

# Designing A Bi-Community Biological Corridor in Oaxaca, Mexico

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## Executive Summary

Habitat loss and fragmentation pose major threats to global biodiversity conservation. The protection of wildlife corridors can be an effective strategy to counteract these trends. In Oaxaca, Mexico, the rich biodiversity of the state faces pressure from commercial agriculture and economic development activities. Oaxaca is both a biodiversity and cultural diversity hotspot, spanning two Mesoamerican cultural areas with 16 distinct indigenous groups, making it the most ethnically diverse of Mexico's 31 states. Of its 570 municipalities, 418 are inhabited and governed autonomously by these indigenous groups. Coordinated efforts by these indigenous communities are therefore particularly important for the maintenance of connected wildlife habitats. In this project, we worked together with two indigenous Chatino communities in Oaxaca - San Juan Lachao (Lachao) and San Pedro Juchatengo (Juchatengo) - to investigate and support the development of a community-based biological corridor.

Recognizing the integral connection between the ecological systems to be conserved and the livelihoods of local communities, we designed a two-pronged approach utilizing environmental and social sciences, aimed at integrating the intertwined objectives of protecting wildlife and creating alternative livelihoods for communities.

In support of Juchatengo and Lachao's conservation objectives, we selected six focal species – white-tailed deer, peccary, coati, puma, ocelot, and jaguarundi – to define priority conservation areas and a corridor to connect them. We first collected camera trap data, remotely sensed data, and field data. We then applied logistic regression to predict species habitat within the two communities. We also applied a high accuracy land use land cover layer, derived from raw satellite imagery, to classify and integrate into the models. Retaining only the models that exhibited relatively high confidence, we identified areas of ecological importance within Lachao and Juchatengo by prioritizing areas where species habitats overlapped. The two largest conservation areas, both located in Lachao, were chosen as endpoints for our corridor. Finally, we mapped the optimal corridor path using probability of species occurrence as a cost surface and generating least cost paths. These results act as a preliminary exploration of potential corridor areas. We expect that future studies will employ our maps to inform future data collection efforts and habitat models. In combination with community consultation, these results will inform the decision for the final siting of the corridor between Lachao and Juchantengo.

In a complimentary analysis, we focused on implications of the conservation project on local communities and explored the potential of alternative livelihood projects (ALPs) to support the development of the corridor. We carried out key-stakeholder interviews with 18 individuals holding leadership positions in the communities and collected field notes from informal discussions and participant observations relating to the project. Based on this data, we analyzed community member's perceptions of the biological corridor and existing and future alternative livelihood projects. We also conducted a broad literature review on international case studies on four types of ALPs that were identified to be particularly relevant to the communities: forest-based carbon offset, non-timber forest product (NTFP), agroforestry and ecotourism. Combining the literature review with the interviews, we characterized the design features, contextual factors, expected positive and negative effects, and implementation barriers for each type of ALP. Based on results from the interview and literature analysis, we assessed the potential of each type of ALP in the two communities. Lastly, through the unexpected patterns and linkages that emerged in the analysis of interview data, we determined

strategic pathways for the communities to connect and support each other while expanding upon existing or implementing new ALPs that will support the development of the corridor.

Combining our findings from the geospatial modeling, interviews, and literature review, we propose the following recommendations:

- Continue to collect data on focal species using camera traps and environmental measurements;
- Increase awareness and support for conservation projects via community outreach and engagement;
- Enhance conservation and income generation through intra- and inter-community communication networks;
- Conduct further research to define data protocols, program monitoring procedures, and adaptive management practices.

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# 1. Introduction to the Inter-Community Conservation Corridor

## 1.1 Overview of the Project

The loss and fragmentation of habitats is widely recognized as a major threat to global biodiversity, and one possible solution to mitigate this threat is the restoration and protection of biological corridors (Keyghobadi, 2007; Gilbert-Norton et al., 2010). Community-based environmental management strategies are increasingly viewed by conservationists as essential to the integration of conservation and socioeconomic development objectives (Fahrig, 2003; Shepherd & Whittington, 2006). In our project, we combined these two ideas to support the design and management of a community-based conservation corridor in Oaxaca, Mexico. The ultimate goal of our project is to integrate the protection of wildlife and habitats and the development of sustainable livelihoods to promote the ecological and socioeconomic welfare of two indigenous communities.

Specifically, we set out to help the communities begin the process of corridor implementation by asking the following two questions:

1. Where are the optimal habitats in the area for establishing an effective conservation corridor?
2. How can we improve the management of the biological corridor to maximize the socio-economic welfare of the communities?

As the primary output of our project, we aim to help our client organization lay the foundation for the first community-based biological corridor in Oaxaca, Mexico (Shapiro-Garza et al., 2019). Recognizing the need for the corridor to address both biological and socioeconomic goals, we designed a two-pronged approach that combined quantitative habitat modeling and qualitative social science interview methods. In the first part (Chapter 2), we used remote sensing, field, and camera trap data to model the distribution of key wildlife species and identify the potential location of the biological corridor. In the second part (Chapter 3), we conducted key-informant interviews and literature reviews to offer advice on alternative livelihood projects for the social and economic well-being of people connected by the conservation corridor. In the end, we combined the insights gained from the quantitative and qualitative studies to provide a comprehensive list of recommendations on corridor planning for our client communities (Chapter 4).

## 1.2 The Client and the Communities

Mexico is among the top ten “mega-diverse countries’ of the world, identified by Conservation International, and Oaxaca is the most biologically diverse state within Mexico. In addition to being a hotspot of biodiversity, Oaxaca is also a hotspot of cultural diversity, inhabited by 16 distinct indigenous groups (Osborne & Shapiro-Garza, 2018). As the first state of Mexico to legally recognize indigenous customary laws and governance practices, Oaxaca is known throughout the country for having maintained strong community-level governance practices and collective action for natural resource management, making it an ideal location for our research on community-based environmental management (Osborne & Shapiro-Garza, 2018).

Our client organization, Integrator of Indigenous and Campesino Communities of Oaxaca (ICICO), is at the forefront of promoting community-based environmental management in the state. Established in 2000, ICICO assists indigenous communities in the productive management and conservation of forest ecosystem services to support the livelihood strategies of community members and build the capacity of the communities to manage these projects on their communal lands (Osborne & Shapiro-Garza, 2018). Overcoming enormous challenges, ICICO has reached out to seven communities and helped them start sustainable resource-management programs, including forest-based carbon offsets, spring water bottling plants, sustainable timber harvesting, and non-timber forest and agroforestry products (Shapiro-Garza et al., 2019). It has also supported communities in starting ecological monitoring programs like carbon-stock measurement and camera trapping for wildlife.

Building on their long-term relationship with the communities, in the proposed Oaxacan biological corridor, ICICO will serve as the active intermediary for integrating research results into community-level planning for habitat and wildlife management (Shapiro-Garza et al., 2019). In order to pave the road for a broader-scale conservation project, in this study, we focus on two communities partnering with ICICO, San Juan Lachao Pueblo Nuevo (Lachao) and San Pedro Juchatengo (Juchatengo), to provide recommendations on the establishment of a biological corridor between them.

Lachao started working with ICICO 13 years ago, whereas Juchatengo started with ICICO approximately five years ago. Through cooperation with ICICO, Lachao has created a sustainable water bottling plant, an ecotourism project, and carbon sequestration initiatives that have provided additional livelihood benefits for the community members. Juchatengo, similarly, has established wildlife and sustainable non-timber forest product harvest programs with the help of ICICO. The two communities will be a starting point for the creation of a trans-community conservation corridor aimed at enhancing the connectivity of ecosystems for wildlife as well as the social and economic interconnections between different communities in Oaxaca (ICICO, pers. comm.).

After initial discussions with ICICO representatives, we identified two main avenues to help ICICO in establishing a biological corridor at the two communities. First, we would help the organization improve the existing ecological monitoring protocols by compiling and analyzing existing camera trap data, ground-truthing remote sensing images, and creating GIS habitat models for critical wildlife species. Second, we would help ICICO review global lessons and conduct a socioeconomic survey in the communities to provide recommendations on alternative livelihood projects to develop alongside the biological corridor (ICICO, pers. comm.). Details on how we carried out those studies will be discussed in later chapters after the description of our project site.

### 1.3 Community-Based Environmental Management

Biodiversity loss is one of the greatest global environmental challenges in the 21<sup>st</sup> century and indigenous communities living in wildlife hotspots can play an important role in reversing this trend. The Convention on Biological Diversity and the Millennium Ecosystem Assessment agreed that ecosystem management and human well-being should be integrated, recognizing that biodiversity and livelihood needs are ultimately complementary goals (Berkes, 2007). Following this belief, community-based approaches have markedly expanded in global conservation projects and the importance of indigenous

communities are increasingly recognized in biodiversity conservation (Brown, 2002; Campbell & Vainio-Mattila, 2003; Brooks et al., 2013).

Community-based conservation projects integrate local communities' socioeconomic objectives with conservation planning. These projects emphasize the participation of local communities in decision and management over the natural resources on their land (Brown, 2002; de Araujo Lima Constantino et al., 2012). Compared to conventional conservation approaches, such projects are widely recognized to have the manifold benefits of higher capacity of incorporating local knowledge, greater responsiveness to local priorities, more efficient implementation with greater local participation and support, and higher long-term success (Berkes, 2007). The decentralized approach to environmental management is also known to enhance social equity and empower marginalized communities (Lane & McDonald, 2005).

However, the community-based approach to environmental management does have its limitations. Many scholars have pointed out that local communities often lack the scientific and technical know-how to undertake systematic monitoring and resource management projects on their own (Danielsen et al., 2009; Burton, 2012). Lack of knowledge and management skills are also reported to obstruct communities from running their alternative livelihood businesses (Ohl-Schacherer et al., 2008; Lyon, 2013). Therefore, technical and capacity support from external agencies can play an important role in facilitating successful conservation and development projects for indigenous communities (Hagggar et al., 2001; Belcher et al., 2010; Lee and Bond, 2018).

### 1.3.1 Background of Indigenous Community Based Conservation Areas in Latin America

For centuries, communities of indigenous peoples have managed their collective territories as subsistence farmers (IUCN, 2019). Because of their reliance on the land, biological diversity is an essential aspect of their management practices and is integral to their livelihoods and cultural values (CBD 2010; Borrini-Feyerabend et al., 2012; Jonas et al., 2017). Furthermore, biodiversity plays into their common rights over land, natural resources, and culture (Martin et al., 2010; Borrini-Feyerabend et al., 2012). In various ways, these practices lead to habitat preservation, species diversity, ecological services, and cultural preservation, even when conservation is not a priority in their decision-making (Borrini-Feyerabend et al., 2012). Ultimately, indigenous communities living in biodiverse ecosystems generate significant benefits to conservation on both local and global scales. The sustainable management practices of these communities can help preserve natural resources, protect threatened and endangered species, and mitigate climate change. (Marin et al., 2010; Borrini-Feyerabend et al., 2012; IUCN, 2019).

To make conservation empowering and culturally compatible in local communities, it is important to include the knowledge, traditions, and skills of the indigenous in community-based conservation (Delgado-Serano, 2017). Examining different community-based conservation programs in the global south provides socio-economic insight into perspectives, governance, and customs in both indigenous and national Latin American conservation initiatives. As we anticipate the continuation of our project over the next 2 years, reviewing projects akin our Oaxaca study offers contextual guidance into program structure, challenges, and successes to be aware of.

## *Ecuador*

SocioPáramo is a landscape-scale network of 18 communities, consisting of indigenous or peasant cooperatives holding collective land titles over páramos (grasslands) and forest lands in the northwestern Andean region of Ecuador (Bremer et al., 2014; Farley et al., 2011). SocioPáramo is part of the broader SocioBosque network established in 2008 by the Ecuadorian Ministry of the Environment (Bremer et al., 2014; de Koning et al., 2011). SocioBosque was inspired by a 2005 local level conservation project with indigenous communities in Northwestern Ecuador (de Koning et al., 2011). The indigenous Chachi people united three communities in the Esmeraldas province, El Encanto, Corriente Grande, and Capulí, and implemented a conservation agreement under the Federation of Chachi Centers of Esmeraldas (FECCHE) (de Koning et al., 2011).

SocioPáramo was created with the intended goals of conserving biodiversity, carbon, and water resources, while reducing poverty across 80% of the Andean highland native grasslands (páramos) (Bremer et al., 2014; Farley et al., 2011). The program was structured as such that payments for ecosystem services (PES) go directly to enrolled communities and individual landholders to incentivize conservation through modified agricultural practices. (Bremer et al., 2014; de Koning et al., 2011; Farley et al., 2011). PES occurred for tenured landholders (communal and individual), that participated in drastically reducing, or ending, agricultural burning and grazing practices (Bremer et al., 2014). The program is part of a protected conservation area, and formal ALP's did not emerge until later as participants started investing PES income towards sustainable agriculture, ecotourism, and hydrology projects (Bremer et al., 2014; Farley et al., 2014; Jones et al., 2016).

Success in poverty reduction and human well-being through PES programs depends on the level of participation and the extent to which livelihoods change (Grieg-Gran et al., 2005; Miranda et al., 2003). Additionally, there are intangible (non-monetary) measurables from participation to be considered, such as increased natural, social, and physical capital (Bremer et al., 2014; Grieg-Gran et al., 2005; Kosoy et al., 2007). In the SocioPáramo program, low opportunity costs and high participation rates resulted in positive financial outcomes, which were in turn invested in the improvement of natural and social well-being outcomes (Bremer et al., 2017; Farley et al., 2014).

Funding from incentives payments were used to support ALP initiatives like sustainable agriculture or ecotourism (Bremer et al., 2014). Participants reported positive financial impacts from incentive payments, either through increased income from direct payments, or long-term benefits from investment in sustainable agriculture; payments have been increasing steadily since 2013 (Bremer et al., 2014; Jones et al., 2016). Communities enrolled in the program viewed SocioPáramo payments as modest but important for community project development (Bremer et al., 2014). Supplemental income from PES was invested in conservation, healthcare, education, and other basic needs, which helped increase intangible benefits in social, natural, and physical capital (Bremer et al., 2014; Grieg-Gran et al., 2005).

Improvements in natural and physical capital in the páramos have occurred as well. Increased carbon sequestration capacity in the grassland soils was noticed 3-4 years after burning practices ended (Bremer et al., 2014; Farley et al., 2014). In 2016 it was reported that those enrolled in the conservation incentives program reduced average annual deforestation in the páramos by as much as 70% between 2011 and 2013 (Jones et al., 2016). Many participants are choosing to invest in conservation due to the

reduced agricultural capacity of their lands (Bremer et al., 2014; Farley et al., 2014; Jones et al., 2016). Ongoing investments are financing organic agriculture and agroforestry projects, while infrastructure development for ecotourism and aquaculture are adding to restoration efforts (Farley et al., 2014; Jones et al., 2016).

According to reports and studies on the SocioPáramo program, the crucial element for success is strong social networks and local community support in conjunction with financial returns (Bremer et al., 2014; Farley et al., 2011; Jones et al., 2016). Studies found building capacity and strengthening networks within organized community social structures provides the greatest potential outcome for improving social, financial, and natural benefits (Bremer et al., 2014; de Koning et al., 2011; Grieg-Gran et al., 2005; Miranda et al., 2003). The findings from the SocioPáramo example suggest that two ways for indigenous community-based PES programs improve equity and livelihood are through strengthening social networks and developing economic alternatives (Bremer et al., 2014; Farley et al., Grieg-Gran et al., 2005; 2011; Jones et al., 2016).

### *Costa Rica*

The BriBri of Costa Rica are a well-organized indigenous community in the Yorkin Indigenous Reserve in the Talamanca region of southern Costa Rica. They have autonomous community sovereignty, similar to Oaxaca. They manage a successful ecotourism program, accessible only by riverboats operated by indigenous guides, followed by a hike to the community (Cusak & Dixon, 2006). The Bri-Bri work in partnership with ANAI, an “umbrella” regional NGO in Costa Rica.

ANAI has been working in the Talamancan region for over 40 years and through their conservation strategy, the Talamancan Initiative, they support the integration of biodiversity, conservation, and sustainable socio-economic development for the indigenous communities in the Talamancan region (ANAI, 2020). Similar to our client in Oaxaca, but on a larger scale, this region-specific NGO partners with local communities and smaller local NGO's (typically founded and managed by indigenous communities) to facilitate transparency and momentum of ALP's and conservation programs (Cusak & Dixon, 2006; ANAI, 2020). ANAI also supports the community through managing marketing and organizing eco-tours (Cusak & Dixon, 2006).

PES is managed through a specific conservation fund set up as a separate bank account that visitor deposit their payments into (Cusak & Dixon, 2006). Money is not directly exchanged in the village, and the payments are distributed as salaries and supplies (Cusak & Dixon, 2006).

Although this sounds like an ideal scenario, there is potential to reduce empowerment within the communities and encroach on their identity as an autonomous entity (Anthias & Radcliffe, 2015; Coria & Calfucura, 2012). As an umbrella NGO in the region, there are opportunities to connect communities in an overarching program, and their discussion alludes to that in their project plans (ANAI, 2020). In an ongoing effort to reduce poverty, increase conservation, and preserve indigenous identity, we must be cognizant of crossing the line from empowerment to commodifying them (Coria & Calfucura, 2012; Delgado-Serrano et al., 2017; Grieg-Gran et al., 2005; Ruiz- Mallén et al., 2015).

### *Honduras: The Mesoamerican Biological Corridor Project*

Twenty communities spanning Honduras and Nicaragua as part of the Mesoamerican Biological Corridor (MBC) have created a participatory community-based conservation program (Jansen, 2018). This program is significant three ways: 1) it is transboundary, 2) there is a high rate of female participation and leadership, and 3) the quantity of communities participating (Delgado-Serrano, 2017; Grieg-Gran et al., 2005; Jansen, 2018). The project is part of the largest continuous stretch of protected rain forest in Central America, covering 35,000 km<sup>2</sup> (Jansen, 2018).

The project is structured as an advisory council, represented by leaders from each community. It is based on three core processes: conservation through ALP's, education and skills training, and establishing local and binational channels to align public institutions with local and indigenous organizations (Jansen, 2018). How these principals play out differs within each community and region, based on governance, natural resources, conservation needs, and available funds (Jansen, 2018).

In 2016 a joint management agreement was signed for the Rio Platano Biosphere Reserve in Honduras (Jansen, 2018). Project representatives assisted with dialogue between the Honduran Forestry Authority, ICF, and the Miskitu indigenous organization MASTA, which resulted in negotiating a strategic alliance that empowered the community (Delgado-Serrano, 2017; Farley et al., 2007, Jansen, 2018). A positive return from the agreement is maps of six areas in the Miskitu territory, created from collaborative efforts with the local indigenous participants. The maps are used for region-specific development planning and land usage agreements between territories (Jansen, 2018). Having recently been granted land titles, the maps help with local governance of territories and natural resource management within the Rio Platano Biosphere Reserve (Jansen, 2018).

The Rio Plantano agreement spearheaded a new legislative bill in Honduras that mandates consultation with indigenous communities, including provisions to protect their values and rights, as they pertain to Honduran forestry regulations (Jansen, 2018; USAID, 2020). The MBC project also established sustainable standards for NTFP products harvested by the Pech people as one of their ALP's. The standards resulted in a 43% income increase for resin collectors, and a fairer prices for producers. Lastly, the MBC project assisted the Pech people in protecting their land rights when the Honduran government planned to designate a key area of NTFP into a national park. Practicing collective action through the MBC project, negotiations led to the Honduran Parliament to designating the area an anthropological forest reservation (de Koning et al., 2011; Jansen, 2018).

Although this case study is large scale, it illustrates the capacity and capability of communities to form alliances in support of conservation and alternative income programs (Delgado-Serrano et al., 2017; Ruiz- Mallén et al., 2015). These case studies exemplify positive outcomes, however, it is important to recognize and anticipate challenges when implementing community-based conservation programs (Delgado-Serrano et al., 2017; Grieg-Gran et al., 2005; Ruiz- Mallén et al., 2015). Furthermore, the communities involved in these projects have a significant learning curve; they will need guidance through processes and challenges projects (Delgado-Serrano et al., 2017; Grieg-Gran et al., 2005; Ruiz- Mallén et al., 2015).

## 1.4 Conservation Corridors

The idea of a “biological corridor” was developed by meta-population ecologists to address the threat of habitat fragmentation on wildlife populations (Hanski, 1998). Habitat fragmentation, the breaking up of a species’ habitat into separate and isolated patches by human disturbances, can increase genetic subdivision, promote inbreeding, reduce genetic diversity within populations and constrain available range and resources for individuals (Gilbert-Norton et al., 2010; Mallegowda et al., 2017). Moreover, isolated populations also face a higher risk of extinction and are less resilient to expected range shifts caused by climate change (Keyghobadi, 2007).

In response to habitat fragmentation, protection and restoration of habitat corridors have become commonly adopted conservation tools (Fahrig, 2003; Shepherd & Whittington, 2006; Gilbert-Norton et al., 2010). “Corridors” often refer to linear habitat features connecting remnant habitat patches to facilitate the movement of species between patches. Corridors can contribute to the health of wildlife population by promoting colonization and genetic flow between patches, increasing total available habitat for individuals, and rescuing populations on vulnerable patches from extinction (Tewksbury et al., 2002; Pardini et al., 2005).

Most notably, the Mesoamerican Biological Corridor (MBC) is a cooperative program between Central American countries and Mexico to address ecosystem and habitat fragmentation, regional degradation, and their environmental and social implications (Lopez and Jimenez, 2007). MBC’s land-use planning features areas under different administrative arrangements, including core natural areas, buffer zones, multiple use zones, and corridor areas. Recognizing the importance of poverty reduction and providing socioeconomic benefits to local populations to ensure the effectiveness of future conservation actions, the project provides opportunities for people to participate and promote investment in the conservation and sustainable use of natural resources to improve the quality of life for the Mesoamericans (Miller et al., 2001; Lopez & Jimenez, 2007).

The state of Oaxaca is a biodiversity hotspot in itself, and the range-wide Latin America jaguar corridor mapped out by *Panthera* crosses through the state (Zeller et al., 2013). Five hundred and eighty terrestrial vertebrate species in Oaxaca are listed within a risk category in the Mexican Red List, the Red List of IUCN and in the appendixes of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Representative endangered species present in the state include jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), anteater (*Tamandua mexicana*) and tapir (*Tapirus bairdii*) (Shapiro-Garza et al., 2019). Maintaining and enhancing habitat connectivity through community-managed biological corridors can shield those species from the threats of illegal logging, poaching, and forest clearing for agriculture (Shapiro-Garza et al., 2019).

## 1.5 Description of the Project Site

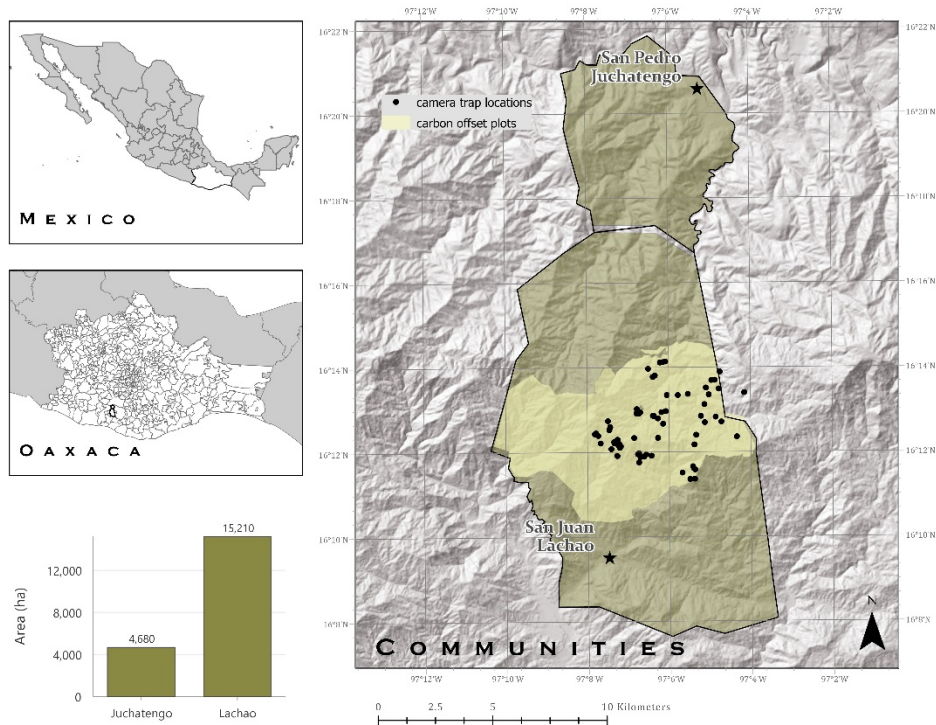


Figure 1.1: Study area of San Juan Lachao and San Pedro Juchatengo with a hillshade background. The black dots represent locations where camera trap data were collected. Boundaries of Lachao's carbon offset plots are also highlighted in yellow.

Figure 1.1: Study area of San Juan Lachao and San Pedro Juchatengo with a hillshade background. The black dots represent locations where camera trap data were collected. Boundaries of Lachao's carbon offset plots are also highlighted in yellow.

### 1.5.1 Geography, Climate and Biome

San Juan Lachao (Lachao) and San Pedro Juchatengo (Juchatengo) are both small indigenous Chatino communities in the Sierra Madre del Sur Oaxaca, a large massif spanning southern Oaxaca that is historically indigenous Zapotec and Chatino territories. Juchatengo is 145 km from the capital city of Oaxaca, and Lachao is little farther south at 192 km. Both communities are accessible via highway 131 which carries tourists directly from the capital city to the port and tourist destination Puerto Escondido on the Pacific Coast.

Mountain chains running from the Gulf of Mexico and the Pacific Ocean converge to create an abrupt topography in the region, producing a wide range of microclimates, soil types, and ecosystems (Chapella, 2005; Sanchez et. al, 2018). The terrain is very mountainous and elevations climb quickly. Juchatengo is at a lower elevation of 860 meters while Lachao is at 2,034 meters. The Balsas River, one of Mexico's longest rivers and known locally as the Atoyac, connects the two communities and passes through the town center of Juchatengo.

The area hosts a warm and sub-humid climate, with an average annual temperature of 22°C and precipitation of approximately 685 mm per year (Dilley, 1995). Seasons in Oaxaca vary between dry and wet; the rainy season runs generally from May to September. Because of the mountainous terrain, there

is high elevational and ecological variability between the two communities. Elevation ranges from 484 to 2,324 meters; this variability creates distinct environmental conditions and therefore ecosystems.

Oaxaca is notable for its high elevation and high precipitation cloud forests, comprised mostly of *Pinus* and *Quercus* species. At mid-elevations, *Pinus* and *Quercus* also dominate, mixed with highly diverse tracts of hardwood. These hardwood forests extend to the valley bottom, interspersed with shrubs, pasture, and agricultural land. Jucahtengo is mountainous and arid with medium to low density forest cover. By contrast, Lachao's terrain is much steeper with deep valleys and high peaks, cloud forests, waterfalls, with very dense forest.

### 1.5.2 Socioeconomic profile

#### *Oaxaca*

Oaxaca is considered one of the bottom ranking socio-economic states in Mexico, along with Chiapas and Guerrero (Sanchez et. al, 2018; Aguilera, 2019, OECD, 2019). Part of the southern region that had been emblematic of the country's developmental divide, it has the highest rates of poverty, with 28% living in extreme poverty, and the lowest educational outcomes in the country (Cassteneda 2017; OECD, 2018; Sanchez et. al, 2018; Aguilera, 2019; OECD, 2019). Oaxaca's industry base of employment throughout the state is very low, with limited change or growth since 2004 (INEGI, 2015; Sanchez et. al, 2018).

Topography and cultural characteristics are key factors in poverty and lower levels of socio-economic development of the state (Pavón, 2014; Aguilera, 2019). Most of the region is traversed by the rugged Sierra Madre mountain range with minimal infrastructure, which can isolate communities (Sanchez et. al, 2018). This isolation can obstruct economic activity by keeping populations small and rural, which reduces knowledge, technology transfer, and the ability to support multi-firm employers (Sanchez et. al, 2018). This results in a low productivity, generating few economic activities that can provide returns and benefits (Hall and Patrinos, 2006; Pavón, 2014; OECD 2018; Sanchez et. al, 2018).

Known for its large diversity in indigenous and ethnic groups, languages, and government systems, Oaxaca has the highest concentration of indigenous populations in the country. The state consists of 18 different groups and 58% of the population in Oaxaca speaks an indigenous language, compared to Mexico's national average of 15% (INEGI, n.d.; CDI, 2015, Sanchez et. al, 2018). For every 100 inhabitants, 66 are considered indigenous, and the average level of education of the indigenous population is 5.4 years (INEGI, n.d.; DIGEPO, 2018). While this diversity of language and culture is a defining characteristic and a heritage worth preserving, it can further contribute to community isolation, reduce transfer of knowledge, and impact socio-economic development based on traditional markets (de la Torre, 2018; Sanchez et. al, 2018).

#### *Community Governance*

Like several indigenous municipalities in Oaxaca, both communities are governed under an autonomous, community-based land tenure program referred to as "Ejidos", based on indigenous land rights, customs, and practices (usos y costumbres) which date back to pre-colonial times (Bray et. al, 2002; Barnes, 2009; Pavon, 2014; REDD +, n.d.). Ejidos are recognized as legal communal municipalities, collectively owning the land through formally acquired land grants (Barnes, 2009; Mathews, 2002; REDD+, n.d.). The lands are pooled and worked primarily via agriculture, in which community members farm designated plots and collectively maintain communal holdings. Each area is somewhat defined by

borders dating back to the pre-colonial era; however, not all official boundaries align with what community members define as their rightful lands (Seler, 1905; McBride, 1923; Barabas, 2014; Pavon, 2014; de la Torre 2018).

The communities are recognized for their specific governance systems through which they facilitate and democratize decision making while minimizing internal conflicts (Pavón, 2014) Within Ejidos are three primary governing bodies: 1) the General Assembly (*Asemblea*), 2) the Commission (*Comisariado*), and 3) the Supervisory Council (*Consejo de Vigilancia*) (Barnes, 2009). The ultimate authority in the Ejido is the General Assembly, through which decisions are made by majority vote (Barnes, 2009; Bray, 2006). The Commission, or *Comisariado*, is the executive branch, with elected officials carrying a three-year term. The Supervisory council ensures decisions taken at the General Assembly are enacted and consistent within the Ejidos (Barnes, 2009).

