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INSTITUTE FOR TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS

THE POTENTIAL OF AGROECOLOGY AS A TOOL FOR RESILIENCE-BASED ECOSYSTEM STEWARDSHIP

ASSESSMENT REGARDING THE INTRODUCTION OF AGROECOLOGICAL PRACTICES WITHIN THE MAYA BIOSPHERE RESERVE'S BUFFER ZONE (PETÉN, GUATEMALA)

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PRESENTS:

MARCELLA ULRIKE SOBISCH

CO-DIRECTOR OF THESIS PMPCA

DR. CLAUDIA RAEDIG

CO-DIRECTOR OF THESIS ITT

DR. HUMBERTO REYES HERNÁNDEZ

ASSESSOR:

LISA STEURER

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Arts Sciences
TH Köln

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TH Köln

Erklärung / *Declaración*

Name / *Nombre*: Marcella Ulrike Sobisch

Matrikel-Nr. / *N° de matricula*: 11117392 (TH Köln), 269395 (UASLP)

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Abstract

In the Mesoamerican forest Selva Maya, multiple driving forces create an imbalance in the sensitive human-nature relation and demand for innovative management strategies for its reestablishment. Within the Guatemalan Maya Biosphere Reserve (MBR), core areas are under strict protective legislation and agricultural activity is permitted only within a bordering buffer zone (BZ), which covers great part of the Guatemalan department Petén. Here, the implementation of agroecological practices by multiple stakeholders aims at tackling the principle driving forces of environmental degradation and thus at reducing the pressure on Central America's largest tropical forest area. Since 2011, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has assisted local stakeholders by carrying out the project "Conservation and sustainable use of the Selva Maya". This project has offered technical support, cooperated with national institutions, and assisted multiple target groups to nudge agroecological transitions at household and community level. As the establishment of agroecological systems face main obstacles stemming from the socio-ecological setting of the respective area, the following work presents a context specific analysis for the adaption of established strategies in the MBR BZ. Therefore, it raises the following research questions: What are the current properties of the socio-ecological system that describes the BZ? How has the GIZ's project nudged and guided agroecological transitions? Which factors have favored or limited the turn to agroecological farming? And finally: Which recommendations derive for the navigation of agroecological transitions? The overall research approach is orientated on the framework *ecosystem stewardship*[1] and incorporates elements of system theory and resilience science. The framework has been adapted by combining two approaches at different management levels. The social-ecological system approach[2] is used to describe the socio-ecological system of the BZ, while the evaluation of the pilot groups' AESs follows the Mexican MESMIS[3] approach for sustainability assessments. By the integration of both approaches, it is revealed that the socio-economic context impedes or hinders the implementation of agroecological strategies for the majority of farmers. The application of the MESMIS framework has revealed that the installed monitoring mechanism is dysfunctional. Findings further indicate that there is potential for transitions of individual AESs, but they demand investments and support with current circumstances to reduce the farmers' vulnerability. The rapidly decreasing social and environmental conditions for family farmers in the BZ are most likely not addressed by solutions that the agroecological approach tackles. Recommendations for the immediate improvement of the strategy include adjustments of the project's proceedings as well as fundamental changes in conservation paradigm and governance to maintain the necessary functionality of the socio-ecological system to protect the Selva Maya.

Keywords

Agroecology • Buffer Zone• Ecosystem stewardship • Maya Biosphere Reserve • socio-ecological system

[1] As published in "Principles of Ecosystem Stewardship" (Chapin, F. Stuart; Kofinas, Gary P.; Folke, 2009)
[2] As proposed in "A general framework for analyzing the sustainability of social-ecological systems"(Ostrom, 2009)
[3] Indicator-based sustainability assessment for agroecosystems (López-Ridaura et al., 2002)

Resumen

Múltiples fuerzas conductoras desequilibran la sensible relación entre la naturaleza humana en la Selva Maya mesoamericana, exigiendo estrategias de gestión innovadoras. Dentro de la Reserva de la Biosfera Maya (RBM), las áreas principales están protegidas bajo una estricta legislación y la actividad agrícola es permitida dentro de los límites de la zona de amortiguación (ZAM) la cual cubre una gran parte del departamento guatemalteco de Petén, donde múltiples actores buscan enfrentar las principales fuerzas conductoras de la degradación ambiental y reducir la presión en el bosque tropical más grande de Centroamérica a través de la implementación de prácticas agroecológicas. Desde 2011, la cooperativa alemana GIZ ha apoyado a los actores locales a través dl proyecto "Protección y uso sostenible de la Selva Maya". No obstante, el establecimiento de sistemas agroecológicos enfrenta sus mayores obstáculos en su entorno socio-ecológico, por lo cual, el presente trabajo presenta un análisis contextual específico para la adaptación de las estrategias establecidas. Este trabajo responde las siguientes preguntas de investigación: ¿Cuáles son las propiedades actuales de un sistema socio-ecológico que describe la ZAM? ¿Cómo ha impulsado y guiado el proyecto de la GIZ las transiciones agroecológicas? ¿Qué factores han favorecido o limitado el giro hacia la agricultura agroecológica? Y finalmente: ¿Qué recomendaciones derivan para la implementación de las transiciones agroecológicas? La selección del método y la interpretación de los resultados están orientados en el marco de *ecosystem stewardship* Los conceptos presentados incorporan la teoría de sistemas y los principios de la resiliencia. El marco metodológico fue adaptado para evaluar la transición de los agroecosistemas mediante la combinación de dos enfoques en diferentes niveles de gestión. El enfoque del sistema socio-ecológico se utiliza para describir la ZAM, mientras que la evaluación de los agroecosistemas individuales es realizada a través del enfoque mexicano MESMIS. Mediante la contextualización, se revela que el entorno socioeconómico impide o dificulta la implementación de estrategias agroecológicas. Los resultados indican que existe potencial para las transiciones de agroecosistemas individuales, pero demandan inversiones y soluciones a corto plazo para reducir la vulnerabilidad de los agricultores. Las condiciones sociales y ambientales que están empeorando para los agricultores familiares en la ZAM probablemente no sean abordadas por soluciones que propone la propuesta agroecológica de la GIZ. Cambios fundamentales, reconsiderando ambos el paradigma y la estructure de la gobernanza se consideran necesarios para mantener la funcionalidad de la ZAM y proteger la Selva Maya.

Palabras clave

Agroecología • Zona de amortiguamiento • *Ecosystem stewardship* • Reserva de la Biosfera Maya • Enfoque sistema socio-ecológico

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Content

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Acronyms

Acronym	Signification
AES	Agroecosystem
BZ	Buffer Zone
BZ-SES	Buffer Zone Socio-Ecological System
CONAP	Guatemala's National Council of Protected Areas
CZ	Core Zone
MAGA	Ministry for Alimentation, Livestock and Agriculture
MBR	Maya Biosphere Reserve
MUZ	Multiple-use Zone
SEGEPLAN	Guatemalan General Secretary of Planning

1 Introduction

Recent history is characterized by severe changes in the relation of human beings and the natural environment. Accelerated trends include population and industrial growth, the overexploitation of natural resources and degradation of the world's production base (von Weizsäcker & Wijkman, 2017). Severe impacts derive from directed changes of the agricultural sector. The production of food has once been centered in the interface of human societies and their natural environment, but the global alienation of producers and consumers has created industries that threaten the production base for local to global societies (Ikerd, 1993). In tropical regions, the advance of the agricultural frontier and expansion of pasture lands are among the main opponents the conservation of remaining tropical forests faces. The changes which have occurred do not only endanger the natural environment but also the well-being of family farmers (Martin, 2015). In many Latin American countries, peasants responded to worsening conditions by turning towards agroecology. As an agriculture that builds on knowledge exchange, agroecological farming enhances not only the productivity and resilience of small-scale farming but provides a global platform for communicating environmentally and socially sustainable practices for intensified self-sufficiency (M. A. Altieri & Toledo, 2010; M. Altieri & Nicholls, 2000).

The present thesis focuses on the case of the Selva Maya. In the north of Guatemala's largest department Petén, agricultural land use has replaced large tropical forest areas since colonization programs were launched in the 1960s. The area was declared a biosphere reserve, which is why today, sustainable agricultural activity is encouraged in the reserve's outer buffer zone (BZ). However, deforestation, illegal migration movements into protected areas and the risk of escaping fires remain critical (CONAP & WCS, 2015). Multiple stakeholders support the rural population with the agroecological transition of their agroecosystems (AES), hoping to decrease pressures on remaining forest areas (CONAP, 2015c). So far, the strategy has not been evaluated. This is why impacts have remained invisible and its adaption is limited to direct responses formulated by the attaining staff. The overall objective of the present work is to analyze how agroecology contributes to ecosystem stewardship in the BZ of the Maya Biosphere Reserve (MBR). Specific objectives are to create a system-theory-based scheme of the BZ, to provide an example for the navigation of agroecological transitions, to identify both practical constraints and suitable incentives for the specific agroecological proposal and finally to formulate case-specific suggestions for the adaption and application of agroecology as a management strategy for environmental protection in the MBR.

Accordingly, the thesis is separated into different sections. The background gives a geographic and historical introduction to the Selva Maya and describes the concepts agroecology and ecosystem stewardship as management approaches. The methods section defines the integration of two methodological approaches to the evaluation of natural resource use. Results span the BZ socio-ecological system (BZ-SES) before presenting the other results derived from the individual assessments. A broad discussion of the feasibility of the approaches used follows. Finally, recommendations dedicated to different management levels are formulated.

2 Background

This chapter introduces to the Mayan forest's geography and the thesis's key concepts *ecosystem stewardship* and a*groecology*, before explaining the case study project.

2.1 The Selva Maya

The Mayan forest (also known as Selva Maya) covers more than four million hectare of Mesoamerica and is therefore the second largest tropical forest in the Americas, highly diverse in ecological and cultural heritage (Figure 1, Figure 2) (CONAP, 2015a).

Figure 1: Classic Maya ruins in the Yaxha National Park (Photo taken on 24/06/2018)

Figure 2: Lush broadleaved forest in the Bio-Itza Biotope (Photo taken on 17/06/2018)

The Mayan Forest is located in Mesoamerica and spreads over areas in three countries: Belize, Guatemala, and Mexico. Geomorphologically, the region is referred to as Maya lowlands, as the principal geological province is the flat sedimentary Yucatan platform (CONAP, 2015). Biogeographically, the Guatemalan Selva Maya forms part of the tropical moist forests biome (CONAP, 2008). Due to its central location, the forest bridges the Americas for migratory species, and is recognized as part of the Mesoamerican Biological Corridor (CONAP, 2008; SEGEPLAN, 2011).

2.1.1 Habitat and biodiversity

The Selva Maya is a biodiversity hotspot, characterized by its exceptionally number of ecosystems, plant and animal species of high conservational value. Terrestrial forest systems include low broad-leaved forest, medium-high forest and medium-high forest in the mountains (CONAP, 2015a). According to CONAP (2001), all forest types are diverse both in flora and fauna. The low broad-leaved forest is located below an altitude of 200 m and periodically flooded. Tree and palm species which are occur here such as bullet tree (*Bucida buceras*) or root spine palms (*Cryosophila argentea*) are low, with heights of less than 6 m. The medium-high forest is composed of broad-leaved arboreal species which have heights from 6 m to 40 m. The lower strata are composed of palms and shrub. Arboreal species which dominate high forest associations might contain mahogany (*Swietenia macrophylla*), breadnut (*Brosimum alicastrum*) and pepper (*Pimenta dioica*). Above 300 m, the arboreal strata of the medium-high forest in the mountains do not exceed 20 m. Here, cedar

(*Cedrella odorata*) is present (as cited in CONAP, 2015c).The jungle is habitat to diverse fauna, including highly endangered mammal and bird species. Among the emblems are jaguar (*Panthera once*), tapir (*Tapirus bairdii*) and scarlet acaw (*Ara macao*). An exceptional number of insects, reptile, and fish species reside in the diverse landscape and its waterbodies.

2.1.2 Culture

Besides its biological value, the Selva Maya is rich in cultural diversity, which includes both tangible elements like explored and unexplored Maya sites as well as language, traditions, and agricultural practices of the remaining Maya population (CONAP, 2015a). Many archeological sites show pyramids which were built during the pre-classic and classic period, when the Yucatán Peninsula was densely habited (Turner, 1976).The Maya who inhabit the Selva Maya today are of diverse backgrounds (Achi', Itzá, Jakalteko, Kaqchiqel, Mam, Poqomchí, Q'anjob'al, K'iche and Q'eqchi') (CONAP, 2015c).

There are marked differences regarding origin and traditions of the present ethnic groups. For instance, while the Itza Maya had migrated yet centuries ago from the northern part of the Yucatan peninsula, the Q'eqchi' Maya settled in the late 20th century (Atran, Lois, & Ucan Ek, 2004; Grandia, 2009). Today, the very reduced Itza Maya population concentrates in the municipality of San José, Petén, Guatemala. Today, there are very few Itza speakers (personal correspondence with Bio-Itzá Association, July 2018). Other than that, Q'eqchi' communities have conserved much of their language, traditions, and agricultural practices (Grandia, 2009). As livelihoods of the Itza have historically been based on agroforestry, the current population still holds knowledge about those practices which they shared with first settlers (Atran et al., 2004). However, indigenous communities are especially exposed to current crisis and their cultural heritage endangered to an extend beyond historic days (Atran et al., 2004; Grandia, 2009).

2.1.3 Historical background

The Selva Maya has historically sustained changing patterns of livelihoods (CONAP, 2015 based on varios). The most ancient populations used the forest in an extensive way, but the domestication of maize and yuca allowed folks to start cultivation yet before 3000 B.C, which caused deforestation from around 2500 B.C onwards (Pohl et al., 1996). The Maya introduced an intensive land management based on terraces. The production allowed to sustain a flourishing culture, trade, and the construction of urban centers. The peak population density is estimated at 150 – 500 habitants per square kilometer (Turner, 1976, pp. 78–79). However, urban centers were abandoned around 800 – 900 A.C. Scientists discuss whether or not overexploitation and deforestation have determined the downfall of the ancient Mayan society (e.g. Ford & Nigh, 2009). Clear evidence exists that among extended draughts and socio-political issues, the mismanagement of natural resources was a factor that contributed to the classic „*Maya collapse*" (Turner & Sabloff, 2012). Until, during and even centuries after the Spanish conquest in the late 16th century, low population density favored the recovery of the Selva Maya. Although in a reduced number, Maya subsistence agroforestry systems persisted (Atran et al., 2004; Grandia, 2009; Schwartz, 1990). In Guatemala,

the area remained remote and forest area conserved until recent developments. The extraction of timber in the 19th century was the only economic activity until international markets first significantly influenced the forest's exploitation. In the period from 1890 – 1970 the demand for chicle (*chewing gum*) made its exploitation Guatemala's principle economic activity (CONAP, 2015a). Immigrants during this time formed a new ethnic group, which is referred to as culture *peternero*. Many of those migrants adapted subsistence farming practices from the Itza (Atran et al., 2004; Tierra et al., 1999).

The situation radically changed from the 1960s onwards, when the department Petén became objective of national development strategies. Under the governance of the Guatemalan military, development plans launched with the launch of the company FYDEP (for its letters in Spanish "*Formento y Desarrollo en Petén*") in 1959. First, the current extension of the Guatemalan Selva Maya was not affected. In the southern part of the department, the FYDEP inverted in the agricultural and infrastructural development, but all area north of 17°10 latitude was dedicated to conservation purposes. Through the program, some urban centers were connected through highways with the rest of Guatemala and the borders to Mexico and Belize and the use of fertile lands intensified (Grandia, 2009; Grünberg, Grandia, & Milian, 2012; SEGEPLAN, 2013a). However, due to inner conflicts and population growth, the pressure on the Selva Maya increased. An intended land reform launched by the Guatemalan government in the 1950s had been reversed by US interventions and resulted nationwide in political instability, civil war, and displacement of Guatemalans in following decades (Grandia, 2009; Holt-Giménez, 2008). In response, the FYDEP formulated a colonization strategy for the distribution of land to landless farmers, which finally resulted in a critical advance of the agricultural frontier. Because of mismanagement and corruption, land was distributed unequally, and large and land plots fell in the hand of few powerful individuals. Further, the original population grew exponentially; settlement of a dimension that could not be handled by the present institutions (Grandia, 2009). In less than 50 years, the population became ten times as big and obtaining land for farming was their declared objective (Schwartz, 1990). Many immigrants settled illegally. In agreement with official and non-official local authorities, land was declared property by cleaning forest area to occupy area with farming activities - a land-grabbing phenomenon known as "*Agarrar*" (Grandia, 2009; Grünberg et al., 2012).

Measure taken to stabilize the situation were orientated on fostering economic-development. The Vice Ministry of MAGA (Ministry of Agriculture, Livestock and Nutrition = Ministerio de Agricultura, Ganaderia y Alimentación) opened its office in Petén in 1994 to accompany the agricultural intensification and development in the region (SEGEPLAN, 2013a). Besides providing minor support to small holders, the MAGA has invested in the development of commercial farms and livestock raising (Grandia, 2009). Other environmentally harmful industries settled, and the northern forests became increasingly exploited. Seven big companies specialized in the exportation of wood and an oil plant was installed in the park Laguna del Tigre (CONAP, 2015c).

High deforestation rates as well as unbearable socio-economic conditions led to institutional changes. In 1989, the FYDEP was first replaced by the INTA (Instituto National para la Transformation Agrarian), which aimed at ensuring better documentation and legalization of ownership. The bureaucratic burdens which demanded not only a basic understanding of institutional functioning but also the ability to cope with the costs to obtain the demanded documentation had made it nearly impossible for subsistence farmers to apply for the legalization, but even so neither FYDEP nor INTA were able to respond to the large number of official applications. The establishment of the organization *Fontierras* to assist with the legalization of land plots did not contribute to significant improvements (Grandia, 2009; Grünberg et al., 2012)

To respond to the environmental degradation, the Guatemala's National Council of Protected Areas (CONAP) was established in Petén in 1989. The administration of biotopes and national parks like Tikal, which had already been installed in 1955, fell under the administration of the council. Further, it paved the way for declaring a large area of the Guatemalan a Biosphere in 1990. As a national conservation project, the Maya Biosphere Reserve (MBR) introduced restrictions to land uses and means of protection for remaining forest areas to more than half of the largest Guatemalan department Petén (CONAP, 2015a). First, this increased the region's confliction. Many settlers within the boundaries of inner areas were facing restrictions regarding agricultural practices or were expected to resettle to the outer zone designated for sustainable agriculture. As a compromise, community concessions were established, which regulate the sustainable and extensive use of forest resources under the administration of CONAP (Grandia, 2009; Grünberg et al., 2012; Zander & Durr, 2011).

Despite the Guatemalan's official peace agreement in 1996, the region remained politically unstable and deforestation rates remained high. Post-civil war, many international organizations joint sustainable development and environmental protection initiatives (CONAP, 2015a). However, efforts to stabilize land tenure in bordering cultural landscapes could neither stop speculations nor injustice regarding access to land. Instead, huge investments taken by donors like e.g. the World Bank to measure and legalize land plots only favored land concentration. Based on the land register ley in 2005, efforts were concentrated on the measurements of land plots, capturing often only the physical extents and owner at time of the measurement. Marginalized and badly informed farmers could sell their land more easily as holders of official documentation. Consequently, pasture land used for livestock production expanded, the agricultural frontier has further advanced, and the pressure of illegal migration to protected areas has increased (Grandia, 2009; Grünberg et al., 2012). Further, the conditions have favored illegal activities, namely drug trafficking and logging. In Petén, farmers were instrumentalized to clear forest area for livestock production or shield strategic locations used for drug trafficking. In other occasions, family farmers were threatened to sell (Zander & Durr, 2011).

2.1.4 Legal & institutional background

The MBR is part of the UNESCO Man and the Biosphere (MAB) Program under which environmentally sound development practices are implemented, studied, and demonstrated in landscapes all around the globe. This protection strategy proposes integrated management schemes to foster both human development and environmental protection. The program was launched in 1971 and accounts currently with an active network of nearly 700 reserves. They are rich in both biological and cultural diversity. Regarding the management of Biosphere Reserves, the cooperation of stakeholders is desired. A particularity of a biosphere reserves is their zoning. The nuclear core zone (CZ) consists of areas under strict conservation legislation, like National Parks and biotopes. The core zones are designated for low impact tourism and research. For the establishment of a biosphere reserve, core areas are recognized and surrounded by a buffer and a transitional zone, where specified human activities are allowed, which are considered sustainable and low-impact under given circumstances (UNESCO, 2017).

In Guatemala, the Selva Maya was declared Biosphere Reserve in April 1990 by decree 5-90 with the objective to sustain natural and cultural heritage and thereby generate socioeconomic and environmental benefits for the Guatemalan society. The core area of the Maya Biosphere Reserve (MBR) consists of five national parks and four biotopes, with Tikal being the most prominent tourist destination. A multiple use zone (MUZ) connects those areas. Here, communities which hold forest concessions perform controlled low-impact practices. Activities include trade with timber certified by the Forest Stewardship Council (FSC) and the collection non-wooden products like the extraction of the edible breadnut (*Brosimum alicastrum*) or the ornamental species *xate* (*Chamaedorea*) (CONAP, 2015a). In its south, the Reserve is surrounded by a buffer zone that expands as a 15 km fringe over 497,500 ha in northern Petén, where activities of the primary sector are permitted, and agricultural and pasture land dominate the landscape (Figure 3, next page) (CONAP, 2015d, p. 23).

The reserve's governance is characterized by a complex interplay of multi-national stakeholders at all levels. These include national as well as international players, which can be actively involved in environmental protection and monitoring or indirectly by communicating needs and facilitating attraction of potential donors. For its environmental value and location, the Selva Maya is for instance of interest to regional institutions like the Central American Commission on Environment and Development (CCAD) The US organization Wildlife Conservation Society (WCS) contributes significantly to wildlife monitoring (CONAP, 2015a, 2015d). Among the institutions which implement sustainable income generation strategies are The Association of Forest Communities of Petén (ACOFOP) in the MUZ and the Guatemalan The Ministry of Agriculture, Livestock and Food (MAGA) in the BZ (CONAP, 2015d; GIZ, 2017). More independent institutions complement funding and technical support with social assistance. An example is the organization ProPetén, which was found in 1991 and has worked interconnected with the Reserve's institutions since (http://www.propeten.org).

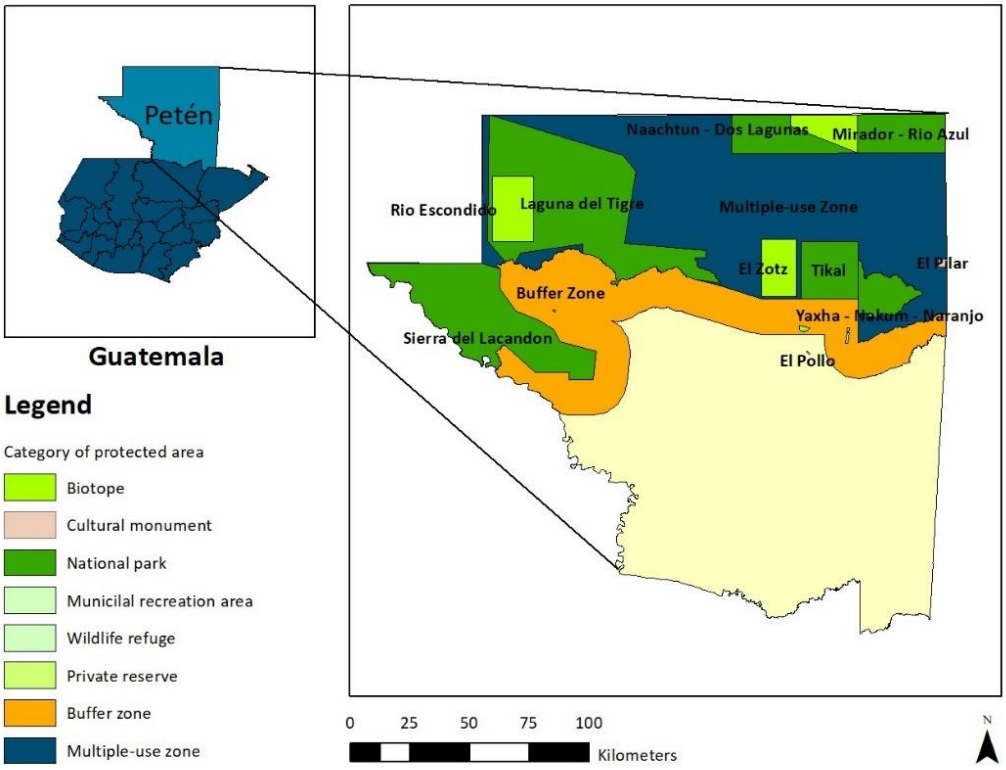


Figure 3: Protected areas within the MBR (Shapefiles provided by CEMEC 2018)

To guide actions taken by these multiple actors, masterplans have been introduced to formulate and common strategy for development and protection (CONAP, 2015a; GIZ, 2017). The plans were developed in cooperation with present stakeholders and the public. The current update consists in five publications published in 2015 by CONAP and the Guatemalan System of Protected Areas (SIGAP). Two publications specifically concentrate on the BZ, where conservational normative overlap with national and departmental law. Responsibilities are shared. To provide basic services to the growing population, the five concerned municipalities cooperate with The Ministry of Education (MINDUC), Ministry of Culture and Sports (MICIVI) and the Ministry of Public Health and Social Assistance (MSPA). Concerning the environment, CONAP, The General Directorate of Cultural and Natural Heritage (DGPCN) and the Center for Conservationist Studies (CECON) are responsible institutions at national level (CONAP, 2015d). Nevertheless, independent international institutions and NGOs influence decision making through presence, actions, and funding. Agroecological strategies form part of both, national and nongovernmental approaches for sustainable development (CONAP, 2015c).

2.2 Ecosystem stewardship

Frameworks offer a specific approach to the understanding of phenomenon by combining interrelated concepts (Jabareen, 2009). In the present work, the ecosystem stewardship framework as described by Chapin et al. (2009) is the lens which is applied to evaluate the potential of agroecology as a management strategy for sustainable development. This chapter is an introduction to the framework's origin and key concepts.

2.2.1 A concept beyond steady state resource management

Resilience-based ecosystem stewardship is an action orientated framework to manage directed change in socio-ecological systems (SES). By embracing the dynamic character of those systems, the framework adds a temporal perspective to steady-state resources management. Not current conditions but possible trajectories become objective to management The global objective for ecosystem stewards is to actively create a resilient ecological base for human well-being under the current scenario of global change and its unpredictable consequences efforts (Chapin, F. Stuart; Kofinas, Gary P.; Folke, 2009).

Accordingly, management needs address ecosystem processes, which form the basis for regulating, provisioning and cultural ecosystem services (Figure 4).

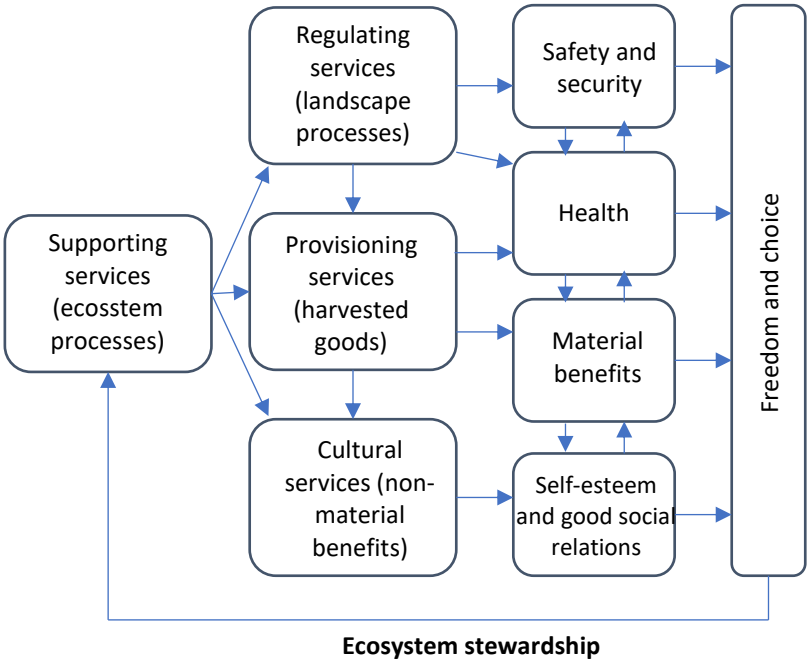


Figure 4: Linkages among ecosystem services, well-being of society and ecosystem stewardship (Kofinas & Chapin, 2009, p. 60; based on MEA 2005)

Ecosystem stewardship requires the application of a system-perspective to describe the dynamic interactions among social and ecological components. Systems theory allows the adaption of general assumptions concerning the interrelation of associates elements to an investigated phenomenon (Von Bertalanffy, 1989). Any system is understood as an established structure whose particular functionality relies on the interrelatedness of its elements. The state of the system is defined by the element's properties at an observed moment. Systems are usually open and interact horizontally with neighboring systems or vertically with supra- or subsystems (Van Gigch, 1987).

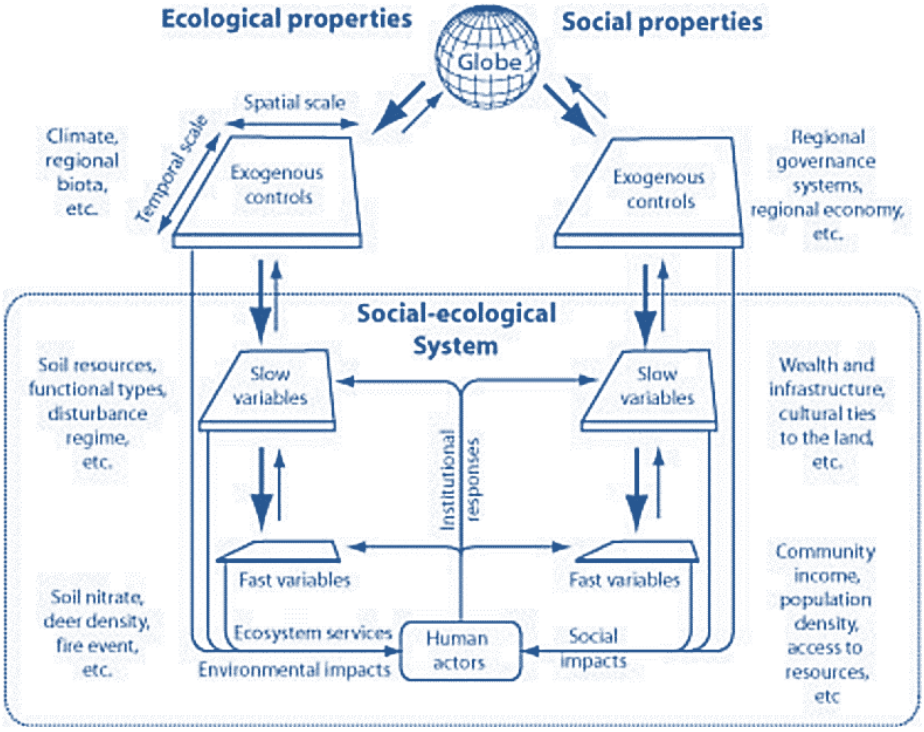


Figure 5: Diagram of a social-ecological System (Chapin, Folke, & Kofinas, 2009a, p. 7)

Chapin et al. 2009 adapt the socio-ecological system approach to link physical, ecological and social processes of change (Chapin, Folke, & Kofinas, 2009). The approach had first been described by Ostrom (2009) who applied system thinking to analyze the sustainability of resource systems. The authors define SES as "systems with interacting and interdependent physical, biological, and social components, emphasizing the 'humans-in-nature-perspective" (Chapin, Kofinas, Folke, & Chapin, 2009, p. 351). They conceptualize SES as open and complex adaptive systems. This means that all SES are influenced by exogenous controls and composed of dynamically arranged variables which respond to changing conditions (Figure 5). The graphic visualizes that the components of the socio-ecological system are slow variables, which are more resilient to change, and fast variables, which are smaller in both temporal and spatial scale. Both social as well as ecological properties are also influenced by exogenous controls. The grade of ecosystem services and the grade of environmental impact are ecological feedback to human actions. Decision making is also influenced by social

impacts. Through institutional responses, human action influences variables of the social and ecological sphere.

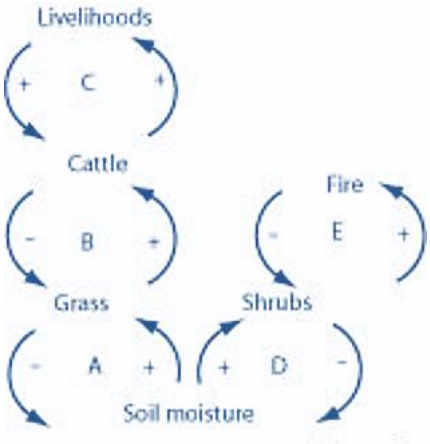
Applying resilience thinking to socio-ecological systems widens the concept of sustainability (Chapin, Folke, et al., 2009). In a sustainable scenario, there is a stabile balance in between the system's components and the productive basis is sustained under current conditions. Through management, this equilibrium is fostered with the objective to guarantee well-being to current and future generations (WCED, 1987). However, Chapin et al. (2009) argue that all socio-ecological systems are changing directionally and are exposed to external stress or stressors. This constructs a scenario of uncertainty. We cannot know the system will behave in the future, after having adapted to external and internal drivers. To sustain the system's functionality in a changing world, it is crucial to enhancement its "capacity of a social-ecological system to absorb a spectrum of shocks and perturbations and to sustain and develop its fundamental functions, structure, identity, and feedbacks as a result of recovery or reorganization", which is how resiliencies defined (Chapin, Kofinas, et al., 2009, p. 350). However, besides stabilizing the functionality of the current system's state, shifts to a more desirable state can be objective of management efforts. Therefore, the trajectory of change become the focus of ecosystem stewardship, and management is adjusted accordingly (Table 1). Ecosystem stewardship is the navigation of change (Chapin, Folke, et al., 2009).

Table 1: Steady-state-resource management, ecosystem-management and resilience-based ecosystem stewardship (Chapin, Folke, et al., 2009, p. 5)

Steady-state resource management	Ecosystem management	Resilience-based ecosystem stewardship
Reference state: historic condition	Historic condition	Trajectory of change
Manage for a single resource or species	Manage for multiple ecosystem services	Manage for fundamental socio-ecological properties
Single equilibrium state whose properties can be sustained	Multiple potential states	Multiple potential states
Reduce variability	Accept historical range of variety	Foster variability and diversity
Prevent natural disturbance	Accept natural disturbances	Foster disturbances that sustain social-ecological properties
People use ecosystems	People are part of the socio-ecological system	People have responsibility to sustain future options
Managers define the primary use of the management system	Multiple stakeholders work managers to define goals	Multiple stakeholders work with managers to define goal
Maximize sustained yield and economic deficiency	Manage for multiple use despite reduced efficiency	Maximize flexibility of future options
Management structure protects current management goals	Management goals respond to changing human values	Management responds to and shapes human values

2.2.2 Feedbacks among the SES's processes

The complex adaptive character of the SESs causes interrelated processes of change. The interaction among the components' processes is termed feedbacks. There are two types. Stabilizing (or negative) feedbacks are interactions where more of one component results in less of another. This way, fluctuations are reduced. The components of resilient systems are interrelated with sets of stabilizing feedbacks. Contrarily, amplifying (or positive) feedbacks are interactions which result in changes of the system's properties, as the more of one component results in more of an interrelated component and vice versa. Trends are increasingly accelerated. Transformability can be addressed by managing amplifying feedbacks . A tool of ecosystem stewardship is their visualization (Chapin, Folke, et al., 2009) (Figure 6).



Process		Nature of feedback
Resource uptake	A or D	Stabilizing
Competition	A+D	Stabilizing
Herbivory	B	Stabilizing
Resource exploitation	C	Amplifying
Disturbance cycle	E	Stabilizing

Figure 6: Exemplary visualization of feedback loops (Chapin, Folke, et al., 2009a, p. 10)

2.2.3 The SES's panarchical trajectory

To describe the cyclic character of SES's trajectories, Chapin et al. (2009) refer to a concept described by Gunderson & Holling (2002). Here, *trajectory* refers to the SES's process of passing through different phases. This development is termed the *adaptive cycle* and describes the specific phases of change every complex adaptive system is expected to undergo. While a viable steady-state regarding resource-use is considered the conservation phase (K), loss of potential and inter-connectedness of its components characterize the following release phase (Ω). Successfully undergoing phases of reorganization (α) and growth (r), the system reorganizes itself by keeping its original characteristics. The passing of tipping points and related shifts into different forms are termed "regime shift"(Figure 7, next page).

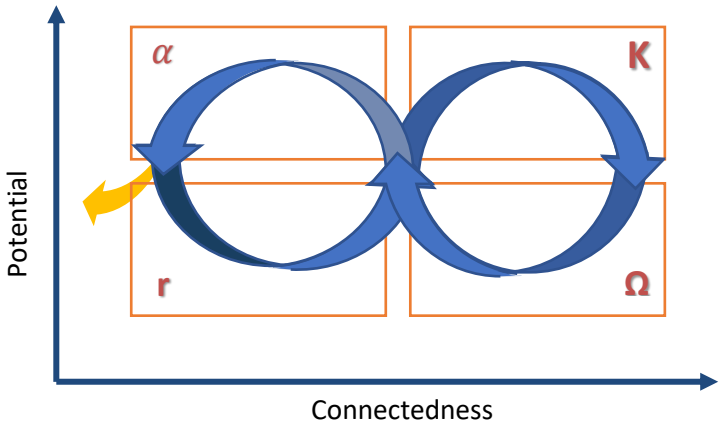


Figure 7: Adaptive cycle to describe a systems trajectory, with conservation phase (K), release phase (Ω), reorganization phase (α) and growth phase (r). The regime shift is visualized with the outpointing arrow (Gunderson & Holling, 2002, p. 6)

According to Gunderson & Holling (2002), the embeddedness of different subsystems within social-ecological system is more than hierarchical. Regarding the embeddedness of those dynamic systems, a *panarchica*l relation is presented. Accordingly, systems are vertically connected and affect sub- and/or subsystems depending on the phase they are in (Figure 8). When several small-scale subsystems in a phase of release cumulate, they drag the larger scale systems towards the release phase. This phenomenon is titled "revolt". Do small scale systems pass towards a reorganization phase, larger scale systems influence the growth phase through "remembering" stable functioning (Gunderson & Holling, 2002).

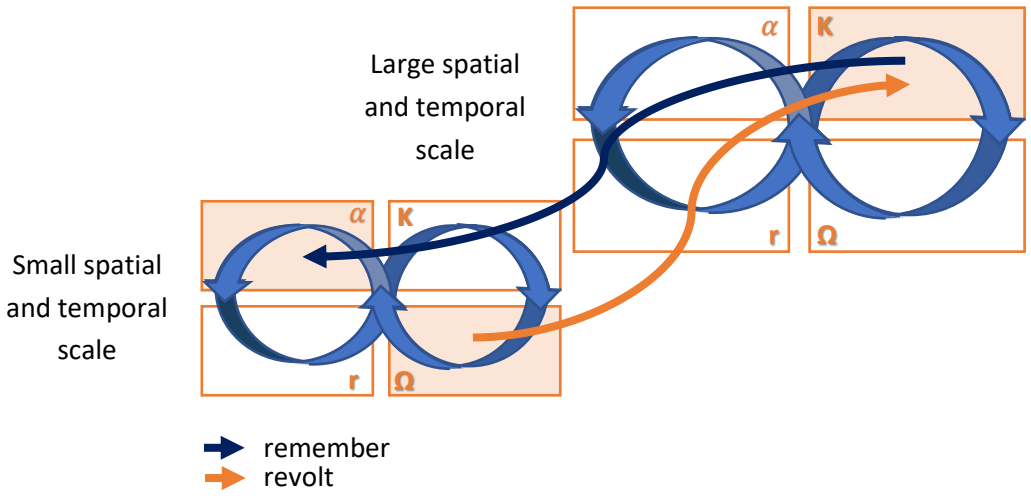


Figure 8: Panarchy regarding interrelated scales. Larger and smaller scales are interrelated through processes of remember and revolt (Gunderson & Holling, 2002, p. 26)

2.2.4 Triple-loop learning for adaptive management of SES

Under a scenario of change, ecosystem stewardship needs to be flexible to respond to unforeseen developments. For enhancing management, it is necessary to foster adaptive learning and reconsider not only measures taken but also underlying goals (Kofinas, 2009). Depending on the degree of reconsideration of management, strategies are adapted with different objectives. Regarding single loop learning, adaption is proposed by changing actions to meet the predefined management goals. Here, they are formulated to meet the GIZ project-objectives (see chapter 3.2). Double loop learning incorporated the evaluation of assumptions and models that have led to the definition of indicators and considers the adjustment of policies. In the present chapter, they are directed towards decision-makers at BZ level. Triple loop learning considers desirable but fundamental changes based on the reevaluation of the governance mechanism (Folke, Chapin, & Olsson, 2009).

