base to promote a forest landscape's the structural and functional integrity (productive, cultural, organizational). There are several individualized efforts in the Mixteca Alta to restore and conserve the forest, control forest pests, and take advantage of forest products. However, collective actions among communities could trigger well-being in larger areas, as in the other regions of Oaxaca, such as "La Chinantla" (CORENCHI) and Sierra Juarez (Pueblos Mancomunados and UZACHI). A first attempt to scale up productive and organizational processes in forest communities in the Mixteca Alta has been the creation of the CRRN Mixteca. Although this committee was created to provide orientation to communities that belong to Forest Management Units (UMAFORES), participation in this forum is not mandatory, so membership is constantly changing. It is necessary to carry out research at the local scale to understand the communities' motivations for participating in the CRRN Mixteca. The rest of the Mixteca Alta also has administrative UMAFORES, but none has an assistance committee like the CRRN Mixteca, even though forums can promote collective action between communities. Another collective project at the landscape level is the Mixteca Alta Geopark, but like the CRRN Mixteca, participation is voluntary and limited to activities within the communities' jurisdictions and not on a regional scale. The classification of landscape units could help communities to understand the importance of regional collective action through institutional mechanisms, while government agencies would be able to help UMAFORES considering that these are not homogeneous spaces. Mixteca Alta communities could synchronically operate if proximities and similarities between them were applied, and landscape units were established to target policies and actions. Without a landscape focus, the CFM in the region is focused only on specific landscape units, which causes uneven forest development in the Mixteca Alta.

Beyond Mexico, the European Landscape Commission illustrates the potential of the standard conceptual and methodological framework for recognizing the still existent structure of the European cultural landscapes and the problem with tendencies for homogenization of landscapes (Jongman 2002). Despite global influence on the rural landscape dynamics (Antrop, 2006), the relevance of public policies is that they may contribute to orienting some future scenarios in specific rural contexts (Min-Venditti *et al.*, 2017).

CONCLUSION

This paper provides a conceptual-methodological framework for zoning forestry social-ecological complex territories to guide holistic forestry policies and promote collaborative forest development at the regional level. Furthermore, this framework conducts to recognize forest policies intervention landscape units in a spatial model. Its potential implementation is illustrated in the Mixteca Alta in Oaxaca, Mexico.

The landscape approach, emphasizing the potential for forest management, recognizes the Mixteca region as a mosaic of landscape units with a relatively homogeneous biophysical, social, and forestry management. Inside these landscape units, different forest social-ecological systems have the potential to improve different agendas related to forest management. This paper demonstrates the advantages of ta landscape approach to guide public policies and community forest collective action to impulse synchronically specific agendas in concrete landscape units, and scale-up results to improve management and practices for forest

restoration and forest health, among other things. This territorial zoning exhibits a different spatial and functional scenario for forestry policies for CONAFOR programs and forest communities. The landscape approach represents a tool for a new forest management scheme, newly explored in Mexico, where broader criteria than just administrative or social may reduce the social-ecological complexity and avoid fragmenting or ignoring the real landscape structure.

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