### *Communities*

San Juan Lachao and San Pedro Juchatengo are small indigenous communities in the south western indigenous Zapotec and Chatino region of Oaxaca and are part of the Juquila District in the Sierra Sur and Costa regions. Both are accessible via highway 131 which carries tourists directly from the capital city to the port and tourist destination Puerto Escondido on the Pacific Coast. This creates a more favorable position for economic growth and extreme poverty aversion versus other indigenous communities in less accessible regions (Sanchez et. al, 2018). Comparatively speaking, both communities fall in the mid-income per capita range compared to similar communities in other areas of the state (CONEVAL, 2010; Sanchez et. al, 2018).

Subsistence farming of corns and beans is the principal means of livelihood in both communities, with some farmers engaging in coffee and honey production and timber sales. Ecotourism in Lachao and small scale “stopover” tourism and small-scale aquaculture in Juchatengo provides some additional income sources (INEGI, 2015; Nickerson, 2017). Current alternative sustainable income projects that are underway include Carbon sequestration, sustainable forestry, ecotourism, water bottling, and small-scale coffee production in Lachao, and Non-Timber Forest Products (NTFP), principally the harvesting of Copal sap, in Juchatengo (ICICO, pers. Comm.).

### *Demographics and Characteristics*

San Juan Lachao is approximately 3.5 times larger than San Pedro Juchatengo in area and approximately 2.5 times larger in population. In both communities there are more women than men, typically because men migrate away from the communities for work; the women out rank the men in terms of being actively employed (Table 1.1) (INEGI, 2015). Juchatengo retains a higher education rate than Lachao, however that might be due to the fact that very few people in Jucahtengo speak the indigenous Chatino language, even though half of the population is registered as indigenous; whereas in Lachao over half the population speaks Chatino, a majority of them speaking Chatino exclusively. In both communities the education rate drops drastically after the age of 14 (INEGI, 2015).

As of 2010, Lachao had 15,210 ha of land area and a population of 4,531. Juchatengo had 4,680 ha with a population of 1,693. Respectively, 10.5% and 30% of the population were classified as “vulnerable for social deprivation” by the Mexican National Institute of Statistics and Geography (INEGI). As part of the Zapotec and Chatino region, both communities have a high percentage of populations identified as indigenous (88.73% at Lachao and 50.67% at Juchatengo). Both communities also have a strong

conservation ethic as they have each set up community conservation areas for the protection of forest and wildlife.

Between the communities, there is a longstanding establishment of borders and land holdings that dates back to the precolonial era; however, there are still discussions and considerations today about the tenure of sacred places and territorial boundaries, whether passed down by word of mouth through the generations, or from actual documentation (Figure 1.2) (Seler, 1905; McBride, 1923; R. Perez, pers comm. August 7, 2019). We take this into consideration in our approach, as the culture must be respected and included, in conjunction with the environmental conservation we are pursuing with this project.

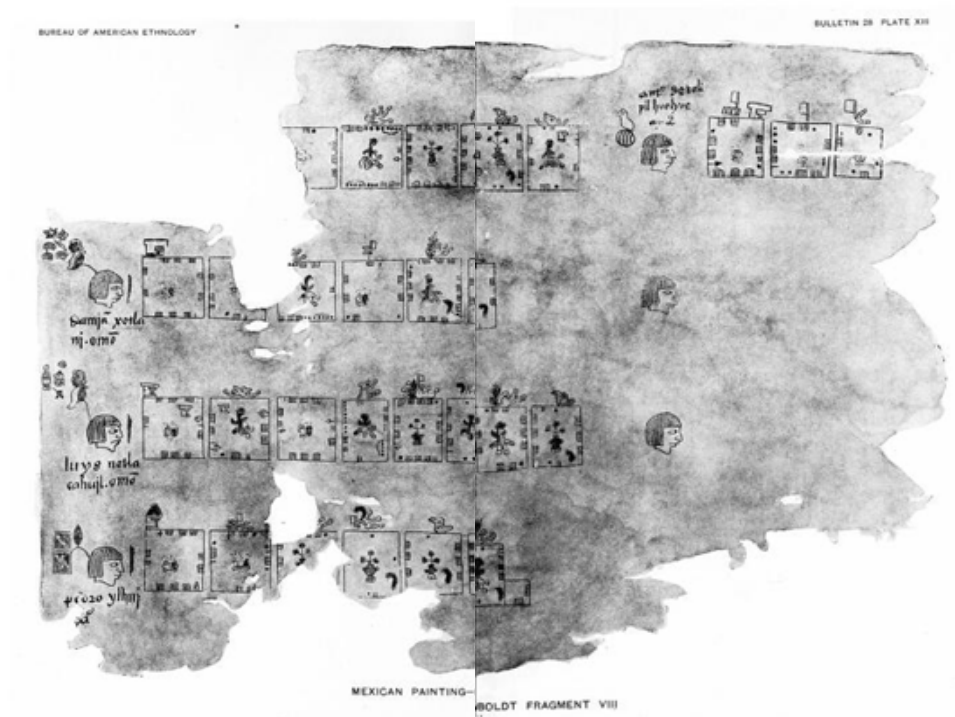


Figure 1.2: Representational drawing taken from original documents of pre-colonial Aztec land distributions per head of family, indicated by hieroglyphs representing the family name underneath the drawing of a man's head, representing the head of the family. Rectangles with hieroglyphs to the right of the head drawings denote the plots, distributions, and functions of the plots (Seler, 1905).

Table 1.1: Total Population, Total Male Population, and Total Female Population are from 2010 (the most recent population census). All other statistics in the table are from 2015 (INEGI, 2020).

Community Population Demographics		
	San Juan Lachao	San Pedro Juchatengo
Total Municipal Area	209.68 km <sup>2</sup>	57.68 km <sup>2</sup>
Total Population	4,531	1,693
Registered Indigenous	88.73%	50.67%
Speaks Chatino Indigenous Language	1,931	26
Total Male Population	2,159	807
Total Female Population	2,372	886
Men Economically Active Employed	98%	99.7%
Women Economically Active Employed	100%	100%
Men Economically Active	79.2%	68%
Women Economically Active	20.8%	32%
Women as Head of Household		
Children in School Ages 6-11	87.1%	98.9%
Children in School Ages 12-14	87.9%	92.8%
Children in School Ages 15 Plus	12.3 %	33.5%

San Pedro Juchatengo, though smaller than San Juan Lachao, has a vibrant town center and lively atmosphere. As one of the main stop-over locations for tourists traveling from the capital city to the coastal resort town of Puerto Escondido, there are a few small hotels, a large tourist square, small cafes and shops. Large tourist buses stop in the market square daily, and the main thoroughfare stays relatively busy. Juchatengo hosts many events throughout the year from pilgrimages to rodeos, sports leagues to holiday festivals. It is said there are more event days than non-event days in the community. Saturday evenings are announced through the ringing of church bells for several minutes, followed by a small display of fireworks. The town is proud of its safety, vibrancy, and congeniality. Additionally, the Atoyac river becomes expansive as it reaches the community, and is a source of family picnics, fishing,

swimming, and recreation for residents and visitors alike. It is relatively straightforward to navigate throughout the community; the town square has a community sports area, a large library, and town hall.

Larger and less densely populated than Juchatengo, Lachao offers a serene mountainous landscape with waterfalls, cloud forests, and dense forest cover. There is also a town square with shops and a few market stalls. Lachao is a less frequent tourist compared to Juchatengo. Visitors go to Lachao to experience flora and fauna, natural settings, hiking, and ecotourism. Lachao is a quiet community steeped in indigenous culture, its members a bit more deliberate and focused on the wellbeing of their surroundings.

#### *Sources of Employment and Income*

Both communities rely on subsistence farming and some large-scale crops such as corns and beans. Juchatengo's economy is boosted by small tourism and aquaculture and many families have cafes and small supply stores in front of or next to their homes. Both communities have programs for alternative sustainable livelihood income (ASL); however, Lachao has four main programs that have been in operation cumulatively over the past decade, while Juchatengo just has one. The programs in Lachao are water bottling, carbon sequestration, sustainable forestry, and ecotourism. Juchatengo recently (within the past 5 years), started a non-timber forest product (NTFP) program harvesting Copal sap from the numerous Copal trees in their highlands.

## 2. Part One: Species Habitat Modeling and Corridor Design

### 2.1 Abstract

Situated in the biodiversity hotspot of Oaxaca, San Juan Lachao and San Pedro Juchatengo boast an impressive collection of faunal species. Protecting these animals is critical to both prevent extinction and support the communities' cultures and economies. In our study, we focused on six species – white-tailed deer, jaguarundi, ocelot, puma, peccary, and coati – to locate potential conservation areas and generate a corridor to connect them. Using camera trap observations collected by community members, remotely sensed data, and information gathered in the field, we employed statistical models to map the distribution of each focal species based on probability of occurrence. We then prioritized conservation areas by selecting sizable regions with overlapping distributions. Finally, we calculated least cost paths to find an optimal corridor site. To facilitate future studies, we also classified a highly accurate land use land cover map for the region. Our results identified two priority conservation areas in Lachao totaling 2,774 ha. In future studies, we recommend adjusting the camera trap protocol to extend into Juchatengo and focus on potential conservation areas that have not yet been observed. Additional environmental variables collected at the camera trap sites would also likely markedly improve our distribution models.

### 2.2 Introduction

Understanding wildlife distributions throughout the study area is an important goal for San Juan Lachao and San Pedro Juchatengo. Wildlife populations have significant economic, cultural, and ecological value for the communities. Healthy populations of wildlife species can influence the prevalence of ecotourism

and food availability, in addition to supporting unique cultural identity. Here, we incorporate camera trap images, geospatial data, and environmental variables to better understand the wildlife distributions within the communities and identify suitable habitats for establishing an effective conservation corridor.

ICICO and Lachao established camera trap monitoring in 2015 to quantify species composition, identify important ecological areas, and develop a land corridor connecting the community of Lachao with Juchatengo. Within the corridor, land would be protected to maintain healthy wildlife communities and promote sustainable use. Lachao is currently focused on improving their camera trap methods to achieve greater success capturing focal species within their boundaries. Following the general successes of Lachao's camera trap efforts, Juchatengo intends to establish a camera trap protocol.

Within the community of Lachao, the camera traps have captured evidence of several wildlife species, including the puma, ocelot, white-tailed deer, peccary, coati, spotted skunk, and anteater. According to the Official Mexican Standard (SEMARNAT NOM-059, 2010), many of the species recorded by the camera traps are threatened or in peril of extinction, such as the ocelot, jaguarundi, anteater, and golden eagle. The ocelot is also classified under CITES Appendix I, the species that are threatened with extinction and prohibited from international trade (CITES, 2019). Within Lachao, community members regard many of these species as culturally or economically significant.

Through collaborations with ICICO representatives, we identified focal wildlife species based on their occurrence in the camera trap photos, and their ecological, economic, and cultural importance. ICICO and Lachao community members are particularly interested in promoting charismatic and economically and ecologically important species, including feline species like the puma (*Puma concolor*), ocelot (*Leopardus pardalis*), and jaguarundi (*Puma yagouaroundi*). Additionally, we selected the white-tailed deer (*Odocoileus virginianus*) because it is a culturally important species. Finally, the coati (*Nasua narica*) and peccary (*Pecari tajacu*) were selected as focal species because, with the white-tailed deer, they are some of the most popular prey species for cats within the area and for local hunters (Soria-Diaz et al., 2018; Aranda & Sanchez-Cordero, 1996). With the prey species distributions, predator presence can be inferred within the study area (Nordberg & Schwarzkopf, 2019).

Our study assessed occurrence of the focal species within the communities and determines the environmental drivers of occurrence. We were also able to test whether high-resolution satellite imagery can yield a reliable classification product in a data poor region. We incorporated our land cover map with other environmental variables and historical presence data to determine species distribution within the boundaries of Lachao and Juchatengo. With this information, we were able to delineate areas of high-biological importance for the focal species within the communities.

## 2.3 Methods

### 2.3.1 Data

#### *Field Data*

Field data were collected by our team, ICICO, and community technicians in the summer of 2019. At 60 locations throughout the communities, 15-m fixed-area plots were established to measure environmental parameters such as land cover type, basal area, canopy cover, and trees per acre. We

also collected geo-reference points at agricultural sites to improve our land use land cover classification (Figure 2.1).

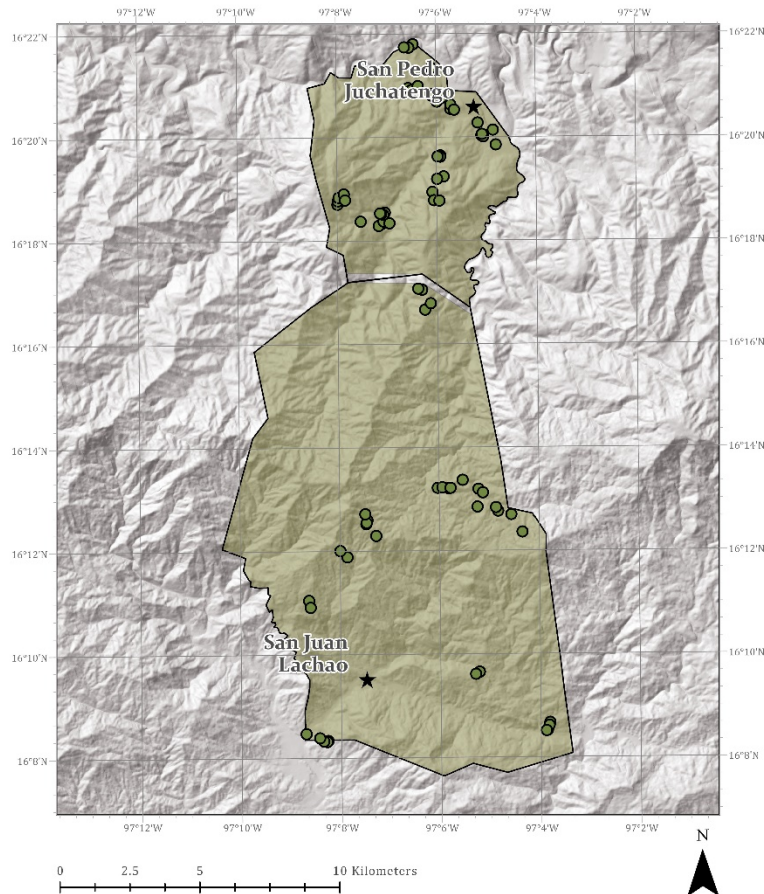


Figure 2.1: Location of geo-reference points used in land use land cover classification.

### Terrain

National elevation data were made available through INEGI (*Continuo de Elevaciones Mexicano (CEM)*, n.d.). These data were 15-meter resolution and used to generate other explanatory variables to model habitat, including aspect, slope, and streamlines. We calculated both aspect and slope in degrees, then transformed aspect to indicate north-ness (1) and south-ness (-1). The streamlines were delineated by calculating flow accumulation and thresholding values above 300 pixels. INEGI's private access stream layer was used for reference when creating the threshold (*Mapa Digital de México en línea*, n.d.).

To quantify variability in terrain, we used the Topographic Ruggedness Index, or TRI (Riley et al., 1999). This variable evaluates the elevation of surrounding pixels to determine how “rough” a particular grid cell is.

### Distance Parameters

We calculated the distances to streams, urban areas, and roads using Euclidean distance. Urban areas in Lachao and Juchatengo were categorized in the 10-meter ESA classification map, which captured only the most urbanized areas of the communities (i.e. the town centers). However, there were several clusters of homesteads visible in the satellite imagery that were classified as bare areas. Because of this, we used both the urban class and the bare class to define urban areas.

The DEM-derived streams served as the reference for determining distance to water. We downloaded data on major roads in the communities from OpenStreetMap (*Geofabrik Download Server*, n.d.).

### NDVI

To calculate NDVI, we used RapidEye imagery (Planet Team, 2017). For the NDVI inputs, we used bands 3 as red and 5 as infrared (NIR). The index was calculated as follows (Rouse et al., 1974):

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

### Camera Trap Data

The community of Lachao placed 25 camera traps throughout the central eastern portion of their territory from December 2015 to October 2019 (Figure 1.1). Local technicians intentionally placed the traps within Lachao’s carbon offset plots and sustainable forest management areas to assess the impacts of selective cutting on wildlife. Traps were set in locations with evidence of wildlife activity, such as trails, prey sites, or tracks. If animals were detected, the traps were left in place for up to six months. The traps were moved after one month if no animals were observed.

The Lachao community provided the data in two forms: a presence-only matrix which listed species observed by date, location, and camera, and as photos and videos stored in dated folders. We looked at each provided photo and video to identify the species and number of individuals present. To avoid pseudoreplication, photos and videos taken within one hour at a camera trap location were considered a single record (Perez-Irineo & Santos-Moreno, 2016). We compiled the information from each camera trap location into a matrix with the number of individuals observed of each species.

Table 2.2: Summary statistics of camera trap positions (n = 67). There were 41 sites in pine-oak forest, 37 sites in cloud forest, and 4 sites in low-lying hardwood forest.

	Minimum	Maximum	Mean	Standard Deviation
Elevation	1,454.0 m	2,039.0	1,771.4	114.5
Slope	2.1	50.6	23.4	11.2
Aspect	-1	1	-	-
Road distance	35.1 m	4,737.5	1,578.6	1,289.7
Stream distance	0.0 m	349.4	118.4	89.4
Urban distance	45.0 m	3,894.5	1,353.5	1,019.3
Ruggedness	9.4	119.7	52.0	24.5

Table 2.3: Total number of observations used to model species presence-absence.

Species	# of observations	Species	# of observations
White-Tailed Deer	50	Puma	24
Coati	41	Jaguarundi	5
Peccary	33	Ocelot	25

### 2.3.2 Forest Type Mapping

Oaxaca, including the region encompassing Lachao and Juchatengo, is data poor. Little high-resolution data exist regarding land cover type, land use, or species presence. Generalized land cover data has recently become available through the European Space Agency (ESA, 2018); however, there is only one broad class for forest cover. Because the communities' species of interest are found in and along forested areas and exhibit preferences (Monroy-Vilchis et al., 2009; Perez-Irineo & Santos-Moreno, 2014; Giordano, 2015; Soria-Diaz & Monroy-Vilchis, 2015), we needed to classify unique forest types. Throughout Oaxaca, forest classes include: montane forest, tropical forest, tropical dry forest, tropical semideciduous forest, pine forest, oak forest, and pine-oak forest (Gómez-Mendoza et al. 2008).

Presently, there are a variety of high-resolution satellites that provide valuable and accessible data for forest classification (Table 2.1). We collected all satellite images freely (USGS, ESA) and through an online education and research program (Planet Team, 2017). Using these different sources, we conducted a systematic forest type classification comparison to find the most accurate product. In order to compare the resulting land use land cover (LULC) classifications, we selected imagery from the late dry season (February – March 2019), assuming that this period would maximize spectral differences between deciduous and evergreen forests.

Table 2.1: Satellite imagery sources and information.

Satellite	Source	Resolution (m)	Number of Bands	Open Source
Landsat 8	USGS	30 (15, 100)	11	Yes (USGS)
Planet	Planet	3	4	No (Planet)
RapidEye 3A	Planet	5	5	No (Planet)
Sentinel-2	ESA	10 (20, 60)	13	Yes (ESA)

The 10-meter LULC map, published by ESA in 2018, defined major classes of naturally occurring cover, such as grassland and shrubs, as well as urban areas and agricultural land. It also indicated an area of tree cover but did not specify species composition. Using this map as a basis for non-forest classes, we re-classified the tree-covered regions with other satellite imagery (Table 2.1). Field data informed our definition of different forest classes and helped delineate the training polygons used for supervised classification. We also downloaded the National Institute of Statistics and Geography's (INEGI) 15-meter Digital Elevation Model (DEM) dataset to create an elevation band. The topography of the study area is

highly variable, so we assumed that incorporating elevation would improve classification accuracy. In total, we created 12 classifications using 4 different sources of satellite imagery. We selected the map with the best accuracy and resolution as the final re-classified product.

### *1. Exploratory Analysis*

The land cover classes were determined from the field data. Initially, forest cover types included pine, oak, mixed pine-oak, cloud, and low-lying hardwood. However, distinct pine and oak classes were combined as pine-oak because the focal wildlife species do not exhibit a preference between the two (Di Bitetti et al., 2005; Soria-Diaz et al., 2016). With ENVI software (version 5.5; 2018), we generated spectral scatterplots and calculated separability indices to confirm that the final classes were distinct enough for accurate classification. The uncombined classes were not sufficiently separable in initial analyses.

### *2. Preprocessing*

The polygons used to train the classification algorithm and assess accuracy were derived from the 60 data points collected in the field. To create training and accuracy polygons from the field points, we generated a 15-meter buffer around each point. Seventy-five percent (n=45) of these data were randomly assigned as training polygons, while 25% (n=15) were used for accuracy assessment.

Landsat 8 Level-2 imagery and Planet Surface Reflectance (SR) Product were provided with completed radiometric and atmospheric corrections. The images were spot-checked for artifacts or other satellite abnormalities. RapidEye 3A imagery required radiometric and atmospheric corrections. We performed radiometric calibration and atmospheric correction using the Quick Atmospheric Correction (QUAC) model in ENVI (2009). Lastly, the Sentinel-2 1C product came radiometrically corrected but required atmospheric correction using ESA's Sen2Cor product (version 2.8; 2019) at default settings.

In order to isolate areas to be classified, the ESA land cover map was resampled to the pixel size of each satellite. Once the layer was resampled, the non-forests classes were masked out from the satellite imagery. The DEM was also resampled and 'snapped' to the pixel size of each satellite. Sentinel-2 images also required resampling because of the variation in resolution between bands. Therefore, we pan-sharpened the 20-meter NIR bands to the 10-meter NIR band. For each satellite, the resampled DEM was stacked with the imagery bands to incorporate elevation into the classification.

### *3. Classification and Accuracy Assessment*

We performed three supervised classification techniques in ENVI with each satellite: maximum likelihood, minimum distance, and Mahalanobis distance. Maximum likelihood is based on the probability that a pixel belongs to a particular class (Al-Ahmadi & Hames, 2009) and is generally robust to small or weak sample sizes (Li et al., 2014). Minimum distance calculates the spectral distance between each pixel and the mean for each vector (Al-Ahmadi & Hames, 2009). Finally, Mahalanobis distance, similarly to minimum distance, computes spectral distance but with a covariance matrix and consideration for class variability (Al-Ahmadi & Hames, 2009).

The land classification training polygons were comprised of pine-oak, cloud, and low-lying hardwood forests, in accordance with forest types observed in the field. For all imagery, we set default specifications within the classification techniques. We generated confusion matrices for each satellite

image and supervised classification technique with the designated accuracy polygons. The matrices included overall accuracy of the classification, the Kappa coefficient, omission and commission errors, and the user and producer accuracies of each forest type. Our final classification map included: cloud forest; low-lying hardwood; pine-oak forest; shrubs; grassland; cropland; vegetation aquatic or regularly flooded; lichen mosses/sparse vegetation; bare areas; built up areas; and open water.

#### 4. *Postprocessing*

We obtained the best results using a majority analysis on the most accurate classifications of each satellite to remove speckle. For Planet, the kernel size was 31 pixels (93 m) and the center pixel weight was 3. Sentinel-2 had a kernel size of 5 pixels (50 m) and center pixel weight of 1. Landsat 8 had a kernel size of 5 pixels (150 m) and a center pixel weight of 1. For RapidEye, the kernel size was 9 (45 m) and the center pixel weight was 1. Majority analysis created some pixel gaps along edges, causing misalignment between the ESA LULC mask and our classification. To address this issue, we used focal statistics on our best classification (Planet) to find the majority class within a 31-pixel x 31-pixel window for each missing pixel.

### 2.3.3 Habitat modeling

#### 1. Abundance and occurrence modelling

The type of model used to map habitat depended on data availability. We first tried to model abundance for species with more than 20 observations, including white-tailed deer, coati, and peccary. However, the models explained very little of the variance in the data ( $R^2 < 0.10$ ). Therefore, we used logistic regression to model species occurrence of these species as well as puma and ocelot, for which there were few observations.

To model the abundance of the focal species for which we had adequate numbers of observations (peccary, coati, and white-tailed deer), we employed a generalized linear mixed effect model (GLMM) with a log-link and Poisson distribution, using the lme4 package (Bates et al., 2015). We incorporated random effects for each individual observation to address overdispersion ( $\phi > 2$ ). We, additionally, included an offset for effort (camera days per month) as each observation was aggregated by XY location, camera ID, and month of the year. After a review of available literature, we derived a list of potentially significant environmental variables for each focal species which we used as fixed effects. These included season, aspect, elevation, land cover, urban distance, stream distance, road distance, NDVI, topographic ruggedness, and slope.

To model occurrence probability of focal species, we employed a logistic regression using presence-absence data. All explanatory variables in this model were identical to the fixed effects in the abundance model. We employed backwards selection, successively removing explanatory variables with the highest p-value and comparing AICc and  $R^2$ , to find the best model. We used a significance level of  $p < 0.10$  for retaining variables in the final model.

To determine the optimal probability threshold for defining habitat versus non-habit, we created a ROC curve, which plots the change in true negative and positive classifications. Using the “max” method, we

chose the habitat threshold by maximizing true positive and true negative rates (Urban, 2019). A different threshold was generated for each species; each resulting value represented the minimum probability needed to classify an area as habitat. Potential available habitats identified for each focal species were spatially intersected to delineate the best possible biological areas within the community boundaries.

## 2. Rule-based modelling

Only four observations were made of jaguarundi, which is classified as threatened by the Official Mexican Standard (SEMARNAT NOM-059, 2010) and is a priority species for the study. Few data exist on the ecology and habitat preferences of the jaguarundi (Giordano, 2016; Perez-Irineo & Santos-Moreno, 2016); thus, we conducted a literature review, which was geographically restricted to Central America, to determine environmental variables thought to influence presence (de Oliveira, 1998; Charre-Medellin et al., 2011; Giordano 2016; Perez-Irineo & Santos-Moreno, 2016) and then created a rule-based model to estimate probable habitat within the communities. We identified important environmental conditions from the literature and selected areas exhibiting these conditions to identify potentially suitable habitat.

### 2.3.4 Site prioritization

The habitat-classified areas acted as weighted zones for the selection of priority conservation sites. We calculated priority values by adding the number of species occurring in a given area, essentially creating an overlay map of species. Each species was equally weighted with a value of 1 so that any areas with all species present equaled the total number of species. Given our low confidence in the jaguarundi and white-tailed deer habitat distributions, we used only coati, peccary, ocelot, and puma habitat as weights. Only a small region hosted all four species; therefore, we chose areas with two or more species present as potential sites. The two largest contiguous areas were selected as our final priority areas.

In three other prioritization scenarios, we adjusted the weights of the focal species to reflect different conservation priorities. For our second approach, we doubled the weights of prey species (peccary and coati). We then replicated this strategy for predator species (puma and ocelot). Finally, after conversations with ICICO, we also produced a scenario with double-weighted puma and peccary habitats. The resulting overlay maps allowed us to assess whether priority sites shifted dramatically under different conservation scenarios. We concluded that the site choices remained unchanged and continued to map a potential corridor between sites where species were weighted equally.

To generate a corridor connecting these two sites, we used the occurrence probability layers (produced previously during habitat modelling) to act as the cost surface. The cost calculation was formulated as follows:

$$\text{Cost} = \frac{1}{(P(\text{puma}) + P(\text{peccary}) + P(\text{coati}) + P(\text{ocelot}))}$$

Layers of cost distance to each site were created and then added together to determine least cost paths. We chose a cost threshold of 2,000 to delineate the area of the corridor.

## 2.4 Results

### 2.4.1 Land Use Land Cover Mapping

Of the imagery considered, the Planet classification produced the best result, with an overall accuracy of 95.1%. The cloud and low-lying hardwood forests had user accuracies of 100% and the pine-oak forest had a user accuracy of 93.6%. Some producer accuracies were lower, reaching 75.8% in low-lying hardwood forest, 83.5% in cloud forest, and 100% for pine-oak forests (Table 2.4). Maximum likelihood with majority analysis was the best classifier algorithm, which achieved these high percentages. The majority analysis improved overall accuracy by an additional 7%. The final classification product included all four Planet satellite bands and elevation data. Other classifiers used, which included minimum distance and Mahalanobis distance, also performed relatively well with respective accuracies of 73.2% and 84.4%.

Table 2.4: Confusion matrix for the maximum likelihood with majority analysis Planet classification product.

	User Accuracy (%)	Producer Accuracy (%)
<b>Cloud forest</b>	100	83.5
<b>Pine-oak forest</b>	93.6	100
<b>Low-lying hardwood forest</b>	100	75.8

### 2.4.2 Habitat Modeling

From available literature and the logistic regression models, we identified environmental variables that influence the probability of presence of the focal species (Table 2.5). The ocelot was most influenced by distance to streams, with probability of presence decreasing with distance from streams (Table 2.5). Similarly, the coati was strongly influenced by topographic ruggedness and elevation, with probability of presence increasing with increased topographic ruggedness and elevation (Table 2.5). For the puma and peccary, the wet season had a positive effect on probability of presence and increased the available habitat compared to the dry season.

We did not identify any drivers of the probability of white-tailed deer presence. Thus, we did not map its distribution. Similarly, the jaguarundi habitat map was not included in further analyses as it was based on a limited amount of literature and had no statistical significance. From the literature review, it was determined that elevation and land cover type are variables thought to determine occurrence of the species.

Table 2.5: Model results for ocelot, puma, peccary, and coati.