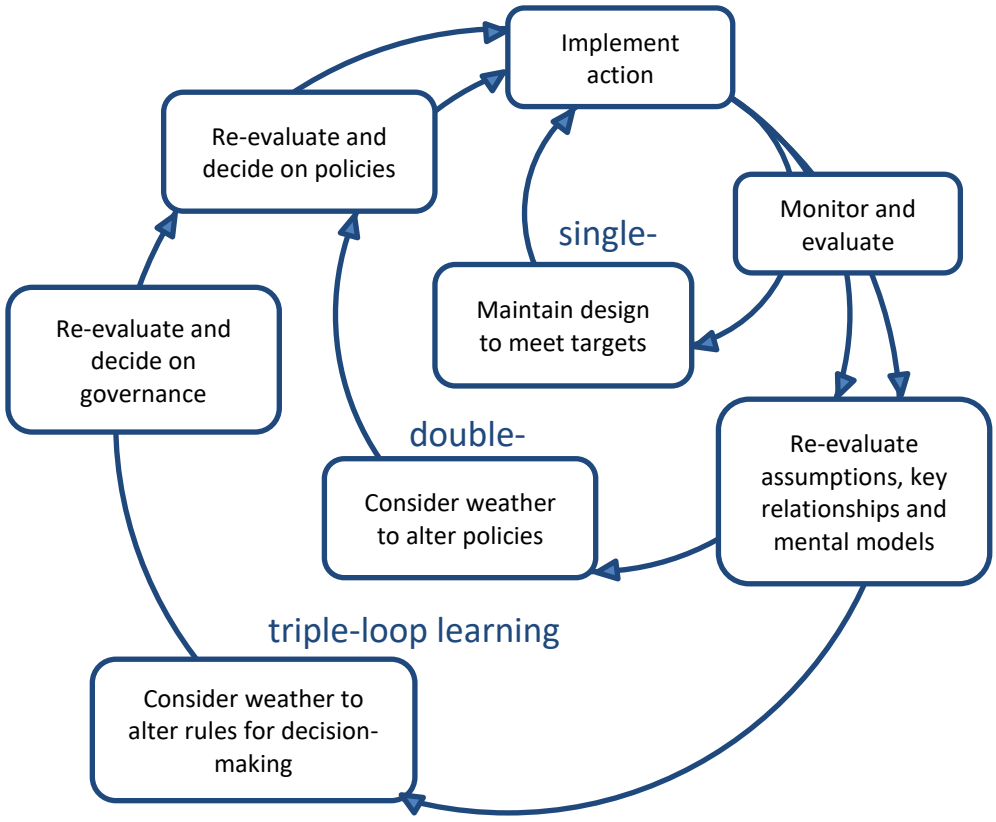


Figure 9: Triple-loop learning for the adaption of governance. Regarding the degree of reconsideration, strategies are adapted by adjusting strategies (single loop learning), policies (double loop learning)or governance (triple loop learning) (Folke, Chapin, & Olsson, 2009, p. 105)

2.3 Agroecology

Agroecology can provide necessary shared vision and guidance to the navigation of change in socio-ecological systems. This chapter is an introduction to the multifariousness of agroecology and its rise to an important alternative to conventional development of cultural landscapes.

2.3.1 A concept hard to embrace

Agroecology is a concept hard to embrace, as the term is used to describe a science, a movement, and a practice (M. Altieri, 1999; Wezel et al., 2009). Its current definitions differ depending on the geographic location, school, and individual interpretation (Wezel et al., 2009). The Food and Agricultural Organization (FAO) presents a collection of interpretation, which range from the French focus on the integrated use of resources[i] to the Costa Rican interpretation of agroecology as a study of indigenous farming systems (FAO, n.d.-a). In the present work, agroecology is interpreted as a form of alternative agriculture with a systematic approach to the design and maintenance of productive, environmentally sound, and socially equal AESs and landscapes. This interpretation goes beyond narrow definitions like the OECD's, who define agroecology as "the study of the relation of agricultural crops and environment" (2003) (OECD, 2003, cited by FAO, n.d.-b) and is much closer to Latin American interpretations, where scientists emphasize the concept's multi-dimensional potential for truly sustainable development (M. Altieri, 1999; M. Altieri & Nicholls, 2000). Just like the concept, the interpretation has evolved vividly over the past decades to distinguish itself from parallel flows of alternative agriculture, to adapt to specific contexts or take larger scales into account.

2.3.2 The evolution of agroecology

The origin of agroecology is estimated at around 1930, when ecological relations were applied to the study of agricultural crops. In following years, mainly European scientist furthered the field. Investigation focused mainly on outer influences on crop plants. It was until the late 1960s when the leading idea became to apply a systematic approach based on ecological principles to the design of sustainable farms. They were termed *agroecosystems* (AESs). In following decades, alternative agriculture gained interest due to the global society's concerns regarding environmental degradation (Wezel et al., 2009). With its systematic approach, agroecology differed from similarly prosperous fields. For instance, the parallel movement organic agriculture focuses on replacements for chemical inputs and destructive tillage practices, while the spatial and temporal design of components within organic agrosystems remains conventional. Agroecologists went further, worked towards truly sustainable AESs and added the social perspective to the idea of environmentally friendly farms (Marzin, Bonin, Mercedes, Vázquez, & Niederle, 2018; Wezel et al., 2009).

In the 1980s, the scientific focus not only shifted towards the advancement and of practices but also served as basis for emerging social movements (M. A. Altieri & Toledo, 2010; Wezel et al., 2009). Worldwide, small holders and family farms had proven to be the losers of the agrotechnical

advances under the Green Revolution, which had failed to enhance their food supply and instead threatened stable social- and ecological conditions of agricultural landscapes. Especially in subtropical development countries, where food supply relies to greater parts on traditional farming systems, agroecology could not only provide low-cost alternatives to agro-chemicals or fertilizers but also a scientific basis for the formulation of ecological concerns against the expansion of large corporations (Holt-Giménez, 2008). In Latin America, agroecology served for endogenous development initiatives, recognizing the interests of indigenous communities and family farmers. Other than in Europe, the existence of small-scale traditional farming defined a different scenario. The indigenous knowledge base, living- and environmental condition of rural Latin America systems were threatened by neoliberal policies, and agroecology became a response to these circumstances (M. Altieri & Nicholls, 2000; Toledo & Barrera-Bassols, 2008). Hence, the interpretation of the term and application of the concept diverged (Wezel et al., 2009).

The agroecological advance in America during the 1980s and 1990s was prosperous. Agroecology was fostered at the farm level up to national policies. The technological knowledge base was nurtured within key publications like “Agroecology” by Gliessman (1998) and advanced within research programs in excellent universities like UNAM in Mexico City. Social movements emerged and achieved the construction of networks, formation of institutions and changes in policy. Milestones of the expansion are the foundations of societies which give voice to common interests of Latin American peasants. The Latin American Consortium on Agroecology and Development (CLADES) in 1989 and Agroecological Movement of Latin America and the Caribbean (MAELA) in 1992 have contributed to the coordination and cooperation of NGOs (Marzin et al., 2018; Wezel et al., 2009).

In the nineties, large scale agroecological transformations of exemplary character flourished in Brazil and Cuba. In both cases, the implementation of agroecological practices was related to a new socio-economic condition caused by globalization. The fall of the Soviet Union in 1991 affected the communist country Cuba. It first led to a socio-economic crisis that threatened the national food supply. The primary sector was destabilized by the cut of inputs such as fertilizer and pesticides. The turn to agroecological practices for subsistence farming led to the establishment of highly diverse productive agrosystems that could guarantee the national food security Research confirmed that family farmers harvested higher yields and the AES recovered faster after natural disturbances than conventional farms. Many Cuban AESs achieved sovereignty over food, energy, and technology to compensate the national deficits (Casimiro Rodríguez, 2016). Nearly half of the Cuban peasants is organized in the National Association of Small Farmers (ANAP). Lessons learned from this exceptional transformation are spread by the Cuban Association of Organic Agriculture (ACAO) in 1993 and Cuban Association of Agricultural and Forestry Technicians (ACTAF) in 1993, which remain important references (Casimiro Rodríguez, 2016; Marzin et al., 2018).

In Brazil the agroecological ideology prospered, as it presented an alternative path for agricultural development. This had beforehand been characterized by land concentration and unsustainable

intensification. Besides associations like the National Confederation of agricultural workers (CONTAD) and The Federation of Agricultural Family farmers (FETRAF), the movement of landless farmers (MST) has guided the social movement and accomplished profound changes in national policies - in favor of family farmers. First achievements in the institutional adoption of alternative farming are the regulation standards for organic farming introduced in 1999 and later the law on participatory certification and certification by social monitoring organizations regarding organic products (M. A. Altieri & Toledo, 2010; Radomsky, Niederle, & Schneider, 2014).

In the 2000s, the achievements of agroecology for food security led to an increased acceptance by governmental institutions and academic associations. The concept's focus extended from the narrow focus on the AES towards the food system (Wezel et al., 2009). Many Latin American countries published laws to favor alternative agriculture. Nicaragua, El Salvador, Mexico and Costa Rica adopted laws concerning organic agriculture. Agroecology was finally introduced to National policies in Nicaragua (2011), Brazil (2012) and El Salvador (2017) (Marzin et al., 2018). In Guatemala, the National Commission of Ecological Agriculture (CNAE) presented a plan for the implementation of agroecology as a national strategy in 2013 (MAGA, 2013). These attempts stand against the oppression family farmer worldwide face as "losers" of the green revolution (M. A. Altieri & Toledo, 2010)

2.3.3 Agroecology as a science

As derives from the term's development, in its most original form it has been a science. In Europe, where the family farming has lost importance, emphasis is put on the scientific dimension of agroecology (e.g. Scotland and France). In Latin America, the scientific component is interrelated with social movements and sustainable development initiatives. Publications from popular authors like Altieri, Nicholls or Toledo range from soil conservation strategies to the call for large-scale agricultural transformations (M. A. Altieri, Nicholls, & Funes, 2012; e.g. M. A. Altieri & Toledo, 2010; M. Altieri & Nicholls, 2000). The first class on agroecology was given at the National University of Colombia in the 19970s. Today, several institutes offer master and PHD programs all over Ibo America. The academic field was fostered by the creation of the Latin American Scientific society of Agroecology (SOCLA) in 2007 (Marzin et al., 2018). The scientific society communicates experiences via journals like LEISA (http://leisa-al.org).

2.3.4 Agroecology as a social movement

A social movement can be defined as "An organized effort by a significant number of people to change (or resist change in) some major aspect or aspects" (Scott & Marshall, 2009, p. 704). The particularity of agroecological movements the appreciation of the multi-dimensionality. The socio-ecological activism has evolved parallelly to scientific and technological advances (Wezel et al., 2009). These developments have been synergic and fed the revolutionary character of agroecology; A joint venture where minorities and academics stand together for the protection of cultural heritage, the natural environment, and livelihoods of the rural world (La Vía Campesina, n.d.). Peasants all over the globe are exposed to global change in quite similar ways. From the oases in

Morocco's drylands to the Tropical gardens in Mesoamerica, traditional farming systems are increasingly endangered by climate change and unfavorable neoliberal policies (e.g. Grandia, 2009; Karmaoui, Ifaadassan, Messouli, & Khebiza, 2015). In the globalized world, agroecology offers a common ground that unites multiple initiatives to oppose social injustice and to demand alternative solutions for sustainable development. Unions of local associations and academic institutes have formed global movements and give voice to millions of farmers (M. A. Altieri & Toledo, 2010; Holt-Giménez, 2008; La Vía Campesina, n.d.).

The Peasant to Peasant Movement (*campesino a campesino*: CAC) describes a movement as well as a strategy to the revitalization of traditional knowledge and incorporation of scientific advances in marginalizes communities. It originates in the highlands of Guatemala, namely San Martín Jilotepeque in Chimaltenango, where agrotechnicians like the American Bunch and the Kaqchikele Mayas fought extreme poverty via the implementation of soil and water conservation strategies. The innovative concept of CAC is the adapted approach for the capacitation in agroecological techniques (Holt-Giménez, 2008). Indigenous ways of learning differ from western epistemology like the perception of knowledge itself, which is understood as inherent in people instead of a result of scientific discourse (Toledo & Barrera-Bassols, 2008). Instead of relying on frontal teaching or semi-participatory workshops, peasants are empowered and logistically supported to share knowledge with other peasants. Exemplary fields make agricultural progress tangible, but farm visits of farmers on other farms have proven to be essential for the adaption of agroecological strategies. Trust is very important, as peasants farm for subsistence and cannot risk anything. It has spread all over Mesoamerica. Today, nearly all NGOs recognize the importance of CAC. Especially the formation of individuals that create exemplary farms and act as *promotores* for agroecology has proven as a successful strategy for the implementation of agroecological practices (Holt-Giménez, 2008).

A movement also closely related to agroecology is *Vía Campesina*, which stands internationally for social justice and the rights of peasants. It was found in 1993 and has become one of the biggest international movements which at the time of writing consists in 182 cooperating organization in 81 countries (Desmarais, 2008; La Via Campesina, 2018). One particularity of the movement is its exclusive membership for peasant organizations and its participatory structure for diverse groups. Among the achievements of Vía Campesina is the redefinition of this peasant identity, which bases in shared values like their close relation to culture, and land. Globally and locally, they demand for food sovereignty and trade liberalization, biodiversity and genetic resources, agrarian reform, gender, sustainable peasant agriculture, human rights, migration and farm workers (Desmarais, 2008, p. 146)[4].

[4] Based on: Declaration of the Vía Campesina's Fourth International Conference, 14–19 June 2004, Itaici, Brazil.

2.3.5 Agroecology as a practice

In the first place, agroecology is an activity practiced by peasants. The agroecological management of AESs enhances the AES's productivity and resilience by increasing labor and knowledge contributions instead of chemical intake (e.g. Gliessman, 1998). These characteristics make agroecological practices appealing for small scale family farms where the family's workforce can compensate the absence of chemical inputs. Therefore, agroecological practices present low-cost alternatives for the maintenance of native AESs or the transformation towards more productive small-scale systems. The ecological principles applied may also offer solutions for the enhancement of conventional farm's ecological performances (e.g. M. Altieri & Nicholls, 2000).

Agroecology is practiced within agricultural management units called *agroecosystems* (AES). This systematic approach is applied to analyses the interaction of resources within a farm unit, which contains biotic and abiotic components including the farmer or family. The systems are open and communicate with the surrounding environment. Energy and material flows within AESs are controlled by farmers to obtain goods. For the design and maintenance of sustainable AESs, the scientific base offers a catalogue of practices. However, regional, local and small-scale conditions vary from system to system and are very individual. No universe resolutions can be formulated for the diversity of possible agrarian scenarios (Third World Network & SOCLA, 2015). More than the adaption of predefined solutions, the management of sustainable AESs is a process of experimentation and innovation, guided by agroecological principles:

- "Enhance recycling of biomass, optimizing nutrient availability and balancing nutrient flow
- Secure favorable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity
- Minimizing losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover
- Species and genetic diversification of the agroecosystem in time and space at the field and landscape levels
- Enhance beneficial biological interactions and synergism among agrobiodiversity components, thus in the promotion of key ecological processes and services" (Third World Network & SOCLA, 2015, p. 8)

The leading idea of the incorporation of ecologic concepts is to appreciate from complex complementarians and synergies among the system's components (M. Altieri & Nicholls, 2000). Those can be created by the "spatial[…], temporal […], physical[…] and individual[…]" arrangement of resources and intakes (Ikerd, 1993, p. 155). Mature AESs are domesticated natural ecosystems with intact ecological functionality (M. Altieri & Nicholls, 2000).

3 Implementation of agroecology in the reserve's BZ

Here, only a very brief introduction to the study area is given, as the BZ-SES is described in detail in the following (see chapter 7.1). Then, the assessed GIZ project is described.

3.1 The MBR BZ

The study area of the present work is the MBR BZ, which expands over 24% of the MBR. The 15 km fringe borders areas under stricter protection legislation, to reduce the pressure on CZ and MUZ. The MBR expands over six municipalities (Las Cruces, La Libertad, San Andrés, San José, Flores y Melchor de Mencos), of which the southern parts are populated. To fulfil its purpose, only agricultural usage is permitted in the 497,500 hectares big BZ (Figure 10, next page) (CONAP, 2015c, p. 27). About 70% of the BZ are used for agricultural production, while less than a fourth is covered by forest vegetation (Table 2). Tropical and karstic soils are flat, which is why MAGA classifies most area as soils suitable for exploitation through agroforestry (SEGEPLAN, 2013b). Only 0.52% of the BZ are protected area (CONAP, 2015c, p. 35). Remaining forest area as well as cultural heritage is divided into private properties and therefore in the hands of landowners.

*Table 2: Type of land use 2012 (CEMEC 2013 cited by CONAP, 2015b, p. 42), *includes secondary vegetation*

Type of use	Area (ha)	% ZAM
Agricultural use*	329,682	70.25
Broadleaved forest (low-medium-high)	111,082	23.69
Riparian forest	877	0.19
Wetlands	18,253	3.90
Waterbodies	9,273	1.98

3.1.1 Climate

The hot and humid climate in the BZ shows small-scale differences. The temperature and humidity gradient runs from west to east (CONAP, 2015c). The present climate classification according to Köppen & Geiger are Aw (climate of the tropical savannah) and Am (tropical monsoon climate). The weather-station in San José reports a medium annual temperature of 25.6°c with an approximate precipitation of 1534 mm, which varies in the course of the year. March and April are dry months, with an average of 227 mm rainfall in April. June is the hottest month, when farmers expect another two dry weeks (*canícula*) (SEGEPLAN, 2013b). Monthly average temperature varies from 22.6°c in December to 28.3°c in June (see climate chart San José, Annex). Interannual changes regarding both temperature and precipitation are documented. Recurrently, the El Niño phenomena affects the BZ and causes extended dry periods which coincide with elevated risk for forest fires (WCS 2013, based on CONAP, 2015c). Extreme weather events like hurricanes or heavy rainfalls threaten farming activities (CONAP, 2015c). Regarding climate change the national institute IARNA estimates temperature increase from 0.5°c to 2.5°c (under A2 and B2 scenarios) and precipitation decrease from 5–15% until 2050 are estimated (as cited in CONAP, 2015c).

Land use and administrative division of the Maya Biosphere Reserve Buffer Zone

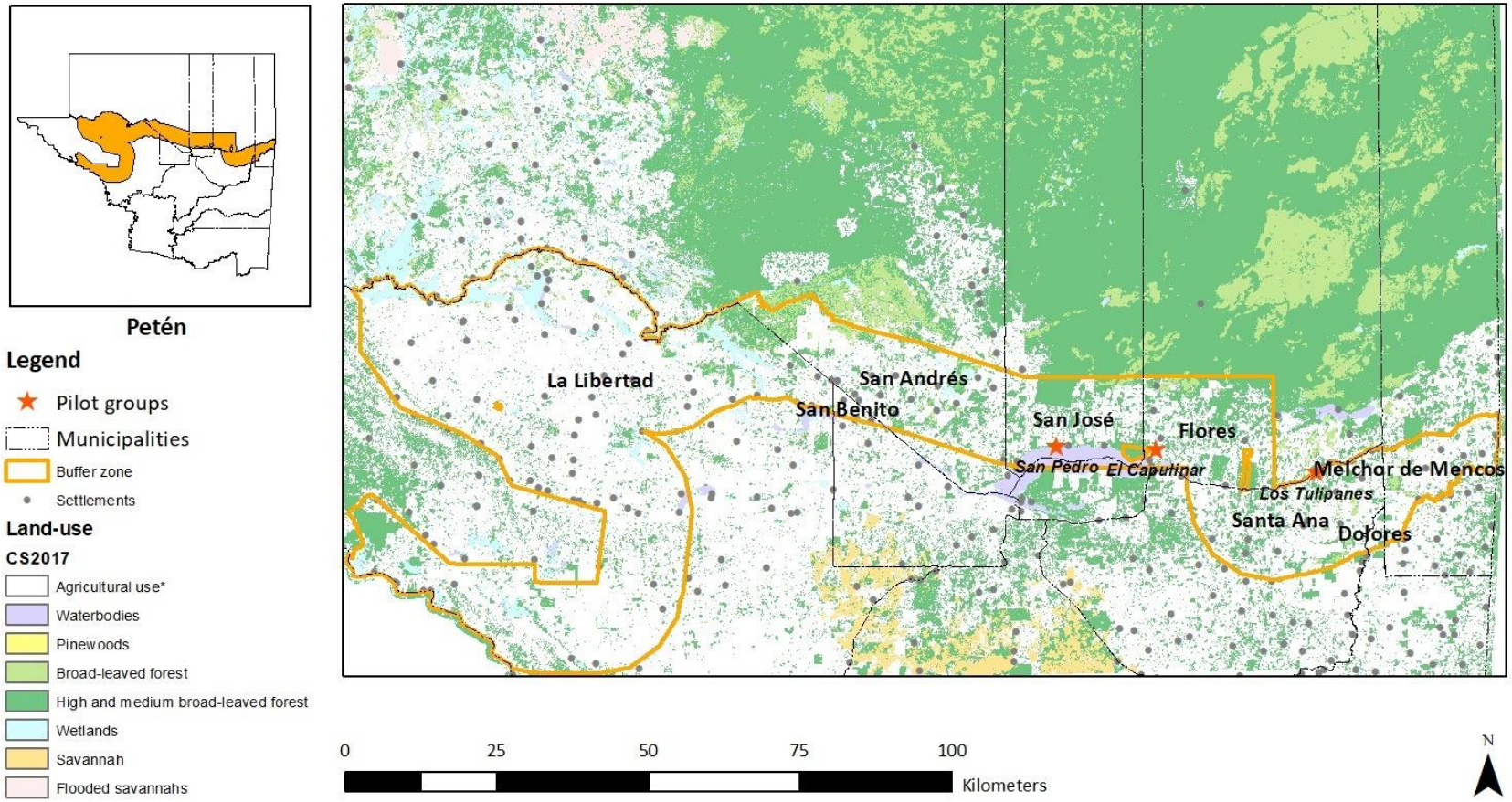


Figure 10: Land use and administrative division of the Maya Biosphere Reserve Buffer Zone (Shapefiles provided by CEMEC)

3.1.2 Population and settlement

The population is distributed in communities mainly situated along the paved roads. In 2007, the BZ's population in was distributed in 118 settlements and estimated at 94,164 (B. Milán & CEMEC 2007, cited by CONAP, 2015c). The BZ is a very heterogenous territory, in which several cultures co-exist. About, 80% of the population are *mestizos,*and of the 20% population of indigenous origin, about 15% are Q'eqchi' Maya (CONAP, 2015c, p. 58).

Table 3: Population and communities in the BZ, municipalities (B. Milán & CEMEC 2007, cited by CONAP, 2015b, p. 55)

Municipality	Population	Settlements	% Municipality of MBR	% Municipality of BZ
La Libertad	54,390	61	66	37
Flores	15,235	15	91	14
Melchor	8,760	11	81	13
San Andrés	8,712	20	97	8
San José	4,845	7	99	16
Santa Ana	2,194	4	10	10
Dolores	28	0	1	1
Total	**94,164**	**118**		

3.2 GIZ program "Conservation and sustainable use of the Selva Maya"

Among the organizations that attempt to implement agroecological farming practices in the Selva Maya BZ is the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). In this chapter, the support is described.

3.2.1 General functioning

The program "Conservation and sustainable use of the Selva Maya", commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) in 2011 and 2014 for a period of four and five years, supports key stakeholders with the formulation and execution of management strategies regarding sustainable development in the Selva Maya. In behalf of the BMZ, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) cooperates with the CCAD to implement measures for environmental protection and sustainable resource and biodiversity use. With the CCAD being the lead executing agency, the project addresses institutions in all three concerned countries and contributes to establish trinational communication between stakeholders in Belize, Guatemala, and Mexico. However, not only institutions but also communities are addressed by the personal attendance of pilot groups by technicians schooled in agroecology (GIZ, 2017).

The program works towards profound reforms in the forest's management and conducts activities in four synergic areas: (1) Protected areas and biodiversity, (2) Land use planning, taking

environmental protection into consideration, (3) Sustainable income generating alternatives and (4) Environmental governance in the Selva Maya. Outcomes regarding the Guatemalan Biosphere Reserve include seventeen updated management plans designed by numerous stakeholders and with the involvement of the public. In Guatemala, the Master Plans concerning the management of the Reserve and BZ have been published in 2015. Also, in cooperation with ACOFOP, pilot projects for promoting the use of non-timber products in MUZ and BZ have generated alternative income opportunities for mainly female groups. In the BZ, the GIZ cooperates with the MAGA and Pastoral to establish stable family farms via the implementation of social agro-ecological practices (GIZ, 2017).

Within the Guatemalan BZ, originally three pilot groups have profited from land-use planning and training in agricultural sound practices (Table 4Table 1). The communities were selected according to the following main criteria (GIZ, 2013):

1. The communities' accessibility
2. The location within the BZ that exert pressure on the protected areas and their resources
3. The willingness to sign a commitment to follow-up on previous work and contribution to conservation of the affected areas
4. The existence of some form of community organization with productive initiatives
5. In the community, land and family land use predominates

The groups differ in location, size, and socio-economic and biophysical settings (Table 4):

Table 4: Characteristic of the pilot groups and communities

	Group 1	Group 2	Group 3
Community:	El Capulinar	San Pedro	Los Tulipanes
Size of original pilot group:	17	29	9
Population size:	~300	~1700	~150
Dominant ethical groups:	Mestizo	Q'eqchi'	Mestizo
Location at:	Route Tikal	Scenery route north of lake Petén-Itza	Route Yaxha
Municipality:	Flores	San José	Flores
Current technical attendance*:	GIZ, MAGA, Municipality of Flores, Pastoral Social-VAP	GIZ, MAGA, Municipality of San José, Pastoral Social-VAP	MAGA, Municipality of Flores
Structural particularities:	Disperse location of land-plots far from community center	Land-plots concentrated in the north of the community center	Households located on land-plots along the road
Dominant land tenure:	Municipal	Municipal	National

Depending on their pilot groups, participating family farmers are attained by technicians of different institutions. These perform aligned actions as well as individual activities. The GIZ facilities the coordination of joint activities. In the field, those are performed with the producers by technical staff known as *extensionistas agrícolas*. Each organization has a different approach to the improvement of agricultural practices. The Municipality of Flores provides an exemplary municipal garden, where endemic crops and traditional agroforestry systems are demonstrated, and seeds and seedlings are produced. Two counterpart organizations fulfill complementary tasks, which are aligned through the GIZ technician. The MAGA focusses on national guidelines to increase production levels by providing support, seeds and seedlings. The Pastoral Social follows a social approach and concentrates on agricultural formation through participatory workshops, field schools and the facilitation of knowledge exchange. Joint efforts aim at establishing sustainable agroecological systems. The systems as well as the individual step-by-step process is defined by a participatory developed agroecological proposal.

Location of the pilot groups' communities

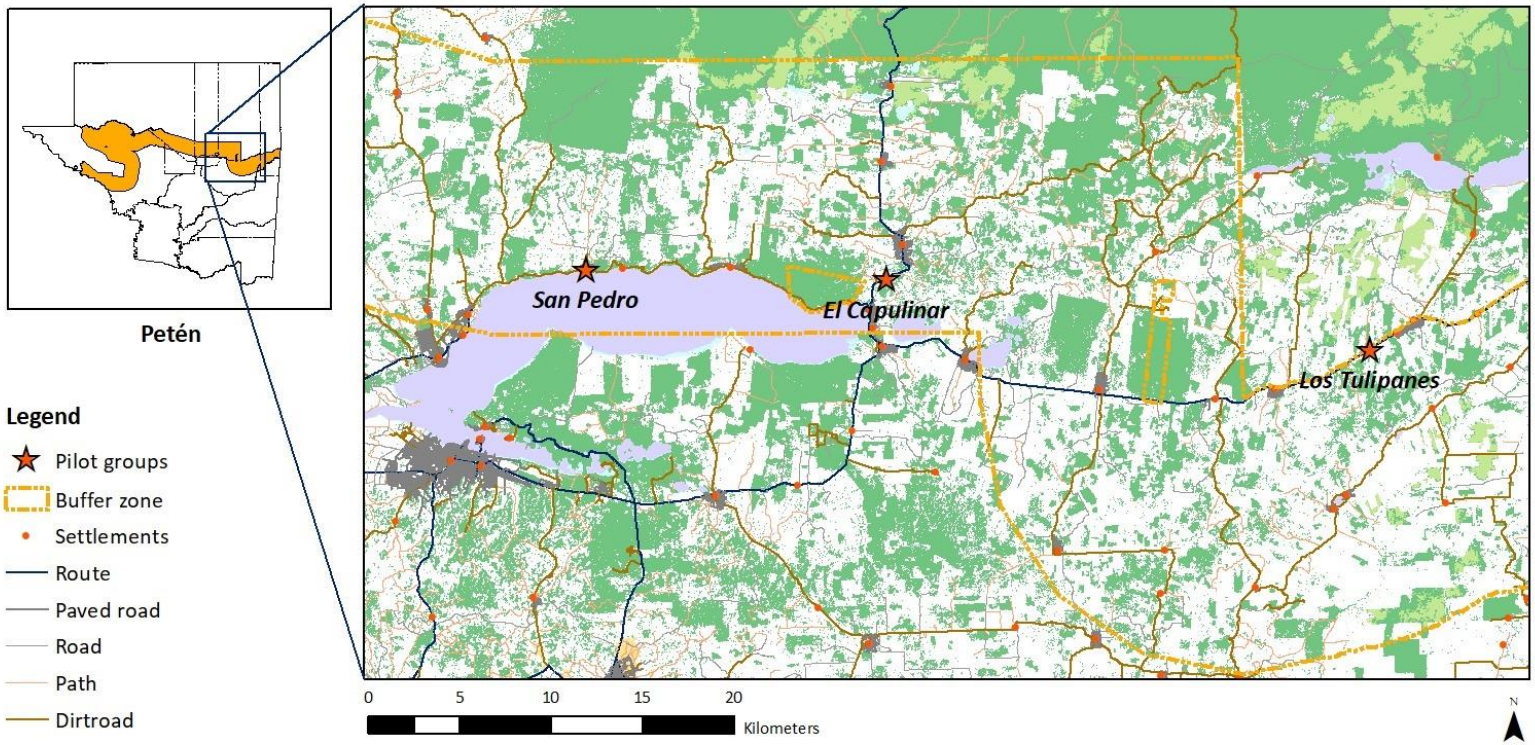


Figure 11: Location of the pilot groups (Shapefiles provided by CEMEC)

3.2.2 The GIZ agroecological proposal

As part of the mentioned GIZ Program, a specific proposal for the implementation of agroecology though the establishment of predefined AESs was developed with local institutions. This cooperation is hereafter referred to as “GIZ project”. The GIZ projects proposal to the implementation of agroecology is the establishment of predefined AESs. The design of an adaptive model to guide the agroecological transition, which was foreseen for the period 2012 to 2019. To design this ideal model for local AESs, an interactive workshop was chosen. In the first place, actors which had already worked towards sustainable intensification of peasants’ AESs were evaluated. Organizations which were expected to have gathered experience in the transition of local AESs were brought together. With their context-specific experiences, they identified factors that need to be taken into account. To broader the organization’s perspective, famers with exemplary systems were selected and contributed to the selection of viable components and strategies (Bonilla Espinoza, Sarceño Arana Castillo, G. Y. Vicente López, & Chocoj, 2012).

The main objective is to nudge and foster agroecological transitions, which meant to reestablish a productive nature-near state of the farmers’ AESs (Nicholls & Altieri, 2016). Regarding the AES’s composition, it was found that the spatial integration of forest, agroforestry, silvopastoral and mixed garden subsystems was suitable for given socio-ecological conditions. These concepts were specified in an interactive workshop. The mixed garden subsystem was defined as an individual but always diverse multi-strata combination of plant and small animal species. Annual and perennial crops grow together and may incorporate maize and beans. The gardening of diverse products is cultivated with the objective to cover the family’s nutritional demands. The agroforestry subsystem describes diversified annual crop systems which incorporate timber. In association with perennials for timber or fruits grow basic grains or shade plants. There is a range of possible associations like e.g. timber with maize or fruit trees with cacao. The associations are expected to re-stabilize energy and material flows. Besides for self-consumption, agroforestry is implemented for sustainable income generation. Wooden perennials can also be combined with the cultivation of protein rich fodder, which presents the silvopastoral subsystem. These might be leguminous shrubs or grasses. As an intensified form of livestock raising it allows to meet the animals nutrient demand on less area and with less external inputs (Bonilla Espinoza et al., 2012).

In the model of the ideal AES, those subsystems are integrated. Their ecological interactions are synergic and their usage essential for the system’s sustainable management. Altogether, the productive subsystems should cover 77,6% of the AES while 23,4% of the total area are foreseen for natural vegetation forms (Bonilla Espinoza et al., 2012, p. 22). Given 10,5 hectares of land, 1,4 hectares are the optimal size for a mixed garden to provides basic grains for eight family members. For intensive livestock cultivation that meets the families demand, 2,1 hectares are calculated (Bonilla Espinoza et al., 2012, p. 21). The nature near agroforestry system, which provides ecosystem services on top of wooden and non-wooden products, is desired in major extension. Emphasis is also drawn to the organization of family and community, which form the frame for outer and inner management (Bonilla Espinoza et al., 2012).

For the implementation of sustainable AESs, three integral methodological approaches have been chosen. The first component "formation" of producers covers content beyond technical practices. Education in psycho social, economic, productive, political and organizational topics accompanies the agricultural transition. Alternative learning via field schools and peasant-to-peasant is praxis orientated. More intensive theoretical classes are offered to interested individuals to form *promotores*. *Promotores* are producers who dedicate themselves to learn and share and thereby multiplicate technical knowledge. The approach builds upon experience gathered by the counterpart Pastoral Social – VAP. The second component "agricultural production" describes the technical and material support offered to participants. Emphasis is put on the planification and structural organization of AESs. The third component is to facilitate the "commercialization" of surplus products. Producer are capacitated to provide high quality and sustainably cultivated products. Local value chains are assessed (Bonilla Espinoza et al., 2012).

The agricultural transitions described the process of individual towards a productive and nature near state. The proposed transitions are orientated on a step-by-step change towards this ideal system (Figure 12, next page). The eight-year process of the agroecological transition has different phases. For the establishment of the mixed garden subsystem, a period of six months to a year is foreseen. The implementation of livestock takes eight to twelve months. To create the agroforestry system, one to two years are estimated. In initial phases, products are for self-consumption, later surpluses are dedicated to local markets (Bonilla Espinoza et al., 2012). Additionally, workshops given in cooperation with Pastoral Social-VAP focused on teaching agroecological measures regarding pest control and soil conservation. These measures range from recipes and methods for the preparation of organic fertilizers and repellents to synergic plant associations. Strategies are spread in educational material (e.g. a guide for the elaboration of organic products (Pastoral Social-VAP, n.d.))[5]. To evaluate the process, a baseline study was conducted, in which the participants were listed with socio-economical characteristics and the reported the amount of produces and profits documented. The increasement of the produced amounts, enhancement of incomes and the individual plant species diversity are predefined indicators (Lisa Steurer, GIZ, personal communication, July 2017).

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[5] A detailed list of taught measures is contained in the questionnaire (Annex)

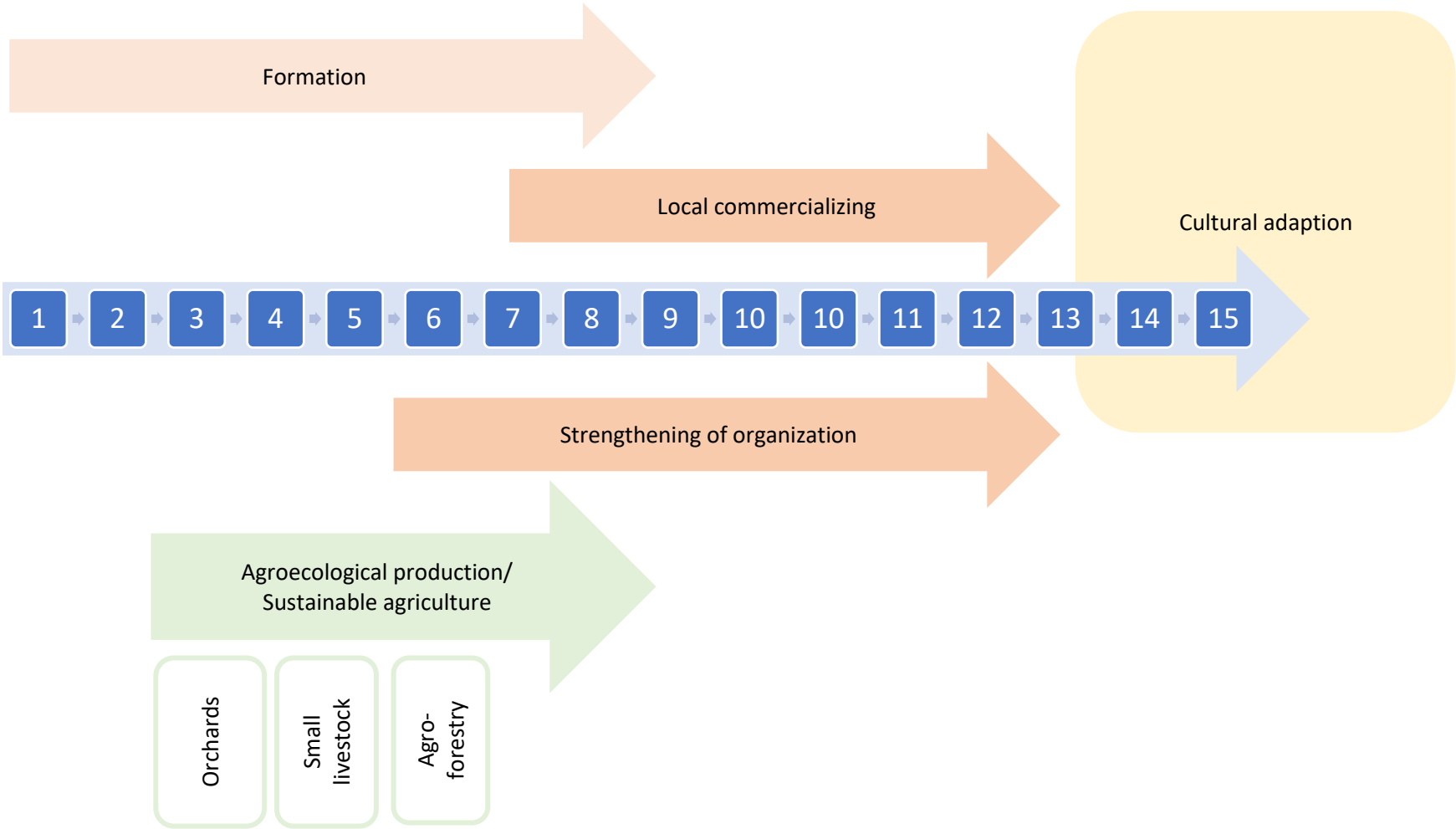

Figure 12: Scheme of the proposed agroecological transition by GIZ and with foreseen steps and expected time for their implementation (adapted from Bonilla Espinoza et al., 2012, p. 27).

4 Problem statement

Ongoing deforestation and growing populational pressure in the Selva Maya demand for innovative strategies, of which supporting family farmers with agroecological transitions is a promising approach. Transitions of AESs is a form of ecosystem stewardship at small scale, as the farmers actively manage their farms towards a nature near state. As agroecological practices are environmentally sound and incorporate agroforestry elements, the agricultural landscape could profit from these changes. Through increasing production levels, the social conditions are expected to be enhanced, and less farmers expected to seek lands in the MBR's inner area. Therefore, the Selva Maye could theoretical profit from both decreasing pressure on natural resources within the BZ and the reducing reasons for migration of family farmers into CZ and MUZ .

However, management which fosters long-term change is a learning process and until today, neither sufficient evidence nor universal strategies for fostering agroecological transitions in the BZ exist. Only detailed monitoring and analysis can reveal their utility for fostering resilience. Agroecology is a science, a social movement and a catalogue of practices – is it also a management strategy for ecosystem stewardship in the MBR? The GIZ project "Conservation and sustainable use of the Selva Maya" offers the opportunity to gain insight to the suggestion's feasibility. The GIZ project started with a baseline study but had not been updated and observed changes had not been evaluated until the present study. Masterplans regarding a diagnosis of the BZ and the alignment of strategies for the conservation of forest and cultural heritage exist, but the farmers' perspective has hardly been considered yet.

5 Objectives and research questions

The overall objective of the present work is to analyze how agroecology contributes to ecosystem stewardship in the MBR BZ. Specific objects lead to four individual research questions (Figure 13).

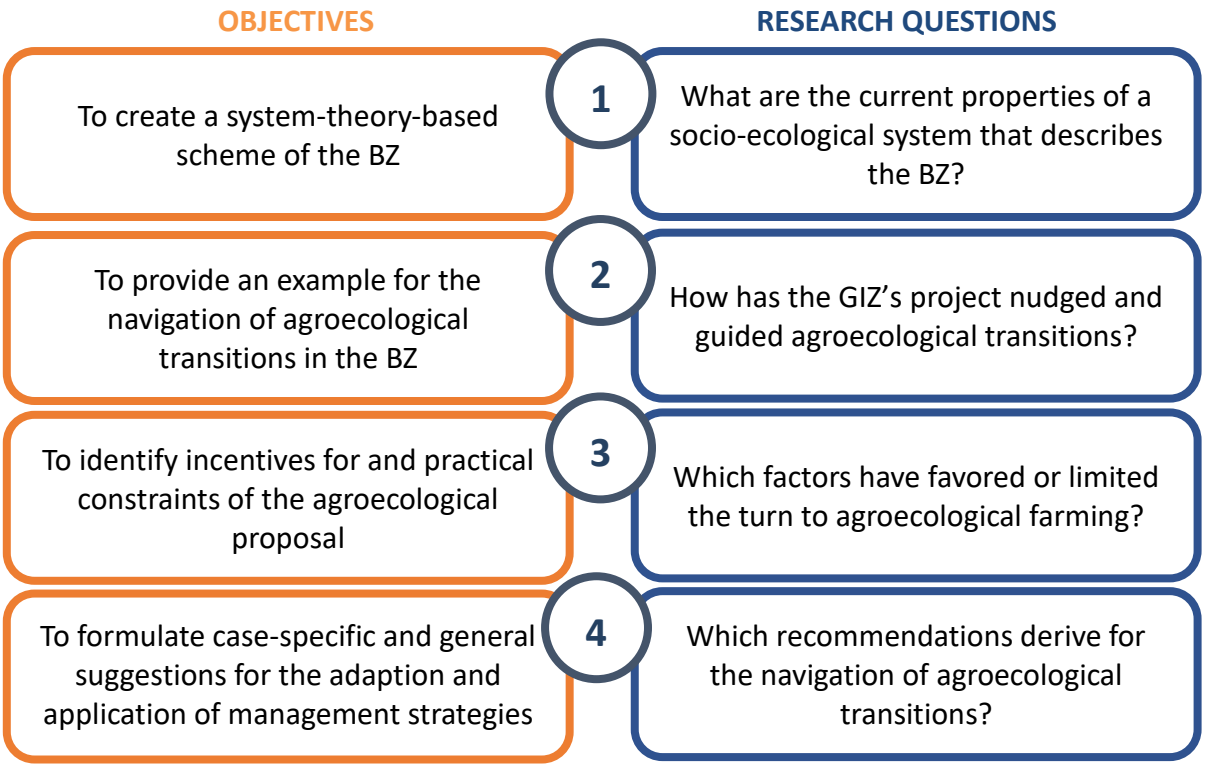

Figure 13: Objectives and research questions

6 Methodology

A mixed methods approach was chosen, which integrates qualitative and quantitative research. The present chapter gives an overview to the methods selected to respond to each research question. The methodological framework visualizes the relation of methods and research questions (Figure 13, next page). The individual selection of methods responds to the research type and scale. Results are ordered and interpreted according to the dominating framework.