	Variable	Coefficient	Standard Error	Z	Prob.
<b>Ocelot</b>	<i>Distance to Roads</i>	-0.557	0.258	-2.16	0.0307*
	<i>Distance to Streams</i>	-23.3	6.09	-3.83	0.000128***
	<i>Elevation</i>	8.01	2.88	2.78	0.00536**
	$R^2 = 0.24$				

<b>Puma</b>	<i>Distance to Roads</i>	0.613	0.180	3.41	0.000651***
	<i>Season (Wet)</i>	0.884	0.495	1.79	0.0738*
	$R^2 = 0.15$				
<b>Peccary</b>	<i>Aspect</i>	-0.955	0.326	-2.93	0.00344**
	<i>Elevation</i>	3.45	1.63	2.12	0.0339*
	<i>Season (Wet)</i>	0.907	0.438	2.07	0.0384*
	<i>Distance to Roads</i>	-1.10	0.215	-5.13	2.88e-07***
	$R^2 = 0.26$				
<b>Coati</b>	<i>Elevation</i>	7.79	1.98	3.93	8.42e-05***
	<i>Topographic ruggedness</i>	28.8	9.55	3.02	0.00254**
	<i>Distance to Streams</i>	-7.42	2.55	-2.90	0.00370**
	$R^2 = 0.14$				

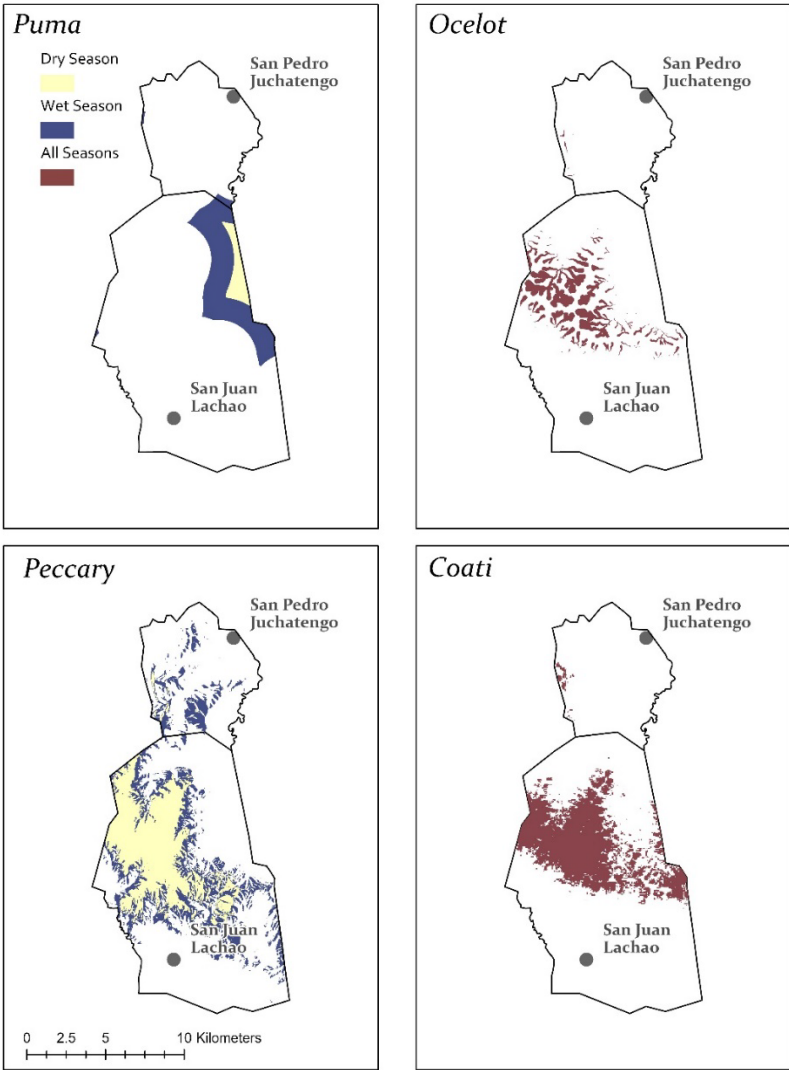


Figure 2.2 : Focal species habitat extents.

### 2.4.3 Site Prioritization

Our species overlay analysis revealed that only a very small area in Lachao hosts all four focal species. This region is confined to the central eastern portion of the community, totaling 7 ha in area. The patches hosting 2 or 3 focal species habitats are larger, occupying 3,286 ha and 1,161 ha, respectively (Figure 2.1). These areas traverse central Lachao from east to west. The ecosystems in this extent of the community primarily exhibit pine-oak and cloud forests and a high elevational gradient. Virtually no habitats overlap within Juchatengo or southern Lachao.

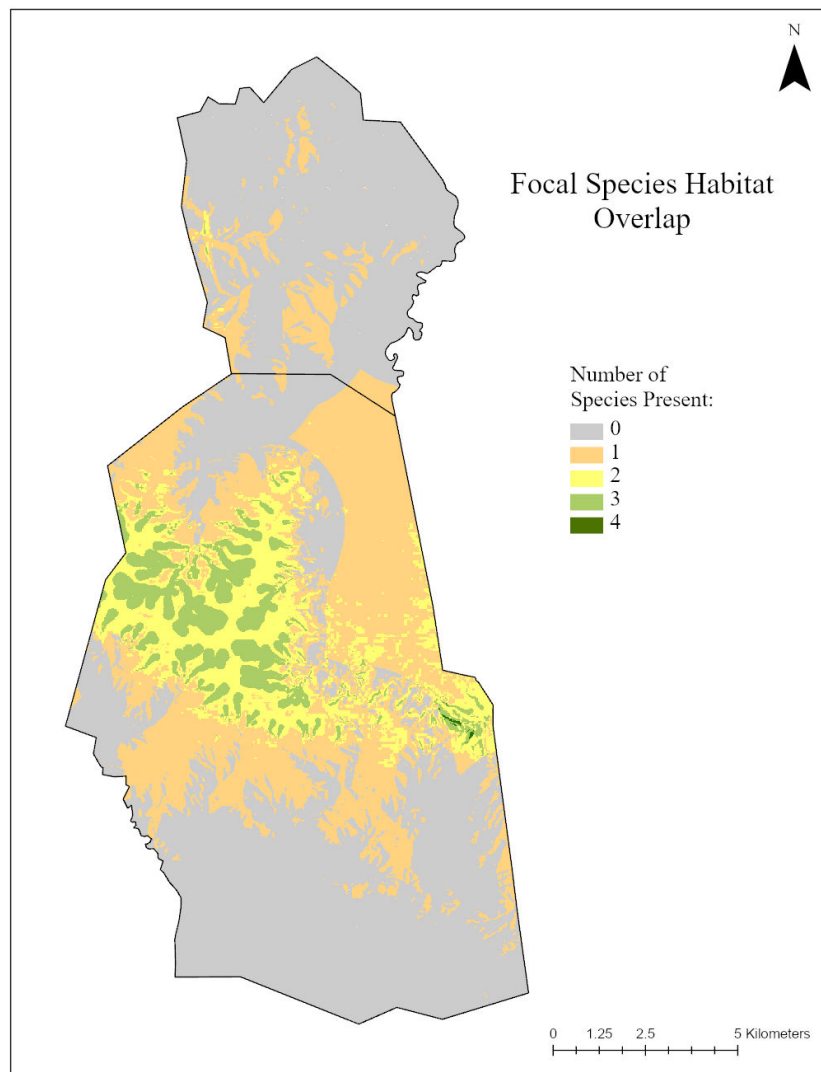


Figure 2.3: Areas where potential habitat overlaps within the communities' boundaries.

Double-weighting of prey species highlighted similar priority areas to the uniformly weighted overlay. Again, the highest priority areas extend east to west across Lachao (Figure 2.2). However, the western

zone appears more ecologically valuable than the eastern zone because the prey species (peccary and coati) occur most often in this area.

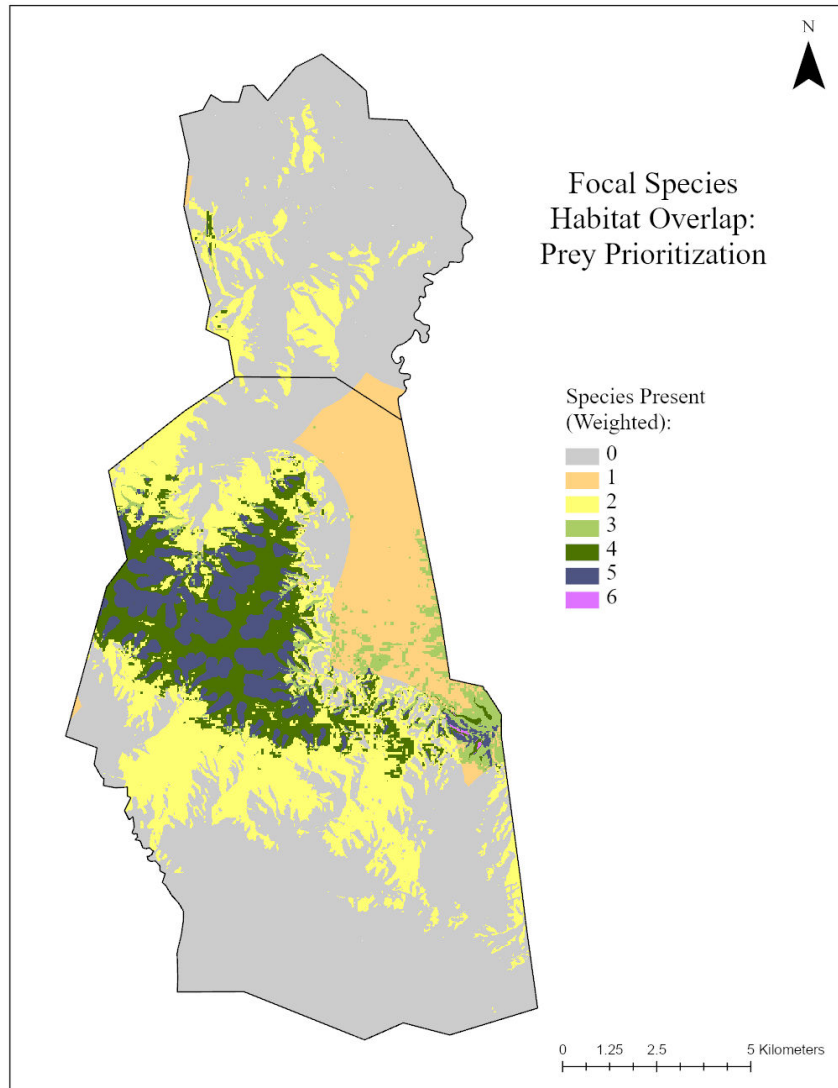
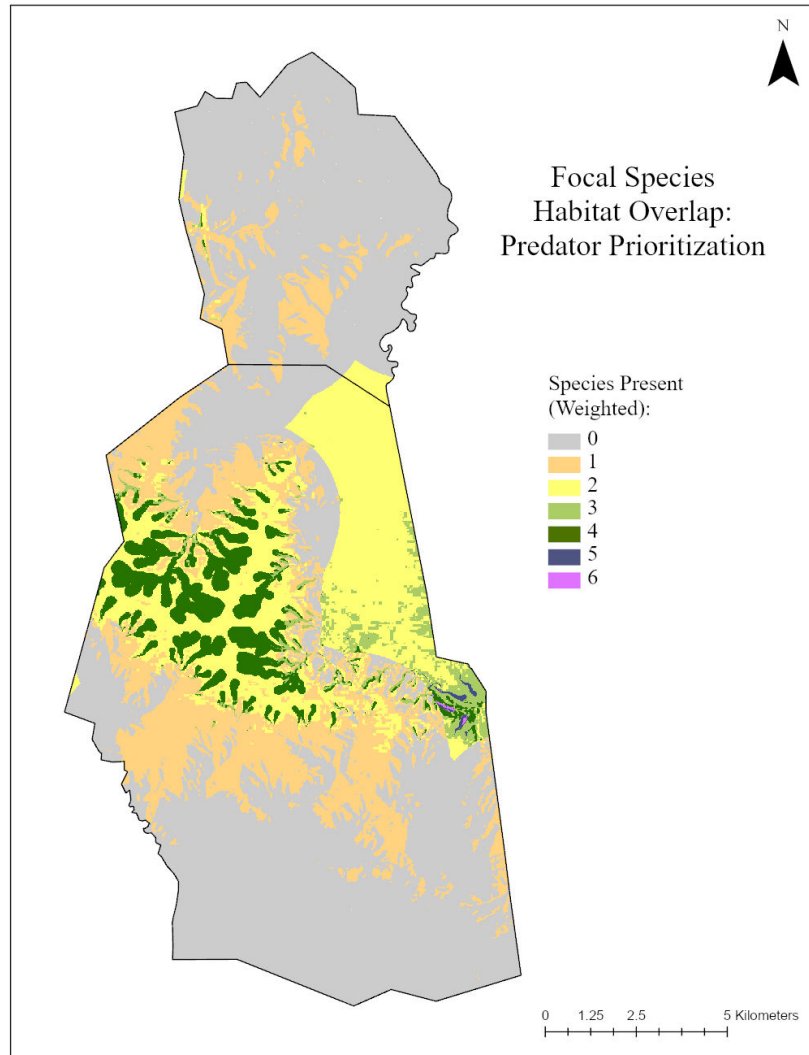


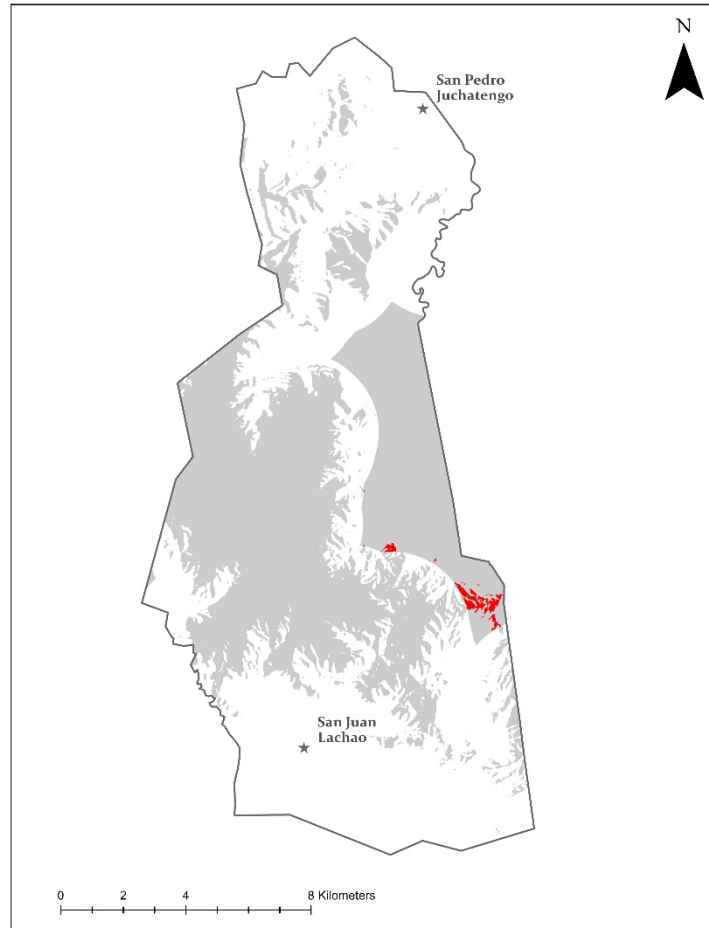
Figure 2.4: Areas where potential habitat overlaps within the community boundaries. Prey species habitats were prioritized with a value of 2, while predator species habitats have a value of 1. Therefore, 1 corresponds to a single predator species, 2 corresponds to either a single prey species, or both predator species overlapping. A value of 3 corresponds to one predator and one prey species overlapping, while 4 represents either both prey species or one prey species and both predator species. Finally, 5 corresponds to both prey species and one predator species, and 6 represents all prey and predator species habitats overlapping.

Increased weighting of the predator species (puma and ocelot) decreased priority conservation areas in the west and increased conservation area in the east. However, the largest priority areas still occur in the western portion of Lachao (Figure 2.4).



*Figure 2.5: Areas where potential habitat overlaps within the community boundaries. Predator species habitats were prioritized with a value of 2, while prey species habitats remained at 1. Therefore, 1 corresponds to a single prey species, 2 corresponds to either a single predator species, or both prey species overlapping. A value of 3 corresponds to one predator and one prey species overlapping, while 4 represents either both predator species or one predator species and both prey species. Finally, 5 corresponds to both predator species and one prey species, and 6 represents all prey and predator species habitats overlapping.*

ICICO indicated that the puma and peccary were the most ecologically and socially valuable focal species. We therefore created a map to illustrate potential areas where both species could be conserved. We found that only a small set of tracts in central eastern Lachao hosts potential habitat for both the puma and the peccary (Figure 2.5).



*Figure 2.6: Peccary and puma habitat overlap, colored in red.*

Our final recommendations for priority conservation areas included one large area in central western Lachao and a smaller area in central eastern Lachao (Figure 2.6). These conservation zones are 2,527 and 247 ha, respectively. The corridor region covers 764 ha.



of coati presence to decrease with increasing distance to streams. The distribution of ocelots often coincides with tropical and subtropical forests and shrubs (Brown, 1989; Shindle, 1995; Emmons & Feer, 1997; Murray & Gardner, 1997; Lopez Gonzalez et al., 2003). However, like our findings, canopy characteristics do not affect the occurrence rate (Di Bitetti et al., 2005). We found the probability of puma presence increased with distance to roads, similar to previous findings (Monroy-Vilchis et al., 2009); although pumas often use trails and logging roads, perhaps because it has greater capability for longer strides and pounce (Harmsen et al., 2010).

We observed a notable separation of habitat between the puma and other focal species. The puma is a known predator of both the coati and peccary (Aranda & Sanchez-Cordero, 1996; Soria-Diaz et al., 2016; Charre-Medellin et al., 2018; Soria-Diaz et al., 2018) and ocelots avoid sharing habitat area with the puma (Perez-Irineo & Santos-Moreno, 2016). Apex predators, like the puma, have been shown to control meso-predator populations through intraguild interactions (Ritchie & Johnson, 2009; Lourenco et al., 2014). These interactions often cause mesopredators, like the ocelot, to alter habitat use or hunting behavior to avoid being preyed on by apex species (Elmhagen & Rushton, 2007; Ritchie & Johnson, 2009; Lourenco et al., 2014).

Probable focal species habitats largely did not extend into Juchatengo. Based on field observation and local knowledge, Juchatengo seems to exhibit drier ecosystems than Lachao. While we have no camera trap observations in this area, we expect that the differences in climate and elevation means that Juchatengo will likely have a different wildlife species composition than Lachao. Further data collection is needed to quantify these differences.

Species with less restricted ecological requirements were modelled less accurately than species with more restricted requirements, irrespective of the modelling method used. Generalist species distributions are difficult to predict accurately (Brotons et al., 2004). Similar to previous studies (Garcia-Marmolejo et al., 2015; Perez-Solano et al., 2018; Soria-Diaz & Monroy-Vilchis, 2015), our results suggest that the white-tailed deer is an adaptable generalist species, preventing us from incorporating its distribution into our corridor analysis. As a socially important species, we recommend re-modelling the species after the camera traps are better stratified across the study area to assess whether the model confidence remains low. Additionally, generalist species like the white-tailed deer should inherently be incorporated in conservation plans based on other species.

The jaguarundi is understudied due to its illusive behavior (Giordano, 2016; Perez-Irineo & Santos-Moreno, 2016) and was captured very rarely on the camera traps in Lachao. However, ICICO recognizes the species as important to the communities and likely in decline. According to the available literature, there is considerable variation in the environmental variables that determine its occurrence; thus, we had low confidence in the accuracy of our rule-based jaguarundi model and omitted it from further analysis.

### 2.5.3 Priority Conservation Areas

The largest area of focal species overlap was in the central western region of Lachao. The coati, peccary, and ocelot exhibited the greatest proportion of predicted habitat in this region. We suggest, therefore,

that the central western area is a key conservation site in Lachao. To our knowledge, the area has a relatively low population density and hosts a portion of Lachao's carbon offset plots.

Across most of the study area, there was little forest cover change from 2001 to 2018 (Global Forest Watch, 2014). However, in the central eastern portion of Lachao, where the majority of camera traps were placed and where the community hosts additional carbon offset plots, we observed some forest gain. This trend indicates that the area is being actively restored and would be a suitable candidate for long-term wildlife habitat. Accordingly, our second largest priority area is situated in this region, holding the only expanse in the study area with all four species distributions.

Because puma habitat was not predicted in the western conservation patch, the proposed corridor would benefit mainly the ocelot, peccary, and coati. We assume it will be critical to maintain a connection between the western and eastern areas to ensure adequate prey opportunities for the puma. Furthermore, the east-west direction of the corridor connects the community conservation area to a larger-scale stretch of high elevation, forested area that spans across southern Oaxaca.

#### 2.5.4 Data Limitations

The camera trap data sometimes lacked information on the precise range of dates, species counts, and site selection considerations of the observations. Additionally, the camera traps were concentrated in the central region of the study area, which undoubtedly influenced the results of the regressions and habitat models. This region is high elevation and primarily cloud forest, which is not representative of the range of environmental conditions across the two communities.

#### 2.5.5 Conclusions

Understanding the wildlife presence and distribution throughout the study area has important implications for the communities. Wildlife populations have significant economic, cultural, and ecological value. Healthy populations can influence ecotourism revenue and food availability, in addition to supporting cultural identity. With our findings, Lachao and Juchatengo can establish a camera trap protocol that will improve upon our current distribution models and ideally lead to a conservation corridor between the two communities. With improved data, future studies may also be able to incorporate more ecologically and socially important species into the corridor.

In the future, it is also possible that ICICO could build collaborations with the communities to the west and east of Lachao. In this scenario, the conservation corridor could be extended into these communities, greatly increasing the potential habitat for the focal species.

The most essential conclusion from our analysis is that further data collection is needed to continue to develop a bi-community wildlife corridor. Our findings will be useful in future camera trap designs and will give the communities a preliminary idea of potential conservation areas. We will provide a comprehensive camera trap protocol to ICICO and the communities, which is the most important next step in this project.

## 3. Part Two: Alternative Livelihood and Sustainable Development in the Conservation Corridor

### 3.1 Abstract

For indigenous communities that rely on their collective lands for living, biological diversity is an essential aspect of their management practices and is integral to their livelihoods and cultural values. Livelihood activities by indigenous communities also have important implications on local biodiversity both as a source of stress and as a potential force of environmental stewardship. Alternative livelihood projects (ALPs) refer to conservation interventions that intend to reduce people's reliance on threatened natural resources, generate economic benefits and increase local support for conservation. ICICO has actively promoted ALPs in the two agrarian communities that we worked with, San Juan Lachao and San Pedro Juchatengo, as a strategy for integrating biodiversity and socioeconomic goals. In this part of our project, we studied the socioeconomic effects of the proposed biological corridor and explored the potential for alternative livelihood projects in the client communities.

We conducted 18 semi-structured interviews with leaders from Lachao and Juchatengo, to determine perceptions of benefits and barriers regarding ALP's and a proposed biological corridor connecting the two communities. We spent time with community members in the field to build trust and gather supporting data from conversations regarding the project. Then, we conducted an in-depth literature review of case studies of four types of alternative livelihood projects identified by ICICO as being of particular interest and relevance for these communities: forest-based carbon offset, non-timber forest product, agroforestry and ecotourism. From the review of literature, we drew lessons that can inform the development of projects in our client communities. Integrating the coding and data analyses from the interviews and the literature review, we determined recommendations towards implementing ALP's and conservation activities that will link the communities and support the corridor.

### 3.2 Introduction

The second part of our study focused on the socio-economic aspect of the proposed conservation corridor. Specifically, we intended to answer the following two study questions:

1) What are the potential impacts of the proposed conservation projects on the livelihoods of people in the two communities?

2) Which types of alternative livelihood projects will be most likely to maximize the social, economic, and conservation benefits from the conservation corridor for the communities?

Toward these objectives, we first designed and carried out interviews of community members to investigate people's perceptions of the existing and potential alternative livelihood projects (Section 3.3). Then, we conducted an in-depth literature review of case studies of the types of alternative livelihood projects identified by ICICO as being of particular interest and relevance for these communities in search of lessons that can inform the development of projects in our client communities (Section 3.4).

### 3.3 Alternative Livelihood Project: The Framework

Since the 1980s, global conservationists have begun to pay increasing attention to the socioeconomic implication of conservation programs and the welfare of indigenous communities (Salafsky & Wollenberg, 2000; Kusters et al., 2006). Because exploitative uses of natural resources that threaten biodiversity are often critical sources of livelihoods for local people, the communities' livelihood demands must be met in order for conservation projects to be effective (Berkes, 2007; Roe et al., 2015). Alternative livelihood projects (ALPs) refer to conservation interventions implemented in a range of contexts that intend to reduce people's reliance on threatened natural resources, generate economic benefits and increase local support for conservation (Wright et al., 2016). Such projects are usually designed with the rationale of promoting conservation by substituting environmentally damaging and unsustainable economic activities, such as timber harvesting and slash-and-burn agriculture, with lower-impact substitutes, such as agroforestry and ecotourism (Faminow & Klein, 2001; Stronza, 2007).

ICICO has worked closely with communities in Lachao and Juchatengo in the development of ALPs to achieve local people's conservation and livelihood objectives. At Lachao, projects currently running include an ecotourism program that encompasses zip lines, tours, and education about their conservation methods, water-bottling from local springs, shade-grown coffee, sustainable timber harvesting, and forest-based carbon sequestration. Juchatengo currently has only one ALP the collection of non-timber forest products (pine resin and copal). In support of the establishment of the proposed conservation corridor, we conducted this study to evaluate the viability of different ALPs in the area.

In our study, we first conducted interviews of community members to learn about their motivations and concerns about the corridor project. Table 3.1 below list all the current ALPs going on in our two client communities. Among those, we identified four different classes of ALPs that are particularly relevant in the two communities we are working with through communications with ICICO: forest-based carbon offsets, non-timber forest product (NTFP) collection, agroforestry, and ecotourism. Among the four, shade-grown coffee agroforestry is a major across the Oaxaca state widely cultivated by farmers in Lachao. Forest-based carbon offsets and ecotourism are developed by ICICO at Lachao and people showed high expectation of those projects during our field visitation. NTFP collection is a recently-adopted initiative at Juchatengo, which has received very positive feedbacks from community members.

Table 3.1: List of ongoing ALPs at the two client communities.

San Juan Lachao	San Pedro Juchatengo
<ul style="list-style-type: none"> <li>• Sustainable timber harvesting</li> <li>• <b>Forest-based carbon offset</b></li> <li>• <b>Ecotourism:</b> interpretive trail, waterfall, and zip-lines</li> <li>• <b>Agroforestry:</b> shade-grown coffee</li> <li>• Water-bottling plant</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Non-timber forest product:</b> copal and pine-resin harvesting</li> </ul>

Focusing on the four categories of ALPs, we then conducted a comprehensive literature review of case studies of these types of ALPs around the world to assess the ecological, social and economic implications of such projects. In the next section, we will discuss in more detail each of the four types of ALPs as they appeared in the literature and in the two communities of Lachao and Juchatengo.

### 3.3.1 Carbon offsets

In carbon offset programs, forest communities engage in activities that enhance carbon sequestration through reforestation or improved forest management programs. Communities can then register the carbon sequestered in their forests as carbon credits under internationally recognized certification schemes and sell them to emitters seeking to offset greenhouse emissions from their activities (Osborne & Shapiro-Garza, 2018). Commonly used certification schemes include: Climate, Community, and Biodiversity Standards (CCBS), CarbonFix Standard, Voluntary Carbon Standard (VCS), Plan Vivo Standard (PVS), and UN-backed Clean Development Mechanism (CDM) and Reduce Emissions from Deforestation and forest Degradation (REDD+) programs (Brown et al., 2011; Atela, 2013; Leach & Scoones, 2013; Hendrickson & Corbera, 2015).

Lachao began to plan and engage in forest-based carbon offset programs in 2014 in partnership with Climate Action Reserve (CAR) and received CAR's issuance of 17063 CRTs of carbon credits in 2017 (Nickerson, 2017). To implement the program, the community set up 500 forest carbon plots and trained community members to measure biomass carbon stock and manage the project inventory. In 2015, Lachao's carbon offset project received a major inflow of funding from the Walt Disney Climate Solution Seed Fund. With Disney's investment, Lachao agreed to protect 10,000 acres of their forest, which also created about 100 local jobs to support the project (The Walt Disney Company, 2015). In addition to Disney, carbon credits produced at Lachao have also been sold to BP Oil, the municipality of Palo Alto, California, as well as Duke University (ICICO, pers. comm.).

### 3.3.2 Non-Timber Forest Product (NTFP)

Non-timber forest product (NTFP) refers to biological materials extracted from forests that are of economic or use value to people (Huynh et al., 2016). Typical NTFPs collected by forest communities include firewood, fodder, construction materials, fruits, honey, rubber, resins, and medicinal plants. The NTFPs are usually collected by people both for household consumptions and for sale at the markets. In many cases, those NTFPs have been an important part of the local culture and livelihood for a long time, and the communities have developed rich local ecological knowledge about their harvest and use (Kim et al., 2008; Maharjan et al., 2009; Harbi et al., 2018).

An NTFP collection project is currently going on in Juchatengo, in which a few community members are trained by the Mexican Department of Forestry (CONAFOR) to harvest pine resin and copal. Practitioners were trained to follow a standardized harvesting protocol for resin tapping that does not damage the trees, under regular monitoring enforced by CONAFOR staff. The resins collected are then stored in buckets and sold in the market of a nearby town, mainly for incense in churches. In addition, both communities currently rely on fuelwood collected from forests for cooking and traditionally use many other NTFPs for fiber, folder, and household consumption.

### 3.3.3 Agroforestry

Agroforestry a land use system where there is a spatial or temporal combination of woody species with agricultural crops and/or livestock on the land. Agroforestry practices are often promoted with the goal of improving the social and economic welfare of agricultural communities while preserving the integrity of the land (Young, 2003). Typical agroforestry systems include shade-grown coffee and cacao, shifting cultivation of tree and herbaceous species, and mixed system of fruits, fuelwood and commercial crops (Regmi, 2003; Young, 2003; Piekielek, 2010).

At Lachao, entrepreneurial farmers have started cultivating shade-grown coffee on their family lands. Coffee plants are grown on forest ground while keeping intact the structure of the original forest. Those coffee plots served as a buffer zone that prevented the encroachment of agriculture into the forests. One of those farmers, Luizinho Carrasco, for example, plants trees to manage soil acidity, produces compost with coffee plant residuals, and uses organic methods for pest control. In recognition of his stewardship on the land, Luizinho's coffee plot is certified by Rainforest Alliance (Carrasco, pers. comm.).

### 3.3.4 Ecotourism

Ecotourism is a relatively new concept that emerged in the 1980s out of an increasing concern over the negative environmental and social impacts of conventional nature-based tourism (Fennel, 2001). The term was defined as "traveling to relatively undisturbed or uncontaminated natural areas with the specific objective of studying, admiring, and enjoying the scenery and its wild plants and animals, as well as any existing cultural manifestations found in these areas" by its creator Hector Ceballos-Lascurain (Donohoe & Needham, 2006). Buckley (1994) defined ecotourism to incorporate the four aspects of "integration of nature-based products and markets, sustainable management to minimize impacts, financial support for conservation, and environmental education of individual people". Ecotourism is often considered as an ALP option based on the rationale that it allows communities to benefit from the value of unexploited nature and thus provide an incentive against more extractive land uses and economic activities (Stronza, 2007; Reimer & Walter, 2013).

At Lachao, natural beauty attractions feature mainly a beautiful waterfall and the cloud forests that people are very proud of. As for cultural attractions, people like to show visitors the traditional folk dance, cave paintings, and traditional Chatino cuisines. Five community members have been trained by the Commission for the Development of Indigenous communities to become ecotour guides and an eco-lodge was built to host visitors. Existing tourism activities include four interpretive trails through the cloud forest and five zip-lines. Currently the scale of the ecotourism business in Lachao is small, drawing about 45-60 visitors in high seasons and 10 in lower seasons (pers. comm).

### 3.3.4 Other ALPs

Other ongoing livelihood projects on in the communities include sustainable timber harvesting and a water-bottling plant in SJH, and a small sustainable aquaculture business in Juchatengo. (See Table 3.1 above).

## 3.4 Interviews

While identifying potential community-based strategies that protect biodiversity and support livelihoods is important, exploring local people's motivations to participate helps us understand how they respond to pressures and incentives (Delgado et al., 2017; Ruiz- Mallén et al., 2015). In Latin America and the Caribbean alone, drivers and motivations differ considerably for indigenous community-based conservation initiatives. Distinct internal and external processes specific to each region can have differentiating effects that impact social-ecological change within each community (Delgado et al., 2017; Ruiz-Mallén et al., 2015; Souto et al., 2014). These can include local and national governance, demographics, ecological environments, beliefs and practices, natural resources, and local economy (Suoto et al., 2014). Incorporating socio-economic and cultural analysis on conservation proposals ensures projects are meeting the needs and goals of communities, based on their unique settings and socio-political structures. Furthermore, research indicates local communities are more empowered when involved in research and implementation processes, i.e., knowledge transfer and peer – to – peer trainings based on experience and contextual elements (Ruiz- Mallén et al., 2015). This can create effective and long-lasting benefits.

The socio-economic component of this project is focused on gathering insight and determining community needs based on the following main question:

'How can the management of a biological corridor maximize the socio-economic welfare of the communities?'

Additionally, we aimed to answer the following sub-questions based on collection and analysis of qualitative data:

- What perceptions do leaders of the two communities hold concerning the potential positive or negative impacts of establishing a biological corridor and various of alternative sustainable livelihood projects?
- What are the primary motivations for implementation of and participation in these projects?
- What are the perceived barriers to the successful implementation of these projects?
- In what ways might the location/access to resources/social or political issues affect each community's ability to successfully implement these projects?

### 3.4.1. Research Design and Approach

The qualitative approach to this section of the project is based on Mixed Methods Convergent research design (Cresswell, 2018). In collecting and analyzing the qualitative data in situ and throughout the analysis phase, the quantitative and broader goals of the study were kept in the forefront as well, thus creating a foundation for convergence. The overall design for the approach in this section is grounded theory, focused on feedback and views of the participants through interviews combined with

observations in the field and informal conversations with community members (Charmaz, 2006; Corbin & Strauss, 2015; Cresswell, 2018).

Data for this portion of our research was collected through 18 semi- structured interviews, 4 unstructured interviews, field notes and informal conversations.

The semi-structured interviews consisted of 25 questions (Appendix 6.2) classified into the following 8 sub sections (Table 3.2).

Table 3.2: Categories or subsections the interview questions were classified under.

<i>Sub-section</i>	<i>Definition</i>
<i>Community Background</i>	Information regarding the demographic, cultural, socio economic, and/or political context of each community relevant to understanding the dynamics of ALP's.
<i>Existing Project History</i>	The history of existing ALP programs in the communities, what worked, what failed, and what they want to pursue.
<i>Project Benefits</i>	Feedback regarding perceived benefits on implementing the corridor, and income generating activities that support the corridor.
<i>Project Barriers</i>	Feedback regarding perceived barriers on implementing the corridor, and income generating activities that support the corridor.
<i>Planning, implementation, and maintenance</i>	Determine any needs they may have in so far as tools, education, and planning to install, develop, and maintain the corridor.
<i>Socio-economics Benefits and Barriers</i>	What socio-economic barriers need to be considered and what are the motivations or perceived benefits that can address these barriers.
<i>Geography and Region Specific</i>	Information on any physical barriers such as terrain, or geographic uniqueness that offer specific benefits towards ALP's.
<i>Lessons Learned</i>	Insight based on experience with their existing ALP's, in particular San Juan Lachao, and how that could work towards inter-community training initiatives.

It is anticipated as the project moves into concurrent phases over the next 18 months, a second, larger subset will be surveyed for further data analysis and inclusion.

#### *Candidate attributes and demographics*

All interview participants were members of the Commission (Comsariado) and the Supervisory Council (Consejo de Vigilancia) branches of the community governing body. These candidates were chosen based on their level of experience and expertise in the existing programs, their commitment to their communities, and the level of responsibility they hold to insure the wellbeing of their communities.

80% of the participants were male, the remaining 20% were female. Participant ages ranged from early 20's to mid-60's, the majority falling between early twenties to mid-30's. The younger participants are part of the Comisariado as "tequio's" or assistants/apprentices. Participants in their 30's were mid-level authority and the older demographic were positioned in the higher offices of president, vice president, secretary, and treasurer. The female participants hold mid to high level positions in the Comisariado and are well respected. All have lived in the communities their entire lives, with familial roots going back generations, some dating back to pre-colonial times.

All participants are employed at other jobs at least part time, as their position within the Comisariado is unpaid and considered a separate public service. The younger assistants typically worked part time learning and supporting the Comisariado, attempting to orient their paid employment, when applicable, in sectors related to sustainable projects the Comisariado was overseeing.

#### *Interview format*

Formal interview participants were interviewed 2 at a time in a private setting and were typically paired up based on their position in the Comisariado. Each interview lasted 60 to 90 minutes. An interpreter asked the questions in a manner which they could understand, as some participants were more accustomed to idioms, phrases, and sentence structure derived from their indigenous Chatino language, which the interpreter was familiar with. The interpreter was a staff member from ICICO and has been working in the communities for several years. His presence helped facilitate the interviews and provide some familiarity with the participants.

#### *Informal interviews and field notes*

Informal conversations and observational field notes were recorded by hand. Typically, conversations and observations happened in the field while assisting with the collection of forestry data and verifying GIS points for the physical mapping portion of the project. A report was established while working closely with the field guides, allowing for further insight from conversations and passive observations. Staying with host families in their homes and sharing meals provided an additional means of connection, conversation, and observations.

#### *Data analysis structure*

We analyzed the primarily qualitative data collected through field research for response patterns, respondent perspectives, connections between positive and negative effects, benefits received, and barriers encountered. All interviews, conversations and field notes were encoded using Nvivo12 qualitative data analysis software. Informal conversations and observational field notes were recorded by hand and coded as data under a separate structure system. Interviews were recorded over an audio device with the participants permission, transcribed and translated before uploading into Nvivo for coding. After the interviews were translated, the qualitative team conducted an initial review of the questions, responses, field notes as well as a review of literature, which informed the design and base coding structure for our analysis.

The coding architecture we employed consists of the following main themes (Table 3.3):

Table 3.3: 8 coding themes and definitions.

Main Theme	Theme Definition
Assets and Community Characteristics	What environmental, cultural, and political characteristics do the communities offer towards installing and supporting the corridor.
Positive Perceptions of ALP's	Perceived successes and positive views of existing ALP's within the communities
Negative Perceptions of ALP's	Perceived failures, mistakes, and negative views of existing ALP's within the communities
Motivations	What motivates each community to either expand upon existing or implement new ALP's.
Barriers	Information on existing or future barriers (socio-economic, geographic, political) that could impact both the corridor and supporting ALP's.
Benefits	Information on existing or perceived future benefits that the corridor and supporting ALP's will bring to the communities.
Program Design	Feedback on existing program design in Lachao that could be emulated in other communities. Information on successes, failures, and needs for a management program in both communities.
Suggestions	Specific suggestions from both communities on implementing new or expanding existing ALP's. Suggestions on support mechanisms needed to implement the corridor.

The interview analysis revealed sub-codes specific to each of the eight themes in the coding mainframe. Specific sub-codes emerged within each theme, which were analyzed in depth to determine patterns and linkages. The sub-codes were quantified in weighted values based on the number of responses, then calculated as percentages. Each issue is ranked based on the weight of the numerical value shown in the data analysis. Analysis includes combined responses from both communities, then separated out to reveal individual community responses (Figure 3.1).

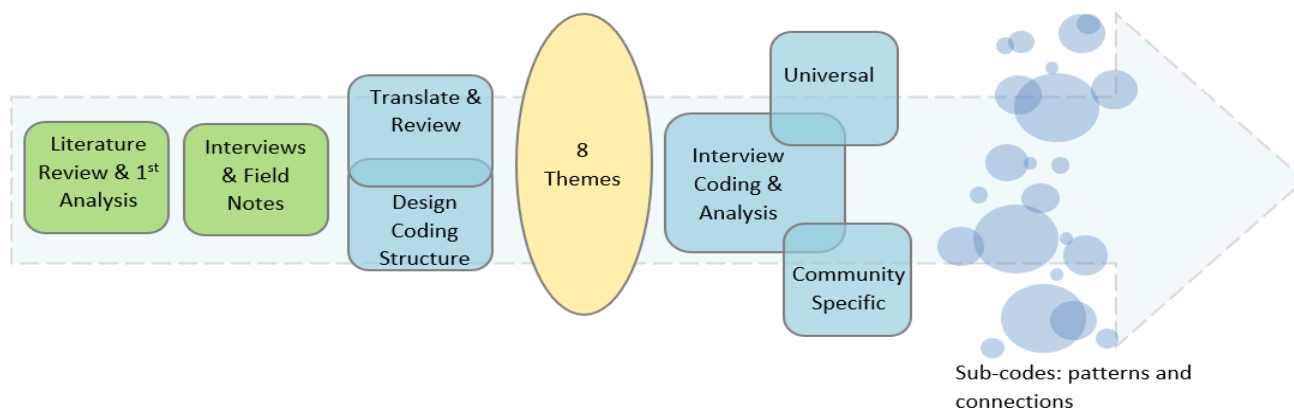


Figure 3.1: Diagram of analysis design and progression.

### 3.4.2 Results Overview

The following sub-sections detail the results within each theme, ranking the issues addressed and commented upon the most in the interviews. The following four themes that have the highest number of sub-codes and responses: *Motivations*, *Benefits*, *Barriers*, and *Suggestions*. These themes have more emotional, passionate responses from the respondents, as these subjects touch on more personal aspects such as education for their children, extreme poverty, professional development, family income, community stability, careers, identity, pride. Respondents revealed more in these areas as they saw new pathways for the future of their communities through this project.

Themes with less responses were given the same amount of examination and consideration which offered unexpected linkages and connections. All data was examined holistically keeping variables such as demographics, ecosystems, and infrastructure in mind when determining final results and recommendations.

It is important to note while reviewing the data we determined the total aggregate of rankings does not always accurately represent the high rankings for the individual communities. Therefore, our results show not only the aggregate, but the individual community results as well, which we discuss further under each theme heading in this section. To ensure program recommendations and management plans are designed for longevity and success, it is important to break down the data to a community-specific level. An overall “high” ranking indicating a specific program could be misleading if the results are heavily skewed between communities.

We witnessed a pattern of sub-code rankings hitting a threshold in groupings of 4 or 5 within various themes (Figure 3.2). A subsequent plateau occurred, followed by a significant drop-off in rankings. This pattern appeared where connections occurred between the communities regarding specific programs, social issues, economic issues, and suggestions, signifying a correlation where a baseline, or “standard” management plan could be a helpful tool to provide a foundation for continuity and structure. When significant differences occur between communities, we flagged those as pathways for adaptability and community-specific planning opportunities.

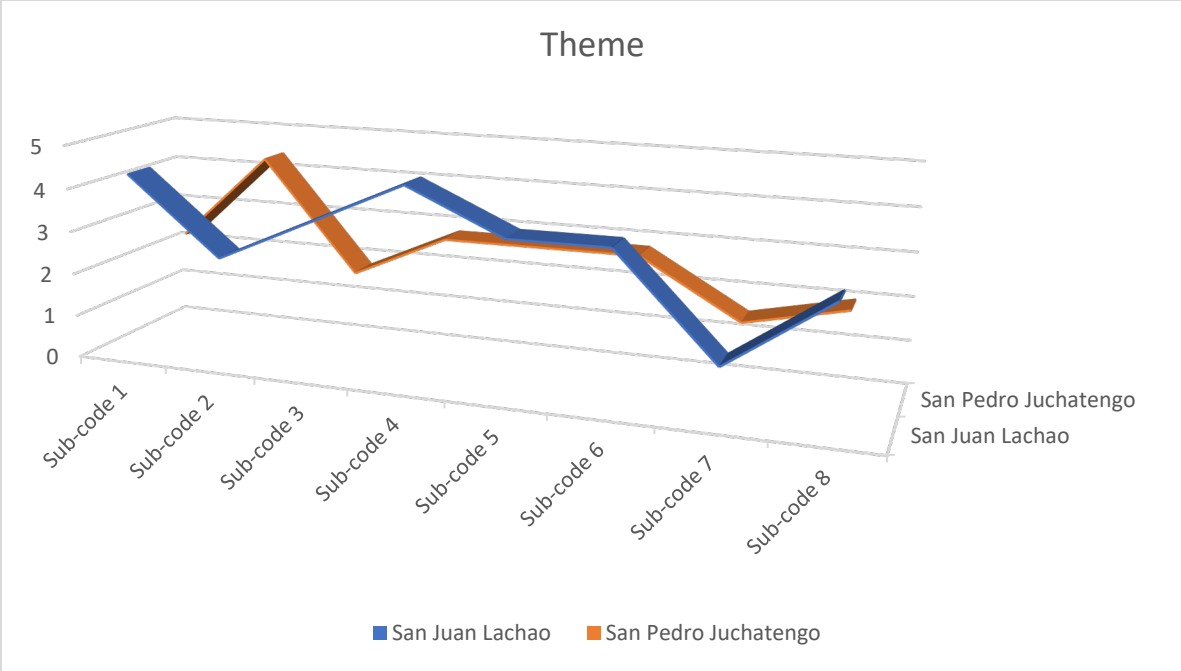


Figure 3.2: Illustration of plateaus occurring before significant drops in rankings, indicating congruencies between communities.

*Findings: Assets, Community Characteristics*

We defined the code for Assets and Community Characteristics as resources within the communities the respondents see as valuable and deserving conservation. When asked openly what characteristics and assets they believe their communities have to offer to both a biological corridor and alternative livelihood projects, the following 12 sub-codes evolved from their answers shown in the table below (Table 3.4). These cover aspects of governance, relationships, biodiversity, historical and cultural characteristics, and natural resources. Table 3.4 outlines the question studied, definition, and sub-code explanation within this theme. The highest ranked comments and feedback from this analysis are Governance, Ecosystem Services, Biodiversity, Historical, Cultural, and Natural Beauty (Figure 3.3).

Main Code	Question Studied	Main Code Definition	Sub Code	Sub Code Explanation
Assets & Community Characteristics	What are the assets contained in the community seen as offering value to a corridor, and to alternative livelihood programs? What are the factors making the situation in a community different from that of other communities?	Resources that people see as valuable in their communities that deserve conservation. What respondents share regarding the uniqueness of their communities	Timber	Using Timber for Carbon Sequestration or for Sustainable Timber Production
			Water/River/Hydrology	Utilization of natural springs for water bottling;

		use of the river for activities and eco-tourism
	Carbon Sequestration	Utilization of specific forest plots for carbon sequestration
	Ecosystem Services	Ecosystem services like carbon sequestration, water purification and soil retention.
	Biodiversity	Including the intrinsic value of wildlife and the forest.
	Natural Beauty	Natural beauty as an asset for eco-tourism
	Cultural	Cultural heritage; arts and artisans; community festivals; religious beliefs & practices; indigenous knowledge
	Hospitality	Capacity and willingness to host and entertain guests in the community: food, lodging & activities; safety, infrastructure.
	Geographic	Natural resource endowments; climate and terrain
	Historical	Key historical events that happened within the community; important historical sites
	Social & Relationships	Community institutions and solidarity; leadership; <u>Good</u> relationship with other communities, NGOs, or the government.
	Economic	Current economic growth with potential for expansion

Table 3.4 Coding structure and definitions for Assets and Community Characteristics theme.

Our results are shown under each theme section using the same data chart format.

Some interview questions resulted in longer responses and discussions than others. Notice where an inter-community plateau starts with *biodiversity* and *natural beauty* before rankings drop off to another level (Figure 3.3). The chart below captures the data from our analysis specific to this theme. We are only displaying data for 7 of the 12 sub-codes, due to the rankings dropping significantly for individual and combined totals after *NTPP*.

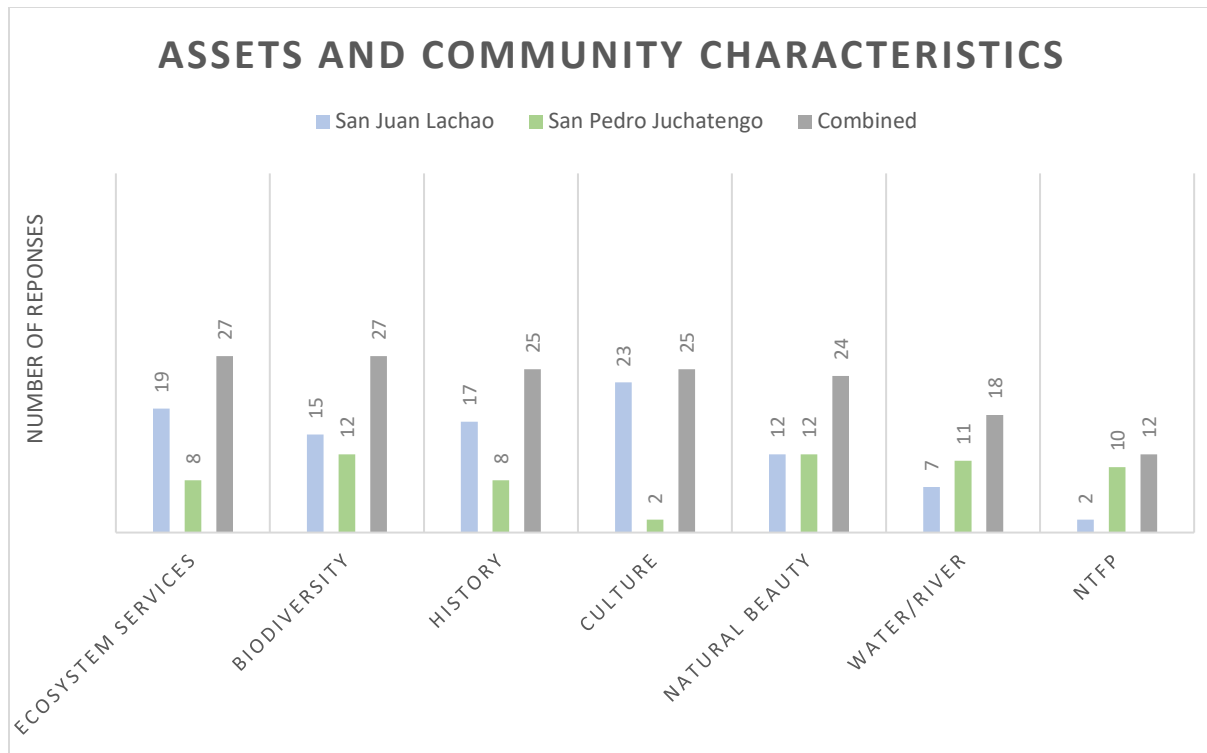


Figure 3.3: Assets and characteristics seen as valued in the communities towards the corridor and ALP's. Eight out of twelve sub-codes are shown based on ranking drop off that occurs after a peak threshold of high rankings.

When reviewing the results, it is important to note what is ranked highest on the aggregate is not necessarily the case for individual communities, highlighting what makes each community unique. For example, of the 27 total responses in both *ecosystem services* and *biodiversity*, they are not among the top ranked assets for both communities (Figure 3.3). The only instance of asset value congruency between the communities is *natural beauty* followed by *biodiversity*.

In noting the differences between community viewpoints on valuable assets, the Community Population Demographics table in section 1.5.3, along with Geography and Environmental descriptions in section 1.5 can assist with deciphering why this occurs. For example, *history* and *culture* rank very high for Lachao, but rank quite low for Juchatengo. Additionally, as mentioned in Section 3.2, Lachao has four established ALP's in place, so there is a lower migration rate due to unemployment.

However, these numbers do not mean culture and history does not link the communities. There is a distinct connection between maintaining their culture and heritage with the level of employment available. Contextual variables such as economy, ecosystems, and natural resources must be considered when developing recommendations. In a conversation with the President of the Comisariado in Juchatengo he was emphatic about high migration rates of their youth to cities and regions that have employment, and how that impacts heritage.

*“I see my oldest son making plans to leave. Many of his friends have left. The youths, they all leave because they need work, they need money, their families need money. I did it myself, but at what cost? We are losing our heritage, our pride, our community strength. I left to make enough money to provide a good life for my family, to start a business so my children will stay. I tell my son to learn from my mistakes. When we lose our pride and our faith in our heritage, in our community as indigenous people, we risk losing our identity, our place in this world”.*

The sub-codes *water/river* and *NTFP* ranked high overall for Juchatengo, illustrating a priority for employment. The common denominator for both communities is *biodiversity* and *natural beauty*. In this example the high-ranking natural resources specific to Juchatengo can be expanded upon for existing or new ALP’s, while the common denominator is the baseline that connects the communities.

Both are concerned about conserving biodiversity and natural beauty and therefore collective action could occur through enforcing corridor protections. A foundational management plan that connects the two communities via the corridor and is adaptable to address concerns of employment and heritage, could reduce migration and support cultural preservation population retention (Figure 3.4).

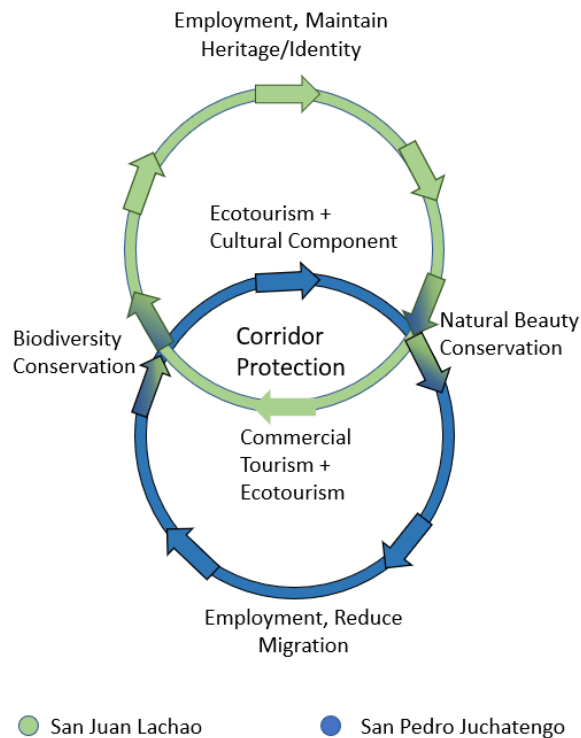


Figure 3.4: Diagram illustrates using corridor protections to address common denominators, while incorporating separate community priorities. Elements outside the circles are current concerns, elements inside the circles operate as connector programs.

*Findings: Positive Perceptions of Alternative Livelihood*

We defined the parameters for *Positive Perceptions of Alternative Livelihood* as feedback on the successes and positive effects of any current alternative livelihood programs within, or near, their community. Comments from Juchatengo combined their feedback on their own program, and what they viewed as successful in Lachao. The reverse occurs in Lachao, which was expected given their 10 years of experience building 4 main ALP’s with ICICO.

There is a total of 7 sub-codes, with top 5 sub-codes are *agroforestry, carbon sequestration, ecotourism, hydrology/water bottling, and NTFP* (Table 3.5). The weights vary by community, as Lachao has four main alternative livelihood projects underway, while Juchatengo has one (See Section 3.2, Introduction). Juchatengo recently started a very small sustainable fishery business (farmed Tilapia), however any comments regarding the fishery were minimal. Therefore, it was included in the coding structure however did not appear in any results.

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Definition</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Positive Perceptions of Alternative Livelihoods</i>	What kind of alternative livelihood projects <u>have been successful</u> in the community?	Feedback about the positive impacts of <u>current</u> alternative livelihood programs.	Timber	Sustainable timber harvesting in designated plots.
			NTFP	Copal, Resin, firewood – whatever is collected and not actively grown
			Carbon Sequestration	Utilization of specific forest plots for carbon sequestration
			Ecotourism	Existing eco-tourism programs
			Water Bottling	Existing water bottling operations from natural springs
			Fishery and Aquaculture	Existing sustainable fishing and aquaculture programs
			Agroforestry	Including coffee, bee-keeping and other agricultural initiatives on forest floor.

Table 3.5: Coding structure and theme definition for *Positive Perceptions of Alternative Livelihood* theme.

The data in this section is based upon responses when interviewees were asked about existing ALP’s within their communities, or what they have witnessed in other communities (Figure 3.5). Specific to Juchatengo their questions and responses were oriented towards what they viewed as successful in Lachao, in tandem with their one ALP program. Regarding Lachao, their responses were based upon their four existing programs.

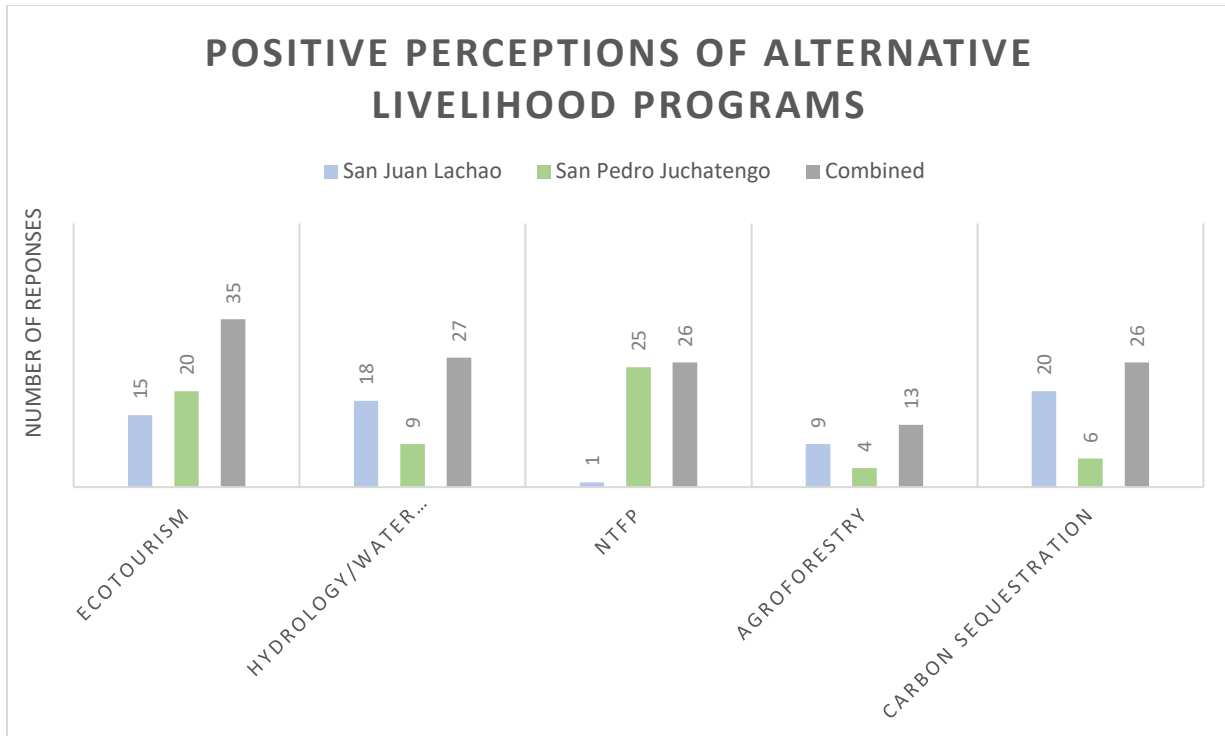


Figure 3.5: Positive perceptions of existing ALP's in the communities. Five out of seven sub-codes are shown based on ranking drop off that occurs after a peak threshold of high rankings.

As with the previous theme, *Assets and Characteristics*, the data within this theme illustrates what is shown as high ranking on the aggregate is not necessarily unified within the communities. Notable differences occur between the communities' feedback on *carbon sequestration*, *hydrology/water bottling*, and *NTFP*. These results illustrate what is viewed as successful programs relative to the individual community.

An example is *carbon sequestration*, with a high combined ranking of 26; Juchatengo expressed some interest, but much of the weight is from Lachao. It is a successful program for Lachao due to their dense forest system and years of experience. Therefore, these numbers suggest a high interest in expanding their existing program. The same is true with their water bottling operations. This is not the case in Juchatengo, with a different ecosystem and infrastructure. Even though there is an expressed interest, it is not their top interest.

Furthermore, nuances of context were evident in the responses from Juchatengo. As one participant stated:

*"Yes, we are interested in the carbon project that has been successful in Lachao, but we are not as lucky with our pine forest, no? Our pine is not growing, we need to plant more. The water filtration project in Lachao is of interest here also. We have the big river, many streams and waterfalls... but until we get the droughts under control and have more reforestation projects to protect the streams, water programs must wait."*

There are some congruencies that highlight feedback on programs Juchatengo does not have, but expressed interest in. This plays into the themes of motivations and suggestions, which will be discussed later in the results. Juchatengo does not have the same programs as Lachao (carbon sequestration, agroforestry, eco-tourism, or hydrology/water bottling). However, the data indicates an interest in implementing these programs, based on the following criteria expressed in their responses:

- Training from Lachao on all programs
- Existing resources (the river, the forest) for ecotourism and perhaps carbon sequestration
- Existing infrastructure and market to support ecotourism
- Feedback from ICICO and Duke

Reviewing the results for NTFP show a high combined number (Figure 3.5). However, when the total input is broken out separately, Juchatengo holds 99% of the input for this program. Incorporating variables unique to each community offers a more informed basis from which to make recommendations. Like the existing programs in Lachao, this suggests support to expand Juchatengo’s existing NTFP operation.

When numbers in both communities display a more even dispersal pattern under this theme, such as *ecotourism*, a connection is likely between the two communities for a mutual solution (Figure 3.5). This pattern also indicates an opportunity for partnership and training between the communities on a specific ALP, which can guide the NGO, our client ICICO, towards a recommended starting point.

*Findings: Negative Perceptions of Alternative Livelihood*

We define the Negative Perceptions of Alternative Livelihood Programs theme as what, if any, types of ALP’s have failed, and feedback on any challenges or negative impacts of existing ALP’s in the community. Like the previous theme, *Positive Perceptions of Alternative Livelihood Programs*, there are 7 sub-codes, all relating to specific ALP’s that are occurring in both communities (Table 3.6). Of the 7 sub-codes only 3 show significant results. The results are community-specific and highlight the different viewpoints of idealism vs. experienced realism, mirroring the previous theme. Furthermore, the weights lean heavily on the community with more programs.