6.1 Methodological framework

The present graphic gives an overview to the methods applied to respond to the individual research questions. The socio-ecological system and MESMIS framework have been chosen as methodical approaches and are explained in detail in the following.

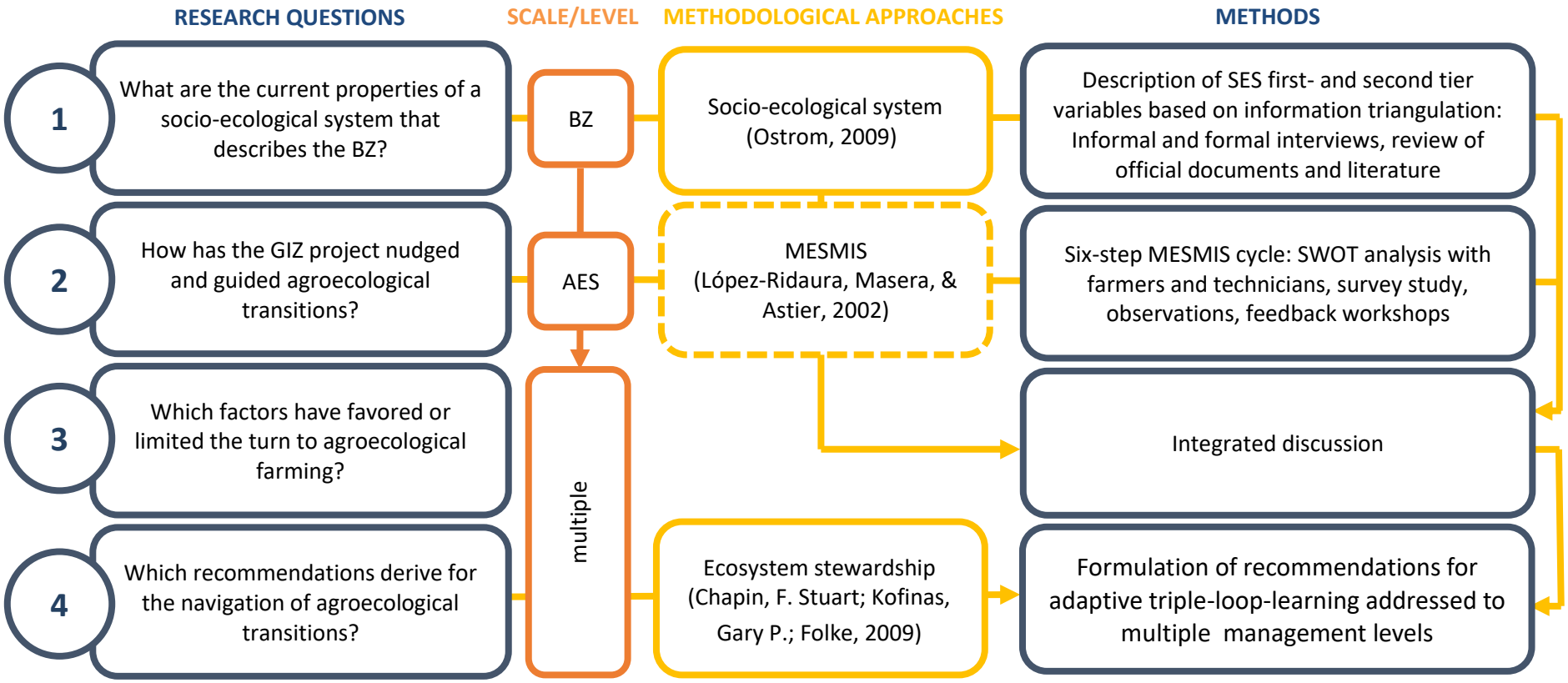

Figure 14: Methodological framework: Individual research questions are related to methodological approach and specific methods

6.1.1 Combined methodical approaches

Two complementary methodical approaches are integrated. Both follow systematic approaches to sustainability and resilience. The first is the socio-ecological system approach by Ostrom (2009). It is a guide for the descriptive analysis of natural resources management systems, which incorporates socio-economic and political dimensions. The BZ was chosen as focal system as a documented agricultural sector exists in this administration unit within the MBR. Economic and social settings at this level affect the embedded AESs. In the present work, AESs refer to the farm-level, given that private properties are units where farmers actively define the BZ's natural resources. Given the distribution of land into private land plots and the absence of large population centers or large public spaces, the BZ rural landscape can be viewed as a mosaic of private farms. Therefore, the BZ-SES can be displayed as a system composed of individual AESs (Figure 15).

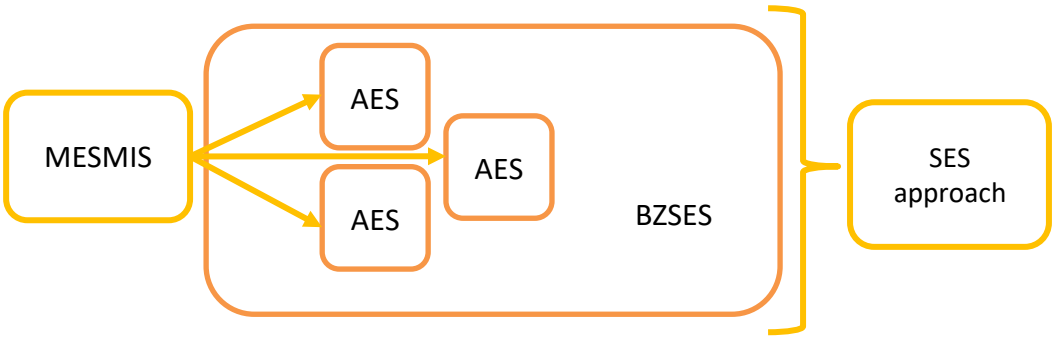

Figure 15: Embedded methodical approaches for multi-level analysis (own elaboration)

Individual AESs are assessed with the Mexican MESMIS approach, which bundles applied methods for the participatory assessment process (López-Ridaura, Masera, & Astier, 2002).

6.1.2 Ostroms's approach to socio-ecological systems

A descriptive line is chosen to create a system-theory-based scheme of the BZ. The framework introduced by Ostrom (2009) facilitates the assessment of socio-ecological systems by guiding the description of predefined variables, which are considered universally important for natural resources management. They are sorted into two categories. First tier variables within the SES are Resource systems, Resource units, Users, and Governance Systems. External first tier variables are Related ecosystems and social, economic, and political systems. Focal action situations occur at their interface. These are described as Interactions. Social and ecological performances are termed Outcomes (Figure 16, next page).

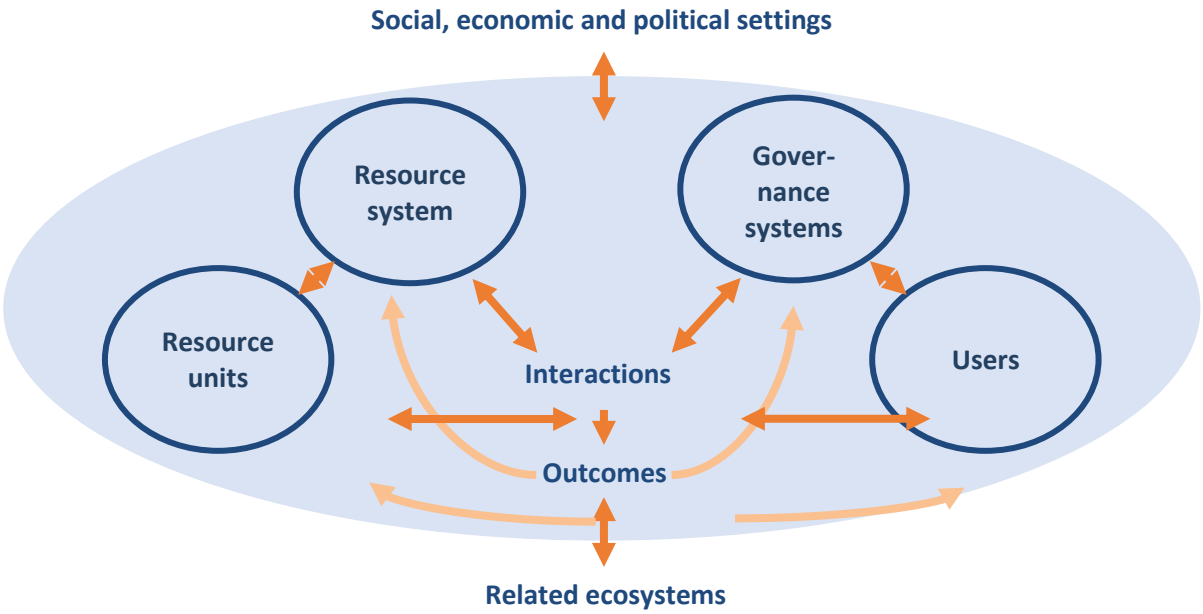

Figure 16: The relation of SES first tier variables descried by Ostrom's framework (2009)

The original SES-approach by Ostrom (2009) is adapted to the present study (Figure 17). No single resource is assessed but embedded AESs. Hence, the first-tier variables *resource users* and *resource units* are merged to AESs. The arable land and remaining forest area are part of the Selva Maya resource system. AES are individually governed resource-subsystems within the governance system of the Maya Biosphere Reserve and the Guatemalan department Petén. Related ecosystems and Social, economic and political setting remain external first-tier variables.

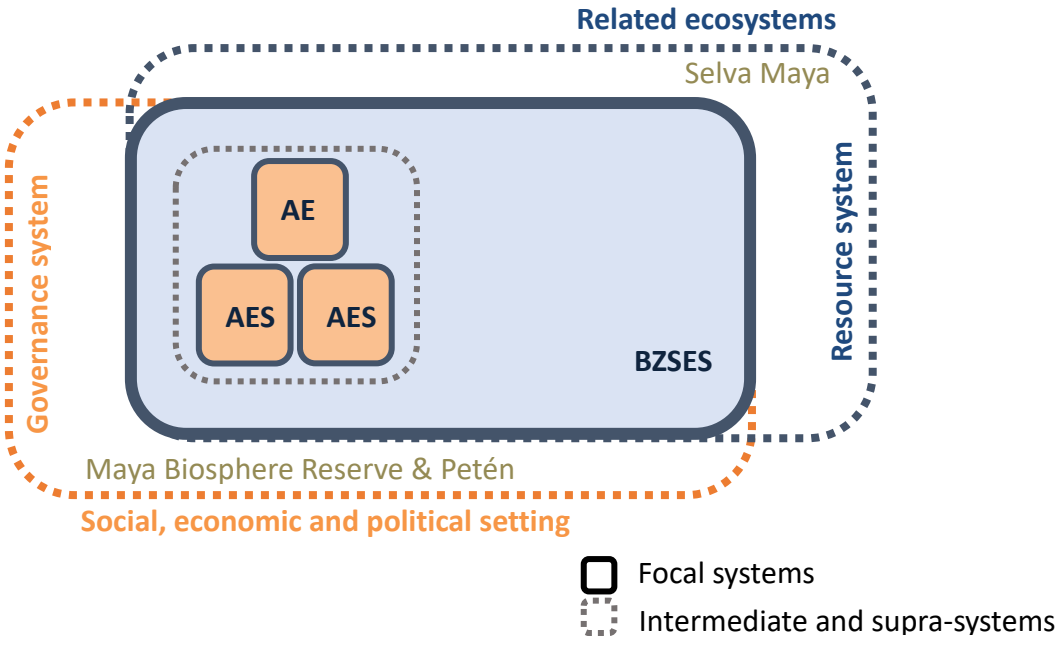

Figure 17: Buffer Zone Socio-Ecological System (BZSES), scheme with embedded Agroecological systems (AESs)

Ostrom (2009) provides a catalogue of second tier variables for the description of the system's first tier variables, which form the base for schematization and modelling. For each first-tier variable, there are three to nine second tier variables. The set and importance of the second-tier variables is what is to be described and evaluated to respond to specific research questions. For the given context, the following variables have been selected (Table 5):

Table 5: First and second tier variables for the description of the BZ-SES or description of aspect (*)

Resource system	
Sector	Human-constructed facilities
Location	Productivity of the system
Clarity of the system boundaries	Equilibrium properties
Size of resource system	Predictability of the system's dynamics
Governance system	
Government organizations	Property rights system
Nongovernmental organizations	Constitutional rules
Network structure	Operational rules
Collective-choice rules	
Monitoring and sanctioning	
Social, economic, and political setting	
Political stability	Government resource policies
Demographic trends	Market incentives
Economic development	Investment opportunities
Interactions	
Deliberation process	
Information sharing among users	
Self-organizing activities	
Related ecosystems	
BZ function	
Social, economic, and political setting	
Economic development	Government resource policies
Demographic trends	Market incentives
Political stability	
Agroecosystems (AES) (Resource units & users)	
Types	Interactions and conflicts
Socio-economic situation of farmers	History of use
Importance of AES for users	Knowledge and mental models
Economic value	Number and location
Consistency and spatial and temporal distribution	

Outcomes	
*Social-ecological performance (Feedback loops)	
Related ecosystems	
*BZ function (descriptive)	

6.1.2.1 Triangulation of data for the description of variables

For data triangulation, different interrelated information sources are used. This way, multiple viewpoints are considered. Consultancy with experts with diverse backgrounds is used to gain an overview, to capture different perspectives and to profit from recommendations concerning official data pools and planning instruments. Land and territorial planning instruments like Master and development plans and related literature which is revised for a more detailed understanding. Individual literature and data searches in the internet are performed to take on a more individual viewpoint and broader the perspective (Figure 18).

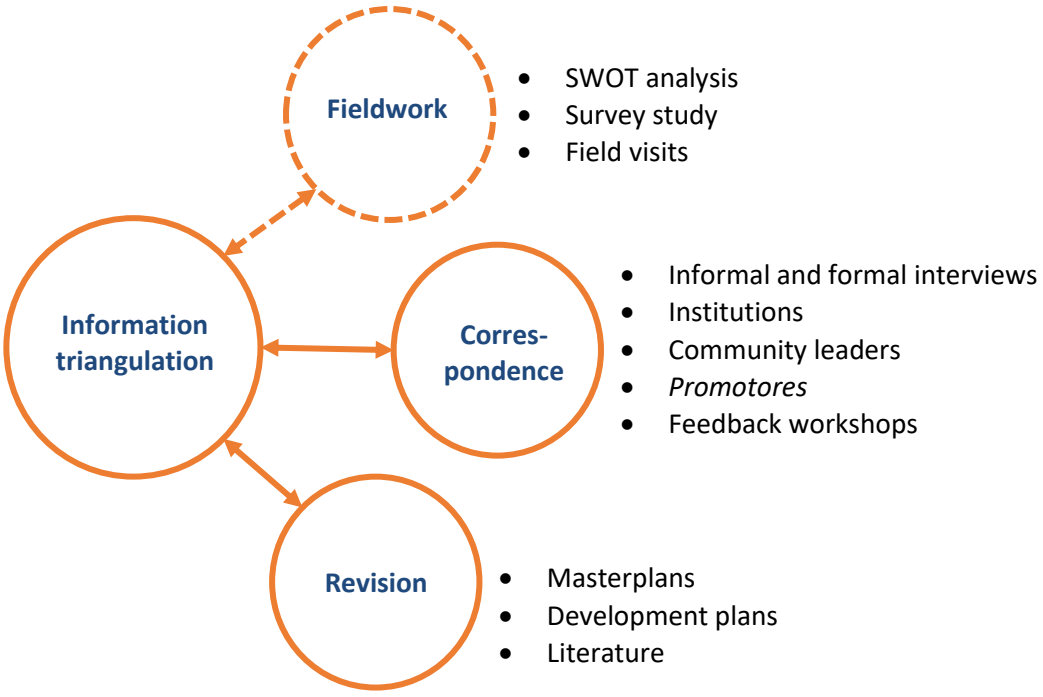

Figure 18: Processes of information gathering with type of research (circles) and sources. Incorporates elements from the fieldwork.

6.1.2.2 Correspondence

For the present study, personal contact was established with several expert. Communication with the GIZ project coordination was initiated in December 2016. Correspondence was first at distanced and then personal during two stays in Petén. In the first place, the contact to the project was established via e-mail and on the phone. The former agrotechnician was consulted, who provided information to former experiences and the process of data collection. First information about the outcomes were shared and data from the baseline study made available by the GIZ. Second, the territory was visited for the period of a month (July 2017). During the stays, the correspondence with the development cooperation organization facilitated the establishment of contacts with stakeholders, which provided a contact network to build upon.

Key actor organizations were visited mostly during this first month, to capture their functionality and responsibilities regarding cooperation and the assistance of farmers (Table 6). It was perceived easy to contact and visit various stakeholders as the consulted organizations were very supportive. A personal introduction to was given to exemplary organizations. Topics discussed were vision, responsibilities and functionality of each. Material in forms of e.g. brochure were also requested.

Table 6: Introductions received by key stakeholder organizations during July 2017

Organization	Name	Position
GIZ	Lisa Steurer	Project coordinator
CONAP/GIZ	Rudy Herrera	Technician
Pastoral Social-VAP	Gloria Gonzáles Licda	Director
MAGA	Aldo Rodas	Administration
ProPetén	Rosa Irene Contreras	Director
Land register (RIC)	Anonym	Administration
Fontierras	Anonym	Administration

Additionally, informal correspondence with workers of independent institutions consisted in loose contact with workers of ACOFOP, Forest Department (INAB), and Word Conservation Society (WCS).

Further, individual experiences with management in the BZ were captured via informal and unstructured interviews. Recommendations for further visits were followed according to the snowball method: A consulted expert is asked for contacts he or she would recommend consulting next and asked to provide or establish the contact. Based on these experiences, semi structured interviews were hold with a selection of interview partners who were able to exemplary characterize the pilot group's communities, surrounding and attendance by the organizations.

During the stay from March until July 2018, formal interviews were conducted. Semi-structured interviews permit to reduce the narrative perspective to thematic key points (Kelle, Reith, & Metje, 2017). The interviewed were informed that the overall objective was to apply a systematic approach

to the description of the three communities El Capulinar, Los Tulipanes and San Pedro and asked to share their experience about the environment, present entities and development. They were asked to share specific characteristics of the communities but also to put their statements into the broader context of the BZ. The period of interest was defined for the period 2011 – 2018, but it was also asked for incorporation of related historical events. Three aspects of interest were divided into sub-aspects. Thereby, selected information regarding the environment, present entities and development was captured. These categories were clarified before and were made visible to the interview partner during the questioning (Annex). Nevertheless, the researcher guided the conversation.

For the interviews, three different kind of experts have been consulted: Representatives of cooperating organizations, community leaders and capacitated *promotores* for agroecological farming.

Table 7: Interviewed experts

Name	Position/ Organization or Community	Date	Available data
Rudy Herrera	Leading technician/ GIZ/CONAP	07/03/2018	Transcription (Annex)
Elmer Lopez	Agrotechnician/ Municipality of Flores	22/03/2018	Audio
Patrocinio Lopez	*Alcalde auxiliar/* El Capulinar	15/04/2018	Audio
Luciano Ródas	*Alcalde Auxiliar/* Los Tulipanes	10/04/2018	Audio
Mateo Choc	*Alcalde auxiliar/* San Pedro	26/04/2018	Audio
Flora Idalba Sintú	*Promotor/* El Capulinar	06/04/2018	Audio
Nixon Esquivel Vazquez	*Promotor/* San Pedro	24/04/2018	Audio

In the field, cooperating activities were observed by the researcher by accompanying the current GIZ agrotechnician Enzo Solari. Accompanied activities included the provision of technical assistance, workshops, and field schools. Many activities were coordinated together with the Pastoral-Social-VAP's responsible staff, which consists in one agrotechnician and an additional social worker. Within the communities, a relation of trust with local farmers was established between the participants and the researcher. This was facilitated through the introduction by the agrotechnicians and cooperation with local authorities and *promotores*.

6.1.2.3 Revision

Information about the territory was extracted through the revision of the MBR's master plans, municipal development plans and literature regarding land tenure and present Maya (Table 8). The four master-plans regarding the MBR were the main information sources. Two of the four plans (III & IV) concentrate especially on the BZ. The departmental diagnosis of Petén alternates the information. All plans include territorial diagnosis, objectives and lists of stakeholders.

Table 8: Secondary data sources

Document	Type	Level	Validity/Period	Editor	Cited as
Reserva de la Biosfera Maya. Plan Maestro (2nd edition). Tomo I & II. (2015)	Masterplan MBR	Territorial (MBR)	2015 (- 2021)	CONAP	(CONAP, 2015a); (CONAP, 2015b)
Reserva de la Biosfera Maya. Plan Maestro (2nd edition). Tomo III & IV (2015)	Masterplan BZ	Territorial (BZ)	2015 (- 2021)	CONAP	(CONAP, 2015c); (CONAP, 2015d)
Monitoreo de la gobernabilidad en la Reserva de la Biósfera Maya. (2015)	Monitoring report	Territorial (BZ)	2013/2014	CONAP, WCS	(CONAP & WCS, 2015)
Territorial Diagnosis Petén; Integral Development Plan (2011)	Integral development Plan (Progress)	Department (Petén)	-	SEGEPLAN	(SEGEPLAN, 2011)
Diagnóstico Territorial de Petén. Tomo I. (2013)	Integral development Plan	Department (Petén)	2013 - 2032	SEGEPLAN	(SEGEPLAN, 2013b)
Diagnóstico Territorial de Petén. Tomo II. (2013)	Integral development Plan	Department (Petén)	2013 - 2032	SEGEPLAN	(SEGEPLAN, 2013c)

Besides the revision of grey literature and scientific papers, two works recommended by an expert influenced the anthropological lens on the BZ's issues: "Tz'aptz'ooqeb : The recurrent dispossession of the Q'eqchi 'people" ("Tz'aptz'ooqeb: el despojo recurrent al pueblo q'eqchi'" by Liza Grandia (2009)) and Itza Maya ("Plants of the Petén Itza' May" by Atran Scott, Ximena Lois, and Edilberto Ucan Ek (2004)) provide insights to the historic oppression of the Maya people, which is often unnoticed in official documentation.

6.1.3 The MESMIS methodical approach

The assessment of the individual AESs was oriented on the Framework for the Evaluation of Natural Resource Management Systems MESMIS. The MESMIS program has been established and applied due to the raising need for monitoring the sustainability of AESs. It was found by Mexican researchers in 1995, who claim to have proposed a systemic, participatory, interdisciplinary, and flexible approach (López-Ridaura et al., 2002). It is a low-costs and relatively simple evaluation process. For more than twenty years, the methodology has successfully been applied in a variety of case studies and allows to visualize and compare the advances of agroecological transitions at farm, community or landscape level (M Astier, García-Barrios, Galwin-Miyoshi, Gonzáles-Esquivel, & Masera, 2012; López-Ridaura et al., 2002). A particularity of the framework is that the applied sustainability indicators are not predefined but developed and measured together with the farmers during the study.

The framework's predefined six-step process was adapted to the investigation (Figure 19). First, the agroecological system is described. Second, critical points are determined. Third, indicators are developed. Fourth, indicators are measured. Fifth, results are integrated and presented. Sixth, conclusion and recommendations are formulated. Ideally the process is repeated every two years.

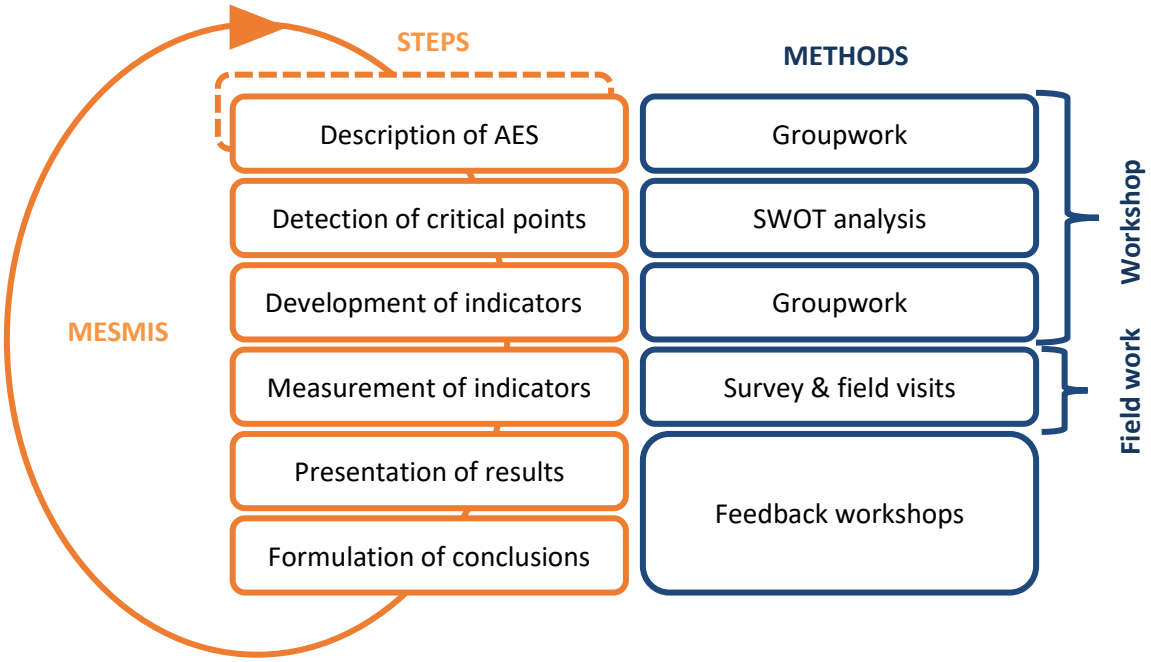

Figure 19: MESMIS evaluation steps and chosen methods, adapted from López-Ridaura et al. (2002

Step one to three were accomplished in workshops, to which all participants of the pilot groups were invited. The announcement was via promotors and local leaders, who were communicated the list of participants appearing in the baseline study. Additionally, representatives of cooperating institutions were informed. The workshops were hold with the objectives to inform about the study and actively involve the participants in the development of indicators. The same agenda was followed on the 14/03/2018 in the public saloon in San Pedro and on the 15/03/2018 in the public school in El Capulinar. The workshops took place from 8:30 till 14:00, including a lunch break and two fifth-teen minutes breaks.

The workshops started with an introductory phase. All participants were asked to introduce themselves. A responsible agrotechnician asked the participants of the program to remember and comment on their personal experience with the project. The researcher was introduced. For the explanation of the investigation's objective and proceeding, the key concepts sustainability, AES, monitoring, and indicator were explained using prepared visual material (flipchart papers). Likewise, the MESMIS six step process was explained.

Inspired by handbooks on participatory tools by e.g. Geilfus (2002) or Burns et al. (2004), the workshop was designed interactively and included many visual elements, groupwork and informal exchanges. All participants were encouraged to join in the activities and share their experiences. To start with, the participants themselves discussed advantages and disadvantages of their AESs interactively. Afterwards, results were collected applying the SWOT matrix (Figure 21, next page).

After lunch, the participants discussed in groups how sustainability could be measured with indicators. Agrotechnicians and social workers assisted the researcher. The discussion was guided according to the questions "How do we know we are doing well?" and "How can we measure if we are doing well?". The method differed in the two workshops. In the first workshop in San Pedro, predefined indicators derived from literature review and were presented on moderation cards. In El Capulinar, possible indicators derived from noted strengths and weaknesses (Figure 24, Figure 25, next page).

To close the workshop, participants were asked to participate in a groupwork drawing exercise. First, participants with similar agrosystems were asked to find each other. To do so, they were asked to draw their AESs most striking characteristic on a moderation card and find people with similar drawings without speaking a word but only showing their results. In groups, paintings with the AES's elements were created and presented in plenum. The results were discussed and explained to the researcher.

Figure 20: Presentation of critical point (San Pedro, 14/03/2018)

Figure 21: SWOT analysis in plenum (San Pedro, 14/03/2018)

Figure 22: "Speed date"-discussion of critical points (San Pedro, 14/03/2018)

Figure 23: "Speed date"-discussion of critical points (El Capulinar, 15/03/2018)

Figure 24: Groupwork for indicator development (El Capulinar, 15/03/2018)

Figure 25: Group discussion for indicator development (San Pedro, 14/03/2018)

6.1.3.1 SWOT analysis

As a starting point for further investigation, a current state analysis of the AESs was conducted with the SWOT (also known as TOWS) method. Therefore, strengths (S), weaknesses (W), opportunities (O) and threats (T) are sorted into a matrix to differ between internal and external factors that favor or threaten their maintenance and development. With this interactive tool, multiple perspectives on a discussed issue can be captured and visualized easily. The SWOT analysis is a tool that was originally applied for the evaluation of businesses and the formulation of enhancement strategies (Gürel & Tat, 2017). Since then, it has been conducted regarding a variety of contexts, including agriculture and development cooperation contexts. As it is differed between internally or externally caused problems, the analysis gives information about the level at which the problem exists.

The SWOT analysis was successfully applied in the workshop. Conducted with farmers, mentioned threats and opportunities indicate favorable and unfavorable conditions at BZ level. SWOT analysis was already familiar to the supporting social workers and facilitators and some participants (Pastoral-Social-VAP personal correspondence, July 2017). The SWOT analysis was conducted interactively in the workshop. To do so, they were asked to form two lines, one line facing the other. Until a signal, advantages and disadvantages could be discussed with the person in front. Then, one line was asked to move one person forward and the last person in the line to head to the beginning of the line (Figure 22,Figure 23, previous page). The exercise stopped when everyone had spoken to everyone. Afterwards, results were collected in plenum. The mentioned aspects were documented on four flipchart papers . The researcher supported to differed between strengths and opportunities as well as weaknesses and threats when aspects were mixed by the participants (Figure 21, previous page).

A simple SWOT analysis was also conducted with the six participants in the conference before the survey's results were shown to responsible agrotechnicians. To do so, the participants were given a paper with the task to note the strengths, opportunities, weaknesses, and threats regarding the implementation of agroecological measures that they had perceived during their work. The results were integrated with answers participants had given to open questions related to the project's success as well as additional comments which had been documented during the survey study.

6.1.3.2 Survey study

For the measurement of the indicators, a mixed-method-approach was chosen, that incorporated qualitative as well as quantitative elements in a survey study. A survey study is an empirical method which allows to gather and process information using a questionnaire with standardized questions and mainly predefined answer choices. This way, obtaining comparable results is much less time intense than through fully qualitative studies. Questionnaires are a common tool for the assessment of AESs. Predefined sustainability indicators can be measured by defining values for answer choices. In larger studies, month long pilot tests and adjustments can lead to the construction of a quantitative questionnaire that covers all possible answers and allows assessors to draw conclusions

about causal relations between the variables (Kelle et al., 2017). In the present study, the size of the sampling group and intentional choice of motivated participants as well as the short time frame impede such proceeding. Instead, the descriptive approach also allows a more individual view and to leave space for the aspects which had not been considered in the rigid questionnaire design. To do so, closed questions were mixed with open questions. Questions with multiple answer choices contain the option "other". This way, qualitative data from the farmers' perspective contributed to the overall picture.

The interview consisted of two parts[6]. The first part of the questionnaire is divided into eighteen different sections, which contain multiple items:

General information. First, general information about the participants is captured, including name, origin and time living in the community. Also, it is asked if a household's member had received the promotor capacitation. This way, the could be sorted into the categories (e.g. community and presence of *promotors* in household).

Changes regarding the quality of life. Very briefly, participants are invited to share their perception of increased or decreased quality of life and name reasons. The question was asked to get an idea about general conditions of life and emphasize the interest towards the participants' personal circumstances.

Family composition. To capture the household size, it is asked for the number of people living in the house. Additionally, it is asked for the children's gender. The question was asked to get an idea about the average household size and composition.

Knowledge exchange and/or shared work. In this section, participants are asked if and how often they participation in a farmer-group and to name common activities. Also, they are questioned if they share obtained experiences with someone else. The participation in a farmers group was mentioned in the workshop as a possible indicator. Also, the cooperation in self- organized or institutional groups give insight to existing network structures.

Land availability and attendance. In this section, it is differed between land plots outside of the city center and terrains within the city center. This way, it was differed between the two differently managed subsystems. For each category, the interviewed are asked to state how many properties they have access to and what they measure. It is requested to name distance and access to the land plot as well as for the extension of different subsystems, like agroforestry or orchards. This way, information about the extensions and accessibility of the AESs and subsystems is obtained, which are potentially limiting factors the researcher revealed via observation. Likewise, it is asked for the aspect workforce. It is asked for the legal status to get insight to the legal security.

[6] The Annex contains an English and a Spanish version of both parts

Internal organization. Different options for planning tools are presented and participants requested to choose the applying options of the multiple choices. The aspect derived from the participatory development of indicators. Also, different tools had been shown through the project's workshops and contributed by the agrotechnicians to the questionnaire. The question means to reveal adaption and application of documentation and long-term planning for agroecological transitions.

Training and innovation. Again, several options are presented and the interviewed asked to choose the applying sources of ideas regarding crop cultivation and livestock. The aspect also derived from the workshop. Among the options is "experimentation" to capture if farmers actively work towards transition and "promotors" and "technicians" to see if support is guaranteed.

Availability of advice and support. Likewise, the interviewed is presented possible sources of advice and support (e.g. neighbor or workshop) and requested to agree or disagree on each.

Dependencies. As an example, the origin of seeds is questioned. Six different options are presented (e.g. buying or exchange). "exchange" is an option to reveal if independent networking exists at community level and "organization" to see if existential dependencies on organizations persist.

Availability and use of water. Regarding the availability of water, it is differed between the village and land plots at distance. Months of availability, sources and strategies are asked for.

Additional income. Five income sources including the salary of paid work or family support are presented. Further, the percentage of the external source of income of farmer is captured. "Salary of paid work" is an answer choice to reveal if and to which degree the AES is run for subsistence farming or as sidelines.

Agrochemicals. It is asked for the usage of chemical fertilizer and pest controls, the brand and amount applied. They are requested to estimate the deriving costs. Besides "yes" and "no", the application "only in MILPA" is given as an option, too. This way, information regarding the application of conventional strategies is gathered, which derived as an indicator from the SWOT analysis. Also, potential monetary benefits for the farmers are measured.

Soil conservation. Among the three categories regarding agroecological techniques is soil conservation. The soil conservation section is closely orientated on the Pastoral-Social-VAPs teaching and training material (Pastoral Social-VAP, n.d.). Regarding selected agroecological strategies, the participants are first asked if they had been taught the strategy, then, if they have applied the strategies since May last year, and afterwards for their perception. These include manure, the application of forest materials (e.g. forest earth), bokashi and/or compost, or green manures (e.g. fertilizer bean), cover crops and liquid biofertilizers. Answer choices are "yes", "no" and in some cases also "somewhat". Regarding traditional practices, it is required to comment if and how much area is left to rest and when the last and next burning were/are conducted.

Plant health. Like soil conservation, the plant health section includes agroecological techniques and measures included in the Pastoral-Socials teaching and training material (Pastoral Social-VAP, n.d.). They include organic repellents and associative techniques.

Livestock practices. This is the third section that questions participants about the application of techniques shown in workshops and field visits. It includes questions about the preparation and of concentrate and vaccinates.

Agroecological project. To capture the projects outcomes and relate findings to the assessed intervention, section includes closed questions but demands the reasoning of most. First, it is required to say if "agroecology" is a familiar term and to explain afterwards. Then, it is asked if participants are doing better, worse or the same with crop cultivation or animal breeding as before the agroecological project. Comments are received to "what has gone well" and "what has been hard". The participants could agree if the lacked knowledge, space or money to "cultivate enough". Also, they were required to say if it could be necessary to sell or clear more land if the current situation persists.

About the forest. Finally, the usage, perception and meaning of forest for the interviewed is asked for. First it is asked for the usefulness of forest to the farmers, by presenting options of usage and ask if incentives are received. Then, participants were asked to explain their personal relations to forest and say if they perception or area in possession have changed. This way, findings should capture environmental outcomes of the project.

Comment section. Finally, participants are explicitly encouraged to comment on aspects they consider relevant for the evaluation of AESs and the project.

In addition to the described interview concerning the diagnostic and indicator assessment, the diversity and amount of species cultivated, and animals hold was asked for. To do so, a list of common plant and animal species was prepared based on the proposal, observation and in cooperation with the responsible agrotechnicians. The choices are read out loud first. In a second step, it is required to estimate the amount produced in the assessed time span (May 2017 until April 2018). Additionally, participants are asked to state for each product if it had been enough for the household's demands and if it had been planted before the project had started. Also, it is required to estimate losses and sale (Annex).

The questionnaire was pre-tested and hold face-to-face with at least one family board's member. The questionnaire was designed in consultation with two responsible agrotechnicians to cover all implemented strategies. It was pre-tested with three local farmers in the end of March, but the wording and complexity was adjusted after initial intents with seven participants in El Capulinar. The individual interviews were accompanied with local promotors, who helped with the explication of the individual options or to overcome language barriers. The researcher was physical presence in the communities during the continuous phase of questioning during April. Appointments with the

farmers were arranged in the initial workshops, via phone or by visits. In average, three interviews were hold a day.

The data analysis was descriptive. Selectively, only items with more consistent data basis were chosen to be displayed. Microsoft Office Excel was used for data analysis. The data was entered by hand into two documents. One document contains the answers to the general questionnaire. Each question had a column. Answers of the participant were displayed in the individual row. Another document contained a sheet for each participant to determine the plan species diversity and production. Results were transferred into the first document. Participants were classified by community or the presence of a promotor within the family. To do so, they were given a number (El Capulinar = 1, San Pedro = 2, Los Tulipanes = 3, *Promotor* within the family: Yes =1, No =2). This way, analysis separating between these groups could be performed using the COUNTIF function. When multiple criteria were defined, the COUNTIFS function was employed. No-responses were treat displayed in the results in two different ways: Either the amount of answers no considered were labeled “NV” or, when percentages were formulated, the number of considered answer choices is labeled “n = (number of answer choices considered)”.

6.1.3.3 Field visits

In addition to the survey study, the AES’s assessment included visits to the individual terrains and lands. A local promotor accompanied the researcher to facilitate the identification of plant species and evaluation of general conditions. Lands within the community’s boundaries were visited directly after the interview. Lands at a distance were either visited in groups or individually with a vehicle, on horseback or hiking. Excursion dates with vehicles were announced and individual appointments arranged at visits. Crop species diversity, number of observed fruit trees and general conditions were documented.

6.1.3.4 Feedback workshops

Six feedback workshops were hold with different sets of actors. Three of them in front of technical staff. To do so, a power point presentation was prepared which included preliminary results (Annex). The results were based on a rigid data analysis. The presentation was designed for one hour of presentation and twenty minutes of comments and feedback, which was documented.

The first presentation was hold in the program’s two-day technical conference in Belize on the 8/06/2018. Here, project planners and technical staff of the trinational GIZ project were present. The second presentation was given on the 19/07/2018 in the GIZ office in from of agrotechnicians from cooperating institutions. Six representatives for a bigger network of extensionists most related to the target communities were invited personally. The third presentation was given on the 22/07/2018 in the union of technical staff Petén of the Pastoral-Social-VAP.

Three presentations were hold in front of the pilot groups during the final reunion on the 25/06/2018 in El Capulinar and Los Tulipanes and on the 26/08/2018 in San Pedro. The visit was

announced via promotors, but also people were also visited personally to invite to the event. A card had been presented which included acknowledgements, encouragement and numbers of the existentialists which had agreed to further support interested families. The presentation consisted in acknowledgements, the explanation of selected print outs from the power point presentations and the handing in from fruit trees to each participant. The turn from the original purpose of quantitative indicator analysis to qualitative people-centered investigation was explained. Comments were received.

7 Results

In the present chapter, the BZ-SES trajectory, its properties and the exemplary assessment of embedded AES are presented.

7.1 A Socio-Ecological System that describes the Buffer Zone

In the present chapter, first- and second-tier variables of the BZ are described based on information triangulation. This way, the Buffer Zone Socio-ecological system (BZSES) is defined.

7.1.1 Resource system: The BZSES's primary sector

The BZSES's resource system equals the territorial extension, as the agricultural sector dominates.

Sector. The BZ-SES itself is an agricultural resource system, as the primary sector dominates both in extension (approx. 70% according to CEMEC 2013) (as cited in CONAP, 2015c, p. 42) and employment (approx. 68% according to INE 2002)(as cited in CONAP, 2015c, p. 80). The commercialized agricultural products are poorly diverse. Farmers and ranchers mainly commercialize basic grains (*maize blanco* and *frijol negro*) and cattle calves. Besides agriculture, only forestry, tourism and oil extraction are relevant economic activities. (CONAP, 2015c).

Location. The particularities of the agricultural resource system are its closeness to large area of protected forest area, its isolation from national centers and bordering to two national borders (Mexico and Belize). The bordering city "Flores", which is located centrally in the south of the reserve, is a regional center where administration, tourist and commercial activities are bundled (SEGEPLAN, 2011).

The overall agricultural productivity is low, which is reasoned with limiting factors like climatic, soil conditions as well as lack of market access and investment capital of small holders. Even so, the department Petén is the main national supplier of basic grains and intermediates buy significant amounts from farmers in the BZ to sell on national markets (CONAP, 2015c; SEGEPLAN, 2011).

Clarity of system boundaries and sizes. The BZ is an administration unit within the MBR with clearly defined geographical boundaries (see CONAP, 2015c Annex 2, p. 272-276). In the field, problems have occurred with communities located on the boarders, as limits are poorly marked different legislation apply for communities that boarder the Zone of multiple use (CONAP, 2015c). In the east, the BZ limits with the national border to Belize, which until the present day has not been defined clearly. In total, the BZ covers 497,500 ha, of which about 6% are covered by wetlands, water bodies and riparian forest (Table 9). The agricultural system consists of land patches used for crop cultivation and/or livestock, on which much of the remaining forest is located. In official documents, no differentiation is made between land used for cattle ranching or agricultural production. An estimation provided by the Masterplan gives is based on a databank from 2001. Accordingly, paddocks account for at least 80% of the land used for agriculture, which indicates "[a] current reality much more oriented to extensive ranching" (CONAP, 2015c, p. 69). The largest private

reforestation company Green Millennium aimed at 25,000 ha extension in 2015 (CONAP, 2015c, p. 71).