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Definition</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Negative Perceptions of Alternative Livelihoods</i>	What kind of alternative livelihood projects have failed in the community?	Feedback about the negative impacts of <u>current</u> alternative livelihood programs	Timber	Sustainable timber harvesting in designated plots.
			NTFP	Collection of non-timber forest products.
			Carbon Sequestration	Utilization of specific forest plots for carbon sequestration
			Ecotourism	Existing eco-tourism programs
			Water Bottling	Existing water bottling operations from natural springs

	Fishery	Existing sustainable fishing and aquaculture programs
	Agroforestry	Including coffee, bee-keeping and other agricultural initiatives on forest floor.

Table 3.6: Coding structure and theme definition for Positive Perceptions of Alternative Livelihood theme.

The feedback in this theme was lower in quantity, but no less significant in the issues raised (Figure 3.6). Complex belief systems, management practices, and social support indicate that although this is a relatively new undertaking for both communities, significant socio-economic topics occur early and should be flagged and planned for in future efforts.

The leaders from Lachao discussed challenges regarding trust and communication between segments of the community that exclusively speak Chatino, live on the outskirts of the community, and/or do not have access to community-wide meetings and communications. Agrarian conflicts were mentioned, specifically regarding poor farming practices and land use classification disagreements. These issues are addressed further in the *Motivations*, *Barriers*, and *Suggestion* themes. There are segments of the community that are afraid of losing their farmland to conservation efforts and are hesitant to try sustainable farming methods. One respondent said the following about language and cultural barriers:

*"...a lot of the culture we live in here speaks Spanish, but several only speak Chatino, they live completely in the Chatino culture, and that part is costly/difficult because for some relating to the government is something that they don't want...."*

*That could become an obstacle that effects how we raise awareness, so in what way would that affect us or in what way would that benefit us to do that for a culture and language does not understand, a culture that says "we don't want them to come in", because here the indigenous people are very jealous, they are very possessive with their territories."*

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*"Our people want to know what is the advantage and what is the disadvantage of trusting what comes from out there (outsiders that do not know the Chatino language and culture) and that is what hinders us, makes us difficult to explain well to our people."*

The following responses are an example of some of the feedback we received regarding agrarian issues:

*"There are certain annexes or small communities, that are impacted because suddenly the rules are not followed, the land is misused, removed to sow corn, removed or burned forests without asking permission."*

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*" Inside the community every piece of land has a certain use. As I said, even though this is not a cattle-raising area, there are always two or three people with cattle,*

*so when you mention a “protected area”, an area you’re going to protect even from the passing of the cattle because they degrade the soil, you have to present the idea for them to consider and express their opinions through a poll. Or maybe assigning an exclusive area in which no one needs to get inside, under the assumption that if you don’t affect their cattle raising activity they won’t affect the conservation project.”*

The slow influx of income as these programs became established in Lachao was mentioned. Some community members accused the Comisariado of keeping the funds for personal gain. Participants expressed a need to formulate better outreach, education, and capacity building in order to perpetuate successful implementation and expansion of these programs. Per conversations with ICICO, and field observations, understanding the economic time frames for these programs will need to be addressed in stages; first at the leadership level, then at the broader community level.

The few comments from Juchatengo addressed similar challenges of communication, transparency, education and support around their existing ALP (Figure 3.6). There is a higher concern in Juchatengo regarding agrarian issues than Lachao. Juchatengo relies more heavily on large crops and livestock than Lachao; as new-comers to ALP’s they are realizing the constraints between of land use classification and conservation, and public perception on the economic impacts.

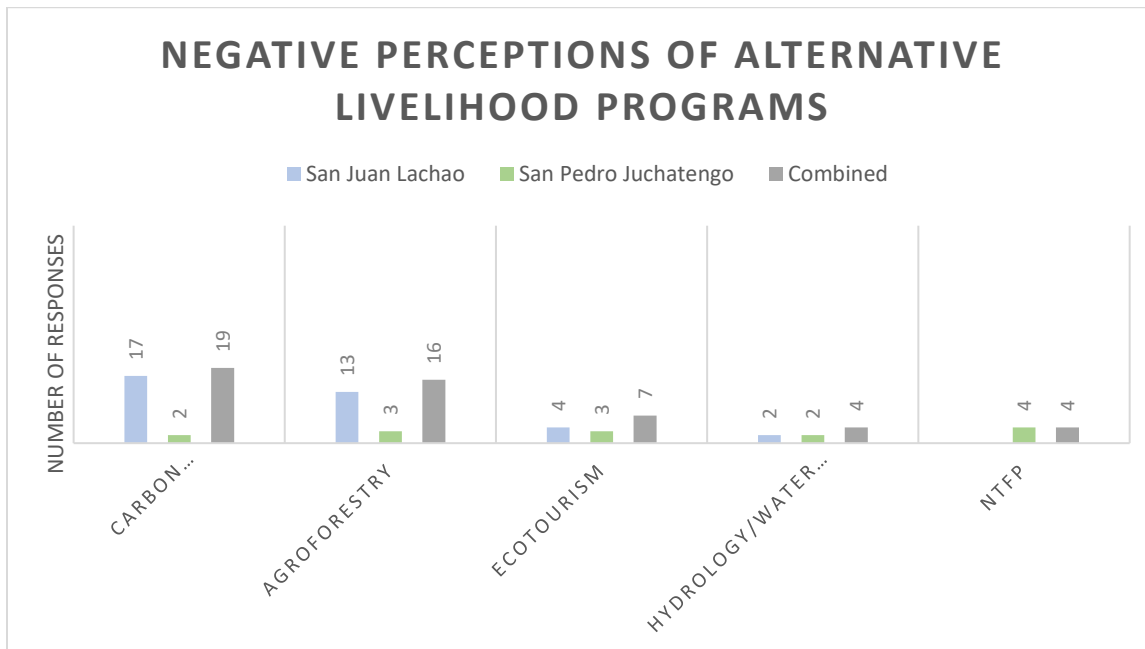


Figure 3.6: Negative perceptions of existing ALP’s in the communities. Three out of seven sub-codes are shown based on ranking drop off that occurs after a peak threshold of high rankings.

When evaluating these congruencies in our data, we also considered additional variables such as years of experience with ALP’s, and feedback from the *Barriers* theme that address specific ALP’s for each community. As shown in figure 3.6, Lachao had more feedback on challenges within their programs than Juchatengo. This reflects a high desire with limited knowledge in the complexity of implementing and

maintaining these programs. Minimal responses in negative perceptions or barriers indicate an idealistic view combined with minimal experience of both the programs and the corridor project, which must be considered in recommendations and management plans moving forward.

The following quotes from two Lachao residents directly involved in existing programs illustrates that idealism does fade through experience. It also is a good example of how Lachao can share their experience to get Juchatengo through any growing pains:

*“I can speak to the fact that, it took us years of effort, years of work where we were at the forefront and many were criticized, many were pointed out, many were insulted but now we have the results so, it is being said, “San Juan Lachao is a role model”, “San Juan Lachao has worked well”, or, “we have the example of San Juan Lachao. Why? Because, well, it has been known, up to a point, that Lachao did the work, it made the impossible possible, if not 100%, it at least tried and through progress, the impossible has been done and we have not gotten stuck.”*

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*“Well yes, but sometimes it is hard to believe what Lachao has achieved unless other communities can see the information that you have. Despite the problems and difficulties that Lachao has had, it keeps moving forward, step by step. It is a very long project that is going slowly.”*

An idealized view of another community’s success is another flag to focus on capacity building and education first, and program implementation second. Programs and management plans must have realistic, attainable goals to maintain support and morale when there are detours and unexpected setbacks. This cannot occur when a program is idealized. Therefore, in moving forward with Juchatengo a solid foundation based in realistic goals, training, and capacity building is paramount.

#### *Findings: Motivations*

We defined Motivations as the stated reasons and desires for participation in the corridor and ALP’s. *Motivations* generated several sub-codes as respondents expressed themselves openly about their intentions, hopes, and goals for their families and their community. Combined with the *Barriers* theme (addressed in the following section) both provided a wealth of insight and connections for our investigation. A total of 16 sub-codes, 10 were classified as high ranking based on either an extremely high aggregate with a minimal difference in dispersal between communities, or a sub-code with a very high community-specific ranking, out-weighting other rankings within that community (See *wildlife conservation* in Figure 3.7). A plateau occurs immediately after the top two, then stays steady for the remaining 7 before another level shift in results.

Table 3.7: Coding structure and definitions for Motivations theme.

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Explanation</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Motivation</i>	What are the motivations for people to participate in the corridor projects?	Reasons for their participation in the corridor projects	Awareness & Personal Will	Awareness among community members (to prevent barriers from within), awareness in other communities
			Community Well Being	Overall social, economic, & educational well-being within the community social systems. Opportunities to strengthen economic, educational & social status.
			Community Solidarity	To strengthen community ties, collective action & the bond between community members. To avoid community decline due to outmigration.
			Conservation	Feedback specific to protecting wildlife and ecosystems.
			Culture	To preserve and develop local cultural heritages, particularly <u>traditional ecological knowledge</u> . To enrich ecotourism, encourage longevity of the Chatino language, art, food, and culture.
			Economics & Employment	To capitalize on the value of their natural resources or to receive other economic benefits connected to the project, including food security, healthcare, and infrastructure development.
			Ecotourism	Interest in either expanding upon, or implementing an ecotourism program
			Empowerment	To obtain more <u>power</u> in self-determination, or to secure ownership of their natural resources.
			Natural Resource Management	Better methods & capacity for <u>managing natural resources</u> . To support natural resource management <u>decision-making</u> .
			Knowledge and Education	To gain <u>new knowledge</u> , especially scientific knowledge, about their surrounding environment.
			Partnerships	To improve relationships with other stakeholders like the university, communities, and NGOs.
			Regulatory & Management Plan	Refers to an existing land and program management plan, ideas for conservation management plans, and community governing policies
			Social Equity	Equity within and between communities
			Sustainable Forestry	Motivation to expand existing or implement new sustainable forestry programs
Water	Water bottling, conservation at the river, rehabbing the river, etc.			
Wildlife	Comments specific to saving wildlife			

As stated in the introduction for the Results section, *Motivations* was one of the themes with a more vested interest from the respondents. These responses offered more in depth material within a higher quantity of data. Given the larger quantity of data an additional table of priorities in this section offers a side-by-side comparison to show an emergence of connections. Additionally, table 3.7 illustrates 6 sub-codes that form connections with other themes (*Barriers* Table 3.8, *Benefits* 3.9). Being cognizant of more impassioned feedback from the questions related to this theme, they were interspersed throughout the interview process to keep responses balanced and discussions at a steady pace.

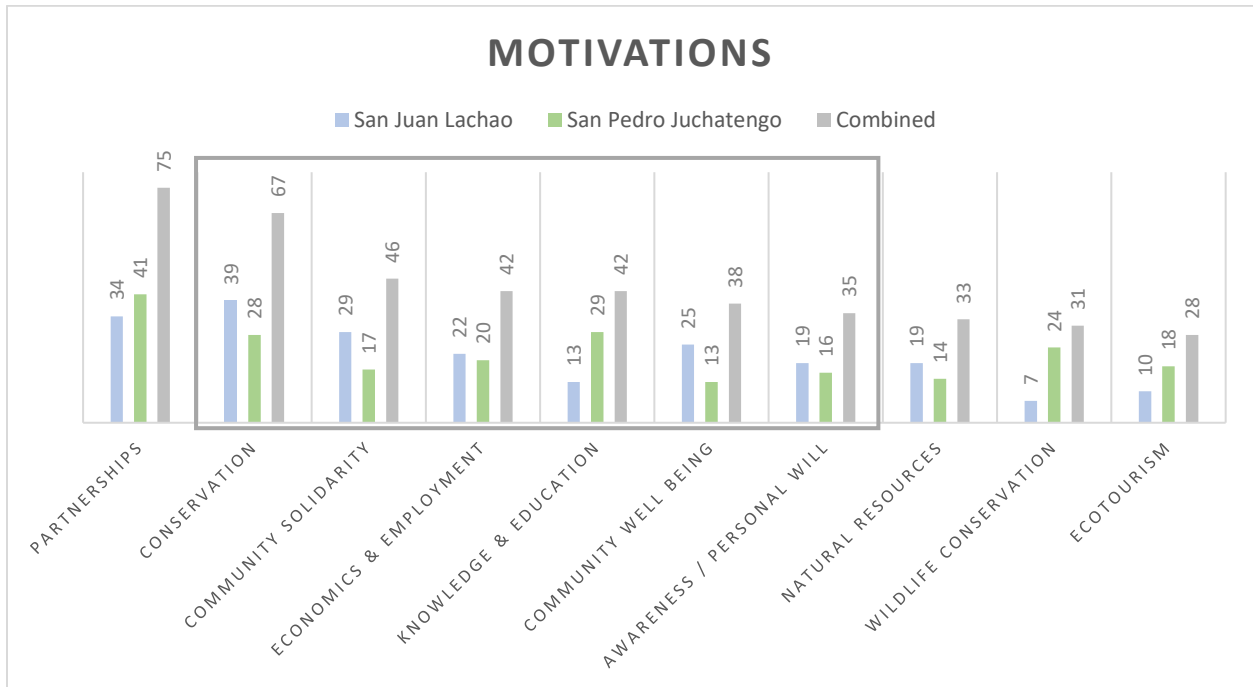


Figure 3.7: Results from Motivations theme. Six sub-codes inside the rectangle form connections with the themes Barriers and Benefits.

Social and environmental issues ranked slightly higher than economic issues, surprisingly. Employment ranked high, however in reviewing the data it became evident that although economics is indeed a huge driver, a connection to their environment, families, community, and indigeneity is a big motivator.

A deeper analysis at the community level indicates employment and education is a slightly higher motivator than community for Juchatengo and Lachao skews heavier towards community well-being and solidarity. Figure 3.7 color codes the top 10 out of 16 priorities for both communities, indicating where connections occur. It is important to keep in mind that if direct connections do not appear, there are no instances of gaps in priorities within the top 10 ranking out of 16 overall sub-codes for both communities.

Overall Juchatengo prioritizes partnerships, education, conservation, and economic activities followed by community wellbeing and awareness on their next plateau, or level down. Juchatengo is extremely

interested in partnerships and training with Lachao, ICICO and Duke, tying back in with professional training as a means towards more financial opportunities for individuals and the community. Based on the data and conversations, the consensus is ecotourism is the best pathway to achieve these goals.

Lachao prioritizes conservation, partnerships, community solidarity, community well-being, and employment, followed by education and economic activities at their next plateau. They also view ecotourism as a viable pathway for these goals through combining cultural and heritage components.

Table 3.8: Color coding illustrates direct, or nearby connections for the top 10 motivators. Motivators are divided into three categories: conservation-based, economic-based, and social-community-based.

Lachao Prioritized Motivators	Juchatengo Prioritized Motivators
Conservation	Partnerships
Partnerships	Knowledge & Education
Community Solidarity	Conservation
Community Well Being	Wildlife Preservation
Employment	Employment
Awareness / Personal Will	Ecotourism
Natural Resources	Community Solidarity
Knowledge & Education	Awareness / Personal Will
Ecotourism	Natural Resources
Wildlife Preservation	Community Well Being

Conservation based

Economic based

Social/Community based

The one direct connection of motivations between the communities is employment. All four community-based motivations (from this point forward referred to as community well-being) although ranked higher on one side than the other show close connectivity throughout, while conservation based motivations are interspersed. Most importantly, there is a higher quantity of community wellbeing priorities that are among the highest rankings (partnerships, solidarity, well-being); combined they rank first (Figure 3.7).

*“... a project directly benefits the community in that it generates jobs, because, if another project comes out, people who do not have work can get it. For example, in ecotourism, I have five guides, in this case, if I make this bigger, I can start helping the people who embroider, the people who weave, the people who work with the mud, I can start gathering them and that is generating benefit directly. In this way helps the community because it generates jobs and because the money that is accumulating is being used for the good of the people not only for one person, but for the village in general.”*

Through field observations, conversations, and data analysis it became evident that community well-being was a linchpin for programs and management plans. Capacity building to address trust, awareness, personal will, and solidarity through language and cultural barriers will be an important first

step towards implementing this project. The direct connection with employment between the communities (Table 3.8) indicates leaders and planners will need to incorporate communication about economics with the community population at large to secure project support. The following are comments captured in interviews and conversations about the importance of community well-being, awareness, trust, and collective action:

*“ Well here I think what would help would be to raise awareness about the corridor among the neighbors, the neighboring communities, so that we all work in tune on the same environmental issues, doing the same activities or the same stewardship across all wildlife. A lot of our citizens say “Well, what good is it that I am taking care of things, but others are not?”*

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*“I think in order to make a commitment, if the project is approved, everyone in the community needs to know how to take care of it.”*

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*“It is not the same to speak with five or six people as it is to speak with fifty so more can discuss, reflect, analyze and value what we have. We must speak with communities so they can understand and from there they can help us. They can support us on how to speak with more people and spread the knowledge and reasons to care for our forests.”*

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*“The biggest fear of the town is that, that, with all due respect, people from outside come and do nothing except to see what is here and hoard it away. And that is the point that many say, “is that it, then, they want to leave us with nothing,” or, “they want to take us away”. I think it is one of the factors that leads us to remove a project.”*

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*“Then, our obstacles are put by us for not explaining to people, that is, the people will oppose if you do not explain, there will be a good result if we explain and inform them, but especially if we set a good example. I think that is dialogue is the most important, yes, especially dialogue.”*

Lastly, partnerships had a presence in all the three categories, also reflected in the previous comments (economic, community, and conservation based). Through education and training via inter-community, university and NGO partnerships, communities identified pathways for economic growth (learning to implement or expand programs), inner and inter-community connectivity, and conservation. Finally, conservation ranked as a top motivation for these programs, indicating the importance of the deep multi-generational connection the communities have to their environment.

*Findings: Barriers*

We defined barriers as feedback regarding challenges in expanding the projects, and what factors may have potential negative impacts on the implementation of the corridor. There were 13 total sub-codes within *Barriers* with 7 high ranking sub-codes before plateauing out (Figure 3.8). Interestingly there were incidents of sub-codes recurring from *Motivations* and *Negative Perceptions of ALP's* in *Barriers*, creating unexpected linkages. For example, *awareness & personal will*, *economic & employment*, and *knowledge & skills* address existing barriers as catalysts for the higher ranked motivations. This indicates collective awareness around needs and goals between communities, and a starting point for inner and inter-community capacity building programs.

Our priority of focus for *Barriers* results is as follows: 1) Linkages and connections with *Motivations* and *Negative Perceptions* themes 2) The order of priorities within these connections, 3) Overall sub-codes ranking within the theme.

Table 3.9: Coding structure and definitions for *Barriers* theme.

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Explanation</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Barriers</i>	What factors are potential barriers against the implementation of the corridor projects?	Comments or feedback regarding the challenges and concerns in implementing or expanding the corridor projects	Awareness, Personal Will, Comprehension	Lack of awareness in community members (of program, procedures, goals, reduced natural resources). Also if there is awareness but no personal will to participate. Basic lack of comprehension due to minimal communication, whether through language barriers or physical location.
			Culture, Language, Communication	Language barriers and cultural conflicts, i.e.: accustomed to excessive hunting and firewood.
			Economics & Employment	Lack of funding or economic benefits.
			External	Political or economic factors outside the community that work against the project or create uncertainties.
			Geography	Remote location reduces social contact = limited knowledge of program
			Governance	Issues passing off programs between administrations
			Implementation	Difficulty in carrying the programs out or in compliance with program requirements.
			Infrastructure	Condition of roads, waste management, garbage, water systems – in order to handle increased visitors
			Knowledge and Skills	Lack of knowledge, technology or skills to undertake the projects.
			Land Use Classification	Conflicts over classification of land use areas, especially between agrarian & conservation.
Migration	Migration due to lack of employment.			

	Physical Boundaries	Access to certain areas, & within community to receive communication about programs
	Publicity	Lack of online and print communication about programs. This applies to within the community, between communities, as well as a lack of online presence in general.

### Barriers: Linkages and Connections Between Sub-Codes

The *Barriers* theme connects to results from both *Negative Perceptions of Alternative Livelihood Programs* and *Motivations*, as previously discussed. Similar to *Negative Perceptions of ALP's*, Juchatengo had a low quantity of responses (Figures 3.6, 3.7, and 3.8), emphasizing further a warning flag indicating inexperience, idealism, or both (Figures 3.6). Most importantly, the overlap of factors between themes suggests a need for communication, training, knowledge sharing, and inter-community connections for the project to move forward in Juchatengo.

Table 3.10: Linkages between recurring sub-codes for Barriers and Motivations themes.

Barriers and Motivations: Common Denominators					
	Barriers			Motivations	
	Juchatengo	Lachao		Juchatengo	Lachao
Awareness	10	31	Economic	31	40
Knowledge & Skills	4	23	Knowledge & Education	13	29
Economic	4	11	Awareness	11	18

Further analysis of the recurring sub-codes (between *Motivations* and *Barriers*) shows a reversal in priorities between the three, however *knowledge* stays in place as the common denominator (Table 3.10 above). Knowledge commentary revolved around the following: 1) inter-community training (Lachao trains Juchatengo), 2) NGO and university training to both communities, 3) Training on specific conservation monitoring equipment and practices (citizen science), and 4) inner-community educational programs (for youth, Chatino, farmers, citizens in remote areas).

*“We need to also have policies with the people, the community, yes , awareness more than anything because the truth is, we are poorly educated. We do not have that culture of valuing what is ours ... for example, our natural resources. We need to raise awareness, train ourselves.”*

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*“You (referring to ICICO and Duke) can help us in many ways, for example, right now a very important factor is the children, right? More than anything we need to focus on the institutions, the young people that are coming up now. Teaching the children is important for the whole community, training us is important also, so we can inform the many people who visit us from different parts of the world, since we are a tourist based road stop.”*

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*“Right now children, young people, they come to us with other ideas about how to maintain, how to conserve, how to sow, how to take care of our nature, our forests, because nature is the most important thing we have because without nature there is no life...”*

*It is nice this is being connected to our youth, for them to learn and investigate over time, because what happens if there are no more forests? The water runs out, the food runs out, it all runs out when it doesn't rain anymore. Everything will disappear. “*

#### Barriers Linkages: Order of Priorities

In both communities, the top barrier is awareness while economics is last (of the three). Awareness barriers consisted of the following: 1) Communication, 2) Understanding the concept of conservation, 3) trust 4) Personal will. Economics also classifies as an awareness barrier; community members do not understand the management and pipeline of program funds into the community. The concept of “people are buying our air” is difficult for some to grasp.

*“Sometimes many people talk to us about why organizations want to come and buy our air, as they say, right? I have said that is not what we are doing, the sale of carbon is made to the voluntary market, it is not that they come to say “I am buying carbon credits here”, it is a voluntary market. If you want to sell, fine, if you don't, then don't.”*

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*“Each program must have a set of rules and norms, and the community must understand those rules and norms. The people have their rules and the things they are used to, for example, in the past they are used to immediate access to money from programs as it comes in. With the new programs, they see the money come in, but do not understand the money has to go back into the new programs, so they say “you do not give us the money”, and they do not support the comisariado or the programs. We (the community and the comisariado), do not have a hand in (or control of), a program of improvement of management practices so that we can say to the community “what you ask of me, I can give you”. We have two situations (problems): the program has its rules, and also the people have their (different) rules.”*

The flip in priorities for *economics* from a low ranking barrier to a high ranking motivation suggests an overall lack of understanding as to the economics involved with implementing and maintaining ALP's and the corridor. Based on commentary the specific economic motivations are personal income (jobs), and income for the community. Obtaining financial support to implement or expand programs was not addressed as a motivation. This is echoed previously in the low quantity of results regarding negative perspectives, indicating an overall necessity for both communities to receive training regarding the economic impacts, good and bad, of the project. Lachao has gone through some economic workshops, however they have requested more.

### Barriers: Overall Rankings

Community-level analysis of *Barriers* replicates concerns in previous themes regarding language and cultural barriers for Lachao (Figure 3.8). The sub-codes *governance*, *implementation*, and *land usage classification* emerge as additional barriers to consider. Feedback regarding governance was specific to passing the projects over between administrations at the end of each governing term. The numbers were slightly higher for Lachao as they have more programs to manage and have more experience in hiccups that occur during administration turn-over.

Typically, there is a time lag for a percentage of the outgoing commission to distribute all information and background to the incoming administration. Economics came into the conversation again, as at times outgoing members have difficulty tracking and explaining budget items to incoming members.

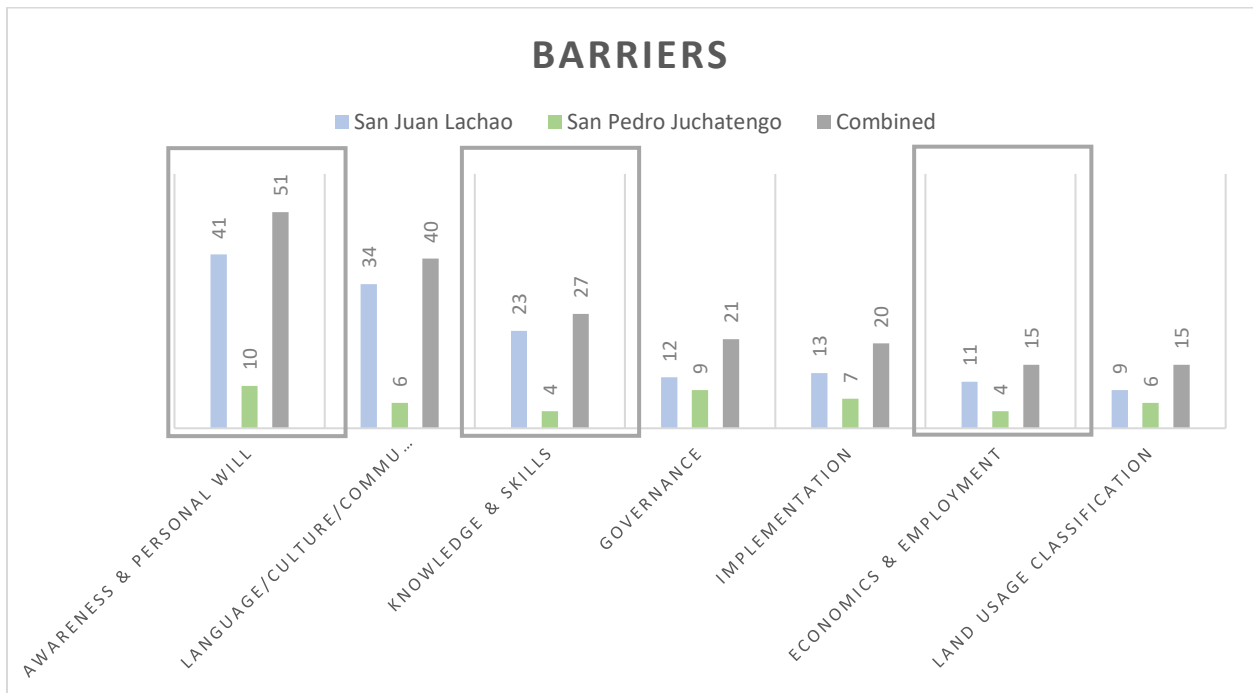


Figure 3.8: High ranking sub-codes within the Barriers theme. Recurring sub-codes between Motivations and Barriers themes are inside the rectangles.

Discussions regarding *implementation* tie back into *knowledge and skills*, and *economics*. The biggest concerns were delivery and resources for training, and the ability to offer jobs and retain employees for the long term while waiting for the programs to turn profits.

Barriers in *land usage classification* consisted of conflicts between farmers requesting more land for grazing and crops, with minimal understanding around conservation benefits and how much that impacts them financially.

### Findings: Benefits

Benefits is defined as perceived positive impacts from existing alternative sustainable livelihood practices within the community itself or in adjacent communities. This may sound broad given that one community has 4 programs in place and the adjacent community only has one program. However, it is interesting to note that both communities place value and importance on the same issues in this area and share common goals.

*Benefits* had a total of 8 sub-codes, with 6 showing significantly high rankings (Table 3.11, Figure 3.9). The highest perceived benefits from existing ALP's included *conservation, knowledge and education, economics, community solidarity, relationships, and natural resources*. It is also interesting to note another recurrence of overlapping sub-codes between *Motivations, Barriers, and Benefits*. Upon closer examination the sub codes of *knowledge and education, economics, and community well-being issues (solidarity, empowerment)* are a connector throughout these themes.

Table 3.11: Coding structure and theme definition for Benefits

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Definition</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Benefits</i>	What positive impacts have occurred from existing ALP's, within a community or from adjacent communities?	Feedback regarding direct positive impacts from existing ALP's	Conservation	Observation of conservation efforts making a difference, increased ecosystems services
			Knowledge & Education	How existing training in ALP's and conservation is making a difference
			Economic	Economic benefits from ALP's
			Natural Resources	Improved availability of natural resources, reduced pollution
			Community Well Being	Increased buy in and support from the community for existing programs
			Empowerment	Empowerment for individuals and the community at large from ALP's. Indications include education, training, income, access to improved natural resources
Partnerships & Relationships	Benefits from partnerships with ICICO, DUKE, other communities. Improved			

	connections within communities
Culture	The value of Indigenous knowledge increasing

Conservation ranked the highest overall for both communities and was the highest ranked sub-code out of all the themes. The other recurrence of conservation was in the *Motivations* theme, where it ranked second highest at 67 (Figure 3.7). Out of all sub-codes connecting multiple themes, *conservation* ranked as the third highest priority, after *community well-being* in first place and *economics* in second place (Table 3.17 under Discussion section 3.4.3) . Comments regarding noticed benefits from conservation initiatives included re-appearance of wildlife considered extinct, increase in quantity and richness of forest systems from replanting efforts, and clean water.

*“Yes, the great benefits, there are several moments in which each program brings a good benefit to the community, whether or not they give us jobs, they still make us value our resources and all those benefits come to the community. Carbon has brought us a very good development benefit for the community, so almost all the projects have brought benefit/profit and that is why we continue with that idea of following the conservation, care, protection of all our natural resources because not only do we benefit, but all of us who live on the same planet benefit because the conservation of the forest, the water is a great benefit. That is why we are aware that we can protect our resources for the medium and long term without earning a lot of money, it is enough that we already have pure air.”*

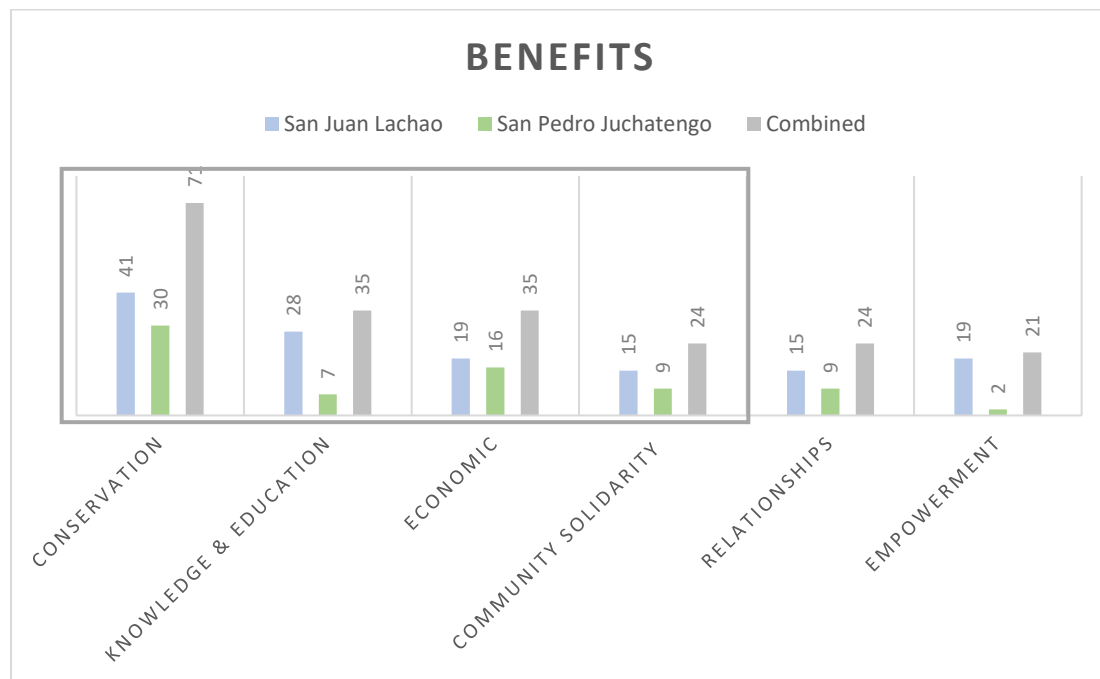


Figure 3.9: High ranking sub-codes within the Benefits theme. Recurring sub-codes between Motivations and Barriers themes are underlined. Economic is underlined twice as sub-code recurrence occurs in both Motivations and Barriers.

Economics ranked immediately after *conservation* for both communities. As a theme connector economics is the third highest sub-code throughout all themes (Table 3.17 under Discussion section 3.4.3). In considering this data, it must be noted that economics, as discussed under *Barriers* and *Negative Perceptions* ranked high for sensitive topics as well.

Economics will be the hot-button issue as it is also idealized through inexperience in idealism as noted in previous results (*Positive Perceptions, Negative Perceptions, Figure 3.7 under Motivations*). Therefore, in considering strategies for management plans, economics is a topic that will require education, transparency, and continual communications.

*“Well here in this case many families and the people themselves also benefit because in a way, the whole society benefits. Say for example the carbon project, nobody can complain that at least one peso did not touch them, that is, everyone benefitted because there was more employment. The only differentiating factor is If more families are employed. More projects could create more employment.”*

\*\*\*

*“Well, I think the main thing overall here is about having jobs. That is the most fundamental basis overall. Publishing, circulating information about the projects is equally as important towards offering more benefit.”*

Unified viewpoints between communities splits off after economics. *Knowledge and education* were a key driver for Lachao, while *community solidarity* and *relationships* were the next priority for Juchatengo. It is worth noting that both sub-codes plateaued out, apart from *empowerment* as the third highest priority for Lachao. *Relationships* captured partnerships between communities, with ICICO, and with Duke. *Community solidarity* and *empowerment* shared similarities, and if encapsulated within *community well-being* they become part of the highest ranked sub-code connector for all themes.

*“Well, I think that here the people have benefitted so much. The communal leaders have benefitted everyone through their services, they have helped schools, clinics, the health centers.”*

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*“Although there are some who give us barriers (obstacles), most of the people already support the project because it is a good project offers a lot of benefits, benefits at the community level, to answer your question.”*

The continued recurrence of connectors throughout the themes offers insight into key socio-economic factors to consider when laying the foundation for the project, both with ALP expansion and corridor design. The entire project aims to physically connect the communities, so the presence of social, economic, and political connections, while not tangible, will influence the success of visible by-products.

*“If we achieve success in our projects, many will want us to continue. There are people from nearby villages who want to visit our community and see what it is (what programs) we are doing well, and we invite people who are interested. I think that is going to do something....When we launch this, we need to launch it so that it is seen through the media, or everything that is called “the internet”. Once we are recognized, I think that many people are going to look for us and look to us.”*

Areas seen as providing the most benefit from these programs are *conservation, knowledge and education, economic incentives, community solidarity, and relationships; empowerment and ecosystem services* ranked in closely as well (Figure 3.9). Conservation does rank the highest overall of any sub-codes in all the themes at 59 in Motivations and 51 in Positive Effects, and connections between Conservation and other sub-codes will be addressed further in the discussion.

*Findings: Program Design*

Our definition for Program Design refers directly to existing sustainable alternative livelihood programs that are in practice within the communities or have been observed in adjacent communities (i.e.: San Pedro Juchatengo observing programs implemented in San Juan Lachao) (Table 3.12). We are examining their feedback on existing ALP program management methods to determine gaps, challenges, and future needs as programs expand.

Table 3.12: Coding structure and theme definition for Program Setup

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Definition</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Programs</i>	How can the community members monitor and manage the natural resources in the corridor?	When people discuss the methods they use to study and manage the environment	Conservation Monitoring	<u>Methods and indicators</u> used by people to track the condition of their environment, both traditional and modern.
			Management: Rules & Norms	<u>Policies and methods</u> used by people to manage the natural resources or project operation. <u>Rules and norms</u> established and accepted in the community that affect how people use and manage the natural resources.
			Self-Governance	Institutions that communities set up to organize themselves and to manage the interactions within the community.

	Collaboration	Mechanisms through which the community collaborates with each other and outside agencies like the government or NGOs.
	Education	Workshops or campaigns for education, <u>capacity-building</u> or <u>awareness-building</u> .

This theme, while not incredibly broad as only Lachao has an established management plan, is impactful from a practical and pragmatic approach. It ties in directly with the *Suggestions* theme and contributes significantly to our recommendations (See sub-codes groupings *knowledge sharing* and *conservation* under the *Suggestions* theme). As practitioners this provides insight into what is working, what is not working, and how they see practices improving and expanding. It allows for strategic planning on the ground and in real time. Out of the 5 sub-codes, three had noticeable feedback, one had a very high ranking for Lachao, the remaining 2 sub-codes had minimal feedback (Figure 3.10). We have found overall that this part of future programs will be an iterative process based in adaptive management approaches that builds off a “base plan” and must be addressed as such in future endeavors.

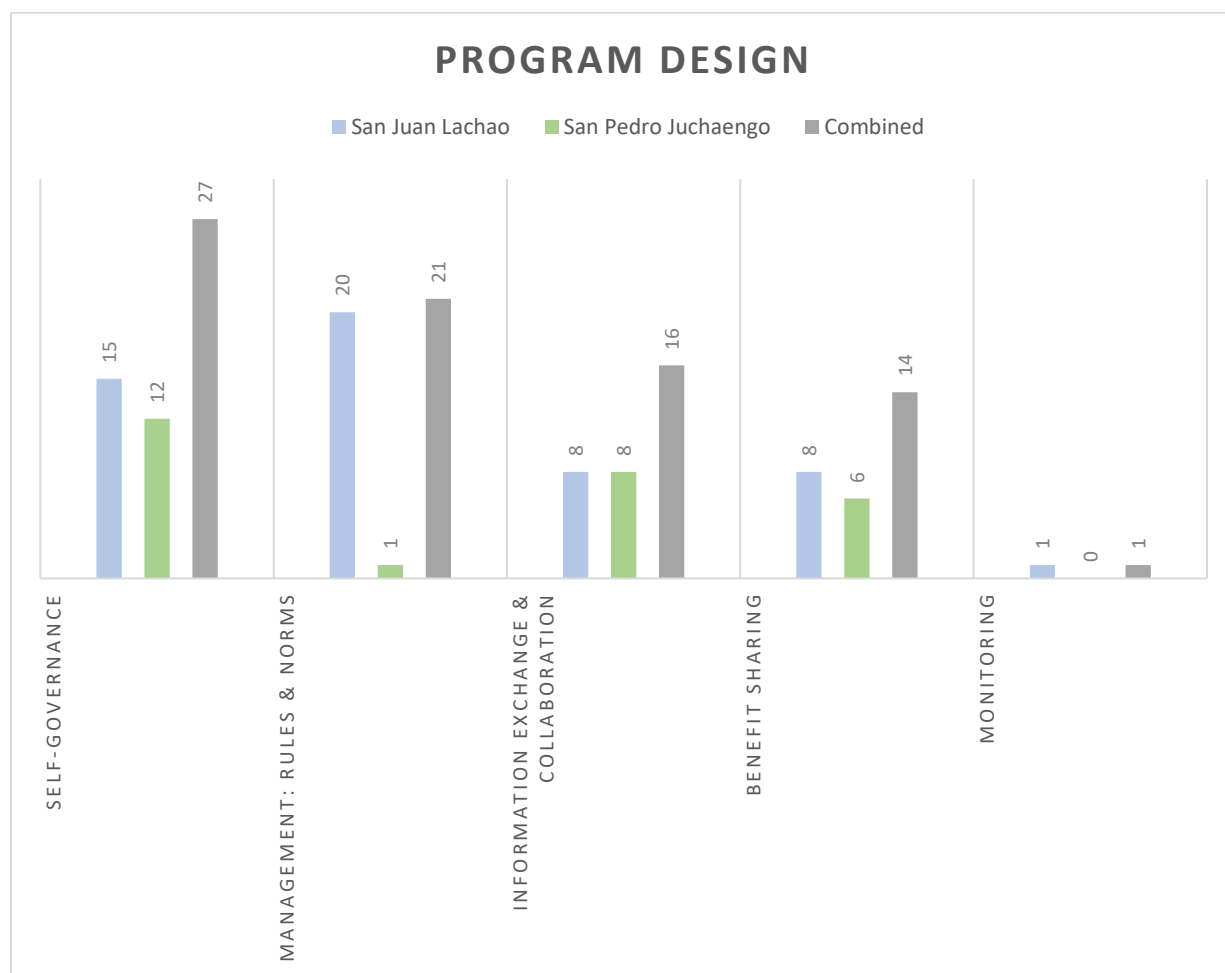


Figure 3.10: High ranking sub-codes within the Program Design theme..

*Self-governance* scored the highest for both communities followed by *collaboration*. As discussed in section 1, the communities have autonomous governance control and follow a system established centuries ago. Responses about self-governance mentioned concerns about transferring project information during community governing administration turn over. The biggest concern regarding information transfer was the absence of a specified system or a centralized location of project history to hand over.

Based on comments from Lachao it appeared information typically was passed on to successors in an individualistic fashion, to be determined by each person. This resulted in delays of transfer, gaps in budget reporting, and miscommunications. On another level any lack of understanding or unaware mistakes, perhaps due to learning curves, occur during transfer that could be addressed prior if everyone had access to a central information resource and a standard format. They also addressed members might be more comfortable to ask questions regarding concepts they don't understand if there is a standard in place. This came up in Juchatengo interviews also but from a proactive, anticipatory perspective once projects start.

*Information exchange and collaboration*, important in both communities, includes knowledge sharing, training, and working together on conservation. Conservation collaboration feedback included working on the corridor and increasing ecosystem services between the two communities. The consensus was by designing programs based on a foundational standard with the ability to exchange information easily, they would be more efficient in supporting the corridor and increasing ecosystem services through collaborative partnerships. This also spills over into *benefit sharing* where both communities spoke of how working together they could increase benefits for the environment and their economies. Furthermore, designing future programs collaboratively could include training workshops, and thus support knowledge sharing.

*"In relation to what you say about the corridor, I feel that to continue to work and encourage these programs, we should connect and exchange more knowledge; sharing our resources, history, and culture with the world while we still have it, and while we can still teach it. There are many things that we still cannot manage and interpret if we do not have help from experts like you, who show us how to value what we have and motivate us as a people to go beyond what we thought possible."*

\*\*\*

*"Yes, the great benefits, there are several moments in which each program brings a good benefit to the community, whether or not they give us jobs, they still make us value our resources and all those benefits come to the community... almost all the projects have brought benefit/profit and that is why we continue with that idea of following the conservation, care, protection of all our natural resources because not only do we benefit, but all of us who live on the same planet benefit. That is why we are conscientious that we can protect our resources for the short term without earning a lot of money, it is enough that we already have pure air."*

*Management: rules and norms* addressed synchronicity across programs and between communities, and scored very high for Lachao. Feedback within this sub-code related back to the *Barriers* theme under *implementation, awareness, and knowledge and education*, and finally *governance* within this theme (Figure 3.8 in the *Barriers* theme). Many respondents felt that, if the corridor project becomes a reality, the existing management plan will need to be updated and any new or expanded programs will each need a set of rules and norms. This will assist with implementation efforts, especially during administration turn over. Their concern and desire for a more synchronized approach with rules and norms indicates a realistic view of what is required for successful implementation. Furthermore, it also indicates continued support, and a desire for education, competence, and confidence in their roles. Lastly, respondents felt that a communication and awareness component would be a helpful addition to the overall program design.

*“I think that to really meet the needs of the community a set of rules or best practices within each program is necessary...A program of best practices for handling each one is necessary, because, as we saw it with the hydrological one, if we do not sit down and go over our mistakes, we have to start over again and again. We must diagnose the problem and what is needed because without tracking what we did wrong, we are only duplicating our work and making more mistakes.”*

#### *Findings: Suggestions*

*Suggestions* was the largest theme overall, as it is the cumulation of all input, and the basis for which recommendations will be provided not only for this report, but also in the client package. It also received the most commentary in field notes and casual conversations, and therefore had the highest quantity of sub-codes. Our approach for classifying the sub-codes was based on the literature review from section 3.2 for the first analysis. In the first analysis we used recurring patterns word frequency, comments, and feedback to capture and quantify data, then designed the final coding structure.

*Suggestions* is defined as feedback and input from respondents about improving new and existing ALP’s based on tangible and intangible needs. Comments and observations on successes and challenges are utilized to suggest modifications and activities that support the corridor while creating circular connections between ALP’s.

Table 3.13: Coding structure and theme definition for *Suggestions*.

<i>Main Code</i>	<i>Question Studied</i>	<i>Main Code Definition</i>	<i>Sub Code</i>	<i>Sub Code Explanation</i>
<i>Suggestions</i>	How can existing ALP’s and conservation activities improve; what new programs are most needed? What guidance, tools, and education are needed?	Feedback regarding how new and existing ALP’s can improve based on both tangible and intangible needs, to support each other and the corridor.	Carbon Sequestration	Expressed ways to expand upon existing program, or comments on reforestation to start a new program.

	Conservation (Wildlife and Ecosystems)	Comments on what is needed to expand program in Lachao and start one in Juchatengo. Camera traps, training, staff.
	Conservation (River and water systems)	Expressed a need and desire for conservation and reforestation around rivers and streams in both communities.
	Cultural Tourism	Suggestions on adding cultural tourism about Indigenous craft, art, language, and culture into existing ecotourism program.
	Ecotourism	Expressed ways to expand existing program, or needs for a new program.
	Education and Awareness	Suggestions on what specifically is needed in education for adults and youths, and ideas/steps on how to create more awareness.
	Enhanced Sustainable Agroforestry	Comments on tools, sawmills, equipment, land designation to expand existing sustainable agroforestry program.
	Garbage Management from Tourism	Comments on a need for improved garbage management on main roadways from tourism traffic.
	Information exchange program	Expressed needs for a way to share information between and within communities, in particular within the Comisariado.
	Inner and Inter Community Communications	Suggestions for workshops and communications and community-wide workshops within and between communities regarding the corridor and ALP's.
	Marketing and Publicity for ALP's	Requests for marketing and publicity plans, mostly for Ecotourism, but other ALP's also. Online, print, radio.
	Model Community Program	Utilizing Lachao as a model community to train Juchatengo and perhaps other communities.
	NTPF (Expanded Programs)	Requests to expand existing NTPF programs.
	Standardized Management Plans	Requests for a format of best practices and standards for each program, that can be adaptable per each community's ecosystem, population, etc.

Out of the 14 sub-codes we focused on 11; there were two plateaus before ranking decreased significantly. Within the results we noticed a pattern of sub-codes that, if divided into groups, would clarify the results further. The following three groupings of suggestions were generated to define priorities: 1) Knowledge sharing and communications, 2) Conservation, 3) ALP's. Similar to *Barriers*,

sorting the larger quantity of data into priority groupings provided results in manageable portions, while allowing for connections or patterns, if any, to emerge (Figure 3.11).

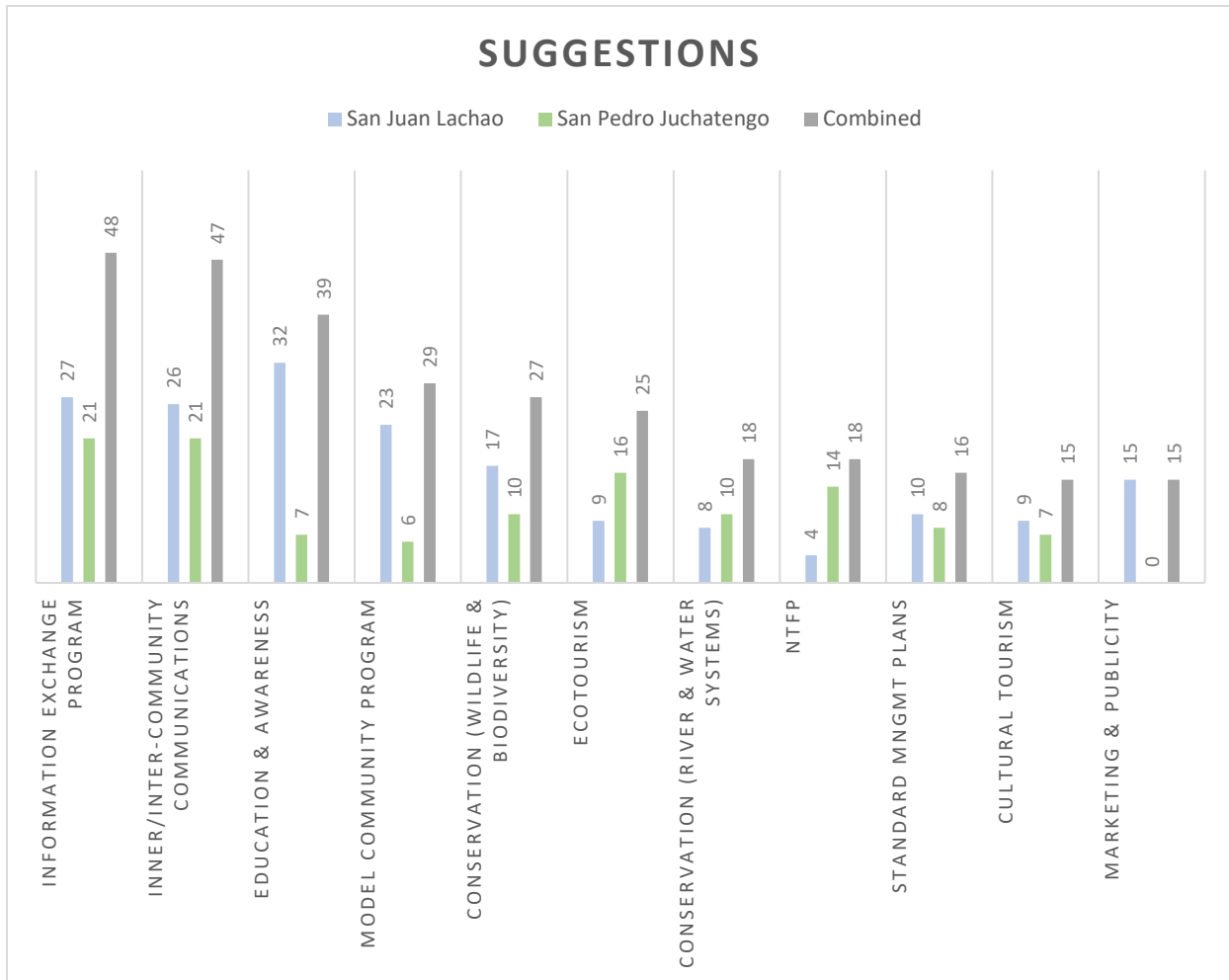


Figure 3.11: High ranking sub-codes within the Suggestions theme. Sub-codes were broken down into three groupings: 1) knowledge sharing, 2) conservation, 3) ALP's.

### Suggestions: Knowledge Sharing

The knowledge sharing grouping consists of 6 sub-codes: 1) *Information exchange program*, 2) *Inner and inter-community communications*, 3) *Education and awareness*, 4) *Model community program*, 5) *Standard management plans*, 6) *Marketing and publicity* (Table 3.14). Four out of six are the highest-ranking sub-codes overall, and this grouping has the highest number of sub-codes. This indicates that both communities placed a high priority on education, information exchange, training, and continuity. This grouping also adds weight as a connector between themes, linking to the same recurring high-ranking sub-code in the themes *Motivations*, *Barriers* and *Benefits*. Lastly, there is a direct connection to *Program Design*, as feedback relative to *standardized management plans* was mentioned frequently.

Table 3.14: Sub-codes and their ranking within the Knowledge Sharing grouping.

Suggestions Grouping 1: Knowledge Sharing			
	Lachao	Juchatengo	Combined
Information Exchange Program	27	21	48
Inner & Inter Community Communication	26	21	47
Education & Awareness	32	7	39
Model Community Program	23	6	29
Standardized Management Plans	10	8	18
Marketing & Publicity	15	0	15

#### Suggestions: Conservation

The conservation grouping consists of 2 sub-codes: 1) *Conservation of wildlife and biodiversity*, and 2) *Conservation of river and water systems* (Table 3.15). This sub-code began as a broad conservation issue, however as more comments were reviewed a distinct calling for water/hydrology conservation initiatives diverged from wildlife and biodiversity. This grouping also bolsters the emerging sub-code connector *conservation* that links with *Motivations* and *Benefits* (Table 3.17 under the Discussion section 3.4.3).

Comments regarding conservation along the rivers and streams discussed a need to reforest along the banks and have specific, dedicated conservation projects for these areas. There is a concern they have not recovered from previous hurricanes as quickly as they would like, and droughts are creating further delays. Juchatengo has experienced severe water shortages recently. Comments regarding wildlife and biodiversity conservation specifically discussed the need for more camera traps, and inventory of specific plants that are disappearing.

Table 3.15: Sub-codes and their ranking within the Conservation grouping.

Suggestions Grouping 2: Conservation			
	Lachao	Juchatengo	Combined
Wildlife & Biodiversity	17	10	27
River & Water Systems	8	10	18

#### Suggestions: ALP's

Out of the 5 ALP sub-codes, 3 had a high number of comments: 1) Ecotourism, 2) Cultural Tourism, 3) NTFP (Table 3.16). Both communities had suggestions for expanding or starting new ecotourism

programs, which was also addressed in previous themes. Ecotourism is viewed as pivotal in both communities, either as an entry point or a means to bolster current programs. Attaching cultural tourism to ecotourism was a notable suggestion from Lachao. It could satisfy the need for connection, preservation, and awareness with the Indigenous in Lachao, and possibly be expanded between the two communities in the future. NTFP suggestions came mostly from Juchatengo, however there was some mention of expanding coffee and honey programs in Lachao, and perhaps promote these as part of their ecotourism packages.

Table 3.16: Sub-codes and their ranking within the ALP's grouping.

Suggestions Grouping 3: ALP's			
	Lachao	Juchatengo	Combined
Ecotourism	9	16	25
NTFP	4	14	18
Cultural Tourism	9	7	16

During our field research it became evident that ALP's, management plans, and the corridor should not be placed into silos. The mechanisms that will support the corridor project and associated ALP's will need to be holistic in approach. For example, in Lachao they display images and share information from the camera traps as part of their ecotourism packages. Conservation, which will include establishing the corridor, helps these animals to proliferate, thereby supporting ecotourism further. Another example is conservation and reforestation around the rivers and springs. Conservation and reforestation efforts around the rivers assist with water quality, which assists with the water bottling plant in Lachao and the river Juchatengo uses for fishing and tourism. In turn, this supports water areas for ecotourism, bringing in more money, to support and expand other ALP's and conservation measures.

Designing management plans and ALP's would benefit from capitalizing on circular connections such as these. This is evident in the high requests within the knowledge sharing grouping, specific to the management plans. Lastly, in examining sub-code connectors, this is a prevalent connection throughout the largest coding themes: *Motivations, Benefits, Barriers, and Suggestions*.

#### Findings: Gender Insights

Gender insights was not a consideration for a theme when setting up the coding mainframe, as there were only two female participants in the entire sample section. However, when reviewing the results, it became apparent the female respondents not only accounted for a higher percentage of feedback, they also had very insightful perspectives that would not have been captured otherwise. Furthermore, their input played a significant role in recommendations, not only for gender representation, but because their insights noticeably shifted ranking weights once final coding was extracted and examined. The sub-codes that the women offered the most feedback on were *knowledge & education* (for adults and children), *information sharing, awareness, indigenous culture, ecotourism, conservation, community well-being issues, economics*, and overall *communication* including *publicity and marketing* of programs.

Both women touched on every connector sub-code in addition to each high-ranking code across all 8 themes (Figure 3.12).

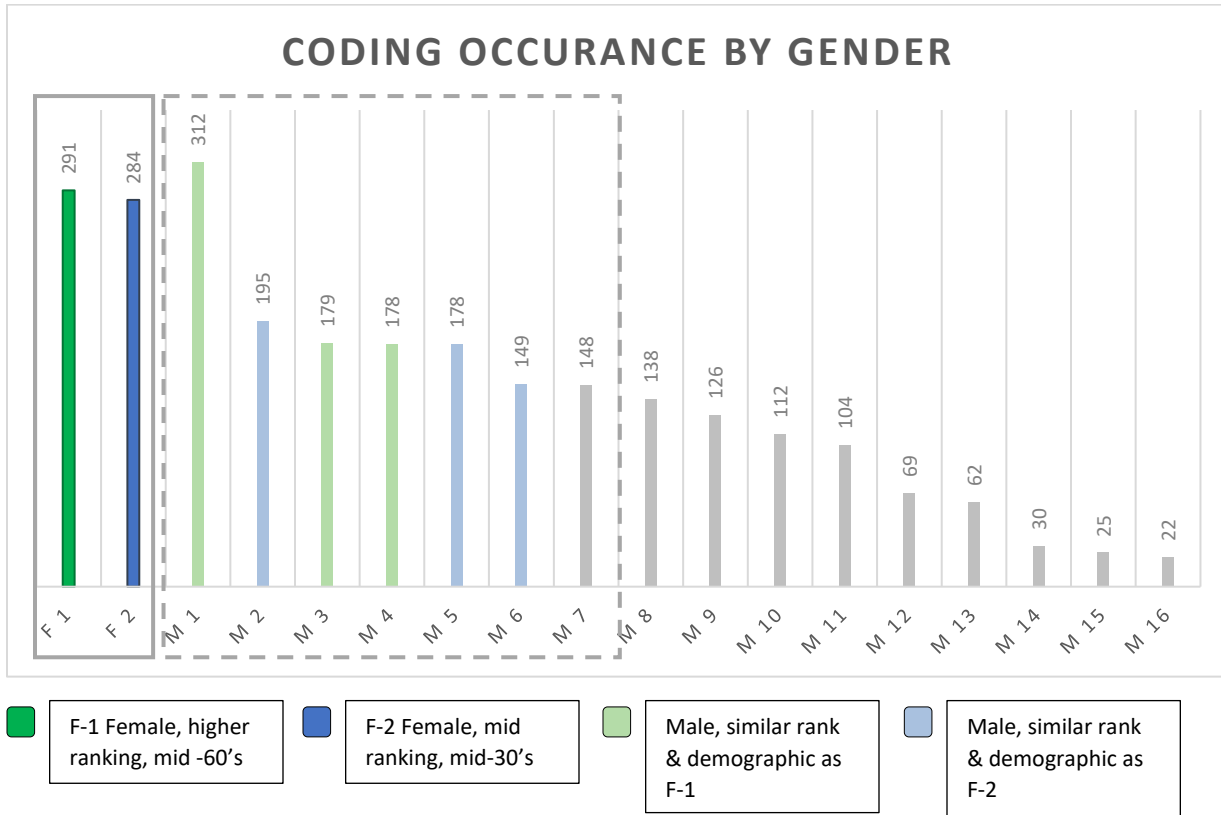


Figure 3.12: Results from female respondents compared to male respondents. Females are inside the solid rectangle and labeled as F2. Male respondents of similar age and rank within the Comisariado are inside the dashed rectangle. Refer to the legend above for distinctions in color codes in the chart.

To provide a clear picture for gender-specific analysis, it is important to note that there were 107 codes (or sub-codes) total within all 8 themes, and a total of 2442 coding occurrences. Divided out equally this would come to approximately 23 comments per code on average, and approximately 125 comments per person. However, that is representational if each person answered the exact same way and quantity.

Some respondents naturally had more feedback than others based on their position in the Comisariado, age, and number of years working in these programs, or generally out in the communities. Furthermore, certain questions elicited more responses and therefore high variances in the quantity of occurrences per code. Out of all the respondents, the top six ranking in the chart above answered every interview question in depth, thereby allowing for more coding occurrences. In the lower coding occurrences those respondents either had difficulty understanding the questions, did not answer thoroughly, or their answers were somewhat repetitive.

One woman was in her mid-60's and held a very high position in the Comisariado and had been involved in the projects since their inception. The other woman was in her mid-30's, held a mid-ranking position

in the Comisariado and had been involved with the programs a few years after their inception. Men that were in similar ranking and demographic are noted in a lighter color scheme than the women for visual comparison.

It would have been ideal to have more women represented in the study sample however that was not available, as we were focused on community leaders for this portion of the project. However, it has been noted, and as this project continues with the next research group recommendations address this gap and focus on the inclusion of more women in the next study.

### 3.4.3 Discussion

In quantifying the responses within the 8 themes, certain themes had a higher incidence of feedback and commentary, wherein our coding framework became more customized. Through our analysis linkages emerged among the highest-ranking sub-codes in what we are referring to as “sub-code connectors” or “common denominators” (Table 3.17). These are where we found patterns of multiple recurrences of sub-codes spanning across multiple themes.

#### *Connectors and Common Denominators*

The themes with the highest prevalence of connectors were *Suggestions* and *Motivations* followed by *Benefits*, and lastly *Barriers*. *Program Design* had connectors as well, however those were encapsulated in the general sub-codes and not teased out as specific connectors. However, it is included as a connected theme given that program designs based on this and upcoming studies will need to incorporate the results shown throughout.