Table 9: Land-use of the BZ (Ariano con base en CEMEC 2013, cited by CONAP, 2015a, p. 42)

Type of use	Area [ha]	Porcentage of BZ extensión [%]
Agricultural use (including extensive livestock)	329,682	70.25
Broadleaved forest (low-medium-high)	111,082	23.69
Riparian forest	877	0.19
Wetlands	18,253	3.90
Waterbodies	9,273	1.98

Human-constructed facilities. The territory has a deficient road network and only few irrigation systems are installed. Only urban centers and tourist routes are completely asphalted. In 2010, about 70% of the road network the department Petén were unpaved, of which 30% were not attained (SEGEPLAN, 2011). Rural irrigation structures are mainly absent (SEGEPLAN, 2013b). In 2008, the China-Taiwan cooperation launched an investment program in the western municipality La Libertad. In 2010, these 25 systems accounted for 65% of the departments area under irrigation (SEGEPLAN base don MAGA 2010, cited by SEGEPLAN, 2011, p. 101). Despite the investments, the maintenance was limited by poor market opportunities and lack of assistance for the beneficiaries (CONAP, 2015c). Besides the infrastructural deficits, the literal absence of markets is another deficit regarding human constructed facilities (see chapter 7.1.3). No storage system for basic grains is mentioned in the revised plans.

Equilibrium properties. The BZSES's resource system is characterized by its users' unequal access to land, credits, market conditions and power. This is caused by historic mismanagement as well as current disqualifies regarding socio-economic situation and access to information of family farmers and cattle ranchers. In 2015, is was estimated that 18% of arable land in the BZ remains in the hands of peasants (CONAP, 2015c, p. 222). It was unknown to all consulted entities how much land has been concentrated and/or dedicated to cattle breeding (correspondence with various, e.g. RIC, July 2017). It is described by various that family clans who are involved in cattle breeding and/or drug trafficking have profited from corrupt land distribution and dynamic land markets and possess large coherent areas. Besides in size, the land plots differ regarding their characteristics. Many farmers have access to only marginal lands, which is unfavorable due to slopes and/or lack of access to water (e.g. CONAP, 2015c; Grandia, 2009; Grünberg et al., 2012).

Predictability of systems' dynamics. Many factors of uncertainty exist, which make the system's dynamics hard to predict. These include manmade drivers of change and unstable socio-economic and political conditions. Governmental decision making of which certain choices give the impression of arbitrariness and influences of lobbying activities impact the political framework for land use (e.g.

the taxation of legalized land plots of the municipality San José (Centro de Estudios Ambientales, 2007)). The BZ's governance is also related to the degree international attention is paid, as funding and management for environmental protection and land regulation have been related to large-scale development packets of international donors (CONAP, 2015a). Their financial resources depend on global developments. Changing politics affect the work lines of supporting-institutions like MAGA (personal correspondence, Oscar Luis Cabrera). Accelerated trends like rapid population growth and ongoing acquisition of land by powerful minorities is not consistently documented and no official predictions occur in the revised documents (see chapter 7.1.2).

Current trends regarding environmental conditions provoke long-term changes with profound impacts on farming, which cannot be foreseen. It is predicted that the region is strongly affected by climate change. higher temperatures, extended dry periods, decrease precipitation and more frequent extreme event are expected (CONAP, 2015c). The environmental system faces several "unknowns" regarding the degree of change and coupled effects that these developments will have on farming conditions (Magrin et al., 2007). Besides by global warming, regional climate is affected by deforestation trends. The risk of forest fires is likely to increase, not also because of dryer conditions but also because of increased forest fragmentation, which might provoke vicious cycles (Numata, Silva, Cochrane, & d'Oliveira, 2017). Short term, climate is also a factor of uncertainty, as precipitation fluctuates not only during the year but also annually. Extreme events like hurricanes, heavy rains or draughts are already common phenomena (CONAP, 2015c).

7.1.2 Governance system: The departmental and reserve's institutional and political framework

The governance system in the BZ-SES is characterized by overlapping conservational and national legislation as well as a broad number of actors involved in its management.

Governmental organizations. The most present actor in the MBR is CONAP (see chapter 2.1.3). However, in the BZ, environmental and social responsibilities are split among several national stakeholders. Territorial planning is supported by the Guatemalan general secretary of planning (SEGEPLAN). Regarding environmental protection, conservation agencies and private owners. Regarding environmental protection, CONAP, the General Directorate of Cultural and Natural Heritage (*Dirección General del Patrimonio Cultural y Natural*: GPCN), Center for Conservation Studies (*Centro de Estudios Conservacionistas:* CECON*)* and private owners are in charge of managing natural resources, environmental education, investigation, monitoring, and sustainable tourism either in cooperation or individually, orientated on the normativity defined in the reserve's masterplans. Regarding human well-being, a different set of national institutions is responsible. Basic services, namely education, health, water supply, infrastructure, and food security, are governed by the responsible national ministries and secretaries (CONAP, 2015d). Besides national and departmental institutions, the BZ is divided into eight municipalities, and autonomously taken decision influence land-use that directly addresses agroecology. For instance, the municipality of Flores invests in alternative farming through the installation and promotion of exemplary orchards).

or suppress the sector's development through inactivity (Elmer López, Municipality of Flores, personal communication April 2018).

Regarding the development of the agricultural sector, the Ministry for Alimentation, Livestock and Agriculture (MAGA) plays an important role. For its extension and the importance of its agricultural sector, Petén is Guatemala's only department where MAGA is represented by a departmental office. MAGA-Petén offers technical and logistic support. National funds regarding rural development catalyze through MAGA, with the objective to increase production levels and increase the zone's economic performance. Means like e.g. seeds, seedlings and technology are made assessible for agricultural intensification and subsistence farming. The Ministry's work is limited by lack of resources, namely means of transport, tractors, staff, and materials (Aldo Rodas, MAGA, personal comunication July 2017).

The National Institute for Forests (*Intstituto Nacional de Bosques*; INAB) is the governmental institution for forest management. It offers information, support with the administration of timber products and valuation of forest patches via the payment of incentives. Groups of or individual land owners as well as farmers of municipal land plots can apply for payment programs. The PINFOR program (1997 – 2016) requested the presentation of an accepted management plan and supports forest vocation, reforestation, or management of natural forest. At least 2 ha of forest must be present. The PINPEP program (Ley de PINPEP, 2010) is addressed to small holders, as the management and recuperation of forest and agroforestry systems under 15 ha is be paid. Only 0.1 ha of initial forest area must be hold (http://www.inab.gt).

The presence of many non-governmental organizations is characteristic for the BZSES, which attracts several interest groups. They range from international conservation agencies to local development associations. Research is conducted by NGOs and universities, namely the University of San Carlos (Universidad de San Carlos de Guatemala, USAC), Wildlife Conservation Society (WCS) and Rainforest Alliance (RA). Regarding environmental conservation, these are important counterparts of CONAP for information gathering and monitoring. These actors concentrate mostly on environmental conditions in the CZ or MUZ (CONAP, 2015a).

A very influential actor regarding development initiatives and public opinion is the church. In Petén, the apostolic vicariate Pastoral Social of Petén (Pastoral-Social-VAP) is an active organization which launches people near initiatives. As a steady institution which people trust in, the Pastoral-Social-VAP has been cooperation partner of many international organization. The catholic church divides the territories in administrative units (*Parroquias)*, which do not necessarily coincide with municipal boundaries. The communication with the communities canalizes via *Parroquias* and commissions, where pastors and the vicarate itself is direct contact with the rural population. Participants in the projects receive workshops and trainings in health, education, and agriculture. Interested individuals receive topic specific schooling to take responsibility as rural promotors. Agroecology is one of the vicariate's matters (www.http://psvap.org).

Present entities with the objective of guaranteeing food security are diverse but follow similar approaches. For instance, regarding the income generation through the transformation of farming systems, the organizations ProPetén and CARE have aided diversify farms and to implement agroforestry. ProPetén is an organization which has formed just one year after the MBR was established and has generated experience during more than twenty years of assistance in MUZ and BZ. Strategies are diverse and include education regarding sustainable management and forest fires (Gloria Gonzáles Licda, ProPetén, personal communication July 2017). CARE is an international human aid organization which had offered aid in sustainable agricultural development, especially for female farmers (http://www.care.org). It was mentioned by many of the study's participants.

Network structure. Official and unofficial networks bind institutional activities regarding both, environmental protection and sustainable development. The actualization of the reserve's Master Plans was conducted with the objective to associate individual institutional efforts. The Master Plans were developed by multiple actors and define specific strategies and joint activities to reach common objectives. More than 350 persons of 95 organizations participated in the development of the actualization in 2015 (CONAP, 2015a, p. 27). Besides official cooperation, an unofficial network of experts who work in environmental protection and development exists. Many cooperating institutions in Petén have headquarters in or around the city of Flores. Local experts have often worked for several institutions themselves or made official or personal connections within the network (Personal correspondence with various). At all levels, organizations and representatives of the communities come together in formal committees, councils, forums, and boards (CONAP, 2015a). However, the wish for improving the alignment of strategies was mentioned by several organizations (namely MAGA, ProPetén and Pastoral Social-VAP). Regarding network of farmers, it was striking that only no institutionalized associations was present. Autonomously managed farmers' organizations were no present entity an expert or document would refer to (observations July 2017 and March to July 2018).

Collective-choice rules. Within the communities, formal and informal autonomous administration structures exist (SEGEPLAN, 2013c). Deriving from the peace agreement in 1996, decentralized and participatory administration structures were constitutionalized. An elected leader (*alcalde auxiliar*) governs at community level (Congreso de la Republica Guatemala, 2002, Article 58). Community councils termed COCODES (*Consejos Comunitarios de Desarrollo Urbano y Rural)* act as supportive structures. They consist of assemblies and an executive committee, where representatives for specific topics discuss he communities' possibilities and involucrate in development projects and activities. Issues can be taken to the municipal level by the COMUDE (*Consejos Comunitarios de Desarrollo Urbano y Rural)* (El Congreso de la República de Guatemala, 2002). Selling or clearing land, however, remains an individual choice, in which the community does not interfere (Patrocionio López and Luciano Rodas, *alcaldes auxiliaries*, personal communication, April 2018).

Traditional norms regarding land management have degraded due to the changing socio-cultural settings. An example can be drawn from the Q'eqchi' Maya. Regarding the cultivation of land, strong

collective rules had existed in the Maya cultures, which regulated both means and ownership (Grandia, 2009). For Q'eqchi' Maya in San Pedro, sawing and burning was a collective activity, which older in the community still remember, but which is no longer practiced today (personal correspondence with Mateo Choj, April 2018). The land register is misleading. Although neither lands around El Capulinar nor San Pedro appear as private lands in the land register, they are individually managed, delimited and sold (personal correspondence with). It is assumed that this is the case for the great majority of unlisted land plots in the BZ (CONAP, 2015a)With the increasingly dynamic land market, owners of neighboring plots are likely to be unknown, and it is more difficult to protect remaining forest from overarching fires (personal correspondence with various).

Monitoring and sanctioning processes. Environmental monitoring and sanctioning focus nearly exclusively on remaining forest area under conservation legislation. The borders are strictly protected, and illegal settlers displaced. The report "Monitoring Of Governance In The Reserve Of The Mayan Biosphere" *("Monitoreo De La Gobernabilidad En La Reserva De La Biosfera Maya"*) is periodically published by CONAP in cooperation with WCS. Regarding the BZ, deforestation rate and sectoral development is summarized. Information about the actual land distribution and use is absent. Regarding ownership of land, the ultimate report (2013, actualized 2014) states that although properties have been measured by the land register (RIC), the geographical information is no guarantee for the legal existence of plots (CONAP, WCS, & Society, 2013). As the information about the property's owner can only be requested from the centralized institution General Property Registry (*Registro General de la Propiedad*: RGP) land concentration is not monitored and cannot be assessed (personal correspondence with RIC, July 2017). Various author criticize the deficient relation between these two institutions and underline the impacts of this data gap (e.g. Grandia, 2009; Grünberg et al., 2012). Regarding the land-use in the BZ, geographic information is prepared by CONAP-CEMEC. The visualization has differed between forest cover and agricultural use, but not between pasture land and agricultural land (CEMEC, personal communication, April 2018). Information regarding remaining forest area and area under forest incentives are made transparent by INAB (INAB, n.d.). No sanctioning mechanism nor presence of executive staff regarding land-use in the BZ was neither observed, detected in reviewed documents nor commented.

Property-rights systems. Historically, the BZ's property-rights-system has been characterized by corruption and social injustice, and until the present day favors powerful minorities (see chapter 2.1.3)**.** There are the following forms of property rights: (1) Private (Legalized land possessed with holder of official documentation), (2) Municipal (Village centers and *ejidos*[7] owned administrated by the municipality), (3) Leased (Land owned by the municipality, but rights of usage owned by the individual farmers[8]), (4) National (Land plots that do not belong fall under the previous categories). For the farmers, it is possible to periodically renew the rights for usage by a symbolic payment. The farmers can theoretically buy their leased lands. This demands large investments, which only two of

[7] Coherent land area cultivated by a group of farmers; Differs from Mexican ejido-forms

[8] The farmers interviewed for the present study did not differ between municipal land and leases land (experience April 2018)

the study's participants considered (personal correspondence with various). Besides the lack of capital to invert, the bureaucratic bourdons are high, and procedures take years to complete (Grünberg et al., 2012). If successfully bought, a payment of tax is requested by the municipalities, either for the area occupied for farming or the extension of the land plot (Centro de Estudios Ambientales, 2007). Organizations like Fontierras have been put in place to assist farmers with the legislation of their properties but cannot support with financing or legal assistance (Fontierras, personal communication, July 2017).

Constitutional rules. Conservation legislation defines the frame for human activities (CONAP, 2015a). Restrictions and regulations regarding resource use derive from the Guatemalan Law of protected areas (*Ley de areas protegidas Guatemala: DECRETO 4-89*) with CONAP as the executing institution. As part of the MBR, the law applies to the BZ. The Guatemalan constitution recognizes the need for sustainable development and the Master-plan justifies recommended strategies based on this law. The declared purpose of the BZ is to protect the functioning of the protected area (Article 16). Industrial use is not permitted, and development is oriented towards the establishment of a balance between natural environment (Article 97) (CONAP, 2016).

Operational rules. Norms which define the natural resource management in the BZ are listed in the Masterplan. This includes the regulation of agricultural activities and exploitation of forest resources. Regarding agriculture the norms include the prohibition of land use change without an extraction and recovery plan which is approved by CONAP. For the use of timber, the plan states under other that timber can only legally be commercialized if the trees have died of natural causes (CONAP, 2015c)

7.1.3 Social, economic, and political setting

The BZ-SES is influenced by a dynamic social, economic and political setting, for which little evidence exists.

Political stability. The Corruption Perceptions Index (CPI) launched by Transparency International (2017) ranks Guatemala's legality 143 out of 180 countries (with a score of 28/100), which equals the score of Lebanon or Kenya (https://www.transparency.org/). Guatemala's department Petén is additionally a remote territory with administrative deficits (SEGEPLAN, 2013c). The peace agreement in 1996 has officially ended the civil war, but the confidence in governmental institutions has still not fully returned (SEGEPLAN, 2013b). Arbitrariness of decision-making and ignorance of the law is evident at all levels (e.g. Grandia, 2009). Besides the institutional stability, public security is not guaranteed. In Petén, violence and criminality cannot be controlled with available resources (SEGEPLAN, 2013c). The INE (based on *Estadísticas de Salud*, cited by INE, 2014, p. 18) registered aggression with fire arms as the main cause of death in 2013, which accounted for nearly a quarter (24.6%) of all reported deaths in the department. The northern municipalities, which partly lay in the BZ, have even higher rates in homicides and criminality than the southern municipalities of Petén (INE, 2014). Family farmers are especially exposed, as they often lack the access to legal

assistance, are easily instrumentalized due to their socio-economic situation and occupy land of potential interest to landowners (Grandia, 2009; Grünberg et al., 2012; Zander & Durr, 2011).

Demographic trends. Due to colonization and high birth rates, the population in the BZ has been growing exponentially since the 1960s (see chapter 2.1.3). For the actual population size in the buffer zone, only forecasts based on the last census in 2002 are available. It is estimated that the population has doubled during the past 15 years and that the trend continues. For 2007, the population was estimated at approximately 94,000 habitants (B. Milián con base en CEMEC 2007, cited by CONAP, 2015c, p. 55). Conclusions can be drawn from the development in the department Petén. The fertility rate in 2013 was 3.0, just under the national average. A forth of the births was given by women younger than 20 (Estadísticas de Salud 2013, presented by INE, 2014, p. 17). Grandia (2009) suspects a general difference between desired family size and actual number of children born. Access to and information about birth control is not accessible for many. By CONAP-CEMEC, migration is monitored regarding the CZ and MUZ, but not concerning the BZ (CONAP et al., 2013). Observations and correspondence suggested that people imm- and emigrate dynamically. Especially young people commented they yearned for working in the United States to escape the lack of perspectives (Ybarra, Obando Samos, Grandia, & Schwartz, 2009). For instance, in SP, the *alcalde auxiliar* stated that nearly every young man was thinking of emigrating (Mateo Choj, *alcalde auxiliar*, personal communication, May 2018).

Economic development. Although the economy in Petén has grown in recent years, SEGEPLAN (2013c) reports poor institutional assistance and disadvantages due to the department's undeveloped infrastructure. The vast majority of Petén's working population is active in the primary sector, without social securities. SEGEPLAN reported more than 70% of the working population occupied in the informal sector (SEGEPLAN, 2013b, p. 106). The sector consists mainly in extensive livestock cultivation and subsistence farming (SEGEPLAN, 2013c). Regarding economic development in the BZ, only personal considerations are presented: The tourism sector most likely stagnates because of the deficient connectivity and the orientation on single-day ecotourism. The agricultural sector with unfavorable conditions for family farmers and unfavorable market condition for the commercialization of products other than basic grains (e.g. Experience with irrigation structures in La Libertad) shifts towards the growing livestock production. The extraction of petrol has overcome its peak in the early 2000s, which is why a stabilization of oil extraction is likely. Stagnating economic development with growth of activities with scarce labor demand are unlikely to create or diversify job opportunities for the growing population (personal considerations based on CONAP, 2015c; CONAP et al., 2013; Ybarra et al., 2009).

Government resource policies. While the economic development of the agrarian sector with profitable livestock production was the main objective of early colonization and development initiatives (see chapter 2.1.3), currently both national organizations in charge of environmental protection (like CONAP) and economic development (like MAGA) compromise in planning. In the masterplan, the expansion of pasture land is named as the principal cause for deforestation as well

as the "fundamental pillar of the BZ's economy[9]" (CONAP, 2015c, p. 67). According to SEGEPLAN, conservation was among the "main achievements" of the development plan launched in 1992 (SEGEPLAN, 2013c, p. 19).

Market incentives and conditions. Economic incentives are set for profitable cattle breeding, while the production of basic grains does not generate great returns for farmers and horticultural products lack markets (CONAP, 2015c). In recent decades, growing meat demand, first from Mexico later from the capital, has influenced the growth of livestock production. A division of labor has evolved, causing that cows are fattened in southern departments like Izabal, which demand the breeding of calves which Petén delivers (Schwartz, 1990). Basic grains are exported, but there is no market for fruits or vegetables. Varieties at central market offer mainly products from western Guatemala, where vegetables can be produced commercially. Only 5-10% of these products on Petén's markets are produced locally (SEGEPLAN, 2011, p. 206). Hence, there is a literal absence of markets for fruits and vegetables produced by small-holders (Figure 26, Figure 27). Communities which are located next to tourist routes or centers sell products on the side of the roads or to hotels. Labeled organic products were not observed in any market (observation, July 2017, March to July 2018).

Figure 26: Market in the regional center Mercado viejo, Santa Elena, Flores (Photo taken 19/06/2018)

Figure 27: Imported products on the central market in Santa Elena, Flores (Photo taken 19/06/2018)

The farmers' capital inverted in livestock is a more reliable anlage than in crop cultivation. Harvest levels as well as prices for basic grains are sensitive regarding climate conditions and therefore fluctuate both inner- and interannually. Similarly, fruits and horticultural products show varying price levels, especially regarding citrus fruits (https://precios.maga.gob.gt).

[9] "[la] pila fundamental de la economía de la ZAM" (CONAP, 2015c, p. 67)

Investment opportunities. For subsistence farmers, access to credits only theoretically exist, as interest rates, risks and bureaucratic burdens exist (Grandia, 2009). For banks like BANRURAL (locally known with the slogan “the friend that helps you grow”) make significantly more profit with investments in livestock ranching than crop cultivation (Grünberg et al., 2012). Credits given to allow family farmers to purchase legalized lands and increasing interest rates impoverished many and led to increased land selling by indebted families (Grandia, 2009; Grünberg et al., 2012). Hence, credit programs every now and then launched by MAGA are often denied due to suspicion or bad experiences (personal correspondence with various farmers, April 2018). Due to recurrent harvest shortfalls, it is likely that capital acquisition for investments is generally impeded, as no agricultural insurences is available that would covers the losses (CONAP, 2015c). Nearly a third of the total population in Petén received payments from the United States, and correspondence with farmers with profitable AESs suggests that this circumstance has allowed to maintain their farms profitable (SEGEPLAN, 2013b, p. 58).

7.1.4 Agroecosystems

Instead of single resource units and users, different types of agroecological systems are presented in the following.

Importance of AESs for users. AES do not only generate income with surpluses sold but are essential for guaranteeing food security for the owners and landless farmers additionally cultivating on the lands. To cover the needs of with basic grains of an average family, a minimum area of one manzana (0.7 ha) for MILPA is estimated, but as soil is left to rest to recover, additional area for shifting agriculture is demanded (CONAP, 2015c, p. 61)

History of use. The vast majority of established AES result from the colonization policies and have been distributed, measured and cultivated from the 1960s on (Grünberg et al., 2012). Given displacement of ancient cultures and dynamic land markets, it is unlikely that many AES older than 60 years persisted.

Types. Agroecological systems can be classified in diverse manners. In the BZ, it can be differentiated between crop cultivation, livestock and mixed systems. For subsistence farming, practices of swidden agriculture (slash-and-burn) with maize as basic grain dominate (CONAP, 2015c). In the western municipalities like La Libertad, livestock systems dominate, while mixed systems are expected to dominate near the lake Petén-Itza. Regarding livestock, traditional forms of livestock cultivation in savannahs have been replaced by semi-intensive systems, where pasture is seeded and maintained on cleared lands. These systems are characterized by little labor demand and low returns per area. In the BZ, not fattened but breeding dominated, which means that calves that have reached a certain age or size are sold. Pasture is burned and reseeded every few years (CONAP, 2015c).

Mixed systems and commercial crop cultivation systems can be categorized by their economic orientation (Table 10, next page). Concerning Petén, a study published in 2012 regarding 31

communities in has shown that more than half of the farmers' within the community had limited and insufficient access to land, which is why they are classified infra-subsistence (Grünberg et al., 2012, p. 36). The overall qualification the Master plan considers for the different types range from poor to very good, ranking commercial systems with marginal crop diversification the highest. Technology used is considered insufficient regarding subsistence systems (given that machete is mostly the only tool available) and acceptable for subsistence with surpluses. Commercial systems account with excellent access to technology. While in western municipalities like La Libertad tractors can be observed, barely any was seen in the study area. In the year of the study, MAGA-Petén was assisting few farmers with the tractor the institution owes, and the assistance was hindered due to various defects of the machine (personal observation and correspondence, April 2018).

Table 10: Types of AESs according to their economic orientation (Workshop about the current situation in the BZ and E. Secaira, 2013 CONAP, 2015c, p. 204)

Type of agriculture	Access to land	Access to credits	Access to technology	Crop diversification	Food security	Overall qualification
Infra-subsistence	Limited and insufficient	None			Critical	Poor
Subsistence	Leased or municipal	Limited with many conditions […]	Limited	High, dedicated to subsistence	Marginal, the minimum	Bad
Subsistence with surpluses	Proper, some have bought more than one manzana	Good	Acceptable	High, dedicated to subsistence and production	Assured	Good
Commercial	Bought or leased, might be little but with intensified production	Excellent	Excellent	Poor, orientated on monocultures	Assured	Very good

Socio-economic situation of the farmers. The socio-economic situation of many farmers depends on their assets land, livestock and capital, which allow to generate profit. Large-land owners with enough livestock are economically secured. Few work opportunities for unskilled labor exist in the region, mainly generated by the tourism sector or occasional demand for workers on cattle ranches (CONAP, 2015c). The situation in Petén is critical and worsening (SEGEPLAN, 2013c). According to INE, absolute poverty as well as total poverty have increased between 2006 and 2011, which is why in 2011, 65.7% of the population were considered poor and 16.3% extremely poor (INE, 2014, p. 25). Many farmers are landless and lack land to cover their basic needs (Grünberg et al., 2012).

Although public schooling and basic healthcare is covered, many struggle with payments for materials and medicine (Zander & Durr, 2011). Many invest in education, hoping for better chances for the coming generation, to find out that no economic development generates work opportunities; even less for those who attained public institutions (Grandia, 2009). However, less than half of the children in Petén graduate from primary school (SEGEPLAN, 2013b, p. 130).

The economic value of the individual AES is determined by various factors, like the farming activities, its environmental properties, management and investment opportunities, size and location. Besides, the lands have significantly increasing value on the property market. The retunes of maize vary from very low to negative. It is usually seeded two times a year, of which the second cycle generates returns from approx. 15% (CONAP, 2015c, p. 61). Given the market situation, fruits and vegetables can hardly be commercialized.

The commercialization of agroforestry products demands the administration of longer value chains (e.g. export of the ornamental plant Xate). Additionally, forest area or area suitable for reforestation on the land plot can be of economic value, as farmers can apply for national incentive programs, that pay for a period of 10 years for forest management (protection or production) and six years for the establishment of forest systems (INAB, n.d.).

Regarding cattle breeding, income is steady, and returns are decent (although low if calculated per area). Economics of scale suggest that the activity is profitable from a certain number of heads on (Schwartz, 1990). Fattening of livestock is economically not adventurous, as industry is concentrated in southern departments, where fodder is more easily cultivated (Grandia, 2009).

Consistency. AES types very dynamic regarding their spatial and temporal distribution. This is due to their form of management as also because of ongoing speculation with land within the BZ. Traditional AES forms of shifting agriculture, where fields are cultivated for a few years before left to rest. On the follow land, secondary vegetations grows. Land patches for the two annual harvests of maize are cultivated on the individually administrated land plots or in arrangement with neighbors on rented patches (CONAP, 2015c). Since the opening of Petén's northern area, land has been objective to speculations. This includes official and unofficial markets. Not only with property rights but also with rights of usage is traded. Land which is sold is very likely to fall in the hands of ranchers, who concentrate lands and turn AESs into pasture lands (CONAP, 2015c; Grandia, 2009; Grünberg et al., 2012; Zander & Durr, 2011).

Interaction and conflicts. Interactions among AESs in the BZ are characterized by high conflict potential. This is mainly due to different interests of ranchers and farmers. It is reported by various that the ranchers follow different strategies to make farmers sell desired lands. They take advantage of the poor access to information and compensate farmers insufficiently, offer compensatory areas which are located in protected areas, threaten them (in some cases with fire arms) or buy surrounding land plots to impede their access to lands (e.g. Grandia, 2009; Zander & Durr, 2011). Due to administrative deficits regarding the legalization of land, conflicts also result from different

parties claiming the same extensions of land (Grünberg et al., 2012). Among farmers, escaping livestock or fires cause harvest losses and shortfalls and threaten established orchards (correspondence with various farmers, April 2018). The fragmentation of ecologically run AES through pasture land most likely impedes synergic interactions among land plots, like pest control or microclimate.

Knowledge and mental models. The BZ is characterized by the heterogenous and co-existence of peoples with different cultural backgrounds which show persistent patters of traditional agricultural practices. Diverse Maya orchards have role model character for sustainable agriculture (Ford & Nigh, 2009). Mayan cultures account for approx. 20% of the BZ habitants, of which about 15% are Q'eqchi' that immigrated from southern departments (Censo 2002, as cited in CONAP, 2015c, p. 58). The local Itza' Maya developed traditional AESs according to the environmental conditions found in the ancient Selva Maya. Agroforestry systems and sensible management of tropical soils were unfamiliar to many migrants. While slow migration flows before the colonization programs in the 60s had favored the adaption of strategies by the *peteneros*, the recurrently displaced Q'eqchi' Maya, who imported less suitable customs regarding soil and forest management (Carr, 2004)The knowledge systems regarding agricultural practices that embrace the most sustainable model is the Itzas' knowledge about the maintenance of diverse Maya Gardens. This knowledge base is rapidly degrading and likely to diminish (Atran et al., 2004). Today, the Itza population is concentrated in the municipality San José. Like the traditions and language, agricultural practices are traditionally taught personally from the older to the younger (Atran et al., 2004). At time of the study, the Itza' society only accounted with 12 wise elderly of which only one agreed to teach about twenty students in the associations' school (Bio-Itzá Association, personal communication, June 2018). Many studies are published on the relations of deforestation frontiers and the cultural background of peasants (e.g. Carr, 2004).

Number and location. While family farmers live in communities, ranchers tend to either live on their lands or manage systems from urban centers. The peasants' AES consist in the household's property, terrains near the village center and land plots at distance. Only few are located at unpaved roads, many need to be accessed by passing through private properties. The land plots are measured and displayed by the land register (RIC) (http://www.ric.gob.gt/geo-portal). The register does not contain information about the actual number of AES, as it is a common and unmonitored practice for rancher to register bordering land plots at the names of family members. The land register can therefore give an idea about individual land plots but not about coherent AES (see chapter 7.1.2).

7.1.5 Interactions

Deliberation processes**.** The deliberation process of the provisioning services the individual land offers depend on the type of AES (see chapter 7.1.4). Regarding agroforestry, activities are strictly regulated by INAB and CONAP, and generally only permit the extraction of naturally fallen trees. In traditional AESs, farmers cultivate with minimal technology use. Slash-and-burn agriculture with annual burns is commonly performed with the use of machetes and joint fire patrols. The use of fertilizer bean (*Mucuna pruriens*) for nitrogen fixation instead of burning has been adapted by many of Petén's communities. Extensive cattle breading demands the clearance of large areas, for which labor is periodically contracted for single or multiple days. Large areas of the seeded pasture is burned every few years (CONAP, 2015c).

Information sharing among users. Democratic structures (COCODE) that involve community members in the planning of development initiatives as well as the population concentration in community centers indicate a high social capital and information exchange in family farmers' communities. The ongoing fragmentation of originally coherent land owned by community members hinders essential communication regarding e.g. date of burning (Patrocinio López, *alcalde auxiliar*, personal communication April 2018). Cattle rancher often live on the ranches or urban centers and little is documented about their socio-economic conditions or network activities (CONAP, 2015c; Grünberg et al., 2012).

Self-organizing activities. Currently, activities among land users are coordinated rather in organized groups than self-organized groups. Participants in the communities were grouped recently in CADER-groups of the ministry. Parallelly, groups of women exist. Both groups are guided by technicians. In EC, an existing group was integrated in the CADER system. An example for failed initiatives is the association ACARI in SP. ACARI had been found before funding was available. To create an officially recognized association, members had to overcome political resentment and costly bureaucratic burdens to found it. The group consisted of more than forty members. Assistance by independent organizations has been orientated on supporting those group activities. Today, the association has only four active members. NGOs blame political disagreements within the community. Consulted farmers stated that conflicts about the organizations' objectives led to the disintegration. While one front received more organizational support and communication with the project, both the pilot group and organization shirked drastically in size.

7.1.6 Outcomes

Socio-ecological performance. The situation of the BZ-SES is characterized by dynamic change. An approach to the socio-economic performance of the BZ is the visualization of amplified feedbacks (Figure 28). The graphic shows the relation of land concentration, the marginalization of farmers, forest loss and environmental change in a simplified manner. Considerations are based on the BZ-SES properties described above.

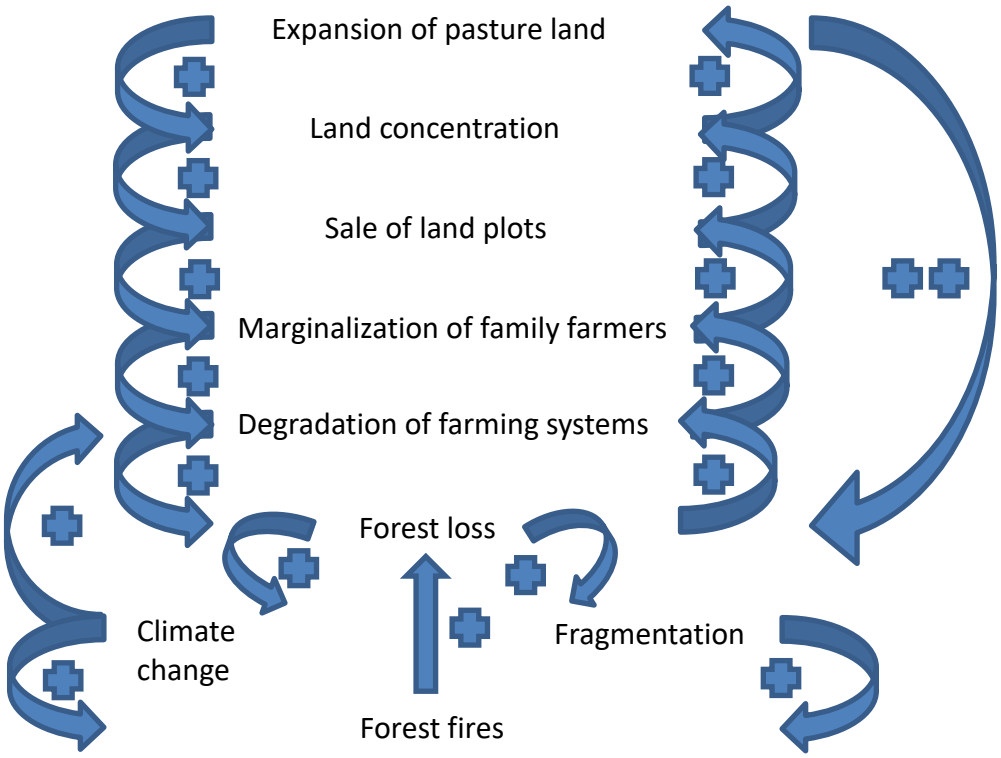

Figure 28: The BZSES's outcomes: Amplified feedback loops cause directed change (own elaboration)

The main causes of deforestation in the MBR are forest fires and the expansion of the agricultural frontier (CONAP, 2015c; CONAP et al., 2013). Environmental changes like forest fragmentation and degradation as well as global warming increase the likelihood of disastrous forest fires to occur (Numata et al., 2017). In the BZ, forest is cleared on private lands. This is due to the expansion of pasture land or caused by agricultural practices that incorporated shifting area (CONAP, 2015c). As less than a fifth of area remains in the hands of peasants, the advance of the cattle frontier is more pronounced (CONAP, 2015c, p. 69). Marginalized farmers are likely to sell their lands in need for cash (Zander & Durr, 2011). This way, more land is concentrated by ranchers and pasture land expands. All feedbacks are considered amplified, which is why directed change is expected. Also, in the case that capital can be accumulated, it is likely that farmers turn to cattle breeding, as conditions are much more favorable.

7.1.7 Related ecosystems

The ecosystem Selva Maya is of global importance. It is a carbon sink and biodiversity hotspot of importance for the global climate system. Also, it is located within the Mesoamerican Corridor, which is why connectivity for migrating species and the maintenance of habitat for diverse species need to be ensured. Besides tropical forest area, the BZ contains biodiverse wetland, which are inhabited by endangered species (see chapter 2.1).

The main purpose of the MBR BZ is to protect remaining tropical forest from human drivers of deforestation (CONAP, 2015c; UNESCO, 2017). The management of the BZ-SES is dedicated towards the stabilization of socio-ecological processed to ensure this desired functionality. To sustain the growing population is important to decreases the immigrational pressure on the CZ, where displaced farmers seek land to cover their food demands (CONAP, 2015c). This way, the Selva Maya is endangered, as the agricultural frontier advances (Hodgdon, Hughell, Ramos, & Balas-McNab, 2015).

7.2 Sustainability assessment of exemplary AESs

Encouraging and limiting factors for farmers are detected with the MESMIS methodology. In the present chapter, the results of the six-step approach are presented in chronologic order: First, the results of the SWOT analysis are presented. Afterwards, results from survey study and field observations are displayed according to the identified critical points. Finally, results from the feedback workshops are shown.

7.2.1 SWOT analysis regarding the pilot groups' AESs

The SWOT matrix shows named aspects regarding the current socio-economic and environmental issues The numbers indicate if the individual aspect was mentioned in the workshop in EC (1) or SP (2) (Table 11).

Table 11: SWOT analysis with pilot groups (14 & 15/03/2018)

	Strengths:	**Weaknesses:**
AES internal factors	• Knowledge and experience[1,2] • Efforts[1,2] • Family involvement[1,2] • Species diversity in mixed gardens[,2] • Visible results[1]	• Lack of knowledge[1,2] • Lack of commitment and willingness[1,2] • Loss of harvests[1] • Pests[1] • Lack of water[1] • Application of bad strategies[1] • Lack of monetary resources for investments[1] • Lack of self-organization[2]
	Opportunities:	**Threats**
AES external factors	• Technical and institutional support [1,2] • Received seeds and seedlings[1,2] • Educated *Promotores*[1] • Availability of land[2] • Knowledge exchange[2]	• Lack of support and loss of confidence[1,2] • Lack of space or inadequate lands[1,2] • Lack of formal work opportunities[1] • Poor compatibility of formal work and fieldwork[2] • Institutional deficiencies and ungovernability[2] • Lack of technical analysis[2] • Lack of organization[2] • Price fluctuation in markets[2] • Soil condictiones[2] • Climate conditions[2] • Lack of water[2] • High prices for clean water[2] • Individual conditions of lands[2] • Loss of what was sown by neighbors livestock[2] • Robbery of harvests[2]

As strengths, the aspects knowledge and experience, individual efforts and family involvement were mentioned in both workshops. In EC, it was mentioned as a strength that progress became visible. In SP, the plant species diversity was put as a strength. Regarding weaknesses, lack of commitment and knowledge were mentioned in both occasions. In EC, participants remarked the existence of environmental conditions like pests and the lack of water. Regarding management, the application of inadequate strategies was mentioned in EC and the lack of self-organization in SP. In both workshops, the participants recognized institutional support and donations as opportunities. In EC, the presence of promotors was specifically recognized, in SP people referred to general knowledge exchange. In SP, they mentioned the availability of land. The lack of support and space was mentioned in both workshops. In EC, participants named the absence of formal work opportunities, while in SP the poor compatibility of formal work and fieldwork was stated. In SP, most mentioned aspects were sorted into the category threats. Additional aspects named were environmental conditions concerning the quality of soils and climate conditions and the individual conditions of the land plots as well as socio-economic factors like price fluctuation in markets and high prices for clean water. Finally, concerns like the robbery of harvest and the loss of seedlings to the straying livestock were revealed.

7.2.2 Results of the survey study and observations regarding critical points

Critical points were targeted with further study. The results of the survey study are presented together with field observations in this chapter.

7.2.2.1 The participation: Sampling group

All participants of the baseline study were contacted and invited to participate in the voluntary study. About half of the project's original pilot group size could be considered in the study. In EC, the participation of originally assessed households was the highest of the sampling groups, as 71% participated in the study. In LT, only two out of nine original members participated. The group size of participants in EC and SP is similar with 13 participants in EC and 17 participants in San Pedro. Of at least five household it is known that the family board emigrated. Three households have overtaken the administration of individually listed AESs of family members. At least two were prevented in time. In total, nine of the original target group had no interest in participating, of which five are from LT. Two households that did not appear in the baseline study were considered additionally (Table 12).

Table 12: Participation and non-participation of original pilot groups size

Involvement and reason for (non-) participation in study	Group 1: EC	Group 2: SP	Group 3: LT	Total
Involvement of baseline study participants and percentage of original group-size	12 (71 %)	16 (55%)	2 (22%)	30 (53%)
Prevented in time	0	1	1	2
Emigrated	3	2	0	5
Near community	0	2	0	2
Refusal	1	3	5	9
Merge of households	0	2	1	3
Passed	1	0	0	1
Other	2	3	0	4
Participation of additional group members	1	1	0	2

The participants were perceived welcoming. Interviews were hold in or just outside the homes with in the majority of cases both members of the family board. Besides to the participation in the interview, the participants accompanied the researcher and accompanying promotor to overserve they backyards, nearer terrains and visits to land plots. Many commented that they had not been attained or invited by representatives of the project for longer.

7.2.2.2 *Self-organization and knowledge exchange*

Promotors. Of the 32 participants in the study, twelve households had at least one member who had received the promotor-formation. In San Pedro, households with promotor accounted for more than half of the participants, while this applied for less than a quarter of the questioned households in EC (Table 13).

Table 13: Proportion of participating households with promotor

General	Group 1: EC	Group 2: SP	Group 3: LT	Total
Size of sampling group	13	17	2	32
Households with *promotores*	3	9	0	12

Group organization. Nearly two thirds of the participants said they were organized in a group of farmers (Figure 29). Ten of these twenty participants reported to be only members of a CADER group organized by MAGA (a form of group building by the Ministry by attendance is bundled to eleven farmers), two households had members that reported to attain a women's' group and two to the SP organization ACARI. The communities' independent organization ACARI in SP had been established individually to foster development through joint farming activities in SP (Nixon Esquivel Vazquez, *promotor*, personal communication, April 2018). Contractionary explanations by several participants reasoned the exclusion of the clear majority of its members and reduction to approximately six active members at time of the study. Three households in SP were only organized in ACARI. One household only accounted with the support of a women's group. One said he was socio in a cattle association.