The sub-code connectors with the highest incidence of recurrence were *knowledge & education*, *conservation*, *economics*, and *community well-being issues* (this encapsulates solidarity, empowerment, and equity). There is a nexus of themes and sub-codes highlighted in Table 3.17 below; *knowledge & education* span across all five connected themes. In moving forward with the corridor project and supporting ALP’s this nexus, these connections will be helpful to understand the drivers for both communities, and topics that need to be addressed early in the planning process.

Table 3.17: Matrix of sub-code connectors and themes they connect.

Sub-Code Connector	Theme				
	Suggestions	Motivations	Benefits	Barriers	Program Design

Knowledge & Education	x	x	x	x	x
Conservation	x	x	x		x
Economics	x	x	x	x	
Community Well-Being Issues	x	x	x		
Awareness & Personal Will	x	x		x	
Information Exchange & Best Practices (Standards)	x				x
Cultural Identity	x	x			

It was anticipated that *Suggestions*, *Motivations*, and *Benefits* would have a high quantity of response data. What was somewhat unexpected was *Barriers*, even though it had a very high quantity of response data, did not have more convergence across themes through connectors. However the results in *Barriers* show the first incidence of common denominators emerging through sub-code connectors (connecting to *Motivations*), but with a complete reversal in prioritization with the exception of *knowledge & education* (capturing training and skills topics), which stays in place (Table 3.10 under *Barriers*). As the primary connector across five of the main themes, *knowledge & education* is the top priority for both communities.

As discussed in *Barriers*, connection emerged with *Negative Perceptions of Alternative Livelihoods* in community response from Juchatengo. Juchatengo had substantial quantities of responses throughout all themes, except for *Negative Perceptions* and *Barriers*. This is where lack of data in results is just as important, if not more so, than high quantities. This highlights a type of idealism and excitement on the part of Juchatengo regarding hopes for improved economic opportunities and natural resource availability through conservation. Given the poverty levels, out-migration, droughts, loss of wildlife, and seasonal jobs, it is quite understandable a level of idealism out of desperation is present. This highlights the need to keep demographics, economy, and resources in the forefront while assessing the data.

In moving forward at the community level idealism and scarcity must be considered in planning, discussions, and program implementation with Juchatengo in a proactive manner. Transparency, open communication, and training workshops with ICICO and possibly with Lachao will be important, which ties back into the most prevalent connector, *knowledge & education*.

#### *Alternative Livelihood Projects*

ALP's that received the most feedback and demonstrated connections with other themes included Ecotourism, Carbon Sequestration, Water & Hydrology, and NTFP. Ecotourism had an unexpected, but important addition of cultural tourism specific to recognizing and preserving Chatino indigenous knowledge and traditions. This addition specifically links ecotourism to concerns of awareness and cultural identity, creates an economic opportunity through expanding an existing program, and acknowledges specific feedback from female respondents in our survey. Ecotourism also connects to Assets and Community Characteristics through *biodiversity* and *natural beauty* (aggregate), and *history* and *culture* (community level).

Based on the literature research ecotourism can be the costliest to establish and the slowest to return a profit. However, both communities are at an advantage (Figure 3.3 under *Assets and Community Characteristics*). The program in Lachao is established with growth opportunities and relies on the expansion of the carbon program for financial support. Adding the cultural component is feasible with minimal overhead. Juchatengo has some infrastructure in place through commercial tourism, festivals, and its location as a stopover between the capital of Oaxaca and resorts on the coast. Given these conditions, feedback, and ranking ecotourism could be a viable consideration as an entry point to connect the two communities in conjunction with the corridor.

On a community level, expansion of the NTFP program was an expected high result for Juchatengo, in tandem with high rankings carbon sequestration expansion in Lachao. The NTFP program for Juchatengo is limiting as harvesting sap and resin is a slow process. The only way to expand is to plant more trees, which is viable but will take time. Given their interest in carbon sequestration and connecting with Lachao, there is opportunity to 1) plant more trees for sap and resin, and perhaps use them towards carbon sequestration, and 2) reforest plots specific for carbon capture and perhaps start an alliance with Lachao to expand their carbon capture portfolio.

The last high-ranking ALP suggests another connection between communities and for the corridor. *Water & hydrology* relates specifically to commentary on reforestation and restoration along rivers and streams, and bolstering water supply for both communities. The large Atoyac river in Juchatengo has its source in Lachao and could be a watershed connector for the corridor and both communities. The river, streams and waterfalls are also important to both commercial and ecotourism programs, and link to connectors for conservation and economics throughout all themes.

In conclusion, the data from the interviews reveals the corridor project and associated ALP's will require foundational plans based on the higher priorities of education, training, conservation, community well-being, communication, and economics. We initially expected results to be relatively straightforward with a few exceptions. Based on literature research and early assumptions we anticipated heavier ALP focused commentary, based on those most profitable and economically viable. We initially constructed our coding framework to reflect those assumptions. Instead we found underlying social, equity, and empowerment issues that will need attention in ALP's and management plans. Moving forward in ongoing studies for this project, these issues will be integral to its success and longevity.

### 3.5 Reviewing global ALP lessons

Community-based ALPs often intend to integrate the achievement of multiple social, economic and environmental objectives. These objectives often include: promoting economic development and alleviating poverty (Hilson & Banchirigah, 2009; Brown et al., 2011), protecting biodiversity and wildlife habitats (Poffenberger, 2015; Roe et al., 2015), strengthening locally-based natural resource management (Shrestha et al., 2014), empowering communities in decision-making and self-determination (Bith, 2011), and promoting social equity for marginalized communities and social groups (Maharjan et al., 2009).

In this portion of the study, we reviewed the existing literature to understand the setups, preconditions, potential costs and benefits, and barriers for the four types of ALPs identified by us as having the

greatest relevance to our client communities. As discussed before, the four types of ALPs are: forest-based carbon offset, non-timber forest product (NTFP), agroforestry, and ecotourism. The primary sub-questions we addressed in this study include:

- How are the type of ALPs usually designed and set up?
- What social, economic, and environmental contexts can contribute to the success of projects?
- What kind of positive and negative effects are likely to result from the type of projects?
- What are the commonly encountered barriers for the type of projects?
- What suggestions have been offered to improve the chance of success for the projects?

### 3.5.1 Methods

In compiling a collection of articles for our literature review, we conducted broad search on Google Scholar and Duke University Library websites. To narrow down the range of search to up-to-date case studies on the specific type of ALPs in concern, we used “ALP type + case” or “ALP type + case study” as search terms for each of the four ALP types and limited the search range to literature published after 2000 (e.g.: “carbon offset” + “case”). We did not constrain our literature to peer-reviewed articles, but incorporated published scholarly articles, project reports, and doctoral/master theses in order to obtain a sufficient number of cases in each category for our analysis.

We screened the literature obtained online and selected those literature that: 1) focused on specific community-based ALP cases, and 2) evaluated the effects of the ALP intervention. Selected articles were then imported into NVivo for further analysis. To provide a consistent structure for our coding of literature in NVivo, we developed a coding guide defining the themes and sub-nodes under each theme (See Appendix Table 2). Corresponding to the study question described above, we determined to structure the analysis into the following six themes: Community contexts, Program setup, Positive effects, Negative effects, Barriers, and Suggestions. We then read through each of the literature and coded their contents under those themes following the coding guide.

Under each major theme, sub-nodes and third-level nodes were created to provide a higher level of specificity to the analysis. Those nodes and sub-nodes were constantly updated and reorganized throughout the literature review process as new contents continued to emerge. For example, we coded the benefits from ALPs under the theme of “Positive effects” into the following nine sub-nodes: Conservation, Cultural preservation, Economic incentive, Social Capital, Relationship, Empowerment, Knowledge and education, Natural resource management, and Equity. In the coding guide, we provided working definitions for each of the node and gave examples from literature to guide the coding of literature contents into these nine categories (See Appendix Table 1).

Our literature collection ended up with 22 cases of carbon offsets, 19 cases of agroforestry, 18 cases of NTFP collection, and 20 cases of ecotourism projects all over the world (Table 3.2). For the purpose of our analysis, we were particularly interested in the frequency each node appeared in a certain type of ALPs to study the characteristics of the ALP type. For instance, the node “environment” appearing with a high frequency under the “Positive effects” theme of carbon offsets would suggest a high effectiveness

of the ALP type in delivering conservation-related benefits. And a high frequency of the node “environment” under the “Negative effects” theme of ecotourism would suggest that ecotourism projects tend to have negative environmental impacts.

*Table 3.18: Categories of ALPs studied in the literature review and number of case studies reviewed in each category.*

<b>Alternative Livelihood Projects</b>	<b>Number of Cases Studied</b>
Forest-Based Carbon Offsets	22
NTFP	18
Agroforestry	19
Ecotourism	20

### 3.5.2 Limitations

ALP is a concept widely used in communities all over the world, but the comparability of different ALP programs should be examined in a critical light. The programs in our literature collection have different political and cultural contexts, different specific setups, and different scales. “Organizing cooperatives” for example, is a highly simplified category of program intervention that may have various organizational and power structure implications. “Economic benefits” could range from providing employment for a few people to generating significantly increasing the income for everyone in the community. The way in which we coded the literature did not allow us to capture such level of details about the projects.

Moreover, although we used the coding guide to standardize our analysis, the determination of whether a claim made in the literature fit a specific theme was essentially subjective. As a result, consistency in coding across different literature cannot be guaranteed at all time. A different person may have come up with a completely different coding scheme and may code the literature very differently even when the same themes were given. Well aware of this limitation, in analyzing the results, we focused more on the general pattern identified rather than the specific scores each theme got.

### 3.5.3 Results and discussions

Our review of the literature, though far from comprehensive, revealed some distinctive characteristics of the four types of ALPs in their ability to deliver different aspects of socioeconomic and environmental benefits. In this section, we will summarize the patterns we saw from the literature review with respect to each type of projects' strengths, weaknesses and common barriers encountered. Then we will apply those insights to our client communities of Lachao and Juchatengo and discuss how can these projects be expected to contribute to the achievement of the communities' objectives as revealed in the interviews.

#### *Carbon Offsets*

##### **Program setup**

Forest-based carbon offset ALPs usually involve the steps of creating forest carbon stocks by changing management regimes and protecting forests, tracking the changes in carbon inventory, employing third-party contractors to certify the amount of carbon sequestered marketing the carbon credits to potential buyers, and sharing the benefits from offsets payments. In a project in Nepal, the Norwegian Agency for Development Cooperation (NORAD) supported trainings for community Forest User Groups to undertake carbon inventories and collect forest carbon stock data on their land. A Forest Carbon Trust Fund was also created to disburse REDD+ funds annually to the stakeholders based on incremental carbon and socioeconomic indicators (Shrestha et al., 2014). In the Trees of Hope project in Malawi, farmers obtain Plan Vivo-certified carbon credits by planting citrus and mango orchards and adopting agroforestry practices, woodlots and boundary planting around arable fields. Field officers chosen by community members provided advice on planting techniques and took on the responsibility of monitoring carbon stocks (Stringer et al., 2012).

##### **Positive effects**

Carbon offset projects has the strongest effects in improving natural resource management among the four types of ALP considered (Figure 3.8). This was probably because the rigorous monitoring, reporting and verification requirements for selling certified carbon credits often mandated quite significant efforts in forest monitoring and management (Poffenberger, 2015). These improvements take the forms of improved tree-planting skills, enhanced fire and pest controls, and capacity-building for local monitoring teams (Brown et al., 2011; Bellfield et al., 2015; Robinson et al., 2016).

Moreover, carbon offset programs also appeared to be effective in promoting conservation and community empowerment. The conservation benefits are mostly created from newly planted and better managed forests maintained for carbon stock, which could also generate benefits in the form of ecosystem services, such as erosion and leaching reduction, fertility improvements and water purification (Brown et al., 2011; Hendrickson & Corbera, 2015). On the other hand, the establishment of carbon forests in some cases helped communities secure their tenure rights and decision-making authorities over the resource (Brown et al., 2011; Robinson et al., 2016).

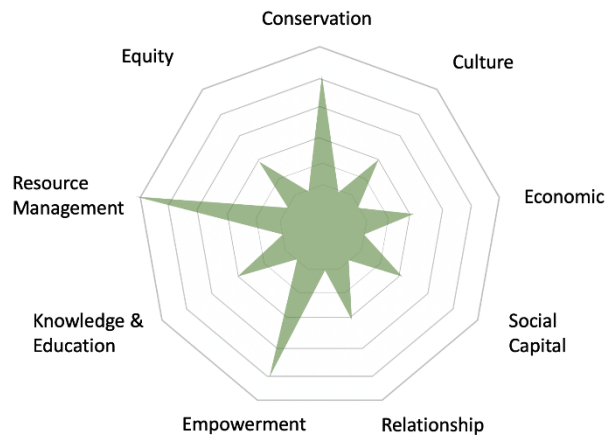


Figure 3.13: Scores of carbon offset projects across the nine Positive effects categories (n = 22). For the ease of comparison, the frequency of each node in the coding was re-scaled to a score of 1-5.

### Context requirements

Carbon offset projects require secure, long-term land tenure and supportive policies from the government. In Uganda, unentitled, traditional land tenure became a major barrier for the communities in obtaining certification for their forests (Peskestt et al., 2011). In the Khasi Community Forest project in India and Program SG in Tanzania, government disapproval and delay could block community access to revenues from their carbon initiative (Bozmoski & Hultman, 2010; Poffenberger, 2015). The combination of secure land tenure and government support are necessary to ensure the investors that the communities can be held accountable to the forest carbon they agree to preserve in the contract.

Moreover, communities engaging in forest-based carbon offset need to have a strong enough resource governance institution in order to implement the complex forest management, inventory and reporting projects over their land (Brown et al., 2011; Poffenberger, 2015). Building on existing governance structures can greatly facilitate the communication of project goals to community members and the acceptance of collective conservation rules (Stringer et al., 2012; Shrestha et al., 2014).

Successful carbon offset projects also require access to globally accepted certifying agencies and linkages to buyers who are usually big international corporations (Paiva et al., 2014; Osborne & Shapiro-Garza, 2018). Between the community, buyers, and the certifying agency, there needs to be a sufficient level of trust, as well as well-maintained channels for communication. Communities undertaking such programs thus should be well-connected to the outside world. Alternatively, strong networking and negotiation supports would be needed from enabling NGOs (Brown et al., 2011; Atela, 2013).

### Barriers and costs

A major potential barrier likely to happen in carbon offset projects is a financial one. Carbon offset projects often require quite high upfront investments in initial seedling acquisition and planting, while the benefits accrued from selling carbon offsets often occur slowly at a low and sometimes unstable rate (Bozmoski & Hultman, 2010; Shrestha et al., 2014; Hendrickson & Corbera, 2015). This implies the demand for quite significant external supports in the beginning period of the project, as well as a careful distribution of project revenues later. A few communities, for example, opted to pool the carbon offset revenues into a community fund that financed common welfare projects like the construction of schools and clinics (Grieg-Gran et al., 2015; Grace et al., 2010).

Moreover, in several cases it was found that community members often have difficulties understanding the rationale behind carbon offset programs (Asquith et al., 2002; Bozmoski & Hultman, 2010). On the other hand, restrictions on access to resources due to the management for carbon stock could be far more visible to community members after project implementation (Milne & Arroyo, 2003; Osborne & Shapiro-Garza, 2018). The lack of understanding on the project's benefits combined with the perception of reduced livelihood security may lead to oppositions against carbon ALPs within a community. Forest-based carbon offset projects that are perceived as unprofitable can be highly vulnerable to competing land uses like agriculture and logging. As market fluctuations increase the appeal of other livelihood activities, farmers may push back against the restrictive carbon offset programs, or opt out of it by converting land into other uses (Grieg-Gran et al., 2005; Carter, 2009; Kongsager & Corbera, 2015).

### **Suggestions**

Based on our observations from the interviews and field visits, Lachao and Juchatengo appear to have the ideal conditions in place for the development of a successful carbon offset program: secure land tenure, strong community governance institution, and a strong willingness to conserve their forests. There is also a quite mature monitoring scheme set up in Lachao with the support of ICICO and CONAFOR. At Lachao, the possibility of conserving more of the cloud forests for carbon offsets can be explored. For Juchatengo where less forest is available, selling carbon offsets on agroforestry or reforestation plots can be an option (Kongsager & Corbera, 2015).

Limiting factors for the carbon offset program at Lachao seems to be the challenge in marketing their carbon credits, and a lack of understanding among community members as suggested in the literature (Asquith et al., 2002; Bozmoski & Hultman, 2010). To address those barriers, ICICO can increase educational workshops on carbon projects in its community outreach, and Duke researchers may help communities conduct researches on the different carbon buyers and certification schemes to identify potential partners that best suit the communities' needs.

### *Non-Timber Forest Product (NTFP)*

#### **Program setup**

NTFP-focused ALPs tend to aim for the development of more sustainable harvesting methods for collecting NTFPs and the commercialization of those products through establishing local enterprises and market linkages that enable local communities to capture a greater share of the benefits (Belcher et al., 2010; Varghese et al., 2015). In Manitoba, Canada, the Northern Forest Diversification Centre developed

sustainable harvest protocols and provided trainings for local people in harvesting, resource management, post-harvest processing and trade (Belcher et al., 2010). In the Dolakha District of Nepal, external agencies supported the foundation of a machino distillation enterprise in the community that provided value-added incomes to the locally collected NTFP. Other projects involved the making of community-based rules governing the harvest of NTFPs and the creation of local monitoring teams to enforce the rules and to monitor NTFP stocks (Gobeze et al., 2009; Chou, 2018).

### Positive effects

NTFP projects performs the most strongly in generating economic benefits for the host communities (Figure 3.9). This is particularly important given that many of the practitioners of NTFP collection are among the poorest members of the community, and that NTFP often constitute a significant proportion of their total income profile (Kim et al., 2008; Gauli & Hauser, 2011). Increased income from projects comes from improvements in the production and management of NTFP products, as well as from better access to markets created by project-promoted commercialization and marketing efforts (Cosyns et al., 2011; Huynh et al., 2016).

NTFP projects are also relatively effective in providing are conservation, empowerment, and natural resource management. Conservation and natural resource management could both be resulted from new monitoring schemes and resource use rules developed as part of NTFP projects (Maharjan et al., 2009; Welford et al., 2015). Empowerment was mostly associated with increased participation in resource-related decision-making and increased bargaining capacity against traders and government agencies (Gobeze et al., 2009; Boissière et al., 2014; Varghese et al., 2015).

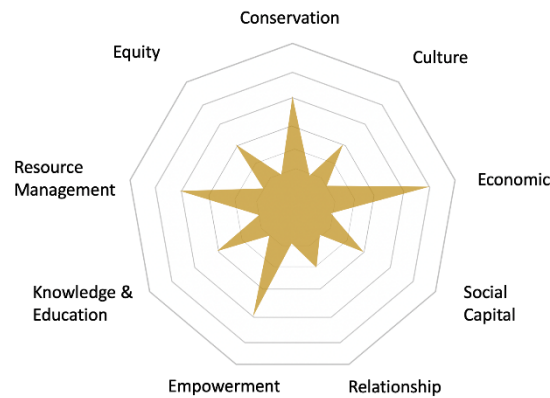


Figure 3.14: Scores of NTFP projects across the nine Positive effects categories (n = 18). For the ease of comparison, the frequency of each node in the coding was re-scaled to a score of 1-5.

### Context requirements

First and foremost, the adoption of NTFP projects requires the availability of valuable forest products to harvest. When those resources are unique and highly valuable, there would be a higher incentive for

people to organize collective governance regimes for their management (He et al., 2011; Harbi et al., 2018). Usually, community members engaging in NTFP harvest are historically dependent on forest for their living and have developed rich tradition and knowledge around the harvest of those products (Mukul et al., 2012; Varghese et al., 2015). Those knowledge and traditions can provide important guidance on the sustainable harvest of the NTFPs, and are valuable cultural heritages in themselves.

Similar to carbon offset programs, secure land tenure and clearly-defined resource boundaries are necessary for NTFP programs for the community to enforce property rights over the resources they are harvesting (Gauli & Hauser, 2011; Chou, 2018). Along with that, communities that intend to implement NTFP project also require either a high level of social capital to overcome collective action problems. A strong-enough monitoring and enforcement mechanism also need to be in place to guard against unpermitted harvests by community members as well as outsiders (Nygren et al., 2006; Belcher et al., 2010). Without high social capital and effective enforcement mechanisms, the NTFPs may easily turn into an unmanaged open-access resource vulnerable to overexploitation.

In addition to these internal factors, successful NTFP projects also requires the presence of a stable and accessible market for selling the products, as well as adequate infrastructure for transporting the products to the market (Gauli & Hauser, 2011). NGOs supporting communities in NTFP projects can help provide those much-needed access to market and market information (Cosyns et al., 2011).

### **Barriers and costs**

One commonly encountered barrier in NTFP projects is the capture of profits by external intermediaries or local elites, which could result in negative impacts on social equity and further impoverish the poorest (Nygren et al., 2006; Harbi et al., 2018). A possible solution for this problem could be organizing NTFP collectors to form cooperatives or collectors' associations. Such collectors' organizations could empower the collectors in the community and provide opportunities for them to deal more directly with consumers (Nygren et al., 2006; Belcher et al., 2010).

NTFP projects generally require low upfront costs to begin with, but considerable costs would be needed for monitoring and enforcement activities against illegal and unsustainable harvest. Harvesters in reviewed cases usually emphasize the demand for increased control since unauthorized harvest and contrabands of rules are commonly observed (Baldauf et al., 2015; Huynh et al., 2016). Setting up those control measures, however, can be costly in terms of budget and personnel. Moreover, the income generated from sustainable NTFP harvests could be low and unstable, which may cause NTFPs to lose favor in competition against logging or farming (Nygren et al., 2006; Belcher et al., 2010).

### **Suggestions**

According to people's expressions in the interviews, the existing NTFP harvests at Juchatengo seems to be popular among community members. They are also are required to follow sustainable harvesting guidelines provided by CONAFOR. However, the scale of the current project is small and there isn't any program there to monitor the stock and production of NTFP, which can be a direction for future projects to work on. Creating an inventory for the NTFPs harvested by community members with their stock and

distribution can help communities make better management decisions and maximize the economic potential from those products (Boissière et al., 2014; Welford et al., 2015). Moreover, there haven't been any facilities set up locally for storing and producing the products. The small scale and the lack of value-addition units combined may suggest that local harvesters have low bargaining powers and are vulnerable to the capture of profits by middlemen (Nygren et al., 2006; Kim et al., 2008).

To resolve this challenge, ICICO can first investigate the feasibility of expanding local NTFP production by quantity and product types. With a sufficient local production level, communities participating in the corridor project can cooperatively establish local NTFP storage and processing center to take advantage of the economy of scale (Varghese et al., 2015; Harbi et al., 2018). It is important, however, to always design protocols and monitoring schemes to ensure that all NTFP collection activities are undertaken in sustainable fashions and do not harm the wildlife (Nygren et al., 2006; He et al., 2011).

### *Agroforestry*

#### **Program setup**

Most agroforestry ALPs focused on providing capacity building support to local communities that promote more sustainable and profitable agroforestry to substitute conventional agricultural practices. In some cases, more advanced crop compositions and growing techniques are introduced by experts from external agencies (Hagggar et al., 2001; McGinty et al., 2008). In other projects, agroforestry can be a revival of traditional local agro-knowledge lost in the age of marketization and globalization (Faminow & Klein, 2001; Nath et al., 2005). In Talamanca, Costa Rica, for example, partner NGOs introduced improved production methods for shade cacao such as pruning, grafting of superior local germplasm, enrichment with fruit trees, and improvement of shade canopy, and provided workshops to train farmers and local extensionists in these practice (Dahlquist et al., 2007). In Nagaland of India, external agencies helped villages establish demonstration plots where new growing techniques could be tested and disseminated (Faminow & Klein, 2001). Another group of ALPs supported local communities in obtaining fair-trade and organic certificates for their products, which allowed the growers to receive a higher price premium in specialty markets (McGinty, 2008; Toledo & Moguel, 2012).

#### **Positive effects**

Agroforestry projects are most effective in delivering economic benefits among the four ALP classes studied, which is likely due to the usually significant share of agriculture in rural economies (Figure 3.10). Most importantly, increased crop diversification and more sustainable farming technique provided improved food and income security over monoculture practices against floods, pests, and market fluctuations (Noordin et al., 2001; Young, 2003). There is also a high expectation among project participants that the tree crops planted will bring considerable cash income in the future (Bugayong, 2003; Fouladbash & Currie, 2015).

Agroforestry projects also perform strongly in promoting knowledge and education. Because agroforestry projects are often connected to long-standing cultivation practices and local ecological knowledge, ALP projects facilitated the transfer of those knowledges on land management practices across generations (Regmi, 2003; Adaba, 2011). Moreover, capacity-building on agroforestry skills,

particularly those conducted on community experimental plots, helped people better understand the ecological processes behind their farming practices on the land (Faminow & Klein, 2001; Noordin et al., 2001). Agroforestry is also scored high in conservation benefits. However, it should be noted that those conservation benefits are often relative to more intensive agricultural practices, rather than preserved natural ecosystems. Environmental benefits of agroforestry systems most mentioned were improved soil and water conservation and enriched floral and faunal diversity (Bugayong, 2003; Young, 2003).

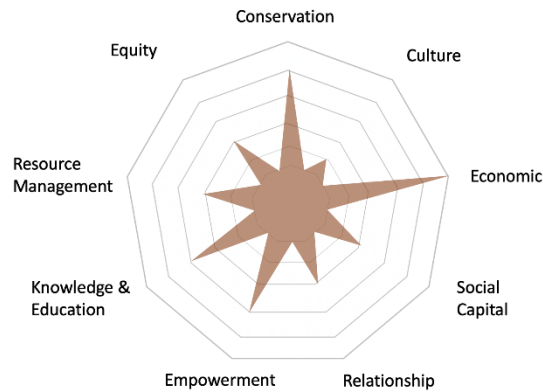


Figure 3.15: Scores of agroforestry projects across the nine benefit categories (n = 19). For the ease of comparison, the frequency of each node in the coding was re-scaled to a score of 1-5.

### Context requirements

The two major prerequisite for the practice of agroforestry are suitable land and relevant agro-knowledge. Communities and farmers relying on subsistence farming may not be able to afford the risk of shifting their land out of conventional production. Furthermore, agroforestry usually requires longer-term investments than conventional cash crop agriculture, so that a secure land tenure is still a necessary prerequisite for farmers to have a stake in the long-term sustainability of the land (Faminow & Klein, 2001; Ababa, 2011).

In some cases, the knowledge needed for sustainable agro-forestry programs can be drawn from local traditional farming practices (Sonwa et al., 2001; Nath et al., 2005). When this is the case, promotion of agroforestry can be facilitated through the revival of these local ecological knowledge, which are likely to be appropriate to local conditions and acceptable to local people (Fischer & Vasseur, 2002; Ababa, 2005). Otherwise, the techniques needed for agroforestry would need to be introduced by experts from external agencies. In such externally-driven projects, a strong connection and a high level of trust would be necessary for the new practices to be accepted in the community (Regmi, 2003; Nath et al., 2005).

### Barriers and costs

One recurring downside in agroforestry projects was the differential impacts on groups within communities. Under traditional division of labor women often engage less than men in farming

activities. As a result, women were sometimes excluded from cooperative developments and the disbursement of new techniques (Bacon et al., 2005; Fouladbash & Currie).

Moreover, it should be noted that the introduction and experimentation of novel agro-forestry practices and crop combinations is often a trial-and-error process and can take both time and resources. Because such experimentations require upfront investment and the setting-aside of productive land, the wealthier farmers with greater land holdings were more likely to make the change and benefit from such projects than the poor (Regmi, 2003; McGinty et al., 2008). Other potential obstacles include low and unstable product price, lack of marketing skills or market access, and limited farmers' involvement in the development of alternatives (Nath et al., 2005; Dahlquist et al., 2007; McGinty et al., 2008).

### **Suggestions**

Agroforestry, particularly sustainable timber production and shade-grown coffee, constitutes a significant proportion of the economy at Lachao but was rarely mentioned in people's comments during the interviews. This is probably because those businesses are already perceived as quite mature by people and thus don't become focal issues in discussions on new projects. As suggested in our review on global experiences, agriculture and agroforestry are still likely to be the mainstay of local economy despite the successful adoption of ALPs. Therefore, attention should always be paid to understand the agricultural contexts and their impacts on wildlife and natural resources (Pollini, 2009; Osborne & Shapiro-Garza, 2018). Community members already showed a strong interest in monitoring the effects of timber harvesting on wildlife and similar projects can be designed to study the effects of coffee and crop plantations. Insights gained from those study can provide important information for the design and management of the biological corridor.

Another suggestion worth special consideration is the need to diversify. Currently, the only sustainably produced agroforestry products in the communities except timber is coffee. Dependence on a single crop can subject farmers to the risk of market fluctuation, which has happened to the coffee growers of Oaxaca in the past (Bacon et al., 2005; Piekielek, 2010). Diversification of products, on the other hand, are often better for biodiversity and can make the farmers more resilient to environmental and market shocks (Méndez, 2008; Affandi et al., 2017). Therefore, entrepreneurial farmers can be encouraged to experiment with different products in an attempt to increase product diversity in regional agroforestry (Fischer & Vasseur, 2002; Young, 2003).

### *Ecotourism*

#### **Program setup**

Community-based ecotourism can take a variety of forms, including interpreted hiking trails accompanied by local guides, homestays with community members, and observation of and participation in traditional livelihood activities. In those projects, community members can benefit from employment as ecolodge managers and tour guides, and through providing food and hospitality services (Jones, 2005; Höckert, 2009; Reimer & Walter, 2013). Moreover, additional income can be generated if

tourism can provide an extra venue for the sale of the community’s handicrafts and agricultural products (Hipwell, 2007; Gerritsen, 2014).

**Positive effects**

Ecotourism probably has the most distinct characteristics among the four classes of ALPs. It leads all ALPs in four potential benefit aspects: Cultural preservation, Empowerment, Relationship-building, and Knowledge and education (Figure 3.11). Ecotourism could contribute to the preservation of culture because cultural heritages and local traditions often constitute cultural attractions as part of ecotourism projects. Tourists’ recognition of community culture and land, in turn, strengthens people’s pride in their culture (Hipwell, 2007; Bith, 2011). Empowerment, relationship and knowledge effects were associated with the significant capacity-building requirement at the kickstart of ecotourism projects. For individual practitioners, training in new managerial and communication skills helped build their self-confidence (Ohl-Schacherer, 2008; Tran & Walter, 2014). For entire communities, the formation of community organizations for tourism management can facilitate collective decision-making and increase the communities’ voice in dealing with external agents (Viljoen & Naicker, 2000; Ohl-Schacherer, 2008).