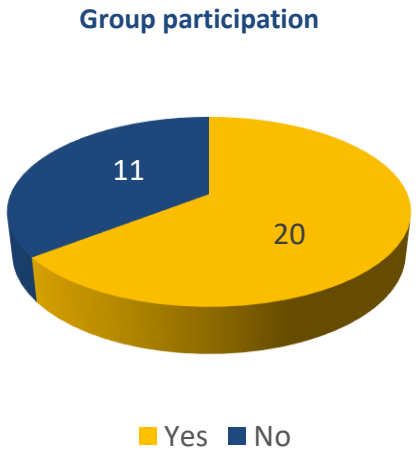

Figure 29: Pie chart regarding group participation

Some promoters were perceived to take a very active part within the community. In EC, several participants reported to participate in a local group that prepares organic means for soil conservation or pest control and promote them among the neighbors. The group's leader had an exemplary AES with orchards, livestock and forest area, for which incentives were received for. He was closely cooperating with the GIZ and had received both capacitation and material (e.g. barrels) to put measures in practice. It was commented by many group members that organic means as well as products were sold by him to the nearer tourist location. He functioned as a middleman for the commercialization of many fruits and vegetables for the neighborhood. This group was recently integrated in the MAGA CADER-program. In the interview with another local promotor from EC (Flora Idalba Sintú), it was spoken about additional promotor groups, which meet periodically to exchange their experiences and perform joint activities. According to her, this group of promotors is close to the church, and several pastors participate in the planning of activities. In SP, a promotor couple is in charge of announcing activities for development organizations. In the interview with *promotor* (Nixon Esquivel Vazquez), he explained that agroecology was like a religion to him and expressed his commitment to the spreading of ecological practices. Some other promotors had received capacitation but did not report to aim at convincing others.

7.2.2.3 Socio-economic characteristics

Income. Most participants generated income with their agricultural activities. For about 30% (n =30) of the questioned, the farm was the household's only income source. In EC all questioned participants reported to sell surpluses (n = 10), In SP, about a third of the sample group said they would not generate any income with their farming activities (n = 17). In more than 20% (n = 30), the household received additional payments from family members to sustain themselves.

Housing. In the three communities, all participants lived in simple block- or wooden houses with open kitchen and shared dormitories. Connections to the public electricity and tube system existed. An average of approximately six family members shared a house. The furniture mostly consisted of hammocks or beds, isolated seating and a table, one or a few cupboards. The stoves were run by open fires. For the majority, bathrooms consist in latrines located outside and the Guatemalan sink *pila (*Common sink, in which water is stored and used for washing clothes, plates and body; Figure 32, p.70)

Poverty. The appearance of the participants indicated that they did not live in absolute poverty or were affected by chronical hunger. However, it was often commented that households struggled to cover basic costs like medicine, public transportation and material for schooling.

7.2.2.4 Access to and availability of land

Land availability. Of all questioned (n = 31), four reported to have no more land than their backyards. In total, eight participants said they had no land plot outside of the village center. Within the village centers, more than half of the questioned had more terrains than only their backyards. Four participants used more than two land plots outside the village center (Table 14).

Table 14: Number of participants with available land type

Number of participants…	EC	SP	LT	Total	NV
...without area besides the household's property	1	3	0	4	1
...without land plot	3	5	0	8	1
...with more than one terrain	10	7	1	18	1
...with more than one land plot	1	1	2	4	1
...with more than one land plot	1	1	2	4	1

The participants cultivated different on different land types. Within the village, the families' houses were usually measured 30x30m up to 60x120m. In the present work, this area is referred to as the household's property. Lands which were located within the village center (either because other properties were used or houseless plots available) or in their direct surrounding are referred to as terrains. They differ from land plots as they are directly accessible and have equal measurements like the household's properties. In EC, a total of 28 properties and land plot were registered; in SP 29.Three properties and terrains are counted in LT, although the land plots here are bordering with the street that defines the communities' center.

Estimated area. In total, the questioned (n = 32) stated to have had at least 808 mz (570.12 ha) of land resources available outside of the village center. The participants did not necessarily owe the land plot. A large area of the 377.5 mz in Los Tulipanes were partly administrated by the participants but owed by absent landowners. Together, 20 participants with land plots from EC and SP estimated to have 430,5 mz (303.76 ha) area outside the village to their disposal (Table 15).

Table 15: Land plot sizes of participants

	EC	SP	LT	Total
Minimum size [mz]	16	1	183	1
Maximum size [mz]	128	128	572	572
Average size [mz]	56.25	38.58	377.50	75.82
Total [mz]	**225**	**231.5**	**377.5**	**834**

The size of land plots used outside of the city center ranged from 0.5 mz (0.35 ha) to 286 mz (201.80 ha). In EC and SP, the maximum size was of 64 mz (45.16 ha), while a participant in LT administrated

286 mz (201.80 ha). Three participants had less than or equal 5 mz (3.53 ha) to their disposal, a total of nine less than or equal 10 mz (7.06 ha). Six participants had more than forty manzanas (Figure 30, next page).

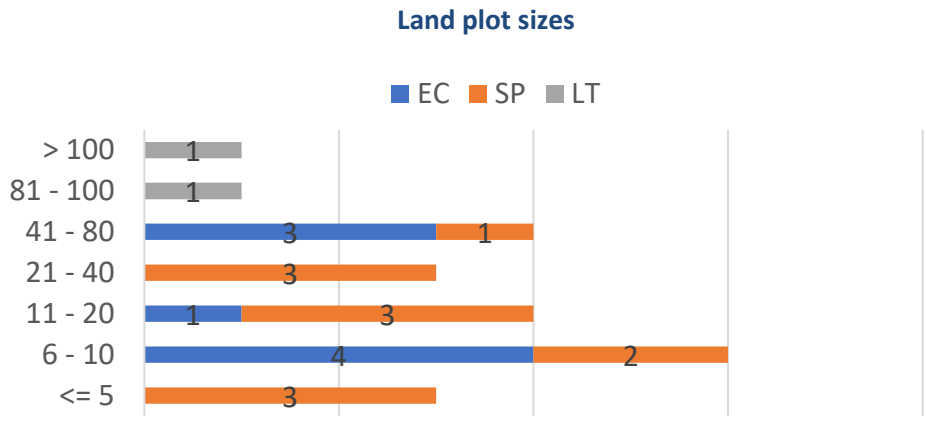

Figure 30: Number of participants with availability land in size-category

Access to lands. Most land plots were at distance and hard to access. No accurate information about the distances could be documented, neither through GPS mapping during field visits, participatory workshop nor questioning. The exemplary visits to land plot showed the difficulties regarding the access. It was observed that not many had means of transportation, which is why the majority accessed the land plots by foot. Some used bicycles or went on horseback. Roads are mainly unpaved. In many cases, gates and other land plots have to be crossed to access the lands. It was commented by many that it generally takes about one to three hours each way to access land plots. It was said that depending on the season, access can be especially difficult, as walking in hot months is exhausting and wet conditions affect roads and creeks.

7.2.2.5 Workforce

The workforce on the land-plot was higher than on the families' properties. In average, 4.83 people supported with agricultural activities on the families' property, while in average 2.78 worked on each land-plot (Table 16).

Table 16: Average workforce

	Average	NV
Workforce on property	2.78	3
Workforce on land plot	4.83	9

Gender. In three cases, the participation of women on the land-plot were documented. In 20 cases, only men worked on land-plots (Figure 12, next page). It was not documented if women participate in the activities in the terrains, but observations indicated it. Generally, women were observed to take on different tasks than men.

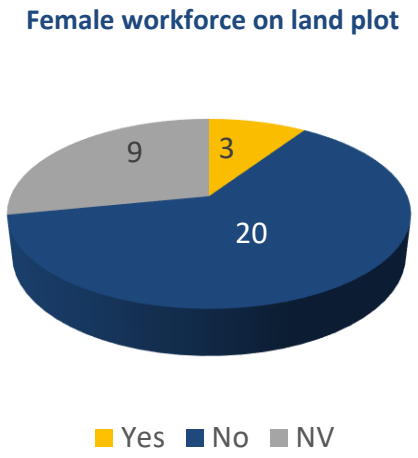

Figure 31: Number of AESs in which women participate on land plots

7.2.2.6 Water

Water supply was observed to be guaranteed only to the families' properties. All three communities were connected by tube to the water network, but the supply was observed irregular. Water is temporally stored within the pila. In many cases, the location of the pila allows ducks to appreciate outflowing water. In the land plots, simple artificial water holes exist. Irrigation structures were absent.

Figure 32: Guatemalan sink pila(Photo taken in San Pedro,27/04/2018)

7.2.2.7 Subsystems

Observation showed the presence of diverse subsystems within nearly all assessed AESs (Figure 33). This was also indicated by the documented cultivated crops and animals. Maize is cultivated in 83% of all assessed AESs (n =29). While edible beans are cultivated by 67% (n =12) of the assessed systems in EC, it is less common in SP, where 33% (n=15) cultivate the crop. Poultry is present in the great majority of all assessed AESs. About half of the systems have livestock, mostly pigs. Cattle is more common to participants in SP, while fish tanks are rather applied by participants from EC. Of all, 34% (n= 29) of the family farmers reported to cultivate at least one of the species Pacaya (*Chamaedorea tepejilote*), Cacao (*Theobroma cacao*) or Vanilla (*Vanilla*), which can grow in agroforestry systems.

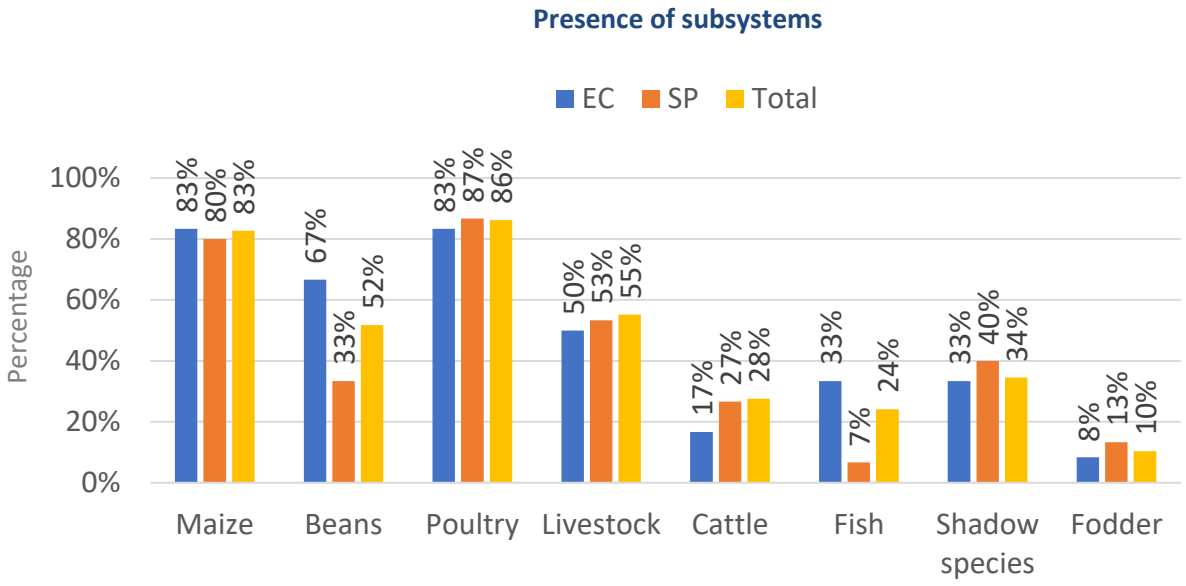

Figure 33: Percentage of AESs with presence of individual subsystems

By observation or nalysis, the individual subsystems could hardly been seperated from each other and were in different conditions and stages. Orchards took on diffeent forms and were mixed with maize and bean cultivation or timber. Few orchards had been planted in an order. The condition of many was critical, as the fruit trees showed presence of pests or seedling showed sign of water scarcity. Only one participant cut fruit trees in the desired form. Pigs walked freely around the village. Observed shadow species were in very initial phases.

7.2.2.8 Plant species diversity

Up to 55 edible plant species were reported in the individual AESs. All assessed households had cultivated at least ten different edible species in the past year. The average agroecological system accounted with about thirty plant species. Both perennials like fruit trees and medium-term plants like vegetables and tubers appeared in average with more than 10 species per systems (n = 29) (Figure 34). The values are very similar in EC and SP, as the difference to the average regarding all categories is less than one percent.

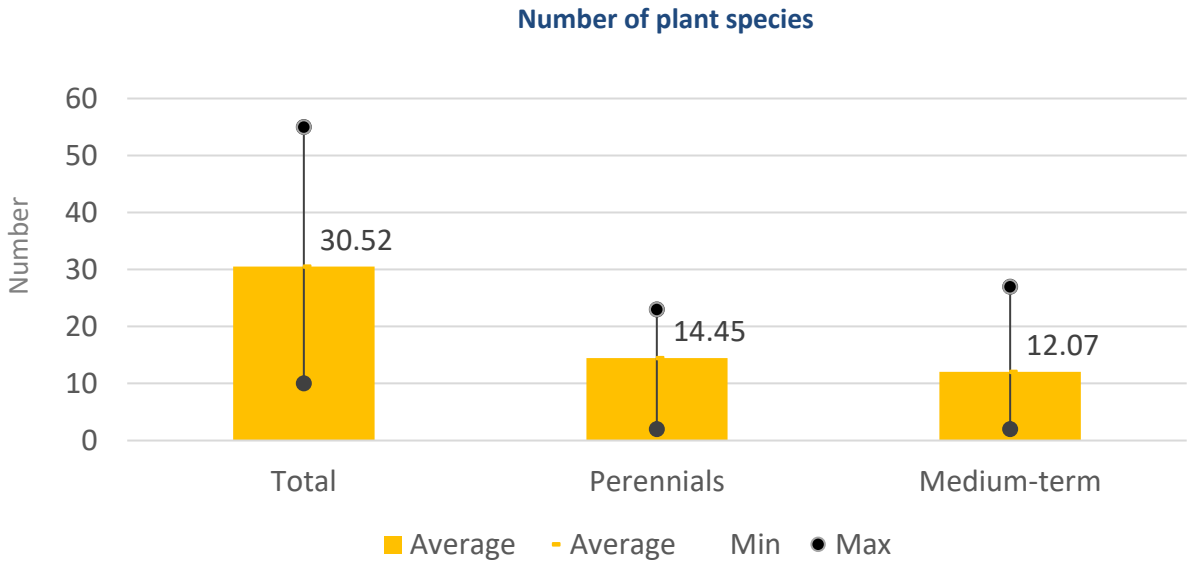

Figure 34: Average, maximum and minimum number of plant species in assessed AESs

Besides the reported diversity of species, genetical diversity was also observed. Different types of Musaceae or mangos grew.

7.2.2.9 Agroecological practices

Soil conservation. The participants reported to have used different soil conservation strategies from May 2017 until April 2018 (Figure 35). More than half of the questioned said they had used green manure, which in all cases referred to the fertilizer bean (*Mucuna pruriens*) (n=29). Equally common among participants in EC (n = 11) was the use of manure, which includes excreta of poultry and livestock. In SP, 29% (n = 17) reported to apply manure. The mix of manure and plant rests bokashi was reported to be used by more than half of the questioned in EC (n = 12) and by less than a third in SP (n = 17). Nearly 67% of participants from EC (n= 12) and just under 29% in SP (n = 17) said they applied forest materials to fertilize their soils. In LT, one out the two participants applied manure to fertilize, while no use of other strategies was reported.

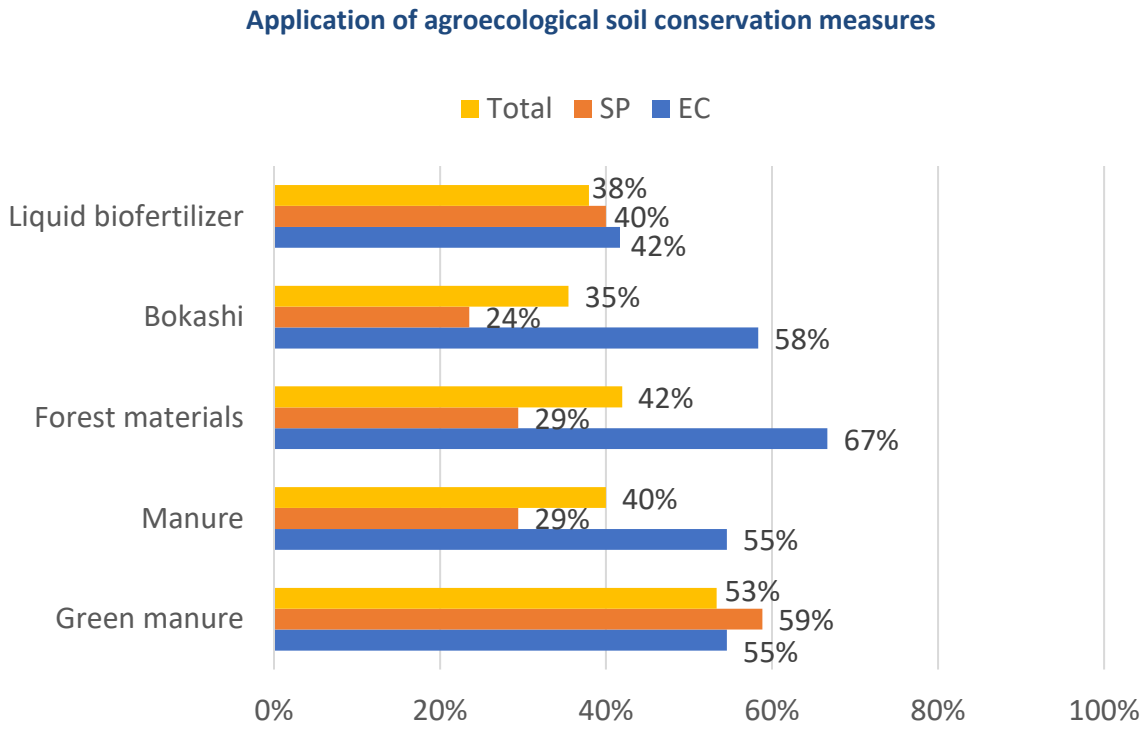

Figure 35: Bar graph applied soil conservation measures: Percentage of AESs applying soil conservation strategies

More people reported to having received capacitation regarding the strategies than to have applied the strategies during the last year cycle (Figure 36). Regarding the capacitation of liquid fertilizer (n = 29) the difference is less than 20%, regarding green manure (n =31) about 25 % and. bokashi (n = 30) 28%. Of all, 70 % (n = 30) said they had received capacitation regarding fertilizing their lands with manure while 30 % said they had applied it during the last years cycle. Of the participants, 76 % (n = 29) reported to have learned how to apply forest materials, while 42 % stated they had used these materials.

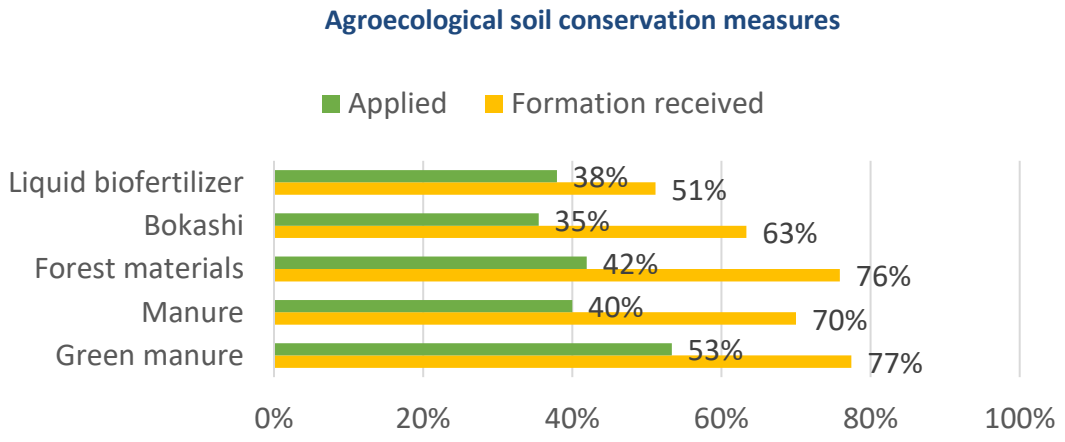

Figure 36: Bar graph formation regarding soil conservation strategies: Percentage of AESs that apply measure or remembered to have received capacitation regarding the topic

Pest control. In EC, 60 % (n=9) said they planted herbs in association with vegetables or natural barriers to repel insects, while the strategy was reported to be applied by 29 % (n = 17) in SP. Liquid organic repellents were reported to have been applied during the past agricultural cycle by 42% (n= 12) in EC, while the use was reported by 12 % in SP (n = 17) (Figure 37).

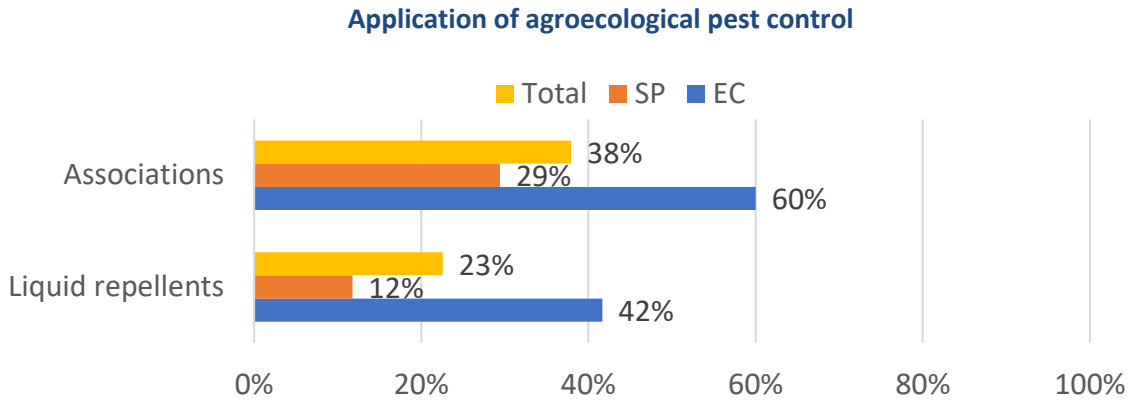

Figure 37: Bar graph application of agroecological measures: Percentage of AESs planting crops in association and applying liquid repellents

Regarding liquid repellents, 63 % (n = 31) reported to have received the capacitation, while 23 % (n=31) applied the strategy. Likewise, the use of association was reported to have been learned by 60 % (n= 29), while 38 % (n = 29) had made use of it in the assed period (Figure 38).

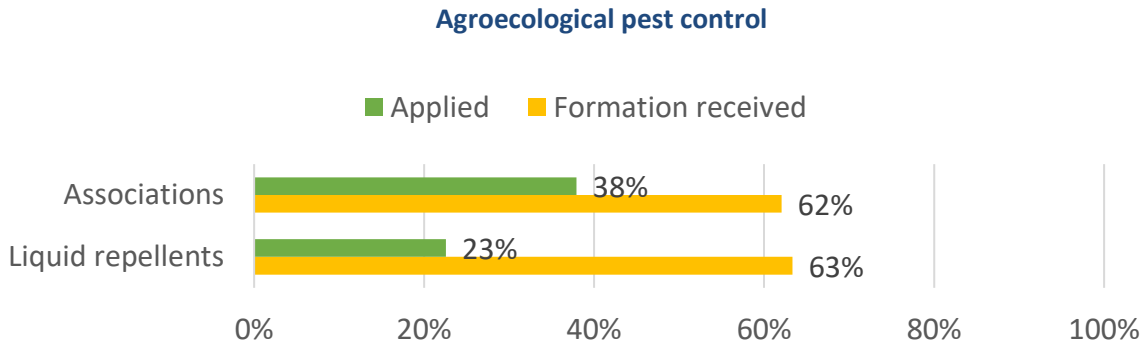

Figure 38: Percentage of assessed AESs which apply agroecological pest control and percentage of those who have received formation

7.2.2.10 Application of conventional practices

Fertilizer. Regarding the application of fertilizers, 11 participants said they had applied chemicals during the last years cycle, while 20 said they had not. Of the 35% (n = 31) which had applied chemicals, the majority was from EC, where 67% (n = 12) of the questioned said they had applied chemicals. In SP, 18% applied chemical fertilizer (n= 17). The participants who used chemical fertilizers estimated to spend from Q50 to Q920 on chemical fertilizers (Q477.61 on average, n = 9).

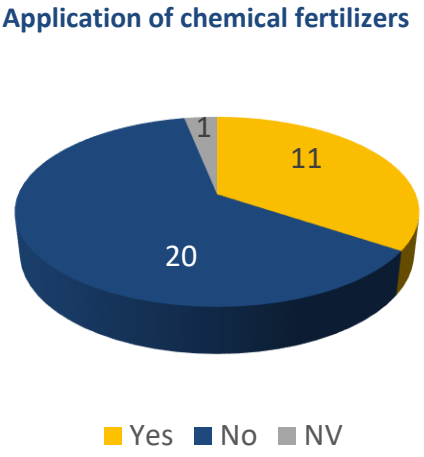

Figure 39: Number of responses received to the question, if chemical fertilizer was applied

Regarding the application of conventional pest control, 23 participants said they had applied chemicals during the past year. Most common were the utilization of Hedonal, Glyphosate, and Paraquat Alemán. The participants who used chemical pest control estimated to have spent from Q80 until Q1080 from May 2017 until April 2018 (Q339.69 on average, n = 22).

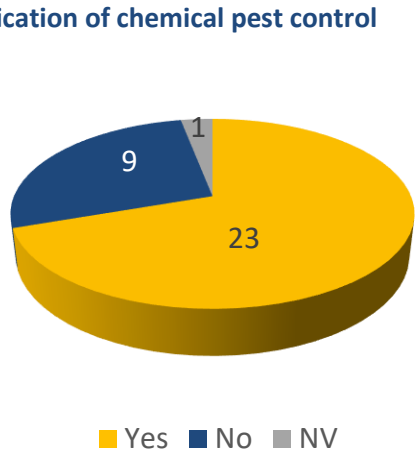

Figure 40: Number of responses received to the question, if chemical pest control was applied

7.2.2.11 Usage of planning instruments

Four participants said they used the planning instrument farm map, while 26 said they did not (Figure 41). Three of the questioned said they had taken notes for costs calculation. No participant could show notes taken on production (Figure 42).

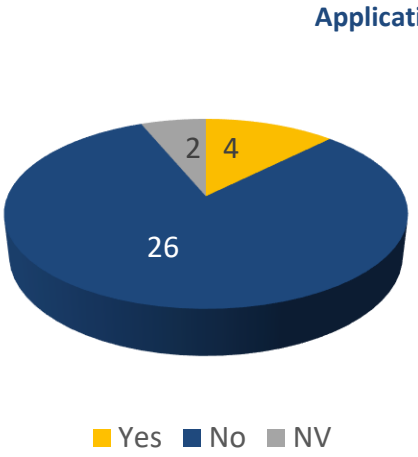

Figure 41: Number of responses received to the question, if the tool cost farm map was applied

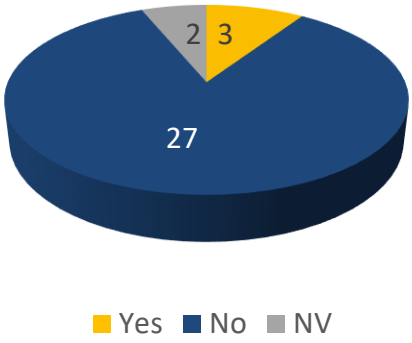

Figure 42: Number of responses received to the question, if the tool cost calculation was applied

7.2.2.12 Familiarity with the term "Agroecology"

When asked to explain the term "Agroecology", two participants out of 25 asked could give a reply. One mentioned that agroecology helped to respectfully treat the natural environment, while an individual in San Pedro interpreted Agroecology in spiritual way on the path towards development (Figure 43).

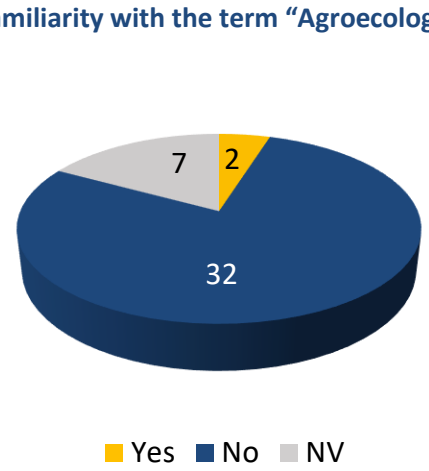

Figure 43: Number of responses received to the question, if participants were familiar with the term "Agroecology"

7.2.2.13 Self-evaluation

Needs. When asked if knowledge, area or money was insufficient for cultivating enough, 25 agreed to lack knowledge (often given with the supplement “You never know enough”), 11 to lack area and 29 to lack money for necessary investments.

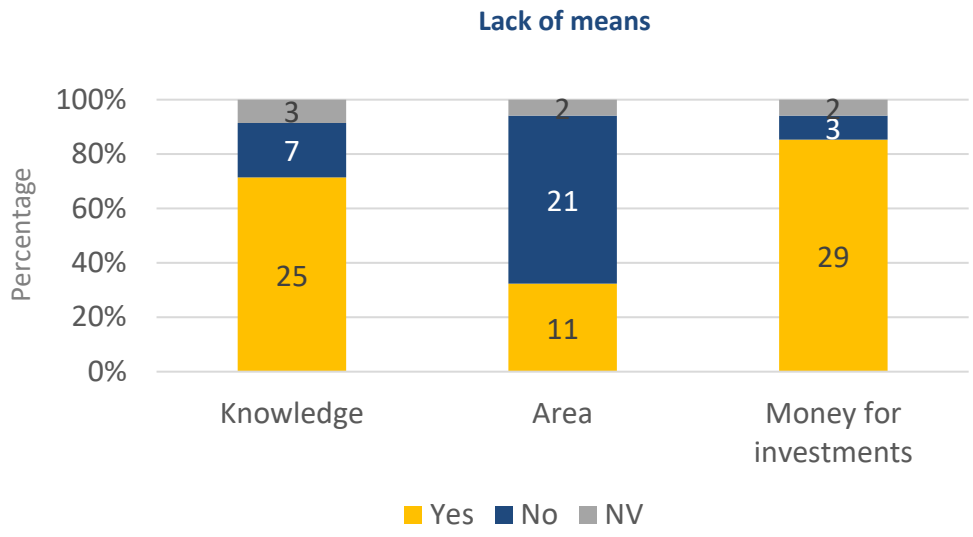

Figure 44: Number of responses received to the question, if knowledge, area or money was not sufficient for cultivating enough

Sells. When asked if it might be necessary to sell their lands, 11 agreed, 15 stated they would not under no circumstances (Figure 45).

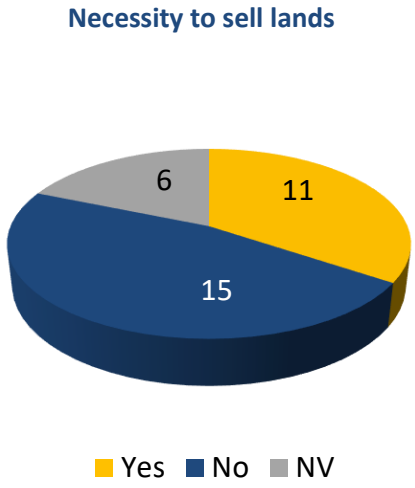

Figure 45: Number of families that consider it might be necessary to sell land

7.2.2.14 Forest incentives

Neither in LT nor in SP forest incentives were received by the participants. In EC, 7 reported to receive incentives and one had applied in 2017 (Figure 46).

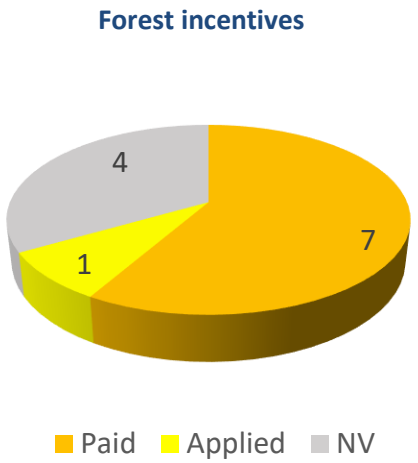

Figure 46: Number of participants that receive or have applied for forest incentives in EC

7.2.2.15 What does the forest mean to you?

"Vida" (life), "*aire"* (air) and "*oxigeno"* (oxygen) were the most frequent answer to the question, what the forest meant to the interviewed (Table 17).

Table 17: Received responses to the question: "What does the forest mean to you?"

Quote (Spanish)	Quote (English)
"Sombra"; "Ahí descansa uno"	"Shadow"; "One can rest there"
"[El bosque] es de las naturalezas más bellas que hay en el mundo, por el sencillo razón que nos da muchas cosas"	"[The forest] is one of the most beautiful natures in the world, for the simple reason that it gives us many things"
"Sí lo agotamos termina, si lo dejamos produce"	"If we exploit it, it ends, if we let it, it produces"
"Sombra, vida y aire"	"Shadow, life and air"
"Sin bosque no hay vida… después no hay viento para uno"; "Cuidarlo"	"Without forest there is no life… then there is no air for us"; "To take care of it"
"Proteger la naturaleza", "aire", "vida"	"Protect nature", "Air", "Life"
"oxígeno, aire fresco", "Animalitos tienen sombra"	"Oxygen, fresh air", "Animals have a shadow"
"Superviviencia por el aire", "vida y aire"	"Survival because of the air", "life and air"
"Cuidarlo"	" To take care of it"
"Contiene oxígeno"	"It contains oxygen"
"La vida del ser humano"; "Tenemos que cuidar y mantener el bosque"	"The life of the human being"; "We have to care for and maintain the forest"
"Una fuente de vida, porque nos da oxígeno. En tiempo de verano ayuda a la superviviencia de los animales o todo ser vivos"	"A source of life, because it gives us oxygen, in summer time it helps the survival of animals or all living beings"
"Lo más bueno que hay para la salud", "Da frescura"	"The best there is for health", "[It] gives freshness"
"Tiene objetivo de vida, da oxígeno"	"It has life as its objective, it gives oxygen"
"Vida", "Mientras no hay incendios lo valoramos más, "aire natural"	"Life", "While there are no fires we value it more", "Natural air"
"Vida, oxígeno, importante para madera, sombra"	"Life, oxygen, important for wood, shade"
"Aire"	"Air"
"Vida", "Sombra", "Recursos"	"Life", "Shadow", "Resources"

"Vida", "Genera salud por el aire que respiramos, vida a animales, trae agua"	"Life", "Generates health by the air we breathe, life by animals, brings water"
"Lida, oxígeno y llama los nubes”	"Life, oxygen and calling the clouds”
"Que no calienta el ambiente"	"That the environment does not warm "
"El bosque da vida, agua, frescura y aire"	"The forest gives life, water, freshness and air"
"Calidad", [hay que] mantener bosque y montañas; hay que cuidarlo	"Quality", [we must] maintain forest and mountains; We must take care of it
"Mucho, vida y aire"	"A lot, life and air"
"Para medio campesino… muy bonito. Antes las sierras [estuvieron] muy bonitos y hoy sólo fuego"	"For half a peasant ... very pretty. Before, the mountains [were] very beautiful and today there is only fire"
"Oxígeno, “Sombra”, “Sin árboles no hay vida"	"Oxygen”, “Shade”, “Without trees there is no life"
"Oxígeno”, “Sombra"	"Oxygen”, “Shadow"
"Cambio del clima"	"Climate change"
"Algo que nos sirve ya más adelante", “Gente [de] fuera lo agotan y pone pasto; hay que cuidarlo"	"Something that helps us later on”, “Foreign people deforest and seed pasture, we have to take care of it"

8 Discussion

In the present chapter, first methods, then the findings are discussed, and recommendations presented.

8.1 Methods

Given unexpected circumstances, the research design had to be adapted throughout the study. In this chapter, the leading framework ecosystem services and the methodological approaches are discussed individually before drawing an overall conclusion.

8.1.1 The utility of ecosystem stewardship as an embracing framework

The concept of ecosystem stewardship has shown to be suitable to evaluate the navigation of agroecological transitions in the highly dynamic BZ, as it emphasizes the importance of considering change and uncertainties. Such drivers as rapid population growth and expected impacts of climate change indicate dynamic relations among the BZ's components, which demand to take predictions and trends into account when taking management decisions. The framework's declared objective to actively navigate change to foster resilience, coincides with the management objective to transition the agricultural sector towards a truly sustainable state.

The framework "ecosystem stewardship" has allowed to choose compatible methodologic frameworks. Key concepts like the emphasis on sustaining the base of ecosystem services rather than assessing a single resource is compatible with the paradigm of environmental protection, which dominated decision-making in the MBR BZ. The systematic approach with focus on the interactions among the social and environmental sphere is likeminded with the interpretation of farms as AESs. AESs can be interpreted easily as in the BZ embedded sub-systems, as both are interrelated but individually governed entities. Given the absence of larger urban areas, public terrains and industries, the BZ could be interpreted as a rural socio-ecological system composed as a mosaic of private AESs.

8.1.2 The feasibility of adapting Ostrom's (2007) socio-ecological system approach

Ostrom's general framework for the evaluation of socio-ecological systems (2009) was chosen to describe the BZSES, as it is designed as a universal outline for the assessment of resource management systems. By providing general first and second tier variables, it allows decision makers to apply findings more easily to another context. Recommendations for implementation of agroecology are easier to transfer. SES generally presents as a flexible framework. Originally, the framework is adapted to single state resource management, ecosystem stewardship calls for management that ensures the individual systems 'functionality. To make the frameworks compatible, AESs as assessed subsystems replaced the original first tier variables resource unit and resource users. Some second-tier variables become obsolete and were not adapted. Ostrom's general framework does not consider multiple scales, which is why findings are presented without separating between administration units with different responsibilities, like the BZ, municipalities

or communities. Experiences from the adaption of the framework to the community level show that this would demand efforts beyond the scope of a master thesis (Delgado-Serrano & Ramos, 2015). As findings from the AES assessment indicate that the community level plays an important role for agroecological development, the turn to multi-level analysis is recommended for further studies. However, the framework puts emphasis on the economic aspect of resource management, while in the BZ cultural and natural components significantly influence the resource management of family farmers. Thereby, it provides the necessary background to discuss the feasibility of agroecology as a management strategy in the BZ. The ecosystem stewardship does not offer such detailed guidance to the analysis of assessed socio-ecological system. This is why although not fully adaptable to the context, the incorporation of Ostrom's framework has facilitated to draw attention to the BZSES's relevant aspects and to order findings in a comprehensive way.

Information gathering was intentionally broad but limited by the given time frame and the limited availability of reliable data sets. The existing masterplans have proven to be the most valuable information source, as they contain a detailed diagnosis of both, the MBR and the BZ in particular. In the documents, relevant topics like environmental protection, agricultural activities and strategies are already discussed. The masterplans were generated by the participation of present organizations, which made it easier to identify important stakeholders. Given the time restriction which impeded more detailed data analysis, the description of the BZ-SES is closely orientated on the masterplan III (Table 8, p. 37). Not all sources were published, or main databanks could be investigated in depth. Therefore, present study contains multiple secondary quotations, (e.g. the frequently source "WCS 2013"). As published in 2015, the plans refer to most recent data sources. However, many information relies on data which does not describe the current state. Population and agricultural data are mostly based on a census conducted in 2002. Also, the contribution of multiple interest groups has caused contractionary statements. On the one hand, the plans have a clear protectionist notion. This shows for example in the glossary, where "resilience" is only related to the ecosystem's capacity for regeneration, "sustainable livestock raising" to the reduction on environmental impacts or "agroecology" defined as "the application of ecological principles to the production of food, fuel, fibers and pharmaceutical products. It involves the study of agricultural production systems as AESs" [10] (CONAP, 2015b, p. 24). On the other hand, the economic development of the agricultural sector is promoted, where commercial AESs with orientation towards monocultures are ranked "very good", while subsistence systems with surplus (presented as an ideal AES and incorporated in the main objectives for sustainable development) are considered less desirable (CONAP, 2015c). Revised development plans of the municipalities Flores and San José were meant to exemplary subsidized the social perspective but contained discussable statements. For instance, the development plan in San José praised the cooperation with the biotope Bio-Itzá, while members of the organization denied any form of cooperation (personal correspondence). Information demanded official entities like the Municipality of Flores were demanded but only made

[10] "la aplicación de principios ecológicos a la producción de alimentos, combustibles, fibras y productos farmacéuticos. Implica el estudio de los sistemas de producción agrícola como agroecosistemas."

available in form of oral transmission (e.g. interview with Elmer López, April 2018). The correspondence with experts in form of formal or informal interviews helped to get an insight perspective to the functioning of present institutions and their networks as well as to relate the findings from lower levels to the context in the BZ. For formal interviews, audios were produced. No more than one could be transcript in the given time frame. However, the explanations of all helped to consider important aspects in the description of the BZSES. Given that the BZ is a very heterogenous area in environmental as well as social aspects, the present study does not claim to provide a holistic description (which is already provided within the official masterplans) but insights to general trends and occurring processes related to agroecological transitions at farm level.

8.1.3 Challenges of the MESMIS sustainability assessment

The sustainability assessment of AESs is more complex than the usual evaluation of farming practices. In conventional farming systems, the relation of costs and benefits reveals the system's efficiency which is aimed to be optimized. When evaluating AESs, the focus is on sustainability, and the social, economic and ecologic dimensions of farming are considered. To do so, several indicators are formulated for their assessment. The orientation on existing frameworks guide the complex evaluations and enhance the comparability of results. To evaluate the AESs' social and ecologic performance, the investigation was originally orientated on the MESMIS framework.

The framework MESMIS was chosen for practical and ethical concerns. The framework has been developed as part of a program by Mexican scientist in 1995 and been applied mostly in Latin American context since. It has specifically been developed for the participatory assessment of AESs, which has enabled graduate students to profit from local knowledge and contribute with their academic background to the evaluation of diverse AESs (Marta Astier, Masera, & Galván-Miyoshi, 2008). Another criterium for the method choice was that the supporting Mexican University itself has had experience in the application of the framework. Ideally, MESMIS is developed in studies that cover several production cycles. However, the GIZ provided a baseline study which contained information about production, income and forest area, which could have been translated in indicators formulated for the current study. Given its successful application, a comparison would have been possible between the sustainability of the systems at the beginning of the implementation in 2013 and 2018, when first results regarding the harvest of fruits were expected to show. Further, a comparison between the pilot group or even individuals could have shown which weaknesses still exist and enabled technicians and farmers to tackle the identified problems. This was meant to compensate the participants' time dedicated to the development of indicators and participation in the survey study. The visualization of the results in a spider diagram would have been easy to communicate from farmer to farmer or farmer to technician. Thereby, the study would have contributed to install a viable monitoring mechanism. In the future, the transition could have been accessed using the developed evaluation tool. Finding could have been comparable to results from similar studies, which made use of the popular tool.

During data collection, it showed that the MESMIS proceeding was neither applicable nor purposeful given the found circumstance. The first steps were completed. The SWOT analysis to define the current state of the AESs' served as a reference for the final set of indicators and were compatible with both, information deriving from the baseline study and indicators which had been successfully been applied in several MESMIS studies. They coincided with the most frequently applied indicators in Latin American studies, such as performance, innovation and cost-benefits relation and appeared to be universally applicable in any regional context (Martínez-Castro, Ríos-Castillo, Castillo-Leal, Cruz-Cabrera, & Ruiz-Martínez, 2014). However, the indicator bases assessment was designed based on expectations that proofed to be incorrect. In the following, assumptions underlying this research which were not met in the study area are discussed.

(1) Reliable data regarding yields, income and extensions can be obtained through conducting a survey study and farm visits

Re-checking of data, both from the baseline study as from the present study, led to doubt the reliability of the obtained data and likewise the available database. Results of the baseline study contained information about the production, farm size and size of forest area within each participant's AESs. Therefore, it was assumed that the farmers could give reliable information regarding the quantity of production and extension of their lands, also for the present study, to draw a quantitative comparison. In the present study, a general uncertainty to formulate exact responses and inconsistency were registered. For instance, it was asked for the number of productive trees and observations made in the field, which revealed that responses obtained regarding amounts were mostly rough estimates as the number of fruit trees reported scarcely coincided with the actual number observed. This similarly applied for extensions. Therefore, the data as well as the documentation from 2013/2014 were questioned. In response to renewed demand, the responsible technician said he had encountered similar problems and that the data collected could only serve as a benchmark.

In workshops, the GIZ project had taught several planning tools to the participants, which could have provided essential reference for the obtained data. In most cases, the tools were not put in practice. Besides the absence of documentation regarding the AES's production, the investigation lacked the geographical information which was supposed to be documented in a plan handed out to all participants at the beginning of the project. Only four of the interviewed participants stated to owe such a farm map. Without any visual relation, statements concerning the extension of remaining forest area or orchards remained vague, and values given about land cover often did not add up to the value given for the AESs' total area. More confident answers were given about the extension of maize fields, bus as shifting agriculture was practiced and soil and annual climate fluctuations influence harvest levels, neither an increased nor decreased production could allow to draw any conclusion about the impact of improved farming practices. Likewise, the field's size served as no indicator, as it was indicated to depended on time availability of male family members than on its productivity.

(2) The family's AES is a set entity

In the original research design of this thesis, the transition of individual AESs was to be evaluated. The unstable conditions did not allow to compare the past to the present state. The systems could neither be explicitly delimited by their extension nor by the number of people living from them, which is why obtained values could not be related to neither a certain area nor household size. Land had been sold, abandoned, or was only temporally used. In many cases, farmers reported to cultivate on additional areas, which they had rented from a neighbor. In many cases, conditions were uncomprehensive, for instance had two participating families swapped their houses, children emigrated and left their land plots to the parents, or, in LT, neighbors left and let large land areas in the hands of the participating families. Further, the observation of the AES was difficulted by the fact that land-plots were often on a long distance to the families' homes and made it necessary to part a day and organize vehicles to access their lands. Despite the case of LT, the communities were not surrounded by cultivated land, but land plots disperse spread in a radius of up to approx. 20 km. The heterogeneity of systems impeded the comparability, as it was hindered to formulate threshold, minimum and maximum values to define the indicator value. For a systematic analysis of farms, the delimitation of the is a basic requirement, which could not be fulfilled in the scope of the present study (Ikerd, 1993; Von Bertalanffy, 1989).

(3) The AESs are in a state of guided transition

It was expected to observe a guided process of agroecological transition, which was only the case for very few assessed AESs. The list regarding pilot group size was misleading, as many original members were no longer considered in the project line. Participants of the GIZ project had received capacitation, seedlings and technical assistance for implementation of orchards and agroforestry systems, but as cooperating organizations like MAGA (depending on current policies) also offers support individually, it was hard for the participants to relate workshops or donations to a certain project. Knowledge about agroecological means, derived from multiple canals, like the church services or radio programs, and could in some cases not be related to the intervention. As great parts of the pilot groups had been excluded from or lost interest in the GIZ project, as attention had shifted towards selected individuals like promotors. The majority was complaining about the lack of means, assistance and motivation to further the transition, In the case of San Pedro, the neighbored community Jobompiche entered in the project in 2015, and the project's attention had shifted to the promising group. Consequently, no conclusion could have been draws from the increased or decreased performance related to the project. Also, the production of a current state assessment with the farmers was very unlikely to be monitored in the future, which raise doubt regarding the utility of installing monitoring with the participants in general.

(4) The research is in the farmers' interest

Despite putting emphasis on the voluntary participation in the study, it is likely that many farmers agreed to participate for other reasons than to profit from a self-assessment. To both, the workshop and the interviewing in SP and LT, people were invited to participate voluntarily. It was neither stated that the participation was necessary, nor any rewards promised more than to obtain information about the individual performances and advances. Even so, great part of the pilot groups (except LT) stood back from their daily activities to part time for the participation in two workshops, an interview of more than an hour each and visits to their private land plots. When asked for the motivation for participation, many said they wanted to support the study, others to further the communities' development. In SP, some said they had been asked to participate by *promotoers*, to show that the community had interest to be considered in future planning. Likewise, it can be assumed that households had interest in showing personal interest, as this is the criteria by which they are considered by the relatively independently working technicians. Given the socio-economic situation of many, it can be assumed that farmers are under pressure to be considered in projects, and voluntary participations forms part of their livelihood strategies.

(5) Problems of understanding can be overcome by cooperating with promoters

It was assumed that cultural and conceptual differences could be cleared, as a local promotor adjusted the wording and personally accompanied most interviews and field visits. Nevertheless, there were problems with the understanding of questions and answer choices. Despite what the pilot test of questionnaire let suggest, many participants were often not able to give clear answers, especially when asked for values within ranges. Instead of evaluating questioned issues on a scale from 1 to 5, the answers were often a simple "yes". It was time intense to explain all answer choices, which is why the interviews took up to several hours. Because of a generally attitude of gratitude towards god, replies regarding the living conditions and general satisfaction with the circumstances were reluctantly given. It can also be assumed that the purpose of the study was misinterpreted, as most of the participants commented and showed plants they had received during the project and had to be reassured repetitively that control was not the study's purpose. It occurred that in additional conversations, more managed land was mentioned that had not been reported, because the participants did not understand the relevance of mentioning it. Regarding the support to substitute the academic perspective with local circumstances, it was underestimated the trust in the study's design, as for instance the question for meat production was reported in weight units and price paid, until only at the end of the survey a participant stated that instead of selling meat based on its amount, piglets had a price based on their age.

(6) Livelihood strategies show regular patterns

It turned out that livelihood strategies were very dynamic, which is why it was not possible to document consistent information with a questionnaire designed for obtaining qualitative data. For instance, the labor situation varied according to the demand of daily workers and decided how much time could be dedicated to agricultural activities. Other strategies were situation-related. Some agroecological measures were depended on the activeness of the communities' farmers groups, which determined the availability of organic repellents. Products were commercialized in many ways. They could be sold to demanding middleman or swapped with productions of neighbors A regularity could not be determined for many aspects. Also, the families' socio-economic situation depended very much on the time of the year, as the commercialized crop maize was seldom stored and generated irregular income.

However, based on methods deriving from the framework, data could be collected for qualitative analysis. This was facilitated by several favorable conditions. Regarding the workshop, it was helpful to use methods which were already familiar to most participants. The methods used in the Pastoral-Social-VAP's workshops are documented in the memories and could be accessed. Familiar techniques included for instance brainstorming and the SWAT analysis. In the initial workshops, support by a social worker, the GIZ's and Pastoral-Social-VAP's technician and in EC additionally interested staff from MAGA and the Municipality of Flores facilitated the documentation and execution of the methods.

The establishment of contact with the farmers was facilitated through the cooperation with the GIZ and Pastoral-Social-VAP staff. The relation between the organizations in SP and EC had fostered a relation of some individuals with the organizations. However, the independence from the organizations allowed to gain insight perspectives. Supportive promoters had lived for years within the communities, accompanied interviews and welcomed the researcher to eat with the family. The communities' leaders were also supportive with scheduling and announcements of activities and available for information. During the week spent during the day in EC and a week during day and night in SP, informal conversations with the farmers allowed to broaden the understanding of local circumstances. In general, the attitude towards the researcher was very positive. Participant's invited to their homes, explained farming techniques and shared personal experiences. It was stated by various that they were happy to receive honest and respectful attention.

8.1.4 Recommendations regarding the assessment of agroecological systems of family farmers in the MBR BZ

Regarding the survey, some considerations have proven advantageous. Despite the hot and dry conditions in April, it is a good month to conduct a survey study. As in most cases it is burned once a year, the past burn is a good reference for referring to the past agricultural year. As the first rains are expected in the beginning of May, the family board is likely to be found at home, waiting for the right moment to burn. Regarding the questionnaire, it has proven helpful to include a comment section on every paper, to capture all relevant information which has not been considered during the design of the questions. This way, data for qualitative analysis could be generated. To determine the plant species' diversity, a checklist was read out loud, and this way the existing burden of little concrete or incomplete answers could be overcome.

Based on the portrayed experience, general recommendation for the evaluation of AESs addressed by developing programs can be formulated. Firstly, it is essential to avoid causing any inconvenience for the participants by aligning the research to the participants' demands. In the present case, it has not been enough to emphasize the study's voluntary. It must be reflected if a certain dependency of farmers and development organizations or the interest in the study's outcomes determine the contestants' willingness to participate. In any case, the schedules of participants are tight, and the adjustment of activities and interviews should be sensitive to the farmers' agenda. Common believes regarding the farmers availability for voluntary activities are harshly critiqued by authors like Lisa Grandia (2009), who compares the situation with forced labor conditions of past times. Besides for ethical reasons, the alignment of interests increases reliability and effectiveness by only considering participants who share the interest to assess the weaknesses of their AESs.

Experience with MESMIS has shown that the holistic analysis of an AES demands certain interdisciplinary, which in the given context could not be accomplished by a single researcher. The cultural component regarding restrains to data collection or misinterpretation of statements needs to be considered. Despite experiences in Central American countries, the found cultural context differed significantly, which caused wrong assumptions. A debriefing of researchers which covers regional and local particularities should be the first step of each individual research design. The incorporation of local assistance in research design should go far beyond the adjustment of wording and cover different mental models and conceptualization methods. In the case of Petén, a manual for the work with communities has been published by CARE in 1998, which gives insight to particularities to the work with Petén's co-existing cultures (Tierra et al., 1999). In any case, it is recommended to seek support by a local academic institution. By sharing experiences with studies in the region, the cooperation could substitute practical experiences. In the present case, the University San Carlos is a suitable option, as it is listed in the Master Plans as cooperating institution and has also contributed to the development of municipal development plans.

Regarding the survey study, it is recommendable to restrain from focusing on abstract information if participants had not received formal education. Instead, it is recommended to incorporate

alternative methods for data collection. The field visits in groups are a well-received activity, as it allows observation and knowledge exchange. Also, the generation of visual materials is an option. For instance, a drawing exercise could generate geographical reference and facilitate the communication of researcher and the interviewed. It should be avoided to incorporate questions which include ranges. Further, it is recommended to restrain from relying on information given about amounts or extensions. However, the observation of the system to syndicate the information should always be offered explicitly as a voluntary service to the participants, to avoid causing anxiety. In general, a first step should be to assure that the time requirement for a participatory approach can be met without causing inconvenience to the participants.

8.1.5 Adaption of the research design

To react to the gradually discovered mismatch between assumptions made underlying the methodology and conditions, the investigation´s methods were modified. The lack of capacity to document clear answer statements was first compensated by an increased focus on field observations and a reduction and adjustment of answer choices in the questionnaire. For instance, instead of only asking for produced amounts, the interviewed were asked if the amount produced met the families' demand. To create geographic reference, workshops for participatory mapping were organized and GPS was employed to verify the location of the land plots. Thereby, an amount of data was produced which exceeded both the capacity of documentation and analysis. Furthermore, it gave the impression of surveillance

Hence, the research design was radically adapted. The fact that the SES approach was incorporated for the contextualization of findings facilitated the shift from positivistic to interpretative evaluation. In the present work, field observations and result of the questionnaires are evaluated qualitatively. Further, a radical approach was incorporated to increase the utility of the study. The role of the researcher became an active one, to compensate the participants' efforts and contribute to the project. To do so, discovered deficiencies of the proceeding and recommendations for their adaption were presented to local stakeholder. Contact numbers of technicians were handed out to interested individuals. The shift was received positively by the involved and supported by the local institutions.

8.1.6 Final remarks on the methodological choice

In conclusion, the compound methods approach has facilitated the necessary adaption of the research design. Both, regarding the SES and MESMIS approach, some methods have proven to be purposeful regarding the assessment , while others showed main deficiencies (see chapter 8.1.2 & 8.1.3). Experiences drawn from the present study can lead to necessary considerations when planting research in the zone or similar contexts. Besides practical considerations, this concerns the study's ethic. Scientific dialogue on environmental degradation tends to focus on the behavior of family farmers. While this is plausible in the case of forest concession communities in the MUZ, it is misleading in the BZ. Family farmers cooperate with NGOs as they share common objectives and live in the communities, which makes it easier to plant research with them. However, time was

named as a limited resource by many, and it must be avoided to demand uncompensated contributions. The researcher should question if only for practical concerns the conducted study unnecessarily adds up to the negative image of peasants and thereby covers up the real problems of land concentration and poverty. Considering that less than 20% of arable land remains in the hands of vulnerable family farmers and most decisions are likely to be taken based on the families' basic needs, behavioral approaches are obsolete. The vulnerable farmers seek immediate solutions, for which any investigation is a welcomed opportunity to generate immediate outcomes. Taking this research as an example, the researcher took an active role in communicating needs technicians could respond to and vice versa (observation and personal correspondence with Enzo Solari, March to September 2018).

8.2 Conditions and their implications for navigating agroecological transitions

In the present chapter, the exemplary conditions of the BZ and the embedded AESs are related and evaluated as favorable or unfavorable for nudging or navigating agroecological transitions.

8.2.1 The AESs' assets

In the following, aspects regarding land availability, plant species diversity and subsystems are discussed. These basic requirements for agroecological transitions were met to different extents.

8.2.1.1 Availability of land

The availability of larger areas to peasants is no requirement for the transition to individually sustainable AESs, but for the enhancement of the agricultural landscape's resilience. To sustain a family of eight, an area of approx. 1 mz (0.7 ha) has been calculated necessary to meet the demand for basic grains (CONAP, 2015c, p. 61). Dense fruits and vegetable gardens for a diversified diet commonly share the household's property with small livestock and the family. Therefore, even integral systems can exist on few extents. For self-sufficiency, firewood and fodder demand requirements forest or secondary vegetation area but can be met by acquiring resources elsewhere if necessary. Thus, the intensification of agricultural activities at small scale might decrease the necessity to farm at distance.

For the participants, the land available for farming activities is more likely reduced than maintained or expanded. The family farmers are often marginalized and land (or the right to cultivate municipal land) as the only possession with monetary value likely to be sold when cash is needed (Zander & Durr, 2011). A solution to free space for orchards or agroforestry patches is to intensify crop cultivation and thereby free area beforehand demanded. However, if the cultivation of basic grains is intensified, and land is "spared", there are different options for the farmers. They can either further expand the MILPA for the commercialization of basic grains; invest time and resources in the installation of orchards, intensified fodder and agroforestry systems; leave area to natural vegetation for fuel self-sufficiency; apply for forest and reforest incentives; or sell rights or rent area to landless neighbors. Given the critical socio-economic situation of most, options which do not demand investments and promise immediate payments are the most likely to be taken. The availability of land was named as an opportunity in the workshop in SP and mentioned by the technical staff. As half of the communities' habitants in Petén do not have regulated access to land, it has become a privilege. The increasing number of landless farmers most likely rises the demand for MILPA patches.

Taking the participants as an example, it shows that EC and SP show similar patterns of access to land plots, while the two participants in LT estimated to have access to more land area outside the city center than each of the two pilot groups individually. The estimated values are very vague and could not be verified, which is why they can only be interpreted as benchmarks. In total, it is estimated that 430.5 mz (303.76 ha)are in the hands of participants in EC and SP, while 377.5 mz (266.36 ha) were estimated in the hands of the two participants in LT. This illustrates the

heterogeneity of access to land in the BZ. According to the legislation, concentration of large coherent areas is forbidden, but it is suspected that many even circumvent this restriction. Among the participants of the present study, there were also significant differences within the pilot groups. Eight of the interviewed families lacked access to land plot outside the villages' center. None of the participants of the communities EC or SP reported to have access to more than 64 mz (45.16 ha) Only three participants reported to have access to less than five manzanas. Also, more than half reported to have at least one additional terrain in the villages' center. Those terrains usually measure 30x30m up to 120x60m and have different usage according to the participants demands and preferences and include MILPA in some cases. Observations revealed that terrains in the village center are more suitable for agroecological farming, as explained in the following.

For agricultural usage, not only the extent but also the conditions of land are important. Regarding land availability, access to inadequate lands and the individual conditions were negative characteristics named in the workshops. Given the unequal land distribution during the colonialization and the disadvantages for family farmers on the land market, family farmers have often access to marginal lands. Conditions can be very individual. Lack of access to water, pronounced slope and soil depth are observed deficiencies of many of the land plots. Agroecology as a science formulates diverse strategies for the compensation of small scale deficiencies However, solutions are very individual, and no universal solutions can be transmitted. Responding to the specific necessities demand individual assistance.

8.2.1.2 Crop species diversity

Plant species diversity lays the foundation for the design and maintenance of resilient AESs. Because of the diversity of products, farmers are less dependent on a single crop. Also, harvest seasons are staggered, which can compensate absent storage systems. This makes AESs less vulnerable to temporal pest outbursts and climate conditions. Also, diversity in AES enhances the potential for innovation. The experimentation with associations in time and space can reveal valuable synergies. In times of changing environmental conditions, plant species diversity allows to identify resistant crops and adapt management strategies (M. Altieri, 1999; Gliessman, 1998). In the BZ, traditional systems contained several species with different and elongated harvest times, like plantain (*Musa*) or tuberculous like sweet potato (*Dioscorea),* which is why subsistence farmers do not only profit through the diversification of diets but also more favorable availability of products (Atran et al., 2004).

Findings indicate that plant species diversity is the core strength of the assessed AESs. The aspect was mentioned as a strength of the AESs in the workshops and by the technicians. The survey study provides an insight. With an average of more than thirty and a minimum value of ten species each, most AESs are highly diverse in plant species number. This applies similarly to perennials and medium-term species, with averages of 14.45 and 12.07 species per system. Besides the documented crop diversity, it was observed that genetic diversity existed, e.g. different types of Musaceae or mangos. The enhancement of the AESs' plant species diversity has been a declared

objective of the assessed project, and many participants specifically named the increased diversity as a success. Besides increased diversity in the individual systems, it is a general gain for the communities, as sharing seeds was documented as a common practice.

8.2.1.3 Subsystems

Data obtained regarding diversity of crops and animals also indicates the existence of various subsystems within most AESs but is no indication for the exploitation of their potentially synergic relations. Integrated AESs combine livestock cultivation with crop cultivation. This way, nutrient cycles can be closed, as plant residues serve as fodder and animal manure as fertilizer. Ideally, dense vegetation cover enhances microclimatic conditions and offers shelter to beneficial insects. Forest material like foliage and earth can be applied to enrich soils in orchards. For instance, in a mature phase, species like Pacaya (*Chamaedorea tepejilote*), Cacao (*Theobroma cacao*) or Vanilla (*Vanilla*), profit from the shade the forest creates (M. Altieri, 1999; Gliessman, 1998).

Of the interviewed, most farmers hold animals and thereby fulfil the basic requirement for the design of integrated systems. Poultry like chicken or ducks are the most common type present in more than 85% of the assessed cases. Half of the questioned were holders of small livestock or cattle, for which 10% of the interviewed stated to cultivate fodder. If livestock housing is provided, the manure can be collected easily and mixed with plant residues to create rich fertilizers. Fish hold in artificial tanks or water holes were present in nearly a forth of assessed systems. The water can be applied directly to the earth. If livestock is not present, manure might be acquired at community level. For the connection of subsystems, not only the possibility but also capacitation for the preparation of agroecological fertilizers and motivation for its application are necessary requirements. Taking the application of manure as an example, 70% of all interviewed remembered to have received the capacitation while 42% reported to have applied manure during the past agricultural cycle. There are differences between the adaption of strategies among the pilot groups. While manure had been applied by 55% of the interviewed in EC, only 29% in SP adapted the strategy. Possible explanations are differences in assistance, activeness of farmers' groups and the access to land plots.

Subsystems regarding crop cultivation and forest area take on many forms cannot be delimited easily. The diversity of perennials, biannual and medium-term species indicate the existence of orchards and mixed forms with MILPA. The shadow species Pacaya (*Chamaedorea tepejilote*), Cacao (*Theobroma cacao*) or Vanilla (*Vanilla*) were cultivated by 34%, but observation showed that plants they were in very initial phases. Regarding the cultivation of basic grains, the subsystem Maize was documented in over 80% of the participant's subsystems, while beans were only cultivated by 52%. It was commented that the association with beans was less common, which is unusual for traditional MILPA systems which normally profit from higher and sustainable yields by the incorporation of the edible nitrogen fixer. However, the application of green manure was reported by 53% of the interviewed. By many it was stated that timber had been planted, as it was promoted as savings for retirement age or the children. What is unknown to the farmers is that the management plan

prohibits any usage other than naturally fallen timber if not cultivated with certified management plan (CONAP, 2015c).

8.2.1.4 Lack of economic resources

The lack of economic resources hinders family farmers in the enhancement and maintenance of their AESs. Investments need to be taken not only for general farming activities and especially for the transition into agroecological AESs. These include payments for material like tools or barrels for the preparation of organic fertilizers and repellents. Besides buying materials, running costs must be paid. Also, seeds and seedlings must be bought seasonally, as not all can be retained or shared. The family farmers' opportunities for self-paid transformations in the BZ are limited. Acquisition of capital is hard for most families, as the economic circumstances in the BZ with hardly any work opportunities for unskilled labor despite daily work hinders the generation of income. Available credits from banks like BANRURAL with bad reputations and high bureaucratic burdens, risks and interest rates, repeal farmers.

Findings indicate that the progress of the pilot groups is significant hindered by the lack of capital. Most participants reported the lack of economic resources to produce sufficiently. In the SWOT analysis, the lack of formal work opportunities and the poor compatibility of formal work and fieldwork were aspects mentioned which the AESs are threatened by. As farming in many of the assessed cases is not profitable enough to meet the families' monetary demands, the need for taking work besides the work on the field leads to decreased availability of work force. When farming activities are reduced, watering vulnerable young orchards are likely to be among the first activities abandoned, as the MILPA is clearly priority for ensuring the family's food security. The socio-economic situation of most is very critical. To keep the farms running, money must often flow in from other sources. In total, only 30% named the farm as the only income source and 20% of the questioned said they were receiving payments from family members and, which indicates negative profitability. Farmers are highly exposed to climate conditions that affect harvest levels and prices of basic grains. Inner- and interannual price fluctuations are likely to contribute to the impoverishment farmers. Economically, they are exposed especially to illnesses, as public health care is deficient and private healthcare results in costs. Consequently, the transition of their AESs is highly dependent on the institutional attention marginalized farmers gain.

8.2.2 Knowledge systems and customs

8.2.2.1 Loss and mismatches regarding traditional knowledge systems

Worldwide, traditional knowledge is the basis for sustainable subsistence farming. In coevolution, the socio and environmental conditions have defined the interplay of agricultural societies and their natural environment. Management strategies have often developed during centuries and passed on from generation to generation. Traditional knowledge systems regarding agricultural practices often contain a broad knowledge base regarding the synergic cultivation of a diverse plant species as well as sustainable soil and water management. Those resilient AESs have adapted to changing conditions and persisted until the present day (e.g. M. Altieri & Nicholls, 2000; Toledo & Barrera-Bassols, 2008). Traditional forms of soil management, which included swidden agriculture (slash-and-burn) become increasingly inappropriate given the current developments. The decrease of available area increases the pressure on lands. The risk of forest fires has increased due to dryer conditions, forest fragmentation and degradation of social control mechanisms.

Given favorable conditions traditional knowledge systems can enhance environmental conservation efforts, but displacements and "modern" circumstances threaten the sustainability of indigenous farming techniques. Given the cultural and environmental heterogeneity of agricultural societies and landscapes, knowledge systems are very individual and site specific. In the BZ, immigration flows of farmers from southern departments to the BZ have caused the coexistence of originally present and imported agricultural practices, of which most show certain incompatibilities with present environmental and social conditions. Despite clear evidence that extensive livestock breeding has the most severe impacts, many critic the arrival of the Q'eqchi's traditional Mayan practices for deforestation, which gives priority to crop cultivation over agroforestry and employ soil conservation techniques which are too intensive for tropical soils (e.g. Hodgdon et al., 2015). More feasible traditional models with ample knowledge about site specific conditions are likely to diminish in the coming years, as the Itza Maya lack resources and favorable conditions to transfer their valuable knowledge (Atran et al., 2004). Slash-and-burn practices of subsistence farmers are harshly criticized for increasing the risk of forest fires, deforestation and soil degradation. However, the BZ shows exemplary that practices regarding extensive pasture lands also incorporate periodical burning practices and exhaust soils on by far larger areas. While shifting agriculture might contain secondary vegetation and orchards as valuable habitats, it is worth overcoming the stigmatization and look at activating the cultural potential (Atran et al., 2004; Ford & Nigh, 2009). It should be considered that fertilizer bean (*Mucuna pruriens*) can be an alternative method for soil conservation for family farmers, while regular burns of pasture land can not be replaced as environmentally sound.

Besides the loss and degradation of the knowledge bases, current land tenure contributes to the poor feasibility and survival of traditional community practices. Mismatch between traditional management strategies result from the incompatible with current land distribution and dense settlements. Not only social norms but also land distribution among the farmers were originally

defined by the community. Local leaders oversaw strict regulations of groups of manageable sizes. Grandia (2009) describes how the Q'eqchi's traditional land management is hindered by the division into private properties. An example can be drawn from SP. Other than the land tenure termed *ejido* lets suggest, the possession of the right to cultivate a certain area follows the same principles as private properties, which are delimited entities within the land owned by the municipality.

Under traditional community management, environmental deficits were compensated by different land assignations. Marginal lands were left for natural vegetation cover. Public lands for spiritual rituals and public forest for the collection of fire woods. Fertile soils with access to water were used for crop cultivation. Orchards provided diverse products to all (Grandia, 2009). In SP, persistent structures witness the incompatible from of traditional farming and current conditions. Only a small number of associates have access to the Bio-Itza biotope, which remains the region's only forest area managed by Maya. The pressure on the Bio-Itza reserve is growing, as SP has expanded. A few years ago, the foundation of the group ACARI was an attempt for self-organization of farmers but has drastically reduced in member size. Persistent believes like managing fruits as public goods mismatch with the idea of commercializing products, and robbery of fruits hinders the development of those who want to participate in sustainable development.

8.2.2.2 Adaption of conventional practices

The adaption of conventional practices by peasants impacts the natural environment and gradually degrades the farmers' production base. Harvest shortfalls are noticeable consequences. The application of chemical fertilizers exploits the tropical soils and decreases harvest levels. Leaching of nitrate contaminates groundwaters and affects the zone's valuable aquatic ecosystems. The application of agrochemicals contaminates both products and environments and further enhances the resistance of parasites populations in the long run (e.g. M. Altieri & Nicholls, 2000; Gliessman, 1998).

Findings indicate that conventional practices are common among the participants, with potential to be reduced by sensitization and the promotion of agroecological means. The application of chemical means was common among the participants, as of the 31 participants questioned, 20 said they would apply chemical fertilizers, while 23 said they applied chemical pest control. There was a significant difference between EC and SP, as 67% of participants in EC but only 18% of participants in SP reported the use of chemical fertilizers. It was commented by many that chemical means were usually applied to MILPA and only surpluses used for fruit and vegetables. Therefore, agroecological measures which can reduce or replace the application of chemicals in basic grains are especially important.

8.2.2.3 Knowledge transfer

When planting agricultural strategies, improved outcomes rely on the combination of traditional local knowledge with technical advances. This combination is delicate to install (Holt-Giménez, 2008). The traditional Latin American perspective on knowledge itself follows a different

epistemological approach than the academic society. In contrary to the western idea of knowledge as a pool of information easily accessible to the public, the concept of embodied knowledge defines the individual knowledge holders themselves as the medium of specific information (Toledo & Barrera-Bassols, 2008). Only the interaction of persons makes this knowledge accessible. Likewise, experience with agroecology and development initiatives in these contexts has shown that knowledge exchange among farmers is enhanced by the establishment networks and facilitation of farm visits. Thereby, horizontal structures and practical applications replace the poorly successful top-down approach in development cooperation (Holt-Giménez, 2008). Further, the formation of especially interested persons as promotors installs accessible knowledge holders in the communities, to multiply and sustain information.

According to the participants in the study, the knowledge base had significantly improved due to the project. Knowledge was mentioned as a strength of the AESs in both workshops. Via the project, many have received capacitation regarding the improvement of farming system. Especially participants' in EC remembered to have received workshops concerning the incorporation of bokashi, forest materials and manure. However, the majority of the interviewed agreed to be lacking knowledge to produce sufficiently and expressed their willingness to learn. It was also striking that many participants more reported to have received certain capacitation than to have applied them recently, which indicates a mismatch of the strategies shown and actual needs or the lack of means to put them in practice.

However, the process and focus of knowledge transfer is discussable. The activities are planned and guided by the cooperating institutions, who approach strongly sustainable AESs. The top-down orientation and ideologic notion might harm the acceptance and feasibility of proposed means. Strategies are taught in interactive workshops and exemplary cases are observed and discussed in field visits. The focus is on organic means, which should enable participants to farm without the application of any chemical fertilizer or pest control. Emphasis is put on strategies which enhance the families' diets or income, like the installation and maintenance of orchards and agroforestry systems. Discussed strategies for commercialization include the orientation to local markets. Given that the installation of orchards is expected to make a difference on small-scale climate conditions and the core motive for the transition, it might be necessary to reconsider if efforts should concentrate from the start on the time-intense preparation of fully organic means, as orchards in initial stages are demanding and workforce a limiting factor for their attendance.

As an attempt to multiplicate knowledge holders and exemplary systems, local stakeholders offer capacitation to interested individuals that commit themselves to share the experience gained. Those „*promotors*" have received the agroecological capacitation by Pastoral-Social-VAP all over Petén and since the project start in 2011 in the BZ in cooperation with the GIZ. In the SWOT analysis in EC, the presence of educated promotors was named as an opportunity. Of the questioned, about a third of the households had a family member which had received the capacitation. The criteria for being

registered as a promotor is the attendance to numerous workshops and not associated with any obligations or basic requirements.

Experiences illustrate that support orientated towards *promotores* has clear advantages as well as disadvantages. It was observed that very few representative promotors had become the focus of current development cooperation and were expected to take on a leading position in their communities. More materials were exchanged, and communication channeled through active promotors, like e.g. the announcement of workshops. This has advantages and disadvantages for knowledge transfer. On the one hand, independent network structures can be enhanced, and resources can be concentrated on the installation of exemplary AESs. This way, the local knowledge and resource base can be enhanced through experimentation and reproduction of materials like seedlings. On the other hand, not all *promotores* meet these demands. Few have exemplary land plots. Promotor activities also demand voluntary work and time. While some *promotores* were received very passioned, others seemed rather passive. When channeling communication with the pilot groups through promotors, they gain power about the group dynamic and integration of members. It was observed in EC as well as SP that the community's society was divided in interest groups and promotors decided on the integration of certain members, which had let to exclusion and resentment of several. Also, it was commented that *promotores* had moved away, and the expensive enhancement of their mature agrosystems was instantly abandoned. This illustrates that installed "knowledge islands", which could multiple the number of farmers adapting agroecological strategies are not necessarily sustainable. This presents an additional obstacle for the upscaling of the GIZ project's impacts.

8.2.3 Networks and communication

8.2.3.1 Development institutions

In contexts where no endogenous movements exist, the presence and agroecological ideal of development institutions is a basic requirement for the initiation of agroecological transition. Agrotechnicians have generally played an important role regarding agroecological development (M. A. Altieri & Toledo, 2010; La Via Campesina, 2018). Besides the technical expertise necessary, the institutions provide the logistic and material and technical capacity for agroecological transitions.

In the BZ, dependencies between the attending organizations and the farmers exist. For decades, MAGA has followed several approaches to support the developing of the agricultural sector. Additionally, several NGOs have launched programs for sustainable development. Participating in development initiatives has become a usual strategy to increase livelihoods, as donations are received on a regular basis, and in return predefined requirements are met. The interviewed had often participated in several programs they were not able to differentiate clearly. Given worsening conditions, it is likely that the dependency is increasing.

Regarding the assistance of pilot groups with agroecological transitioning, the necessary continuity and quality of the technical assistance necessary for navigating transitions were not guaranteed

completely. Technical and institutional support along with provision of seeds and seedlings were recognized as an opportunity in both workshops. However, the lack of assistance was named as a threat. Many reported that assistance was punctually and irregular. Some commented they felt badly informed about existing offers like workshops or field visits. Some participants reported that for the mentioned above, they had lost the confidence in recurrent development projects. It was put emphasis on the necessity of assistance regarding pest management and development of orchards. It was observed that communication was deficient and no mechanism for anonymous feedback existed. This is problematic because of the explained dependency of marginalized farmers on institutional attention and there is no room for constructive criticism.

Inner- and interinstitutional deficiencies hinder the constant attendance of pilot groups. Poor institutional cooperation was an aspect mentioned by the technicians which affects the alignment of activities. This hinders to unfold the institutional potential, as different responsibilities and opportunities of each organization can be synergic to reach individual aims. For instance, institutional cooperation between GIZ and MAGA combines logistic capacities. This can compensate individual insufficiencies, as the lack of resources includes the general lack of laboratories and materials, but also means of transportation to attain remote communities. The Pastoral-Social-VAP has built trust in communities, as they have shown continuous presence and put emphasis on the social component of sustainable development. The cooperation also enhances the knowledge systems. The expertise of technicians is very individual. Some contribute with the working experience under present conditions, while international work experiences open perspectives for agroecological transitions. Another inner and inter-institutional obstacle is the irregularity, for which the participants of MAGA named changing policies and related work-lines as causes. The abandonment of initiated processes was also related to the constant change of staff and their individual responsibilities.

8.2.3.2 Lack of self-organization

Agroecology can be applied individually, but isolated transitions alone are less likely to reach the necessary magnitude to impact farming conditions. This applies to ensuring both, ecosystem functioning and favorable social framework. Agroecology as a joint venture can free this potential. This shows the experience from Brazil. In Brazil, bottom-up movements of farmers had reached to modify policy and political will to guarantee a favorable framework for family farming. In Latin American contexts, the ideologic component of the concept agroecology pave the way for amplified feedbacks that enable transitions at landscape level (M. A. Altieri & Toledo, 2010).

The poor autonomy of farmers' associations in the BZ decreases the chances for independent initiatives. In the zone, there is no dominant organization led by family farmers (Grandia, 2009). In SP, experiences with the foundation and downfall of the organization ACARI show bureaucratic and social obstacles that impede to bundle farmers efforts without political will. Another example for the institutionalizing of groups can be drawn from EC, where a promotor and his group of eleven are very dedicated to agroecology and closely cooperated with the project. The group reported to

have met independently on a regular basis to prepare organic repellents and fertilizers. Recently, it was grouped as a MAGA group (*CADER*).

The general lack of organization among participants also practically hinders the proposed AESs' transitions as many strategies are designed to be performed in groups. As the preparation of organic applicants demands time and ingredients, it is more efficient to prepare them together. Experiences from the active group in EC or women's groups show the benefits of joint efforts. Group building is pushed forwards by development cooperation.

8.2.3.3 Level of participation

The influence of participants on relevant decisions depends on their level of participation. In this context, the term does not refer to the willingness but the possibility of farmers to involve in planning processes. Arnstein (1969) has defined different degrees of participation, which are visualized as a latter (Figure 47). For sustainable development cooperation, it has proven essential to perform planning with a high degree of participation to sustain nudged or implemented changes. The absence of influential and autonomous farmer organizations at BZ level shows that in the given context, citizen power has still not been claimed.

Regarding the assessed project, farmers have not sufficiently been involved in the planning of nudging agricultural transitions, which shows the general proceeding as well as comments received by the farmers. The process of implementation indicates that the step "placation" has not been overcome at the current state, which is why tokenism instead of empowering is still taking place. For the design of the proposal, organizations with experiences as well as farmers with exemplary AESs were consulted in an interactive workshop in 2011. In a second step, it was decided on communities which met predefined criteria. Potential participants were informed in workshops about the requirements for participation without their contribution to the planning process.

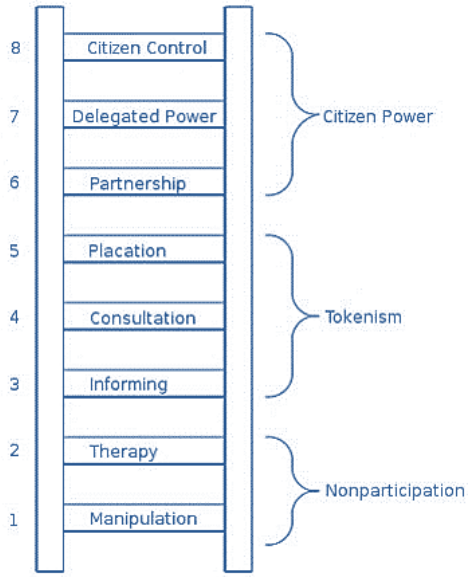

Figure 47: Ladder of participation (Arnstein, 1969)

At the current stage, the level of participation is still low due to established structures and the process of attendance. The fulfillment of requirements is controlled and there are no feedback mechanisms rather than the personal consultation by technicians. The turn of attention towards local promotors can be interpreted as placation, as selected individuals receive the power as communication channels and material receivers by the organizations many depend on, which impedes autonomous power distribution among participants. Experiences from EC and SP indicate that this has caused the exclusion of several. Although groups

were formed, and participants encouraged to engage in independently organized activities, only few have the necessary motivation or logistic means to autonomously organize meetings.

Results of the survey study indicate that partly, nonparticipation practices endanger the project's positive outcomes. A striking indicator for the farmers' unawareness of key concepts and goals was the unfamiliarity with the term "Agroecology". Of 23 questioned, only two could respond, who were perceived as the promotors most engaged in cooperation. Given the low formal education level and relation of dependency between family farmers and present entities, family farmers are even vulnerable to manipulation. Different interests exist that demand the cooperation of farmers. At BZ level, the notion of sustainable development is conservationist. Many participants receive numerous workshops and seemed to be repeating mantras when asked for the personal relation to the forest. Within the communities, personal interests exist. The most dedicated group's leaders in EC not only commercialized organic repellents but also functioned as middleman for the commercializing of the harvested organic products to the nearby tourist industry.

8.2.4 Lack of viable monitoring mechanisms

In contrary to the subjective perception of the farmers, who named visible results as a strength, it was impossible to assess neither successes nor failures without having accompanied the progress. The elaborated baseline was evaluated by the researcher as poorly reliable information, because during the survey, no clear statements could be received regarding extensions of area or amounts of production (see chapter 8.1.3). Annual reports cover only basic advances and did not provide more detailed information about the individual progresses. Other than the baseline, there is no form of individual documentation existent, neither by the farmers nor the program. Neither photos or geographical information can be related to individual land plots. As there is no anonymous feedback mechanism, the adaption of strategies is restricted to direct responses formulated by technicians to subjectively perceived difficulties.

Self-documentation as suggested to participants could serve as a reference for the assessment of progress but has not been adapted. Means for planning shown include the planning of agricultural activities, the documentation of production and cost calculations. Regarding the progress of agroecological transition, the farm's plan contains a self-assessment of the current state and the future vision for the AES. Although elaborated with most participants in the beginning of the project, only four reported to still have or make use of the plan. Cost calculations were reported to be used by two. Several circumstances might explain the poor application of planning instruments. First, it is an unusual activity for which no incentives are set. Participants commented that farming activities are usually schedules according to weather conditions and moon cycles. Given high uncertainty regarding weather and market conditions, cost calculations are not reliable. Second, written documentation forms are hindered by the farmers' capacities. Most of the participants have not received formal education beyond primary school and many are illiterates.

8.2.5 Environmental conditions

8.2.5.1 Tropical soils

Tropical soils are delicate to cultivate, because of their characteristic nutrient cycles and little depth. In natural ecosystems, most nutrients are hold in covering forest vegetation and soil formation is limited to surface layers. Therefore, favoring characteristics for crop cultivation like the cation exchange capacity are poorly pronounced. In slope, nutrients are easily washed out, and material eroded, which is why exposed soils are highly affected by tropical rain regimes. In many of the BZ's properties, the calcic parent rock is poorly covered by flat soils and farming conditions are highly dependent on the lands' topography and land use history. Although conditions can be enhanced by the incorporation of agroecological management strategies, such as incorporating deep rooters, introducing cover crops or modifying the terrain, soil conditions determine the capacity of producing basic grains and demand high efforts for their conservation (Gliessman, 1998). In the case of overexploitation, yields decrease notably.