Ecotourism projects involve considerable interactions with external agents, which holds great potential for strengthening a community’s connectedness to the outside world. New connections with NGOs, tourists, research institutes, governments and businesses brought by tourism exchanges could become valuable assets for the communities that facilitated further capacity-building and development activities in the communities (Walter, 2009; Bith, 2011). Furthermore, many ecotourism projects employ local residents as guide to provide environmental education to the visitors, which also encouraged people to learn more about the local geography, biome, and culture (Höckert, 2009; Reimer & Walter, 2013).

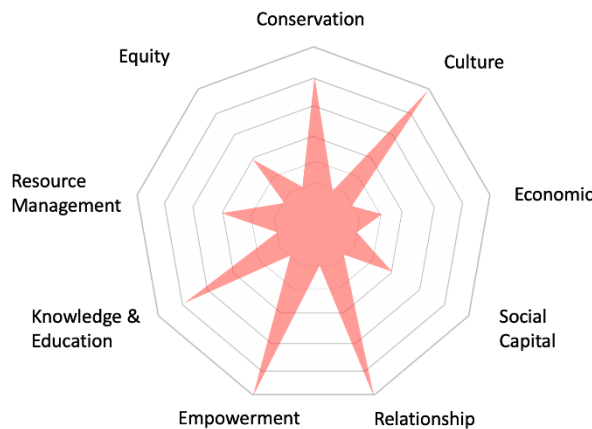


Figure 3.16: Scores of ecotourism projects across the nine benefit categories (n = 20). For the ease of comparison, the frequency of each node in the coding was re-scaled to a score of 1-5.

## **Context requirements**

Ecotourism projects usually require the presence of natural beauty or biodiversity richness that can constitute unique attractions for tourists (Gould, 1999; Reimer & Walter, 2013). They also usually require the existence of a flourishing tourism market in nearby cities from which tourists can be drawn, as well as adequate infrastructure for the transportation and hosting of tourists (Viljoen & Naicker, 2000; Foucat, 2002; Lyon, 2013). In many cases, the presence of charismatic “flagship” species or geographical features can play a crucial role in project promotion (Gould, 1999; Hipwell, 2007). In addition, unique local culture, arts, and “way of life” can also constitute cultural attractions for the visitors (Hitchner et al., 2009; Reimer & Walter, 2013).

Successful ecotourism projects also require its practitioners to be equipped with adequate marketing, accounting, management and hospitality skills, which are usually absent in communities less connected to the global economy (Ohl-Schacherer et al., 2008; Lyon, 2013). These sets of skills need to be cultivated through external capacity-building supports before ecotourism activities can start (Höckert, 2009; Bith, 2011). In some cases, communities and external agencies who trust each other develop co-management schemes in which the agency takes over the marketing and logistical parts of the project, relieving the pressure of the community (Cusack & Dixon, 2006; Ohl-Schacherer et al., 2008).

## **Barriers and costs**

According our review of literature, communities intending to engage in ecotourism programs should be aware that ecotourism projects require considerable costs in capacity building and infrastructure investment upfront, and tend to have long pay-pack periods (Ohl-Schacherer et al., 2008; Bith, 2011). In multiple cases, economic benefits from ecotourism were reported to be low and accrue to few members of the community. Tourism incomes are also highly vulnerable to international market fluctuations (Höckert, 2009; Lyon, 2013). As a result, those projects alone usually do not provide enough incentive for the conservation of lands (Stronza, 2007; Wyman & Stein, 2010).

Ecotourism ALPs, moreover, can have questionable effects on social capital and equity within a community (Figure 3.11). The rich elites in communities often tend to be in better positions to benefits from tourism in hosting visitors, while marginalized groups took more burden from reduced resource access (Reimer & Walter, 2013; Tran & Walter, 2014). Meanwhile, in a few cases, membership to tourism cooperatives were exclusive, which may widen existing social divisions within the community (Höckert, 2009; Lyon, 2013). While gender equity was actively promoted in some projects by involving women in decision-making and re-defining gender roles within households, uneven participation and employment across gender were still prevalent (Foucat, 2002; Reimer & Walter, 2013; Tran & Walter, 2014; Rodríguez-Piñeros & Mayett-Moreno, 2015).

Communities intending to engage in ecotourism business should be prepared for a “cultural shock” brought by the inflow of outsiders. Disturbances on local culture by tourists was a key negative impact reported in several cases, and “language and cultural difference” was also a widely perceived barrier

(Weinberg et al., 2002; Stronza, 2007; Bith, 2011; Lyon, 2013). Ecotourism projects were also often dominated by external interests or a small group of people with limited information-sharing and participation opportunity for the broader community (Charnley, 2005; Ohl-Schacherer, 2008). Additional barriers that ecotourism projects have encountered include poor infrastructure, lack of management and business skills, and waste disposal and damage to ecosystems (Ohl-Schacherer, 2008; Höckert, 2009; Bith, 2011).

### **Suggestions**

Lachao and Juchatengo each certainly own some attractive natural assets for the development of ecotourism. Results of the interviews also showed a very strong interest in the development of ecotourism projects and people from both communities tend to perceive ecotourism in a very positive light. However, our review of global lessons revealed that ecotourism projects rarely realize their economic promises. Even when they do, benefits are often restricted to a few practitioners within the community (Stronza, 2007; Höckert, 2009; Bith, 2011). Therefore, it is important for people to have a more realistic expectation of what ecotourism can bring before committing any significant resources to such programs.

Although ecotourism tends to hold less economic potential than agroforestry and NTFP according to our literature review, they do provide complementary incomes in better-protected ecosystems. More importantly, the empowerment of individual practitioners and the connections to outside agents are all very valuable assets that ecotourism projects can create, which may be more important than pure economic profits for the community's welfare in the long run (Gould, 1999; Höckert, 2009; Walter, 2009). The preservation and promotion of indigenous cultural heritages is also recognized as a community priority by many interviewees to which ecotourism can make great contribution (Höckert, 2009; Bith, 2011). Therefore, designing ecotourism projects in a multi-objective manner might be a more fruitful strategy for communities than focusing merely on economic returns.

## **4. Integrating Conservation and Livelihoods for Corridor Planning**

The trans-community conservation corridor project in Oaxaca is planned with the dual objectives of maximizing the protection for wildlife species and maximizing socio-economic welfares desired by the community members. Ideally, science-based monitoring and modeling can help us identify the geographical areas of conservation priority and guide the planning of land-use activities. The core areas of the corridor should be preserved for wildlife passage, while the remainder of the landscape can be planned for different types of livelihood activities based on local priorities.

In the following section, we will integrate the findings from the previous two sections and give our recommendations for the planning of the trans-community conservation corridor and the development of ALP programs. Those recommendations we propose will be reported back to ICICO and the community assemblies and subject to further deliberation by community members.

## 4.1 Recommendations on Corridor Planning

In this section, we integrate the findings from our quantitative and qualitative analyses to propose the following recommendations for ICICO and the client communities on the design and management of the biological corridor.

### 4.1.1 Conservation planning

Of the four species modeled, we found several commonalities in habitat preferences. The puma, ocelot, and peccary tended to occur farther from roads, while the ocelot, peccary, and coati were more likely to be found in high elevation areas. These trends suggest a potential synergy between wildlife conservation and alternative livelihood projects, considering that areas with high elevation and distance to roads are less accessible to people. However, the proposed corridor resulting from the distributions spans from east to west across central Lachao, but does not extend into Juchatengo. One intuitive explanation for this result is that the peccary, coati, puma, and ocelot exhibit minimal habitat in this area. However, it is also possible that our focal species were not modeled in Juchatengo because of statistical error. Regardless, to promote the continued collaboration between the two communities, we propose that future data collection and modelling focus on species that exist in both Juchatengo and Lachao.

Additionally, based on our results, our primary recommendation to the communities is to continue data collection in order to improve our distribution models. In the short term, this will involve revising the current camera trap protocol in Lachao and creating a new protocol in Juchatengo. These methods will incorporate camera trap sites across different ecosystems and will also optimize capture of focal species. In the future data collection methodology, the communities may also wish to prioritize a different set of focal species, depending on community goals and values.

We also recommend data collection of environmental variables at each camera trap site to improve the accuracy of our models, including understory density, land cover type, basal area, canopy cover, and trees per acre. These variables would also facilitate recommendations on forest management within the conservation zone. Furthermore, the need for continued data collection across the study area presents an opportunity for community engagement.

Finally, the feasibility of the proposed conservation area should be discussed between ICICO and the communities. Ownership and land rights could impact future corridor implementation and land management.

### 4.1.2 Expand conservation management areas

Results from the interviews revealed three sub-code connectors linking 6 of the 8 themes, which culminate in top priorities to consider when expanding existing or implementing new management plans and ALP's. Community well-being is their top priority, which encompasses empowerment through skills training, education (youths), language and cultural awareness; solidarity through conservation awareness; and empowerment through inter-community connections. Community well-being was followed by a conservation, while economics was the last of their top priorities.

With a very strong conservation ethic, they valued their ability to “take care of the land” and “protect the wildlife” more than economic profits. Conservation is viewed as a pathway towards community well-being, solidarity, and empowerment.

Promoting widespread pro-conservation values through capacity building within and between communities would make it easier for community members to accept projects that are more beneficial to the health of ecosystems like carbon offsetting, sustainable NTFP collection, and ecotourism (Reimer & Walter, 2013; Rodríguez-Piñeros & Mayett-Moreno, 2015). With these practices, the communities can explore the possibility of setting aside new areas for wildlife conservation, sustainable forest management and reforestation. Preferably, the selection of sites and the planning of ALPs on those areas can prioritize optimal wildlife habitats identified from the modeling study in order to improve habitat connectivity for wildlife species in the landscape.

#### 4.1.3 Systematize monitoring programs

Tied closely to the strong conservation ethic, community member interview findings also revealed in the interviews a very strong motivation to learn more about the flora and fauna on their land. Therefore, there is an imperative to improve the existing ecosystem monitoring program of camera traps to better deliver the information that both community members and researchers need. In order to support the creation of the biological corridor, the monitoring programs should include data collection of environmental variables and species presence across the study area. Our research team from the Duke Nicholas School, with expertise in ecological sciences, is well-positioned to offer the communities' technical support in monitoring design and in data analysis. Knowledge gained from those monitoring programs can be regularly presented to people in community meetings. They can also be expanded to become an environmental education component of the local ecotourism experience (Charnley, 2005; Reimer & Walter, 2013).

In addition to the monitoring of wildlife population and carbon stocks, monitoring programs should also be designed to address local priorities. Collecting data about the stock and distribution of key NTFPs like *copal*, for example, can help improve the sustainable management of the resource (Welford et al., 2015; Chou, 2018). Moreover, findings from science-based ecological monitoring can help the communities make a stronger case for the sustainability of their agroforestry and NTFP products in their attempts to access certification and specialty markets (Dahlquist et al., 2007; Toledo & Moguel, 2012). Through the assembly, community members can decide for themselves which natural resources are most important to monitor. And monitoring programs can also include community-defined ecological indicators to better incorporate local ecological knowledge (Jollands & Harmsworth, 2007; Timoti et al., 2017). External agents like ICICO and Duke University, on the other hand, can provide communities with advices on how to best monitor the resources they are interested in.

#### 4.1.4 Support local entrepreneurship

The best ideas for local sustainable development often arise from the minds of entrepreneurial community members (Berkes & Adhikari, 2006; Chirozva, 2015). At our client communities, we witnessed the emergence of local entrepreneurship in the spring water bottling and ecotourism projects, under the direction and guidance of ICICO. However, from field conversations and interview data, we found that those projects are currently facing financial barriers that prevent further staff recruitment or program expansion.

We suggest such financial barriers can be overcome by pursuing external funding streams that support ongoing sustainable entrepreneurship in the following outlets:

- 1) Grants through university and NGO connections.

- 2) Building upon existing portfolio partnerships with clients in the carbon market and utilize their existing portfolio as leverage to obtain new clients.
- 3) Establishing internal financing arrangements within the community. Establishing a “conservation bank”, or conservation fund would allow for responsible tracking and distribution of profits. This would reduce occurrences of mistrust or resentment within the communities, while offering a medium from which community leaders can plan for future projects and expansions.

Through their continued partnership, the communities, ICICO, and Duke can collaborate on grants research and applications utilizing their international connections. Furthermore, the continued project research through the university, ongoing program design, and community connections can be incorporated into a project portfolio to use when applying for multiple grants.

Specific to Lachao, they can utilize their existing carbon market portfolio to obtain more clients and build a presence. Their contracts with the state of California and Disneyland are starting to turn a viable profit, and they are gaining attention. In a conversation with ICICO while in the field, we learned that a new client has recently approached them and they are developing a contract. As profits increase funds can support expansions of ecotourism and water bottling. Gaining momentum in this arena boosts morale and encourages further entrepreneurship ventures.

In some ALP cases, project developers have supported the establishment of community revolving funds to provide low-interest financing for ventures of entrepreneurial community members that intend to improve the welfare of the entire community (Maharjan et al., 2009; Ahmad & Krott, 2012). At Lachao and Juchatengo, such community funds can be drawn from the revenue of existing carbon offset, payment for ecosystem service (PES) programs, and tourism (both eco and commercial to encapsulate both communities). It is recommended that both communities establish a separate fund specific to sustainable development and conservation. For Lachao, a percentage of profits from their 4 ALP's can go towards their sustainability fund, whereas Juchatengo can take a percentage of income from their one ALP and income from commercial tourism. Leaders of projects can then apply for this funding by making presentations to the assembly or *comisariado* to demonstrate the project's viability.

#### 4.1.5 Strengthen communication and outreach

In addition to the financial barriers, communication barriers and a lack of understanding and awareness, particularly among the older members of the community and the indigenous Chatino population, were shown to be an obstacle for the conservation and ALP projects. It is acknowledged by ICICO staff that more time would be needed for those groups to trust outside agents and to change certain practices (ICICO, pers.comm.). Getting everyone, especially the marginalized groups, on board would be critical for ensuring the effectiveness and equity of the projects. Therefore, we suggest that ICICO should strengthen its communication programs to help community members better understand the projects, with targeted efforts to reach out to the pure Chatino groups.

As discussed in section 3.3 *Interviews*, one recommended strategy is to incorporate cultural tourism into the existing ecotourism program in Lachao. This will increase profits with minimal overhead, increase family income, and generate connections and trust with the indigenous and these new programs. It will

create a circular awareness dynamic as well; awareness of outside agents regarding indigenous knowledge, and awareness of the indigenous populations as to the benefits of these programs.

A second recommended strategy is to design future management plans as a foundational standard, with rules, norms and best practices for each program, but adaptable to fit the individual needs of each community. The management plan will create a common ground and repository for all program developments, budgets, challenges, and growth benchmarks. It is recommended that part of the foundational management plan have specific sections for inner and inter-community workshops, communication formats, program marketing and publicity (online and in print), and training.

In global agroforestry and NTFP projects, one method that has proved effective for disseminating information is the creation of demonstration plots in communities (Hagggar et al., 2001; Fischer & Vasseur, 2002). Scholars also suggest that local promoters should be used whenever possible since farmers learn best from their peers and neighbors, those who understand their point of view (Faminow & Klein, 2001; Noordin et al., 2001). Therefore, we recommend that ICICO adopt such an approach by setting up demonstration plots in current sustainable forestry, carbon offset and NTFP harvest project areas as local hubs for participatory research and learning. Study tours can then be organized for targeted community members so that they can more directly experience the benefits of those land management practices (Noordin et al., 2001; Piekielek, 2010). Lachao, with its existing successful community governance structures and resource management practices, has the potential to take a leadership role and become a “model community” to host such educational tours.

#### 4.1.6 Establish inter-community networks

Wildlife corridors are landscape-scale ecosystems that cannot be effective without the cooperation of different communities in the region (Mesquita et al., 2010; Mallegowda et al., 2017). Many of the interviewees also expressed a desire to strengthen solidarity and cooperation within and between communities. We suggest that connection between communities participating in the conservation corridor project can be promoted through the creation of a regional community network. Ideally, the expanded corridors can connect to more habitat patches, especially those large and intact patches currently protected as state and national parks, so that they can more effectively serve their function of facilitating wildlife movement and increasing population health (Moller et al., 2004).

Following the lessons from international experiences, such an inter-community network can take the form of a landscape level “Federation”, or coordinating committee with representatives from each participating community as board members (Maharjan et al., 2009; Poffenberger, 2015). Such a network can serve as the platform for communities to plan conservation and monitoring at the landscape scale, exchange information and best practices on resource management, and facilitate the communication between communities and external agents (Hitchner et al., 2009; Baldauf et al., 2015). Under the rubric of the inter-community network, regional hubs for the processing, certification and marketing of sustainable agroforestry and NTFP products can also be established to enhance profits with an economy of scale (Bacon et al., 2005; Cosyns et al., 2011; Varghese et al., 2015).

While the blueprint of a broader inter-community network holds great potential in promoting conservation and socioeconomic benefits, it should be recognized that establishment of these networks by ICICO will take significant time and resources. It will also take time as well as communication efforts

for neighboring communities to become aware of the corridor project and get convinced of the benefits of joining. Ideally, if the initiatives in the currently-participating communities are viewed to be successful, new communities may be encouraged to get on board. Some communities are already visiting Lachao to learn about their programs and determine how to emulate their successes within their own regions, indicating buy-in and support regionally is viable. Communities can also be encouraged to participate with better opportunities to connect to resources from external agencies like the Climate Action Reserve and Duke University. However, given the time and budgets it requires, this recommendation should be viewed more as a long-term goal.

## 4.2 Future Research

Our project is not a one-time effort and will be carried on by ICICO and other Duke research teams. For the reference of future researchers, we propose possible next steps to continue pursuing the overall project objectives in upcoming years.

### 4.2.1 Engage communities in participatory planning

To follow up on our project, it is important for future research teams to include the maps from this study and review interview findings and suggestions with to the community leaders for review and further feedback. This will be an important future step to maintain momentum and involvement, and generate workable, achievable action items. The wildlife habitat maps, for example, should be examined by experienced community members to check whether they are consistent with local realities and traditional ecological knowledge. This step could also start an ongoing citizen science program to expand on current data gathering activities. It is recommended that a broader door to door survey be designed as a next step to build upon the socio-economic data from sections 3 and 4 of this study. A cross-section specific to women in general and children's education, both relating to conservation activities, the corridor, and ALP's would be an ideal scenario for surveys. Moreover, engaging community members in the planning of ALP activities and management plans is important for gaining more local support, increasing understanding and awareness, and ensuring the feasibility and equity of projects (Fischer & Vasseur, 2002; Cusack & Dixon, 2006; Atela, 2013).

### 4.2.2 Test the protocols in the field

The revised wildlife monitoring protocol that we provide to ICICO and the communities should be implemented in the field in order to test its effectiveness and feasibility. We suggest that future research groups work with ICICO to establish the new camera trap protocol and collect additional environmental data. Further data collection could support more significant habitat modeling and corridor design between the communities. It is also important that local community members participate in the setup and maintenance of the camera trap monitoring so that they can independently continue the data collection (Danielsen et al., 2009; de Araujo Lima Constantino et al., 2012). Ultimately, local communities should be empowered to interpret the scientific information obtained from those programs and to use them for local adaptive management.

#### 4.2.3 Continuous monitoring and adaptive management

Adaptive management refers to an iterative approach to environmental management in which the effects of policies are carefully monitored and evaluated to provide feedback for the design of new policies (Lee, 1999). This approach integrates management and research and allows environmental managers to track the progress of projects and more flexibly adapt current practices to research findings (Stuart-Hill, 2005; Mog, 2006). To practice adaptive management in this project, we suggest ICICO and future researchers set up methods to continuously monitor the ecological and socioeconomic effects of corridor-related projects and track whether the intended objectives of the projects are being achieved. Duke research teams can help the communities analyze the results from those monitoring programs and provide further recommendations for program improvements and adjustments.

#### 4.2.4 Information repository program

Transfer of knowledge and a forum in which rules and norms are established for each project was one of the higher ranking issues in the interviews. The World Trade Organization (WTO) recognizes the importance of the dissemination of techniques for planning, management, regulation and monitoring of ALP's and conservation management (Cusak & Dixon, 2006; WTO b 2002). In 2002 the WTO released guidelines for communities participating in ALP's, offering guidance on the location and distribution of program information, training, and management plans (WTO a&b, 2002). Long term success of these programs will require access and use of foundational information and resources (Cusak & Dioxn, 2002).

The benefits of creating a central information system is the storage and incorporation of conservation management plans, financial planning, training programs, program status and developments, future planning, and marketing and publicity, in a central location. This also addresses concerns expressed in the interviews regarding awareness and community solidarity; the Comisariado can use it to distribute information regarding project developments with the greater community at large. Additionally, it can be holistic and store camera trap, mapping, and conservation data. This tool will aid in capacity building efforts with ICICO and the communities while building collaborative efforts between the communities. An information repository program may also reduce confusion and mis-communication during the change-over of governing body administrations . It is recommended Duke students and researchers partner with ICICO in establishing the repository, and perhaps it can become a long-term effort between the University, ICICO, and the communities.

This will take time and will require dedicated staff in the communities and at ICICO to maintain. There will be a learning curve; it needs to be intuitive and non-complex in order for participants to adapt and utilize it long term. The central repository will need to be stored and available online through a cloud-based platform, however it is entirely possible the communities will want printed versions, as their internet access is interrupted frequently. The long term management of the corridor and ALP projects will require consistent evaluation, commitment, and adaptive management practices (Cusak & Dixon, Grieg-Gran et al., 2005, Bremer et al., 2014). A central information program will bolster such efforts, assist with building capacity, and bolster efficiency. We argue that initial efforts in time and execution will pay-off exponentially in the future.

#### 4.2.5 Communication and publicity program

In the interviews there was a concern regarding public awareness of the programs. We searched online for any type of social media content, or small web-pages, about their conservation and ecotourism programs, as in Lachao they were under the impression they had a Facebook site. Our exhaustive search returned zero results. A communications and publicity program could be an addition to the Information Repository suggestion or stand alone.

We recommend utilizing both online and print mediums, with a two pronged approach. Online marketing and publicity campaigns can be useful in gaining international attention, and platforms like Facebook, Instagram, and Twitter are free. Small websites can be designed with free or relatively inexpensive applications. Should this become a student project, this could be another collaborative effort between Duke, ICICO, and the communities. Utilizing Duke to promote and discuss the programs internationally would increase international exposure. Print marketing efforts can go towards inner and inter-community communications, advertising educational workshops and new developments. Additionally, printed material can be posted at tourism markets and hotels in Juchatengo to draw additional interest from travelers stopping over.

Similar to the Information Repository, this will take time and effort to establish, and will require one to two people to update and maintain. However, the learning curve would not be as steep as the repository, and once the operation is up and running, updates and maintenance will be relatively straightforward. Printed material efforts would need to be managed by the communities for the most part. Therefore, commitment and budget must be established and adhered to from the onset.

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## 6. Appendix

### 6.1 Coding Guides

<b>Positive Effects</b>	<b>Working Definition</b>	<b>Example</b>
Conservation	Protecting wildlife, ecosystem and ecosystem services.	<p>“Farmers mentioned that due to the intervention of homestead and rubber-based agroforestry, soil erosion had been reduced to a great extent.” (Nath et al., 2005)</p> <p>“The traditional coffee agroforests also serve as corridors and refuges for many plant species of the forests threatened by land use change and, especially, operate as germplasm reservoirs of useful plant species.” (Toledo &amp; Moguel, 2012)</p>
Cultural Preservation	Preserving and promoting local cultural heritages, particularly traditional ecological knowledge.	“Today the tradition of honey hunting is practiced by youth and young people in the community as an activity they are proud of and not hidden away as a primitive activity.” (Varghese et al., 2015)
Economic Incentives	Promoting economic development, increasing livelihood security, creating jobs, capitalizing on the value of natural resources or receiving other economic benefits as an outcome of the project.	“In comparison to 2006 when no special management practices were adopted at all, this showed an increase of 46% in production and 83% in household cash income.” (He et al., 2011)

		<p>“Ecotourism has brought varied positive changes, including more jobs and incomes leading to an improved standard of living; better and more varied services.” (Weinberg et al., 2002)</p>
Social Capital	<p>Strengthening community pride, solidarity between community members, and the community’s ability in solving collective action problems.</p>	<p>“Several strands of evidence suggest that community forestry activities have had a positive impact on social capital. CFUGs were widely considered to provide a new forum for community members to meet and discuss general social issues as well as to learn about new activities happening in the community.” (Maharjan et al., 2009)</p>
Relationship	<p>Improving the relationships with other stakeholders like the government, research institutes and NGOs.</p>	<p>“They have become a valuable way of linking up with development partners who are also involved in scaling up agroforestry and other agricultural innovations.” (Noordin et al., 2011)</p> <p>“Through the community–company partnership, many members of infierno have developed professional relations and friendships with the urban-based guides and staff of rainforest Expeditions.” (Stronza, 2007)</p>

<p>Empowerment</p>	<p>Enhancing individuals’ or communities’ power and ability in making decisions and realizing their objectives.</p>	<p>“The lodge project has catalyzed the creation of new cultural skills and institutions in these indigenous communities, especially managerial capacity and improved ability (both individually and collectively) to interact and negotiate with outsiders.” (Ohl-Schacherer et al., 2008)</p> <p>“They are using the results of participatory research to adapt government development projects to better meet the needs of their members.” (Haggar et al., 2001)</p>
<p>Knowledge and Education</p>	<p>Gaining new knowledge and awareness, especially scientific knowledge, about the surrounding environmental and social systems.</p>	<p>“Over the course of the project, other local practices, ecological insights, and grassroots innovations were observed and disseminated.” (Faminow &amp; Klein, 2001)</p> <p>“The farmers’ responses also suggested that the projects had led to greater awareness of the potential harmful impacts of slash-and-burn agriculture.” (Fischer &amp; Vasseur, 2002)</p>
<p>Natural Resource Management</p>	<p>Improving people’s capacity and methods for managing natural resources.</p>	<p>“One hundred and eleven respondents (88%) noted the beneficial outcomes of fire management, tree planting and/or feral animal control activities supported by the</p>

		CFI scheme.” (Robinson et al., 2016)
Equity	Promoting equal treatment and access to benefits for marginalized communities and social groups.	<p>“The cooperative both reproduces and ameliorates income disparity within its membership. Members with lower incomes and smaller landholdings derive a certain amount of social capital from their association with the cooperative.” (Piekielek, 2010)</p> <p>“Before tourism development, these women had had very limited possibilities to participate in the official meetings and in the decision-making. Therefore, tourism had brought a significant change to some of the women.” (Höckert, 2009)</p>

Table 6.1: The nine categories of expected benefits from alternative livelihood projects, the definitions for the concepts we applied in coding, and corresponding examples from the literature.

## 6.2 Interview Guide

*Concept: What is the perspective of the Community Leaders on the potential benefits and barriers for implementation of the multi-Community Corridor, and related income-generating activities (eco-tourism, water bottling, carbon sequestration, agroforestry, habitat restoration and enclosures for at risk species, coffee, other non-timber forest products)?*

(Framing for questions) We are interested in focusing on the possible siting and implementation of a multi-community biological corridor, and developing any related income generating activities within each community. We'd like to ask you some further questions about this aspect of the project, your impressions and feedback.

*General Community-Specific Background:*

- What are your general feelings about the inter-community biological corridor and any related income generating activities?
- How does your community benefit in pursuing the biological corridor? Are there any barriers?
- How is your community planning to become a part of the biological corridor?

*Historical Background:*

1. (If they are already involved) How did your community get started with the multi-community biological corridor project? What about any related programs [x type of PES project: *eco-tourism, carbon sequestration, coffee, agro-forestry, non-timber forest products, water bottling, etc*]?
2. What projects has your community completed to date? What were the obstacles? What were the benefits?
3. What motivated you, as a leader, to start implementing these programs [x type of PES project]?
4. What is your specific role with the projects presently?
5. What projects do you envision for the future?

*Overall benefits and barriers for implementation of the biological corridor and related income generating activities (PES):*

1. What are the benefits that motivate your community to participate in the biological corridor project? What are the benefits that motivate your community to implement other related income generating projects [x type of PES project]?

2. What obstacles do you see your community facing, and how do you think they could best be addressed?
3. Can you think of any examples where past projects have overcome similar barriers?
1. What would make the community biological corridor, and related income-generating activities (PES), easier to implement within your community?
4. What has been the most difficult part of changing to PES and conservation projects? What feels overly burdensome or unnecessary?
5. Based on your experience, do you have any additional thoughts about how the corridor project, or the related projects, can effectively support your community?

#### How to Address Planning, Implementation and Maintenance

2. Gathering data and maintaining accountability and transparency will be an important part of this project. Bearing that in mind, how do you think any current barriers could best be addressed?
3. What tools, access to data, organizational arrangements, and guidance materials would help get to this ideal outcome?
4. Are the environmental benefits of sustainable industry (PES) vs. conventional agriculture, hunting, and timber operations understood by members in your community? Where should effort around education be directed?
5. Does your community have plans in place for maintaining the corridor and related projects for the next 10, 20, 30 years?
6. What is something that you wish you could tell the people creating the conservation/agroforestry/biological corridor projects?
7. In an ideal world, what is your vision for how these projects could best support your community?

#### Maximize Benefits and Overcome Barriers in the Political Realm:

- Are there any concerns about working with the Mexican government to achieve federal declaration/protection of the corridor project? Is there a system of checks and balances?
- Based on the 3-year governance turnover within each community, what are your thoughts on project success? Do you have end of term specific meetings with outgoing and incoming community leaders?
- Are there any political obstacles in connecting with the other communities? Are there any benefits? Any region-specific geography and natural resources that pose obstacles, or benefits?
- Are certain communities acting as role models to emulate for other communities? Are there any inter-community outreach programs?

#### Maximize Benefits and Overcome Barriers in the Socio-Economic Realm:

- Do you think there is income potential from the corridor project? Who would benefit from the income?
- Do you think there is income potential from the related income generating projects? Who would benefit?
- What barriers are there to gaining support and participation in your community? Is there interest in the projects that offer alternative means of income?
- In the larger context of Social/Community connectivity: What are the benefits shared between communities? What are the obstacles between communities (social, political, geographic, economic)?
- Are the social and economic impacts being measured for this project in your community? What types of impacts have already been noted for the project?

#### Geography/ Region Specific

- Are there region/geographic/community specific programs, related to the corridor, that would be the most profitable for your community?
- What are the geographic barriers in your community, or region, in regards to connecting to the corridor, or to related income generating activities? Do these barriers possibly create competition with other communities?
- What are the unique geographic characteristics and natural resources in your region that benefit the corridor and related income generating activities?
- Do you envision future sustainable income-generating projects specific to your community's unique geography and resources?

#### *Lessons Learned*

- What can your community teach other communities, in regards to project success and challenges? How can you guide the others?

#### Follow Up:

- Are there any additional thoughts that you would like to add?