Unfavorable soil conditions affected the study's participants. In fact, the lands of the pilot groups are situated in areas classified as suitable for agroforestry only. While observations showed that modifications terraces or the incorporation of cover crops in land plots like was unusual, the association with deep rooters was planted by many. Besides the cultivation of basic grains, small scale differences significantly influenced the plant growth of perennials. The farmers claimed the lack of access to technical soil analysis as a limiting factor. As MAGA lacks laboratories to offer soil analysis and most family farmers resources to pay private institutions, farmers need to experiment. Given that seedlings and time are investments taken, the fact that no technical soil analysis was offered slowed the process of agroecological transitions down and demotivated many.

8.2.5.2 Harsh climate conditions

The BZ's climate is characterized by extremes and uncertainties. Working conditions are hard during the hot season. Water is scare for months. As precipitation fluctuate both monthly as well as annually, it is hard to plan farming activities. When the ENSO phenomenon occurs, droughts are even more extended as usual, which recurrently reduces harvest levels. Besides draughts, other events like heavy rains and winds are natural risks that are expected to increase under each scenario of climate change. As there is no insurance or governmental supports, farming under such conditions is an existential risk for vulnerable farmers. The response agroecologists formulate is the installation of agroforestry and fruit trees subsystems, which enhance microclimatic conditions on site and can - in number - stabilize the regional temperature and rain regimes. Unfortunately, these subsystems are especially vulnerable to weather conditions in their initial phases, as growth and acclimatization of seedlings is significantly hindered by the lack of water or inundation. Climate conditions were received as a threat to the AESs in both workshops.

8.2.5.3 Lack of irrigation infrastructure

Given the irregularity of climate patterns, the installation of irrigation infrastructure could significantly contribute to enhance farming conditions. The lack of viable irrigation structure significantly hinders farming activities and impede in many cases the installation and maintenance of orchards in land plots. Despite the closeness of EC or SP to the lake Petén-Itza, water was mentioned as the main limiting factor for agricultural activities in all three communities. In the land plots, supply is often restricted to simple water holes served as water storages. Improved water holes with materials like nylon are an expensive inversion usually taken by cattle farmers to avoid the dry fall during April. Local maize varieties are quite resistant to draughts, but orchards demand watering, especially in initial phases.

For most participants, water was a limiting factor which especially affected land plots at distance. Within the community, all participants reported to have access to the local tube. However, it does no guarantee a steady water supply. In SP, the water tower is not powered all week, which is why water is stored in the traditional sinks *pilas*. The steep slope impedes the transport of necessary amounts of water directly from the lake. Depending on the distance, necessary amounts can hardly be transported from the household's properties. In LT, which is without access to lake or wetlands, the price of fresh water was named as the main obstacle to produce vegetables or even to mix organic repellents. Like taught agroecological pest control strategies, measures for water storage (e.g. filling soft-drink bottles during rainy seasons) are compatible with orchards and fruit trees near the household, while they are deficient for watering in land plots. Agroecological means have limited influence. Therefore, the shortage of water is an obstacle that only inversions in infrastructure can overcome.

8.2.5.4 Access to and attendance of land plots

The access to and attendance of land plots was a major obstacle to the realization of the agroecological proposal. Other than the ideal AES the project suggests, the pilot groups' land plots in EC and SP were at distance to the village center, which is why the attendance of land plots and management of material flows face practical constraints. The distance contributes to the lack of workforce to meet the demand of time intense subsystems. The insecurity and harsh working conditions hinder family involvement. The difficult access to land plots hinders the transportation of materials.

Workforce cannot be allocated efficiently. The proposal is designed to create labor for eight people, but the workforce is unequally distributed, and its shortage affects individual subsystems unequally. While in average 4.83 family members are involved in the cultivation of backyards and attendance of small livestock, in average 2.78 persons per AES attain the land plots. It must be considered that this number also contains part time labor, as only in 3 cases the farm account for all the families' income and many have voluntary positions, too. Time is a limited resource and demanded by all subsystems. Forest patches, for example, demand a lot of attention. They are exposed to recurrent

fires. To maintain forest patches on the property, fire patrols are necessary. Fuels must be removed. Barriers must be maintained. Agreements with the neighbors must be held. As most of the participants' AESs hardly generate enough income to cover running costs, no assistants can be contracted. In many cases, the family board fulfilled most tasks, while the young were only supporting and looking at other professions.

Traditional female household tasks are incompatible with farming practices when the land plots are at distance. That only in 3 cases, women participated in agricultural activities in the land plot shows that work is traditionally shared within the family. Another indicator is that more participants in EC adapted the strategies where the majority had more than one terrain in the village center. The family's involvement is an aspect mentioned as a strength of the AESs in both workshops. However, the involvement depends on individual conditions. Mothers have time to participate if the households' demands like food preparation and childcare can be met at the same time. No data was collected regarding the attendance of terrains within the village's center, but observation showed that women are actively involved in their cultivation.

The connection and maintenance of interconnected subsystems is essential for closing nutrient cycles and appreciating synergies among the AESs components. It was observed that means of transportation were rare, as within the pilot groups in EC and SP only one member each accounted with a car; few accounted with horses or bicycles. Access was additionally hindered by the roads' conditions, the paths' exposure to sun or gates. To connect e.g. small livestock with MILPA, manure and fodder must be transported physically. Also, the watering of fruit trees and orchards with water from the network is impeded by the distance.

8.2.6 Absence of economic incentives

8.2.6.1 Unprofitability and price fluctuations

Many family farmers face to impoverish, because most farming activities at small scale are unprofitable and farmers are exposed to recurrent harvest losses. Taking the workforce into account, cultivating basic grains is a losing deal, as high price fluctuations and the absence of storing capacities forces farmers to sell with little returns and buy when prices are high. The fluctuations additionally contribute to food insecurity, as high prices for basic grains are likely to coincide with bad harvest years. Given the socio-economic situation of most, dependencies on additional income sources exists. Further, it is difficult to establish profitable AESs under given market conditions. Many requirements more than increasing or diversifying production must be met. Even when cattle breeding is introduced, it is not profitable until a certain number of animals - out of reach for farmers without strategies for capital acquisition. Instead of working towards economically sustainable agriculture, agroecology proposes the turn to self-sufficiency and local markets. However, financial obligations remain. As land is often the only possession with monetary value, AESs are likely to be sold when passing a financial threshold. In a study conducted in communities in Petén regarding decisions to sell land in Petén, the necessity of cash was named as the main reason by most (Zander & Durr, 2011). Given the need for a transition to diversified production systems and a parallel

development of markets, the enhancement of the AESs' profitability is a long-term process. However, the increased diversity supports the families' diet and helps to reduce the households' cost for food.

8.2.6.2 Market demands

The global rise of alternative agriculture is linked to the relation of consumer and producer, as changing demands in markets provide incentives for the organic production of healthy and/or fair food (Marzin et al., 2018). When no direct contact between producer and consumer is established, the products' quality needs to be labeled. The dispense with chemical inputs is often made visible through certification to justify higher prices in the sale. Conventional certification is usually carried out by external institutions, which causes financial burdens for production at small scale. As an alternative, participatory certification can be carried out by the producers themselves in cooperation with official rating institutes. In this case, associations of farmers define a list of criteria to be met, which are controlled by intern evaluation mechanisms and officially recognized by governmental authorities. This system has successfully been implemented in Brazil. In addition to viable certification mechanisms, the interest of wealthy and accessible consumers is a prerequisite for generating higher profits with the trade of the organically produced (Radomsky et al., 2014).

The BZ is characterized by the absence of favorable market conditions for family farmers. Apart from ecofriendly tourism, there is no sales market for organic products - or products in general. Even on local markets, most of the fruit and vegetables are imported from western Guatemala. Maize is often the only commercialized crop. The situation was mentioned by the technicians, who name the lack of markets especially for the organically produced as a threat. The capacitation includes commercialization strategies like the processing of food. Exemplary groups with intensive accompany like the breadnut-women-group can access machinery and export markets. Local initiatives like the community market in SP have initially received attention but to the time of the study, only two stands remained, which indicates unsatisfactory benefits for participants.

8.2.6.3 Cost reduction

Another potential incentive is the reduction of expenses, as the to turn to agroecological measures provides alternatives to costly external inputs. This includes direct savings through the reduction or replacement of chemical means and indirectly the prevention of decreasing production levels caused by environmental degradation. Further, it can prevent increasing demands for conventional inputs due to environmental change and the causes of conventional practices. Regarding livestock, the cultivation of protein rich fodder can reduce the costs for fodder. However, although the incorporation of agroecological measures can reduce monetary expenses, labor costs might be increased as measures often include time intense tasks.

Regarding the pilot groups, it is unlikely that cost reduction for inputs is an incentive for investing in agroecological transitions. This is due to two considerations. First, most presented means are specifically applicable in orchards. According to the farmers, application of chemical pest control

and fertilizer are most commonly applied in the MILPA subsystem. It was not specifically asked what chemicals were applied for but finding support this thought, as costs for fertilizers do not vary much with the farms' size or presence or number of fruit trees but the MILPA extension. Second, as orchards often are being installed during the project, potential costs for inputs applied refer to additional costs related to the transitions.

An exception is fertilizer bean, which was the most accepted strategy, applied during the past year cycle by more than 50% of the questioned. However, fertilizer bean (*Mucuna pruriens*) is a strategy that demands knowledge about its correct application. The bean regrows on the field, but only if burning practices are totally excluded. Therefore, the bean is vulnerable to overarching fires from neighboring fields. Others had lost the seeds and claimed to lack access to more. It was mentioned that the efforts taken for seed preparation were labor intense. In SP, many people were not used to apply fertilizers at all, which indicates that the application of fertilizer bean (*Mucuna pruriens*) was no replacement of existing strategies but a response to decreasing soil conditions.

For livestock alimentation, there is few demand for agroecological alternatives for fodder. The most common animals present in the assessed AESs were poultry and pigs. It was observed that constantly available components of the families' diets basic corn mixture and tortilla leftovers were shared with those animals. The outcomes of the intensification of pasture systems for larger livestock is additionally questionable as (given the demands for calves in southern parts of Petén and bordering departments) usually not the fattening but the breeding of animals generates income, and complex fodder systems might increase labor costs without increasing returns.

8.2.7 Insecurity

8.2.7.1 Political instability

Political stability is a basic requirement for the stability of any economic activity and its deficiencies significantly harm sustainable development initiatives (see chapter 7.1.2). The formulation of laws and law execution can directly influence resource use. Also, policy frameworks influence market conditions. Regarding economic activities, stable conditions enhance the willingness to invest in innovation and long-term planning. Both are essential factors for the long-term transitions of agroecological systems. The political framework also determines the presence and cooperation of different entities. Regarding sustainable development, cooperative and participatory governance structures are required.

The political framework in the BZ is characterized by high instability, which significantly harms the capacity and motivation of farmers to turn to agroecological practices. Institutional work is hindered by the lack of staff and resources. Insufficient attendance of farmers, agricultural activities of family farmers are hindered by the absence of rural infrastructure. Law is not executed and monitoring deficient. The presence of different interest groups defines policies unfavorable for farmer, which face both economic and conservational restrictions. Besides duality and arbitrary changes in official policies e.g. regarding the taxation of properties, unofficial power-networks threatens subsistence

farmers and convey the image of a weak state that cannot guarantee to fulfil its promises. The gravity of the situation and degree of corruption showed clearly given the tolerance of powerful families, which are publicly known to be involved in drug trafficking or the fact that a forth of death causes is due to aggression with fire arms. Given this political framework, it is very difficult for farmers to overcome the financial and bureaucratic burdens to buy land, it is far more likely that possessions pass in the hand of large land owners that have access to the necessary information, and thereby decrease the landscapes functionality.

8.2.7.2 Loss and shortfalls of harvest

Not only environmental conditions but also the poor execution of laws and norms lead to harvest losses, which are an existential risk for vulnerable family farmers. In SP, which is a community of more than four times as many habitants than EC or LT, two aspects related to human risks were mentioned: The loss of the harvest to the neighbor's livestock and the robbery of harvest. Although it is officially prohibited in SP to let livestock graze freely, observations showed that horses and pigs walk in the streets of SP. In the families' home-gardens, vegetables and seedlings are protected by any mean (e.g. fences made from planks) against the animals. Regarding the land plot, it was mentioned by many that the neighbor's cattle endangered cultivated crops. The numerous incidents are often without consequences, as the law is not always executed. Due to the increased population, social norms and rules are hardly to be controlled, as neighbors are increasingly unknown. Concerning robbery, the fact that fruits have been a common good in traditional Q'eqchi´ society might contribute to the casualness by which those losses are reported. It was common among participants to give surpluses of fruits to family and neighbors. Given the growing number of landless families, it can be assumed the socio-economic circumstance increasingly favor robbery of food. According to some participants, not only the fruits, but also the whole tree was cut by thief. This affects the turn to agroecology, as rewards of the increased efforts that take the installation of orchards and agroforestry subsystems are not secure.

8.2.8 Motivation

8.2.8.1 Increased efforts

For any agroecological transition, the farmer's efforts are the main driver of change, as external inputs (e.g. fertilizers) are compensated by dedicated time. Agroecological means often demand radical changes in livelihood strategies, like the preparation and application of organic repellents and fertilizers. Generally, the efforts farmers take to cultivate their land plots are enormous and poorly rewarded. From a European point of view, working conditions are unbearable. As the land plots are at long distance and means of transport are rare, it takes most of the farmers more than an hour to reach their land plots. Few go on horseback, some ride a bicycle on unpaved roads, most walk. Topography and exposure to the sun aggravate the way additionally. Most work is done by hand, using *machetes*. The climate with temperatures from up to 44°c allows to perform some tasks only in early morning or late evening hours. Risks contain violence due to the unstable security situation and poisonous snakes are common. Like knowledge, the aspects farmers' efforts were

sorted as a strength and the lack of commitment as a weakness in both workshops as well as recognized by the technicians. This indicates that assisting personal underestimates the efforts necessary an agroecological transition demands.

8.2.8.2 Ideological incentives

Given the absence of economic incentives for most, it can be assumed that the motivations for dedicated farmers are of different type. One is the seek for improved of living conditions for the family. Comments concerning the household's improved well-being were often related to the diversity and availability of foods for the family's diet. Incentives are also of ideologic nature. Many farmers proudly announced that organic fertilizers had supported the production of large vegetables and fruits of good quality. This might be related to the capacitation, as the educational component of the capacitation was accompanied with sensitization and education concerning the impacts of chemicals on the environment and human health, and frequently referred to. That a dedicated interviewed stated that agroecology was like a religion shows the strong passion some individuals share with ideologic agrotechnicians. This applies especially for promotors. Promotors, who were often organized in groups led by pastors, had been given a respected position as diffusers of agroecological means. The farmers' perception of the forest, their willingness to participate in the study and perceived ride regarding advances indicate high potential for the cooperation with family farmers and agroecological transitions. In EC, only one participant refused to take part in the study, in SP there were two refusals. Only in LT farmers showed few interests in the study, which is why only two interviews were conducted.

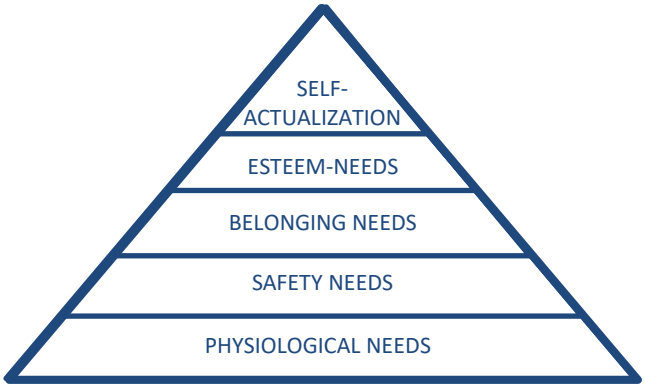

Figure 48: Hierarchy of needs (Maslow, 1943)

Ideological incentives can be problematic in the given context, as farmers are highly vulnerable and exposed to external stresses and stressors. As shown by Maslow (1943) in the pyramid of needs, the fulfillment of basic needs is forming the base for any other motivation (Figure 48). The fulfilment of basic needs for themselves and the family is always priories by the human agents. The next level is the feeling of security and safety. For most participants, long term planning is hindered by unstable conditions and the unpredictability of future political and environmental circumstances. As organized in groups, for the passioned, agroecology provides a common interest. Promotors receive encouragement from the church and the community, which might cover their esteem needs. Given the closeness to nature of many, one might encounter self-fulfillment in traditional forms of agriculture. However, the degradation of environmental conditions and availability of land might endanger the farmer's food security in the future and thereby eliminate ideologic incentives for agroecology.

8.3 Recommendations for the adjustment of agroecology as a stewardship strategy in the MBR BZ

In this chapter, the high potential for agroecology for ecosystem stewardship as well as the main obstacles the proposal faces are discussed before formulating specific recommendations.

8.3.1 The urgent need for acting to prevent the BZ-SES from collapsing

The current trajectory of the BZ-SES today shows similar patterns to historic developments. The collapse of the Maya culture is related by most historians to a mix of driving forces. Just like today, these included changing climate conditions, growing population pressure and deforestation. The forest which is today a provider of ecosystem services not only for a single empire but of global importance, had recovered during postclassic times only to face similar drivers of change again about just a thousand years later. Colonization programs have attracted settlers which have turned large areas into agricultural and pasture land. In 1990, the declaration of the Selva Maya Biosphere Reserve can be interpreted as a reorganization phase (see chapter 2.1.3). Results of the present work suggests amplified feedbacks, which draw the BZ-SES towards a degraded state (Figure 49).

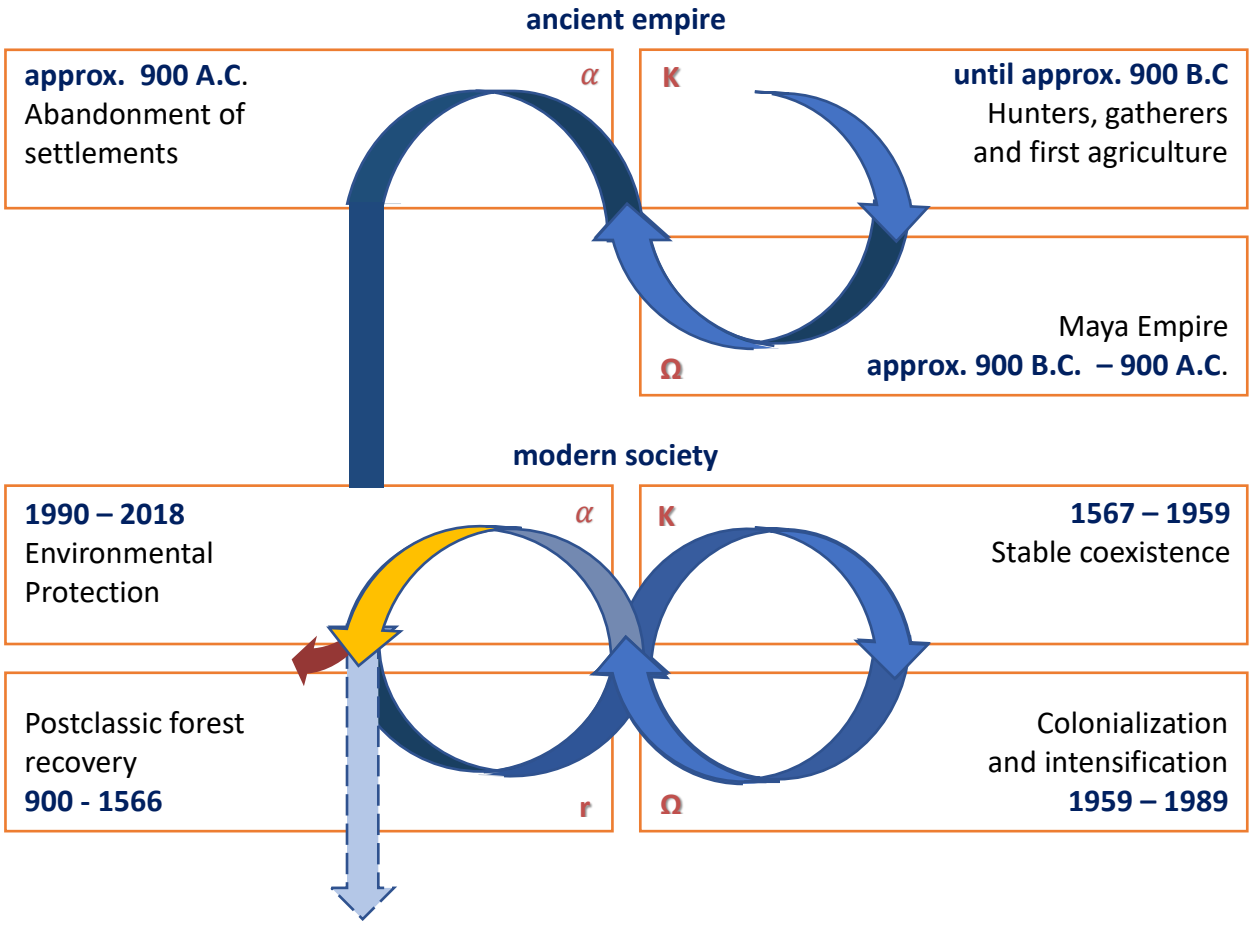

Figure 49: Adaptive trajectory of the BZSES. Historic development is sorted into phases (orange rectangles). Today, the BZSES is at a turning point, either developing into a new recovery phase (light blue arrow pointing downwards) or shifting into a degraded state (little red arrow pointing sideways) (own elaboration orientated on Gunderson & Holling, 2002, p. 12)

8.3.2 The agroecological landscape as a biodiverse stable-state

Ecosystem stewardship and agroecology are similar approaches to foster human-nature relations. According to the ecosystem stewardship paradigm, the path towards sustainability is actively managing socio ecological systems towards a desired alternative state. A long-term sustainable state is characterized by low vulnerability, high environmental and social resilience, adaptive capacity and transformability of the focal SES (Chapin, Folke, et al., 2009). Equally, the overall goal of agroecological strategies is the creation of sustainable landscapes composed of a mosaic of resilient AES, that guarantee well-being of the agricultural society by assuring food and energy sovereignty and social justice for peasants (M. A. Altieri et al., 2012). In both ideals, the base for this resilient landscape is formed by its empowered habitants, who shape their natural environment in a diverse and sound matter and thereby sustain their production base by maintaining the system's ecological functionality.

The main characteristic of resilient eco- or AESs (both at individual or landscape level) is diversity. The concept of biodiversity addressed both, the vegetation cover and soils. By sustaining the ecosystem's functional traits at landscape level, related supporting ecosystem services guarantee the long-term supply of provisioning, regulating and cultural services. Those services are directly related to agricultural activities. Certain diversity components like landscape diversity, functional composition, genetic diversity or species number contribute to the provision with the following ecosystem services: (1) Production by societally important plants, (2) Stability of crop production, (3) Maintenance of soil resources, (4) Regulation of water quantity and quality, (5) Pollination for food production and species survival , (6) Resistance to inversive species with negative ecological/cultural effects, (7) Pest and disease control, (8) Biophysical climate regulations, (9) Climate regulation by carbon sequestration and (9) Protection against natural hazards (Modiefied from Díaz et al (2008), cited by Chapin, 2009). Hence, ecosystem stewardship that fosters biodiverse landscape is a basic requirement for the installation of individual resilient AES. Vice versa, mosaics of diverse AESs may create sustainable conditions within SESs. The ideal of a natural matrix of AES forming a resilient landscape challenges the persistent paradigm of environmental conservation (Tenza Peral, García-barrios, & Giménez Casalduero, 2011).

Examples of local AESs orientated on traditional practices are highly diverse in their functional composition, species number and the genetic diversity of crops (Bonilla Espinoza et al., 2012; Ford & Nigh, 2009). The Mayan AES contain orchards, MILPA, agroforestry and mixed forms. Not only at individual, but also at community scale, both Itza and Q'eqchi' Maya appreciated synergies between different subsystems, like planting orchards next to forest patches. Thereby, they appreciated the benefits from diverse vegetation forms (Atran et al., 2004; Grandia, 2009). Through shifting cultivation, secondary vegetation covered a major part of the AESs. Given the bioclimatic conditions, these are fast growing and quickly reinstall the functioning of a forest system that regulates water cycles, microclimatic conditions, enhances pest control mechanisms and soil productivity (Ewel, 1999). Also, they incorporate agroforestry systems which can be nearly as diverse as forest cover (Palm, Vosti, Sanchez, & Ericksen, 2005).

The desired development of the BZ-SES is towards a mosaic of sustainable AESs, which supply ecosystem services that guarantee the well-being of the rapidly growing population. In the BZ, there is potential to restore AESs with depleted knowledge base and diversity. The exemplary assessment presented in the present study has shown that famers are willing and cooperative to enhance the diversity of crop species and genetic diversity (see chapter 8.2.8). Given that a growing rural population demands sustainable livelihood strategies, workforce is available for the installation and maintenance of diversified AESs. For decades, several organizations have focused on the establishment of exemplary systems and the reestablishment and enhancement of the knowledge base. Ideally, the cover with sustainable AES could enhance the overall resilience of the BZ-SES by directly providing ecosystem services to the most vulnerable and simultaneously at various scales through both horizontal and vertical interactions of the BZ-SES components (AESs) (Figure 50).

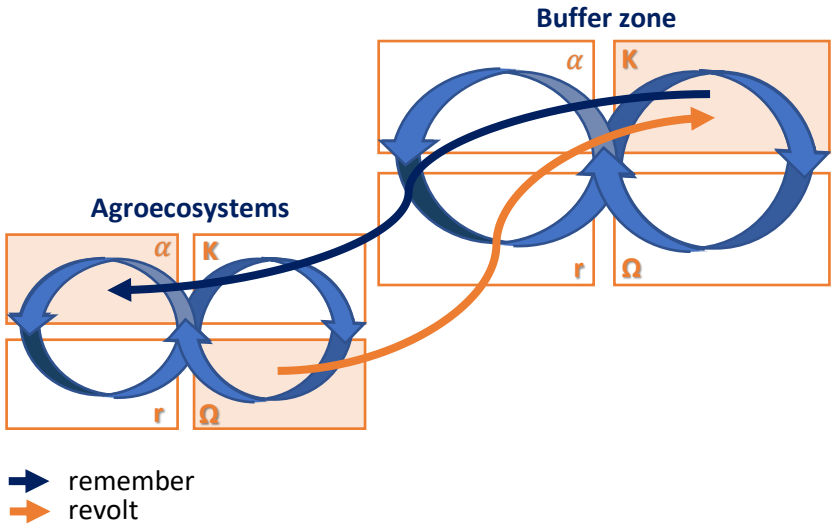

Figure 50: Resilience at AES level and BZ level influencing each other: Exploited AES (in Ω-Phase) revolt the stable state of the BZ. Persistent conditions at BZ level (K-Phase) are "remembered" at AES-level

A landscape composed of pasture lands does not only fail in provide ecosystem services but also in livelihood strategies for its habitants. Poor natural vegetation cover fails in regulating water and nutritious cycles or climate. Furthermore, a SES with poor labor demand per area cannot employ the population, which is already impoverishing. Regarding provisioning services, extensive livestock breeding does neither contribute to enhance the food security nor wealth of the rural population. Area which could be dedicated to the production of basic grains is used to obtain monetary returns via the exportation of calves, that only benefit few. Ongoing land concentration and economically favorable conditions enable the acquisition of capital, area and influence. It is likely that pressure on CZ and MUZ increases when the production base of marginalized families becomes overexploited due to increasing demands of the landless and unemployed. Unfortunately, current trends with amplified feedbacks indicate the likelihood of the BZ-SES to completely shift towards this regime.

Without a functional BZ-SES that buffers migration pressure, the MBR is put at risk of an eventual collapse regarding both, its social and environmental properties.

According to the masterplan, current management in the BZ is orientated towards a contractionary state, which compromises between environmental conservation and economic development. Regarding environmental conservation, the maintenance of the forest cover is clear priority. Regarding agriculture, MAGA launches several development programs, of which the majority is orientated towards the economic development of the sector. While subsistence systems with surplus are ranked “good”, commercial monocultures are considered “very good”. Although considered poorly sustainable, a goal considered as high priority (Rudy Herrera, CONAP/GIZ, personal communication, March 2018) is the implementation of semi-intensified systems, where fodder is intensively cultivated (CONAP, 2015c, p. 224). As a desired future state regarding the BZ cattle sector, the plan considers very good market prices, high profitability and market prices and a very good sustainability of those farms, which is defined as a forest cover of more than 20% per hectare (CONAP, 2015c, p. 211).

8.3.3 Management shortcomings that hinder the GIZ agroecological proposal to generate sustainable impacts at BZ level

Management shortcomings and obstacles impede the success of agroecology as a management strategy. These include spatial, temporal, threshold behavior and cascading effects type described by Galaz et al. (2008).It is estimated that only 18% of the area remain in the hands of subsistence and subsistence with surpluses, which is why agroecological transitions at landscape level through the promotion of agroecological measures in family farming are unlikely to occur (CONAP, 2015c, p. 222). The Agricultural proposal approaches long-term change, estimating 15 years until the AESs sustainability and cultural acceptance. Since land markets are very dynamic and farmers are extremely vulnerable, they demand short term solutions that help them to cope with stresses that need immediate investments. The management might decrease the vulnerability regarding food security, as it diversifies the families’ diets and helps to cut costs for alimentation, but because of the deficient market situation does not increase the financial capital, which is why the threshold (need for cash) remains. Consequently, the implementation of agroecological measures is insufficient in opposing cascading effects that the expansion of pasturelands and marginalization of farmers provoke (Table 18, next page).

Table 18: Shortcomings in management (Galaz et al. (2008), cited by Kofinas, 2009, p. 89)

Type of shortcoming	Definition	Consideration regarding the GIZ agroecological proposal in the MBR BZ
Spatial	Does not match the spatial scales of ecosystem processes	Applies: Family farmers possess less than 20% of the remaining area (see chapter 7.1.4)
Temporal	Does not match the temporal scales of ecosystem processes	Applies: The proposal approaches long-term change (15 years until culturally accepted) but amplified feedbacks favor land concentration more rapidly (see chapter 3.2.2)
Threshold behavior	Does not recognize or is unable to avoid socio-ecological regime shifts	Applies: It does not enhance the economic situations of farmers who remain vulnerable and, if cash is needed, most likely sell their AES (see chapter 7.2.2.3)
Cascading effects	Unable to buffer or amplifies cascading effects between domains	Applies: Social- and environmental conditions for farming worsen with the expansion of pasture land at landscape level (see chapter 7.1.6)

The greatest contributions for large-scale changes In Latin America did not derive from the strict orientation on organic farming measures but deriving opportunities for family farmers to demand more favorable setting (see chapter 8.2). Both in guidelines and application of the proposal, the interpretation of agroecology is reduced to its most practical form. The masterplan defines agroecology as the incorporation of ecological measures and systemic view in AESs (CONAP, 2015a, p. 23). National guidelines for the application of agroecology do not differ between organic or agroecological means (MAGA, 2013). The absence of autonomously organized farmer groups and generally few sources regarding the Itza Maya practices indicate that the "right fit" of agroecology has not evolved yet (Figure 51).

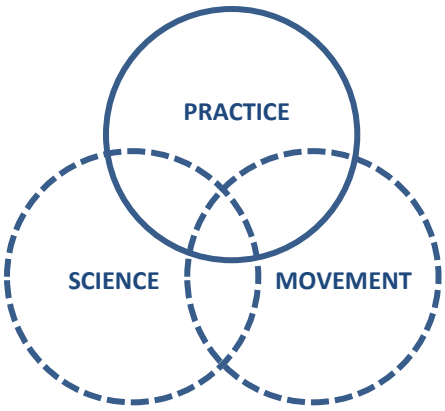

Figure 51: The three dimensions of agroecoly. In the BZSES, the focus is on promoting practices and the components science and movement were perceived absent.

8.3.4 Recommended management adjustments for enabling agroecological ecosystem stewardship

This chapter gives recommendation for the adjustment of management that incorporates agroecology for enhancing the resilience in the BZ. Therefore, it is referred to the triple loop learning process proposed by Folke et al (2009) (see chapter 2.2.4). Recommendations are sorted into the categories single-, double- and triple-loop learning. Additional considerations are made regarding the expected magnitude of change and obstacles to adapt the management process (Table 19, p. 116).

Recommendations regarding the adjustment of strategies to meet the predefined indicators were formulated and presented to representatives of local stakeholders (GIZ, MAGA, Pastoral-Social-VAP, local leaders and the pilot groups). Predefined indicators are the enhancement of the species diversity, increased production and income levels by a certain number of households. To the farmers, it was recommended to enhance the communication of needs and critics. To the named institutions, it was recommended to reinclude excluded pilot group members, to implement participatory monitoring mechanisms, to receive anonymous feedback and to invest in soil analysis and irrigation structures. The expected magnitude of change is to increase the number of applicants of agroecological measures, and to enhance the knowledge base regarding organic farming practices in the pilot groups' communities. Obstacles are the scarcity of resources, which include technical staff. Also, the project ends in 2019, which impedes to accompany the potentially nudged agroecological transitions by the GIZ.

Given that the institutional framework and unfavorable conditions at the BZ level impede individual agroecological transitions and the model's multiplication, recommendations regarding the adjustment of policies are expected to cause change of greater magnitude. It is recommended to adjust institutional coordination and formulate a joint vision, which gives priority to neither economic development nor conservation without the creation of clear benefits for the rural population. Economic incentives and investments should be directed towards family farmers instead of livestock activities, as it is clearly the better option for both environmental and social sustainability. It is further recommended to enhance market conditions to set economic incentives for the production of fruits, vegetables and agroforestry products. Investment need to be taken in the enhancement of rural infrastructure, to combine technology with local knowledge. Most importantly, it is recommended to enhance the transparency of land concentration and react accordingly. This way, farmers that put AES in place could benefit from the transitions by selling surpluses and thereby inspire the remaining farmers in possession of land or usage rights. Besides increasing pressure on natural resources because of the growing population, obstacles are the severe scarcity of human and financial resources as well as national interests and power distribution.

For an agroecological transition at landscape level, fundamental changes regarding both management paradigm and governance structure are necessary. Overall, land reform is demanded, that redistributes land concentrated by minorities among the growing rural population. Adaptive

co-management with empowered local communities, with a truly participatory structure and learning mechanisms for the recurrent adaption of strategies, could reactivate the potential for traditionally divers AES by eliminating the obstacles current structures present. It is recommended to restrain from focusing on advances but communicate dysfunctional management towards the critical socio-economic conditions of family farmers. Obstacles are the mentioned before, plus the dominant paradigm of conservation and economic development. Also, the erosion of traditional knowledge and values as well as the low education level ongoingly decrease the conditions for adaptive co-management. It must be acted quickly to restore the functionality of a viable BZ with its potential harmonious interplay of humans and their natural environment.

Table 19: Recommendations, magnitude of expected change and obstacles regarding the planning and progress for single-, double- and triple-loop-learning adaptions of management

	Single-loop learning	Double-loop learning	Triple-loop-learning
Planning and progress	• Install participatory monitoring mechanisms for AES • Receive anonymous feedback • Ensure participation of the participants in planning and execution of the agricultural proposal • Guarantee transparency regarding donations and requirements • Support with applications for forest incentives • Reintegrate excluded members	• Formulate a joint vision to align institutional action • Monitor land concentration and react accordingly • Set positive incentives for horticultural production and negative incentives for cattle raring • Direct investments towards family farmers (to enhance the rural infrastructure) • Avoid or minder misfits regarding recommended management strategies	• Nudge reforms for equal land distribution • Install adaptive co-management mechanisms regarding both economic development and environmental protection • Design favorable conditions for traditional land management • Communicate dysfunctional management and rise global attention towards the critical socio-economic conditions of the remaining Maya population
Magnitude of expected change	• Fostering agroecological transitions of an increased number of individual AESs • Increasement of local and regional knowledge base regarding alternative farming practices	• Fostering subsistence AES towards subsistence AES with surpluses • Stabilizing feedbacks and hinder the advance of pasture land on private lands	• Reestablishment of the BZ's ecological and social functionality by navigating towards a resilient landscape composed of diverse AESs with forest patches • Decreased pressure on the Selva Maya in CZ and MUZ
Obstacles	• Available staff • Funding to take necessary investments • End of the GIZ project in 2019	...and: • Power imbalance • Administrative deficits (scarcity of staff and financial resources) • National economic interests • Growth of the rural population	...and: • The currently dominating conservation and development paradigm • Formal education level of the rural population • Shifting values and eroded knowledge base

9 Conclusion

The present thesis illustrates a case for the application of agroecology as a management strategy. The example is drawn from the MBR BZ, where the GIZ has supported the formulation and implementation of an agroecological proposal. An evaluation is conducted by assessing the addressed AESs and their socio-ecological context. The usage of the ecosystem stewardship framework proposed by Chapin, F. Stuart; Kofinas, Gary P.; & Folke (2009) provided valuable concepts for the interpretation of agroecological transitions as navigated change. Different approaches were combined. This allowed to shift the focus towards limiting factors at BZ level, as the survey study revealed not only the deficiency of the monitoring mechanism but also showed that individual transitions were partly impeded due to external factors.

Responding to the question, how the BZ-SES is composed, results revealed the highly unfavorable conditions for agroecological transitions at both the individual and the BZ level. The adapted SES approach formulated by Ostrom (2009) guided the description to identify the factors that enhance or limit the feasibility of the agroecological proposal. Not only farmers, but also the institutional framework lack necessary resources to enhance the situation. Mayor obstacles derive from socio-economic and political conditions, like poverty, insecurity, land tenure, the lack of economic incentives, the depletion of traditional farming practices, and the absence of adaptive co-management mechanisms. The analysis could not provide a complete picture of the heterogenous BZ but indicate amplified feedback processes which increasingly worsen the conditions for family farmers. Due to these trends, the land in the hands of family farmers is rapidly decreasing and and current supports are unlikely to enhance the situation. However, findings also suggest that the BZ holds great potential for an agroecological transition, as environmental protection is tin the interest of both the constitutional framework and family farmers.

Findings indicate that through support from the GIZ project, the diversification of several AESs and the enhancement of local knowledge regarding agroecological measures was achieved. Many farmers reported an enhanced quality of life related to the increased availability of fruits and vegetables. Model AESs and networks of *promotores* were recognized. During the fieldwork, results from a survey study and observations revealed factors that limit the agroecological transitions of individual AESs. These include the distance of the land plots from the households and the farmers' lack of economic resources for the maintenance of profitable AESs. Also, deficiencies in the process like the lack of documentation, irregular attendance of beneficiaries and shifting attention towards a reduced number of individuals were documented. Hence, the data base regarding original beneficiaries was considered insufficient and misfits of the chosen evaluation approach MESMIS impeded the detailed assessment of individual agroecological transitions. However, the attempt generated valuable insight to outer factors that hinder farmers in the adaption of agroecological means.

Recommendations regarding deficiencies of the implementation process could be detected and communicated to several relevant stakeholders. However, it is suggested that only fundamental

changes that address both the institutional functioning and underlaying development paradigm that guides institutional efforts can activate the potential for agroecological transition towards an ecologically and socially resilient landscape. This way, cascading effects of amplified feedback processes could be opposed, and a shift of the BZ-SES towards a degraded state be impeded. Measures must be taken as soon as possible to activate the remaining potential and empower family farmers to become the ecosystem stewards the Selva Maya needs. Economic incentives and investments must be directed exclusively towards family farmers, as a diverse AES landscape is clearly the better option for both environmental and social sustainability of the BZ and MBR. Ensuring reliable investment opportunities and developing rural infrastructure is considered more effective to enable farmers to transform their AES than offering capacitation regarding organic measures.

Further studies primarily need to investigate how to overcome the obstacles that create unfavorable conditions for family farmers. As participatory structures at community and municipal level are already put in place, investigation could focus on network structures (e.g. regarding the contributions of COMUDE in decision making) to foster cooperation. Multiple-scale analysis and the incorporation of political ecology approaches could draw attention to power imbalances (Bryant & Bailey, 1999). More detailed consideration on literature about BZ functioning could compare experiences from similar management structures (UNESCO, 2016). The scientific dialogue regarding agroecological measures should provide more evidence regarding potential contributions of traditional management for ecosystem stewardship at broader scales. A comparative study concerning agroecological transitions at landscape level could reveal what is needed to activate the inherent potential of agroecology to incorporate the farmers' perspective in ecosystem stewardship.

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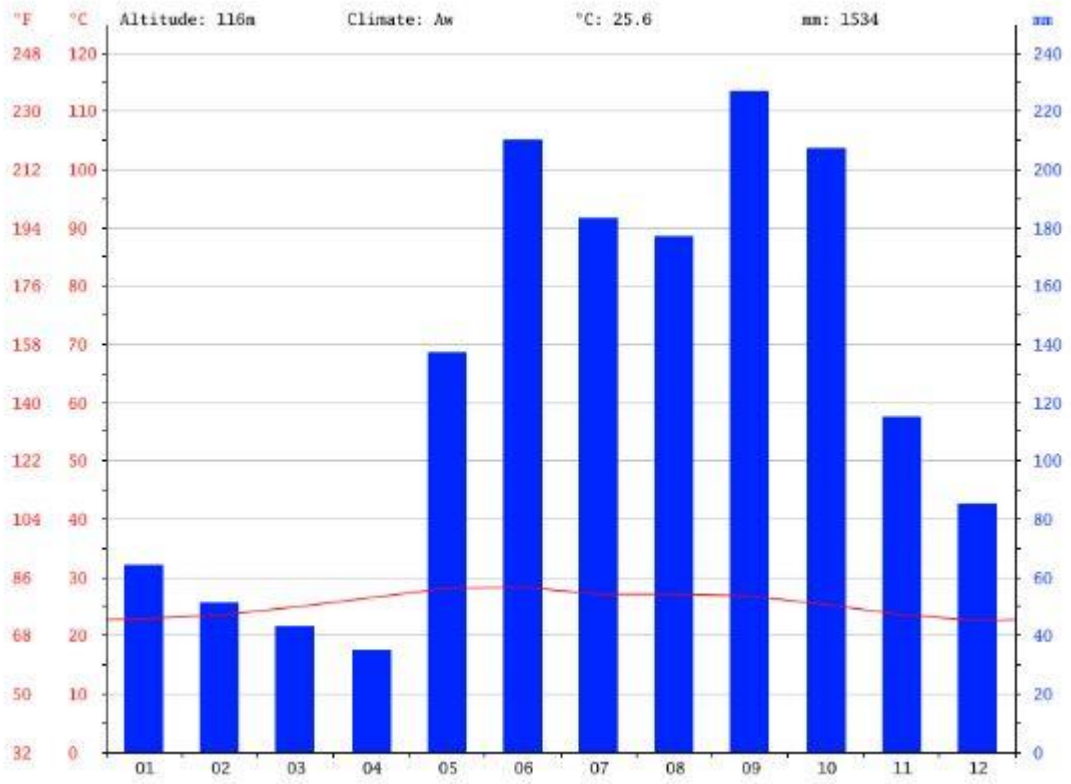
11 Annex

1. Climate chart San José



2. Feedback workshop with agrotechnicians

-

2.1. Participants

Number	Name	Organization	Position	Years in org.	Area	Approach
1	Enzo Solari	GIZ	Technical assessor	1	ZAM - MBR	Agroecology
2	Cesar Agusto Cacau Pop	Municipality of Flores	Technician in agricultural production	2	Municipality of Flores	Agroecology
3	Elmer Lopez	Municipality of Flores	Coordinator	18	Municipality of Flores	Mixed
4	Amalia Valladarez	MAGA	Technicain in Agricultural development	9	Rural Area Municipality of Flores	Mixed
5	Oscar Luis Cabrera	MAGA	Technician technological transference	12	Petén	General
6	José Mendoza	MAGA	Technician in family agriculture	1	Municipality of Flores	Mixed

-

- 2.2. SWOT analysis

	Strengths	Weaknesses
intern	• Work experience and expertise of technicians [1,2,3] • Institutional cooperation with logistic capacity [1,5] • Low production costs [2] • Presence of diverse plant[4] and animal[2] species • Practice of agroecological strategies (e.g. soil conservation, organic repellents)[2] • Participation[2] and expertise[3] of pilot groups • Communities' social capital (respect, cooperation, …) [1,4,5]	• Cultural boundaries [1,5] • Lack of resources (staff[1], means of transport[3], laboratory and material[4]) • Bad working conditions for technical staff (e.g. salary) [3] • Access to communities and long distance to land-plots [2,4] • Different objectives of organizations and participants[1] • Lack of communities' self-organization • Poor institutional cooperation[1] • Participants' resistance to change[2] • Abandonment of processes (change of technicians, change of owner, change of work lines, change of staff) • Lack of commercialization strategies[2]
	Opportunities	**Threats**
extern	• Availability of land[1,3,4,5,6] • Institutional cooperation, presence and capacitation [1,3,6] • Economic development • Alternative production methods[2] • Seek for a better diet and production of healthy food[4] • Mitigation of environmental change[2]	• Climatic conditions[2,4,5,6] • Lack of markets and no market for organic products[5] • Environmental change [2] • Political instability[3,5] • Legal setting of land ownership[5]

3. Expert interview

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3.1. Spanish version:

La entrevista forma parte de un conjunto de entrevistas con expertas para aplicar un enfoque sistémico a la descripción de las comunidades El Capulinar, Los Tulipanes y San Pedro. La transcripción se reenvía para la verificación de lo documentado y para ofrecer la oportunidad de eliminar contenido delicado. Al final se pregunta el favor de recomendar fuentes adicionales de información y socios de entrevista adecuados. Además, se considera opinión sobre la dirección de la investigación apropiada.

La entrevista es semi-estructurada y trata de capturar información sobre categorías de variables definidos por el enfoque "sistemas socio-ecológicos" (Ostrom, 2009): *Configuraciones sociales, económicas y políticas (S), Sistemas de recursos (RS), Unidades de recursos (RU), Sistemas de gobernanza (GS), Usuarios (U), Interacciones (I) → consecuencias (O),* y *Ecosistemas relacionados (ECO).*

Se pregunta el favor de compartir su experiencia personal respecto a los temas

1. medio ambiente
2. entidades presentes
3. desarrollo

Se solicita facilitar la experiencia general como también las diferencias entre las comunidades mencionados. Además, descripciones sobre condiciones relacionadas a escalas más altas sirven para determinar el contexto regional. El estudio se enfoca al periodo entre 2013 y 2018, pero trata de tener la perspectiva histórica en cuenta.

Aspectos por cubrir:

Medio ambiente	**Entidades presentes**	**Desarrollo**
• **Recursos naturales**	• Actores claves (Presencia, influencia, grado de participación de los campesinos, …)	• Proyectos desarrollados y experiencias con la implementación de técnicas agroecológicas
• **Degradación o mejoramiento del estado** •	• El campesino como usuario de unidades de recursos	• Momentos claves
• **Agrosistemas presentes**	• Entidades de recursos (recursos comunes, recursos privatizados, …)	• Problemas (y soluciones propuestas)
• **Tenencia de la tierra** •	• Interrelaciones claves (Servicios ecosistémicos, cooperación, …)	• Lecciones aprendidas
• **Dificultades para la agricultura resultando de condiciones específicas** •	•	•
• **Delimitaciones** •		
• **cambio del uso de la tierra**		

3.2. English version:

Interviews with experts

The present interview forms part of a set of consultancies with experts. The overall objective is to apply a systemic approach to the description of the communities El Capulinar, Los Tulipanes and San Pedro. The transcript is later sent to the participant to verify information and to offer the opportunity to remove sensitive content. In the end, the interview partner is asked to recommend additional sources of information and further interview partners. In addition, opinions on the research design is considered.

The interview is semi-structured and tries to capture information according to categories of relevant variables, which defined by the socio-ecological systems approach (Ostrom, 2009): *Social, economic and political configurations (S), Resource systems (RS), Units of Resources (RU), Governance Systems (GS), Users (U), Interactions (I) → Outcomes (O),* and *Related Ecosystems (ECO).*

The sharing of personal experience regarding the issues

1. environment
2. present entities
3. development

Is requested. Further, the interview partner is invited to provide information about the general experience as well as the differences between the mentioned communities. In addition, descriptions of related conditions at larger scales serve to determine the broader context. The study focuses on the period between 2013 and 2018 but tries to take the historical perspective into account.

Aspects to be covered:

Environment	**Present entities**	**Development**
• **Key characteristics of natural resources and present ecosystems**	• Key actors with characteristics (presence and intention, influence, degree of participation of the peasants, ...)	• Developed projects and experiences with the implementation of agroecological techniques
• **Status and trends of the ecosystems**	• The farmer as a user of resource units; Self-organization and participation efforts	• Key moments
• **Present agrosystems and land-use**	• Resource entities (common resources, privatized resources, ...)	• Problems (and proposed solutions)
• **Land tenure**	• Key interrelations (ecosystem services, cooperation, ...)	• Lessons learned and formulated consequences
• **Difficulties and opportunities for sustainable agriculture resulting from specific conditions (ecological or socioeconomic)**	•	• General trends and future prediction •
• **Delimitations and related ecosystems**		

3.3. Transcription

Transcripción Rudy Herrera 7.03.2018, 8:50 – 9:50, Oficina CONAP, Ciudad de Flores

M: [Muchas] gracias por participar en la entrevista […] [Empiezo con la] retroalimentación y te me presento a mí y la investigación: Soy estudiante de una maestría de doble titulación de ciencias ambientales y manejo de recursos naturales de las universidades Universidad Autónoma de San Luis Potosí y la Universidad de ciencias aplicadas de Colonia. […] La entrevista ahora forma parte de un conjunto de entrevistas con expertos. También van a entrar algunas [expertos] del MAGA y los agrotécnicos que están involucrados […].

M: […] Empezamos con San Pedro […]. ¿Cómo es la situación [ahí]?

R: San Pedro, por empezar, es un grupo indígena Q'eqchi. La cultura Qeqchi- en el pasado - fue muy respetoso - se dice - a la naturaleza, de lo cuál ellos antes de tumbar el bosque perdían permiso a la naturaleza [..]. [Hoy en día] ya no lo respetan [por varios motivos:] La presión, la necesidad [o] por tener un espacio de tierra para cultivar. [Ellos] trabajan comunal, [es decir], uno se ayuda [a otro] con la agricultura. [Eso es porque] muchos de ellos son familiares. Todos los hombres trabajan en la tierra y muchas mujeres también. [Trabajan] en los patios y fuera del traspatio [y] de la casa. [Ahí] la mujer cultiva especias [para] recibir alimentos o medicina. [Pero] si tú preguntas a muchos de ellos que cantidad de cultivos tienen, ellos […] van a decir que [sólo] cultivan maíz, frijoles y pepitoria. Pero cuando tú vas a las zonas de recogidos […] en su área […] ellos tienen una diversidad de especies ahí.

M: ¿Entonces ellos tienen un traspatio, pero también tienen […] parcelas?

R: [Sí], tienen su parcela […]. La mujer trabaja principalmente en el traspatio y el hombre es él que trabaja en la parcela.

M: ¿Y eso no cambio durante el proyecto?

R: Eso se mantiene […]. Eso ya es mucho la natura [de] la cultura Q'eqchi. [El] hombre es el señor de la casa y él es el que manda - y sólo es él que tiene derecho a opinar. La [opinión de la] mujer [es secundaria] y a veces [los hombres] no permiten que las mujeres participen […] en las reuniones y […] actividades […].

M: [Con] respeto a la comunidad [y] a la organización entre ellos: Ya dijiste que son muchas familias con parcelas […] ¿Así sería el compuesto de la comunidad […]? […] ¿Tienen sus traspatios y sus viviendas [a dentro del centro] - y las parcelas […] quedan un poco alejados?

R: Retiradas […] del área de viviendas […]. Cada uno tiene su ranchito [en el área de viviendas, su […] terreno para vivir con sus gallinas y sus cultivos del traspatio. Pero el trabajo lo hacen en la parcela. Se podría decir que en el grupo Q'eqchi hay más involucramiento de la mujer [dentro el centro de] la comunidad. El hombre [en el campo] cosecha la pepitoria [o] cosecha chile - dependiente de los cultivos que tiene.

M: ¿Y ves algún problema con [dicha] separación del trabajo? […]

R: No. […] Es así. Es su cultura y ellos [lo hacen así]. Aparte es un poco difícil de cambiarlo.

M: [Hablamos del] medio ambiente y los recursos [naturales] que están ahí […] ¿Sus terrenos tienen valles […], es decir, son separados?

R: Algunas tienen cierras, pero no muchos. Muchos de ellos plantan árboles como acercas para [marcar] los límites de las parcelas. Pero muchos [no]. Son familias […].

M: […] ¿Es un espacio común? Y respecto al bosque que todavía tienen en sus parcelas: ¿Hay bosque primario o es […] secundario?

R: Todo [el bosque] es secundario. [El] bosque primario en el área donde hemos trabajados - en la zona de amortiguamiento - ya desapareció. Todo ha ido […] por el tema de colonización […]. [En] la región de la MBR a partir del paralelo 17'10 […] se convirtió a una nueva especie de forestales. […] Un bosque primario como tal no lo es […].

M: ¿El bosque secundario también [les] provee [con] servicios ecosistémicos?

R: De hecho, es un [área de] bosque [de lo cual] mucha ya tiene [de 50 años a 80 años]. [Las familias] lo usan para extraer productos como leña [y material] para construir sus viviendas o acercas. También sacan productos no maderables: Pueden sacar xate, colectar pimienta, chico, chico zapote y muchas cosas […] que son nativos del bosque […].

M: ¿Y [hay] algún espacio […] común? ¿[O algún área donde] comparten [el manejo] entre todos? […]

R: Por lo general […] cada uno tiene a su parcela - no estoy seguro si en caso de San Pedro tengan un área comunal […]. La situación de las tierras acá en peten es que a cada uno se le han dado una parcela y una caballería. En ese espacio [todavía] hay […] áreas delgadas del bosque […] y las áreas de cultivos. [Digamos] que […] la importancia para nosotros para trabajar en la zona de amortiguamiento es que esas personas cuales están ahí, […] conserven el bosque, no lo agotan y no habiten a su área de cultivo, […] para que exista está conectividad del bosque […].

M: ¿Y las personas que ya están involucrados en este programa - es la mainía de la gente [de] San Pedro?

R: Sólo es un parte. […]. [Había] criterios formulados al inicio del proyecto [y se] seleccionó a esos tres comunidades. [Eso es porque] no había recursos para todos. [Esos] comunidades […] hacían presión sobre las zonas núcleos o las áreas [obtenidas]. Estaban agotando el bosque o estaban

cazando […]. Orto criterio era que en las comunidades se iba [sólo] con una parte de la población - porque no podemos ayudar a toda la comunidad por [la falta de] recursos para atenderles a todos. [Así] se trabajaba con un numero de personas que […] estaban interesados. [Se hizo] la experiencia piloto con ellos. En una comunidad […]como san pedro [tú vas a escuchar que no son] 100% […] agricultores, sin embargo, uno o dos son carpinteros otros dos son pastores de la iglesia - no toda la comunidad la gente iba - pero es posible que tengan su parcela.

M: [Enfocándose en las dinámicas regionales] - ¿La mainía de la gente tiene trabajo en [la ciudad de] Flores? ¿[Desde] ahí también hay un flujo de [ingreso hacia la comunidad]? […]

R: ¿De fuentes de afuera? Digamos […] que San Pedro es una comunidad [donde] la mainía de la gente no creo que tenga trabajo en Flores. Estamos al otro lado [del lago] y ellos se dedican a la agricultura. Puede ser que [si] no hay trabajo en las parcelas […] van a otras fincas y por ejemplo las hijas pueden dar servicios en los hoteles y restaurantes.

M: ¿[Dices que] el turismo también [es] una fuente del ingreso?

R: De hecho, aunque no sé en la orea […]es en toda la ruta luciérnaga - es una ruta luciérnaga que hay ahí en el norte del Lago Peten Itza.

M: ¿Y […] cambió mucho, [la actividad turística]? ¿[Cambios en el estado de las comunidades entre 2013 y 2018 podrían venir de estar casadas por esos cambios?]

R: [Del] turismo no estoy seguro. Lo que si podríamos decir es que […] es una zona transitaria [donde] seguramente paran a comprar un agua o para hablar con la gente, pero un cambio de podría pensar es que [se organizaban] por ejemplo para hacer [una] construcción donde van a poner su mercado y van a vender sus productos. […] Aunque no lo hagan diario todavía, tienen [ciertas] fechas del mercado. [Por] eso también las comunidades ya se dedican a eso mercado.

M: ¿[Y] el mercado nació de los proyectos con ustedes?

R: De repente de la Pastoral Social […], pero eso es algo que me llamó mucho la atención y que hecho creencia en el caso de San Pedro

M: Claro. Por la perspectiva de la economía [de la comunidad].

R: San Pedro y Jobompiché […] son las dos comunidades que trabajan con la Pastoral Social ahí […] con nosotros.

M: Ya hablamos un poco de la tendencia de la tierra. ¿La gente todavía [posee] sus propiedades?

R: Sí, se conoce por comunidad [pero] lamentablemente no se han dado el título de la propiedad.

M: ¿No se han dado?

R: No, [sólo] a algunos. Bueno eso había que ver [porque] algunos sí [lo] tienen. Pero creo que son lamentablemente pocos, porque es un trámite que tienen que [solicitar]. Cuando se fundó la ZAM, se compartió por propiedad privado. Ahí es la zona que se han desarrollado para tener ganaderos […]. Eso antes de antes de la declaratoria en Petén estaba sectorizado entre diferentes secciones: Aparte del 17'10 por arriba era parque de reserva forestal, la parte [al sur] estaba para desarrollar el ganadero y el parte en el sur se ha hecho para desarrollo agrícola. Para desarrollar maíz principalmente. Cuando se declaró la reserva ya hubo un montón de área que había sido deforestada y primero desarrollado por la ganadería. Esa cierta dinámica [hubo] antes, hasta que el momento [de lo cual] estamos hablando, [cuando] se ha hecho el plan de majeo para la ZAM. Se dice uno de las estratégicas principales es de [reemplazar a] la ganadería extensiva por una ganadería intensiva – […] los sistemas silvopastoriles [funcionan] como una medida para poderlo cuidar.

M: ¿Y los sistemas silvopastoriles también están apoyados por el CONAP?

R: El CONAP - decimos que conozca de ellos. Lo que ejecuta eso es el MAGA y nada más la Pastoral Social. Aún no existe un acuerdo con el MAGA y el CONAP respecto [al procedimiento adentro de] áreas protegidas. Hay un convenio [en lo cual] trabajan ellos. Porque para el CONAP [dicho trabajo] es alineada con la conservación […]. Es decir, se retiene el avance de la frontera agrícola. Es una medida en que estamos […]. Ahí estamos diciendo que el bosque se está estabilizando y también la agricultura. [Se ha] dado esa opción de trabajar en pequeñas reservas. [En] pequeñas áreas una diversificación de cultivos está permitiendo a esa gente generarse ingresos para que no van a agota el bosque.

M: […] Si la gente no [está satisfecha] y vende su tierra – como pasa mucho aquí – […] entra la ganadería?

R: Sí. Eso es la primera amenaza que viene del ganadero: [Para ellos] no tiene sentido de que el bosque está. Para ellos es un obstáculo que tienen que agotar […]. Tienen que tener el pasto para el ganado, entonces el hecho de que hay un bosquecito ahí [hace que] el ganado se sitúa a la sombra y eso no les sirve al ganadero, entonces [piensan que] hay que aqotarlo en una vez. Eso es […] una mala técnica, porque el ganado debe tener sombra […]. Todo lo que tiene en la boca es asimilando y sólo está dirigiendo el pasto [ahí] […] y después se busca más comida […]. Pero si no tienes el bosque, se deshidratan. Ya se han hecho estudios que muestran que no es la mejor manera.

M: ¿Y en el caso de San Pedro? Decimos que […] a la gente le iría mal - por ejemplo, falta de agua [durante] una época seca […] - ¿Serían muy vulnerable a vender la tierra? ¿En esto momento?

R: Prácticamente, lo que se ha obligado a ellos, en San Pedro no se si habrá mucha venta .. esa información también se tiene que ver [de] que movimientos habrá de personas. Aunque al principio tuvimos más gente - recuerdo yo - de San Pedro – […] involucrada al programa. Y se han retirado. No se si vendieron la tierra. Los grupos de q'eqchis por lo general venden en grupo. Normalmente vas con una persona y no te venden la tierra. No dejan entrar a gente de afuera. [En el caso de que] tú vas y tú vas a comprar […] No te dejan […] Hay un consejo de acianos [..]de la comunidad que son los [con cuales queremos cooperar]. Es interno.

M: ¿Y cómo es con las organizaciones que entran - por ejemplo, el CONAP, MAGA, Pastoral Social - ¿ahí si hay cierta confianza?

R: Sí, ahora la hay. Yo te puedo decir que en el pasado máximo [la conianza] por las comunidades de cuales estamos hablando […]. San Pedro, El Capulinar y Los Tulipanes son comunidades cuales ya aceptaron a CONAP, porque CONAP resolvió el problema de la tierra […] Porque están en la ZAM [y] aquí es donde se permite la propiedad privada. Y [respecto a] lo que mencionaste hace un momento: Había un proyecto con el objetivo principal [de] legalizar la tenencia de la tierra […]. Llegaba un momento donde se les dieron su título de propiedad. Pero este proyecto se detuvo porque [había consecuencias inesperadas]. En el momento en que se dieron la propiedad [a ellos], lo vendieron a otra [persona] y se fueron a las áreas protegidos.

M: [Resumiendo lo de que hablamos]; de los usuarios de los recursos naturales tenemos el campesino, que realmente es él deseado porque el mantiene el bosque …

R: Quedamos que él es el más necesitado en la tierra.

M: …Pero también tenemos al ganadero, que entra y para él el bosque es un obstáculo.

R: Sí

M: ¿Tenemos otros grupos de usuarios de recursos de cuales puedes pensar?

R: De usuarios también por ejemplo en el caso de la ZAM los palmeros. [Ellos] compran una extensión de tierra para establecer la palma.

M: ¿Y la gente es consciente de eso? [Por ejemplo en el caso de] que en San Pedro si habría alguien que tendría a algún relativo cual quiere implementar la palma africana…

R: Ahí por la dinámica que tienen ellos, no, como […] son mucho más cerrados y unidos. Ellos no venden tan fácil. En las [otras] comunidades hay una dinámica diferente, […] se ponen de acuerdo [pensando:] "Sí, vamos a lograr muchas cosas si vendemos" y [dice uno:] "Nos vamos a ir a un área que conozco" y ellos les lleva por allá y agotan el bosque ahí. Pero en el caso de San Pedro no es eso. Ahí me gustaría afirmar que esa […] propiedad que está ahí está un poquito más […] estabilizada. Es decir, [saber] si lo [pasan] a sus hijos. Eso es lo importante ahí. […] Porque ellos lo pasaron a los hijos, así que para siempre se quedaron, [y] también [saber si] había por aquí […] las

extensiones de bosque que […] están afirmadas, así que [a partir del] INAB […] se [obtiene algún ingreso] […].

M: Eso es algo que escuché: […] Había problemas con el pago [..]. ¿Sí llega?

R: No, sí se paga, Llega. Los que están adentro de este proyecto lo reciben. El dinero viene de Probosque.

M: [Hablando de las medas de cooperación]. Si ustedes quieren comunicarse con esas comunidades - decimos para por ejemplo proponerles que usen los incentivos o [proponer participación] en el proceso de [la] toma [de] decisiones. ¿Cómo lo hagan? ¿Cómo se comunican? ¿Lo hacen a partir del Maga? ¿ [O] a partir de los campesinos? ¿O también se habla con los ganaderos?

R: No, el propietario que tiene la parcela es en cooperación con [las organizaciones] y a él es a [quién] se habla. Sólo él y él mismo – bueno – en cada grupo cada uno tiene a su parcela, entonces se platica con ellos para ver si están [todos] de acuerdo. […] La dinámica es -según yo lo escuchaba - si un líder dice que sí, todos dices que sí, y si el líder se queda callado, nadie dice nada.

M: A partir de líderes, ¿y Los COCODES también [juegan un papel]?

R: Bueno, los COCODES son electos. Es un grupo que es electo por la comunidad. Pero por lo general son dos líderes. Gente que votan por ellos porque la primera es una presidencia. Sí, puedes decir que convencer al líder es determinante. Y a veces existen lideresas, [que manden a los hombres] en los grupos q'eqchis […]. [Trata de] las esposas de los líderes, por ejemplo. Y [inoficialmente] son ellas que tomen las decisiones. […]

M: ¿Y con los ganaderos? ¿Cómo es la [comunicación] con ellos? ¿Ellos también están participando y están aceptados por parte de la comunidad? ¿O es más gente que viene de afuera?

R: Sí, viene de afuera y son muy herméticos. En el caso de San pedro no hay ganaderos; no entra el ganado. En cambio, en Los Tulipanes son ganaderos. Si gustes, cambiamos a hablar sobre Los Tulipanes. La gente viene el oriente de Guatemala donde su cultura es crear ganado. [Es] su actividad principal. Ellos [..] no tienen un huerto traspatio; ellos tienen sus ranchos [con] casas de láminas; ellos tienen otro estado de forma de vida. [El] hecho de que [alguien] tenga a una vaca [lo define]. Una persona de agricultores tiene el estado [bajo] de […] cultivar la tierra y [el] ganadero [tiene] una vaca. Eso ya hace una diferencia [para ellos]. […] Por eso también se seleccionó a la comunidad Los Tulipanes ([…] fue CONAP en conjunto con la GIZ que decidieron que aquí queremos trabajar. Hubo una tabla de criterios de como se seleccionó a las comunidades […]). Los Tulipanes era un grupo muy activa, es gente que tiene fuerte presión sobre el parque nacional Yaxhá y una presión hacia Tikal, y al biotopo el zots

M: Si dices presión, ¿[eso quiere] decir [que] lo usan como sería un terreno comunitario?

R: Agarran áreas grandes del parque. Vinieron y se pusieron ahí. […] Así fue que comenzamos a trabajar con la implementación de estratégicas agroecológicos.

M: ¿En Los Tulipanes también hay diversas fuentes de ingreso? ¿O viven de la ganadería?

R: Principalmente de la ganadería.

M: ¿Se podría decir que es un sistema un poco más cerrado? San Pedro abierto al turismo y pasajero …

R: [En el] caso de Los Tulipanes [trate de] una comunidad al lado de la carretera […] Ellos no tienen una estructura de identificación de lo que se llama el centro del pueblo, sino también se manifiesta por allá puesta una escuela, ahí la iglesia, todo está dispersa, no tienen una confirmación de comunidad. Hay una persona clave, Rosé Barrera, [quién] tiene un sistema agroecológico, y él y su familia son muy activos. La comunidad de Los Tulipanes responde a una zona en las afueras de Yuxhá [y] son beneficiarios del parque. [Por] los esfuerzos de la conservación del parque, son asociados, [es decir] ellos pertenecen a un grupo de lancheros [o] al grupo de guías del turismo.

M: ¿Cuáles son las principales organizaciones ahí?

R: El MAGA, CINAP, GIZ y la municipalidad de Flores

M: ¿Hay diferencias clave entre el manejo del municipio de Flores y San José?

R: El trabajo de la municipalidad de Flores está muy enfocado en las comunidades - más que San José. Eso hace una diferencia. Una vez más involucrado en la municipalidad, el COCODE está muy activo.

M: ¿El COCODE es la estructura principal para garantizar la participación de la gente?

R: Si, todo se canaliza [por el COCODE]. Con cualquier asunto respecto a las comunidades, se habla con el COCODE. Si el COCODE no acepta, nada prosigue […]. Es clave instalar una buena relación con ellos (ej. en el caso de la comunidad Paso Caballos). Respecto a los usos de la tierra en Los Tulipanes, ahí está la ganadería. Se nota la diferencia cultural observando las diferentes viviendas [sin el traspatio típico de los q'kechi]. Son ladinos (mestizos) con maneras de vida diferente, viendo del oriente.

M: Hablando de [la comunidad] El Capulinar. ¿Es parecida a Los Tulipanes?

R: No es parecido. Existe una población indígena dentro de El Capulinar, pero normalmente la gente […] ladino, y también se mezcla un poco. [La actividad agropecuaria es más diversificada], se crían cerdos, algunos tienen ganado, ...

M: ¿Ellos son más abierto al mercado?

R: Ellos están a la ruta a Tikal. [Por eso], tienen una dinámica diferente. Ellos piensan en la [variedad] de productor que pueden vender a El Remate. Como, por ejemplo, el señor Don Nayo, que ha diversificado su parcela y v una vez la semana a el Remate para vender [una variedad de productos], si sea banano, plátano, aguacate…

M: [Es decir], ¿es el mercado para el turismo o también se exporta a otros lados?

R: Todo está consumido local. Hay [una demanda] por el redondo, los restaurantes y hoteles.

M: ¿En San Pedro también ves el potencial para el turismo?

R: La playa es bonito. [No está tan desarrollado].

M: ¿El medio ambiente juega un papel clave? ¿También hay área común? ¿O él valor principal es estético para atraer a turistas?

R: Hay parques municipales y reservas privadas para la conservación. Áreas de visita.

M: [Entonces, ¿los servicios ecosistémicos claves aquí están basados en la provisión de alimentos por el lago, la posibilidad de cultivar el suelo y el valor estético?]

R: Y también la ubicación como la existencia de áreas protegidas.

M: Se podría decir que otro usuario clave de la región es el turista.

R: Hay una belleza que busca alguien que pueda entrar a la comunidad. En las comunidades Los Tulipanes y El Capulinar son los parques, San Pedro está al lado del lago.

M: Para hablar ahora de los proyectos y los problemas relacionados…

R: [Los problemas son] el avance de la frontera agrícola por la venta de tierra, que trae como consecuencia la deforestación, los incendios, la cazaría o la eliminación de la vida silvestre. [También], cada vez las comunidades son más pobres, porque por ejemplo agotan sus recursos, agotan su bosque, sobreexplotan el suelo… […] El proyecto fue buscar prácticas agrícolas amigables para el ambiente, que no hicieran mejor presión para el bosque, sino el uso de abono orgánicos para mejorar la productividad como también la diversificación de los cultivos.

M: Entonces entiendo que el bosque tiene diferentes utilidades. […] ¿Ellos toman en cuenta que hay que hay que [proteger el bosque]?

R: Ellos no lo [valoraban]. Lo vean como un obstáculo para producir.

M: ¿Y todavía es así?

R: Eso ha cambiado mucho. Sobre todo, en esa región. Los incentivos le dan una utilidad.

M: Los usos [actuales] son entonces [obtener] la leña y [el pago por] los incentivos; y el bosque afuera [de las parcelas] tiene la utilidad de atraer a turistas […] por su valor estético […]. […] Respecto al bosque que se queda adentro de la parcela. ¿Sigue siendo bosque conectado? ¿[Se mantuvo la conectividad] ecológica?

R: Un obstáculo grave es el proceso de solicitar los incentivos. Es un proceso tedioso. Requiere un plan de recursos que cuesta mucho dinero. Lo burocracia toma tiempo y cuesta. La gente requiere soluciones al corto plazo y no invierte […].

Por [dar un] ejemplo [de esas soluciones], en el caso de El Capulinar, tienen sus áreas de cultivo, que son muy diferente a los de Los Tulipanes. Aquí, adentro de las parcelas, ya se mejora el abono orgánico por la aplicación de bocacci Mejorando su suelo con [los] desechos orgánicos, [hay]más valoración de tierra [y] más […] tácticas de la agricultura para se produzca un buen suelo que se incorpora a los áreas de cultivo y por eso mejora la productividad. Pero también [diversificaron]. Y por la idea de diversificar […] lleguen con siembra de tomate, pepino, cebolla [y más] cultivos que no se dan en esa región y no soporten [la falta del agua] ni los alta temperaturas. [Lo cultivado] tienen que ser especies nativas - y la idea nuestra es que se usan especies nativas que soportan los largos sequías y generalmente [garantizan] alimento al corto plazo. Estás cosechando dos meses una cosa, dos meses otro producto… - eso es la idea: Que ellos generan ingresos, se alimentan y lo que sobra se puede vender.

M: ¿Al mercado central?

R: Al mercado local.

M: ¿Y a los turistas?

R: A la gente que pase por allí.

M: Hablando del medio ambiente […], ¿qué significa el lago para la gente?

R: Es su fuente de vida. Fuente del agua, fuente de alimentos también, por la pescadería, [colecta de] cangrejos, … […]

M: ¿Más de todo en San Pedro?

R: San Pedro sí, Los Tulipanes no tanto porque está fuera - ahí la limitante [principal] es el agua. Y en el caso de El Capulinar - sí tienen acceso para ir a pescar, pero también está un poco [más] retirado.

M: ¿Esos son los dos [principales] limitante que define el medio ambiente? ¿El suelo y el agua (por las sequías)?

R: Los suelos son muy poco profundos.

M: ¿Hay una diferencia entre las diferentes comunidades?

R: No hay mucha diferencia entre las tierras del Petén con excepción a la cuenca del lago donde el material viene de una parte más alta. Ahí los suelos son mejores. Esa región en la cual estamos trabajando nosotros, en la parte este de la reserva, son suelos muy pobres. Poco profundos, suelos del bosque, etc. Entonces hay años en que dan maíz y ya el otro año no dan nada. Tienen que incorporarles mucha fertilizante. Y eso sale muy caro. El cultivo del maíz no es rentable.

M: ¿Sólo es para la autoalimentación?

R: Lamentablemente, la gente tiene que esperar tres meses para que les venga el alimento y un pago y se quedan comprando maíz, comprando el otro ...

M: ¿Las estaciones también son un problema?

R: El ciclo de producción es muy determinante. Entonces lo que hacen es [diversifica] la producción. Si siembras el maíz, también tienes la calabaza, la pepitoria. Que te sirve para que también la vendes. Las secas, y la vendes. O también chile. O también otro mes se tiene naranjas o mangos. Aguacates. Eso son las cosas que tienen si incorporan en nuestros proyectos de los huertos mixtos. A diversificar los cultivos. Luego identificamos que hay que poner los árboles. Si el pasto no dio nada, era mejor poner árboles. Y meter cultivos en medio, mientras crece el árbol.

M: ¿No había más problemas con el agua después?

R: [Tiene en cuanta] la época de la lluvia. Si logras sembrar la planta en buena época [no hay competencia].

M: ¿Los árboles frutales no usan mucha agua y al final queda menos [para los cultivos básicos]?

R: No, los frutales también capturan agua [en todos sus partes]. No necesariamente [usas] sólo el agua del lago. Y también tienen la [característica que] buscan agua más adentro del suelo, mientras el cultivo tiene raíces con poca profundidad, y no logra llegar [a las fuentes de agua], aquí se seca el suelo.

M: ¿Una fortaleza del medio ambiente es que sí hay agua en profundidad que es accesible para los arboles?

R: Por eso es por lo que el bosque ha estado ahí. El bosque si soporte.

M: ¿La gente lo saben? ¿Valoran el bosque por esas cuestiones del microclima?

R: Es un proceso. Un proceso que tiene que trabajarse mucho con el acompañamiento. Están con ellos cada vez [hablando de eso], y si se entiende. Sí cambia las percepciones. A veces pasas a un rancho, y sólo hay un solo árbol. Si preguntas “¿Por qué no tienen más arboles?” dicen “Si viene el viento, me va a caer sobre la casa”. ¿Qué tengo que hacer yo? Sembrar árboles con raíces extensas

[horizontales]. Por ejemplo, el mango. Eso es lo que se han hecho. Meter especies frutales en los huertos.

M: Entonces se podría decir que el conocimiento también es de los variables claves. De mi experiencia de México, ahí es un poco distinto. Lo ejidos están también establecidos y la gente sí sabe. Pero aquí son muchos migrantes …

R: Vienen ellos a aproximarse. "Quiero comer y aquí me quedo". No es que han nacidos aquí. Diferente a las comunidades ahí como Xultún, cuales vivían del bosque. Vivien de chicle, xate, pimienta, ramón, etc. Pero las comunidades que vienen no hacen eso. No saben cómo.

M: ¿Y esos usos no son tan llamativas?

R: Hay una resiliencia a parte de ellos. Por ejemplo, de las especies que [usan]. Ñame, piña, la malanga, … Esas especies son de acá, y aguantan las sequías.

M: ¿No solo es importante tener una diversidad de especies, sino también [una selección adecuada]?

R: Sí, de las especies endémicas.

M: [Volvemos de enfocamos en el uso del lago, como ya hablamos del aprovechamiento agrícola]. ¿Hay ciertas restricciones para la pesca?

R: Existe una ley de pesca. Pero la mainía de la pesca que ellos hacen es del autoconsumo familiar […].

M: ¿Y eso está permitido?

R: Sí, se permite. Si hay alguien que se dedica a la pesca, no va a sacar 100 libras diarias, pero 20 libras ya es mucho - y no pescan todos los días. No es un batallón de personas allí pescando en el agua. Sólo algunas personas aisladas.

M: ¿Me quieres comentar algo de los proyectos desarrollados? Algún [aspecto] clave, que para ti sería muy visible y para mi menos obvio de observar. [Por ejemplo:] Problemas, soluciones, … ¿Algo que harías diferente la próxima vez?

R: […] La participación [en estos proyectos] es comunitaria; no existe ni una presión, es por interés. Pero también ese interés puede cambiarse a un apropiamiento - siempre cuando la persona no está obteniendo lo que uno se espera. Lamentablemente, para nosotros, es que la gente se acostumbró mucho a recibir. Todo el tiempo les daban, pero nuestro proyecto no funciona así. En el proyecto, nosotros damos, pero la comunidad pone. Y si [damos] semillas, ellos tienen que sembrarlas (con la asesoría nuestra). Aquí la clave es la accesibilidad de ese [acompañamiento]. [Pero], ¿Cuándo sé yo, que esas personas lo pueden hacer solos? ¿Cuándo lo van a seguir a hacerlo solos? Eso es el reto. [Observamos] que muchas personas tienen […] gran interés y empiezan con mucha dinámica y

mucho entusiasmo, pero luego se escucha que [el resultado] no es [algo] inmediata, [sino] que es un proceso. El aprendizaje también tiene un costo: Tiempo, poner atención, sacrificar alguna o otra cosa. Esas son las cosas que normalmente lo las toman en cuenta […] y piensan […] "con el gobierno es más fácil, que viene y trae fertilizante y maíz" (así es la dinámica), [y] que "nos trae cualquier cosa, ya está". Pero si viene con algún proyecto, en cual es necesario trabajar y vas poniendo… - ahí muchas veces veo yo que la gente resiste.

M: […] Pero aún hay esos problemas, ¿ves [el éxito del proyecto?]

R: Digamos que, para mí, el hecho que elaboramos este estudio (y otro que estamos desarrollando con Cintia y otros parecidos), nos va a ayudar a definir si realmente hicimos un cambio; si haya un impacto. Porque yo te puede decir que la gente me habla a mi y siempre dice que van bien, pero si vas más adentro te das cuenta de que hay cosas que no te han dicho. No hablan mucho del proyecto, [es difícil obtener información]. Hablan de muchas cosas aislados que no son del tema. Ellos no tienen eso en su mente […]. Cada comunidad es diferente. Entonces hay que hacerlo así. Cada cosa es apropiarla y adaptarla a lo que hay ahí. A ver cuanta gente sigue interesada, eso te va a dar una idea de lo que realmente quedó. Cuanto fue el impacto del proyecto.

M: Para la encuesta que voy a desarrollar, ¿tú tienes algún interés especifico que quieres [que pregunto]? ¿[..] Cuál tipo de impacto [te interesa a ti]?

R: Para mi es lo que no se han desarrollado [por el cambio frecuente de técnicos (e.j. de la pastoral social)].[…] ¿Qué sirve el proyecto que siguen agotando al bosque? ¿Si no estamos dando el mensaje que sí el bosque es importante? Eso es lo que tenemos que señalar.

M: ¿Las percepciones?

R: Sí, las percepciones de la importancia del bosque. ¿Cómo ven el bosque ahora? En muchos años anteriores, siempre se han visto el bosque como obstáculo. Y [en muchos casos] sigue siendo así.

M: Entonces, ¿por qué no entran a las escuelas?

R: De hecho, ¡[se hace]! Lo que se hace con la Pastoral Social y el MAGA, eso es un componente. Una [otra] componente que se [desarrolla] con CONAP es a partir de la educación [..]; ej.. a través de la sensibilización de la gente en la zona del uso múltiple, a partir de los incendios que son tres departamentos que están aquí al lado y muchos van al nivel escolar. Por que ya eso realmente forma parte. Tengo el departamento de incendios, y a la otra oficina está el control financiamiento […]. El grupo meta son ellos, porque van a las comunidades. Entonces es [eso].

El otro día vio a un niño y dijo a su papá: "Yo no quiero que quemamos el bosque. Volvemos a ver que pasa si lo dejamos". Y era un niño. Dijo que no comamos, pero vayamos a ver qué pase. […] [Así], veo que lo que estoy haciendo vale la pena. […] Al final no es certificar familias […]. Al final es señalar a niños que […] hay cosas que se puede hacer. Uno nunca puede decidir a un campesino que

sean tonos. [Es todo lo contrario]. Ellos manejan el asunto de otra forma. Eso es lo que se tiene que cambiar: Nosotros los científicos muchas veces vemos y pensamos que no entiendan, que es difícil que decimos… Hay que meterse con mucha empatía. [Ponerse en el lugar de ellos] y a partir de ahí pueden pasar cosas muy buenas.

M: En eso estamos […] Muchísimas gracias por la contribución.

R: [Sólo respecto a la percepción:] Si nosotros realmente logramos un cambio en la gente [respecto a] eso, apoyarían al asunto de la protección mucho.

M: Hago todo lo que puedo para que [el estudio contribuya].

R: […] Vas acercando las cosas. Con la encuesta y lo que veas en el traspatio tenemos información [más clara sobre una segunda etapa].

M: Pensaba [en devolver la información].

R: Sí, a uno les gusta mucho [ver los logros] y ponerse orgulloso.

M: Muchas gracias.

4. Survey study

- 4.1. Spanish Version:

Nr.:_____

Encuestador/a: _____

Fecha y hora: _____

Lugar: _____

Observaciones:

Sobre el estudio:

- La encuesta dura en promedio una hora
- La encuesta es parte de un estudio para evaluar los impactos de la implementación de estrategias agroecológicas en la región
- Los resultados se presentarán a todos los participantes
- Si usted está de acuerdo, los resultados se comunicarán a las organizaciones involucradas
- Si usted está de acuerdo, los resultados se usarán en un trabajo académico
- Si usted no quiere compartir alguna información, por favor siéntase libre de **NO** contestar y hágaselo saber al encuestador
- La participación es voluntaria
- La frase *"El año pasado"* comprende el periodo desde mayo de 2017 hasta abril de 2018:

May. 2017	Jun. 2017	Jul. 2017	Ago. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dic. 2017	Ene. 2018	Feb. 2018	Mar. 2018	Abr. 2018

1. General

1.1 Nombre y apellido (1) y nombre y apellido de su pareja (2)

(1)

(2)

1.2 ¿En qué departamento nacieron?

(1)

(2)

1.3 ¿Cuántos años lleva(n) viviendo en la comunidad?

(1)

(2)

1.4 ¿Cuántos años lleva(n) cultivando y/o criando animales en el norte de Petén?

1.5 ¿Cuál es su motivo principal para cultivar y/o criar animales?

subsistencia **[<] [=] [>]** generar ingresos

1.6 ¿Graduaron de la escuela de promotores?

(1) Sí No

(2) Sí No

---

2. Cambio de la calidad de la vida

2.1 ¿Son más o menos felices que en 2013/2014? Más Menos Igual

---

¿Por qué razón?

---

3. Composición familiar

3.1 ¿Quién vive en su casa?

Adultos: F [ ] [ ] [ ] M [ ] [ ] [ ]

Hembras: F [ ] [ ] [ ] [ ] [ ] [ ]

Varones: M [ ] [ ] [ ] [ ] [ ] [ ]

4. Intercambio de conocimiento y/o trabajo

4.1 ¿Participan en gropos locales de agricultores? Sí No

4.2 ¿Cuáles?

4.3 ¿Cada cuando se reúnen en los grupos para realizar una actividad juntos y/o hablar de cultivar y/o criar animales?

1. Casi nunca
2. Anualmente
3. Mensualmente
4. Semanalmente
5. Casi diario

4.4 ¿Qué hacen en el grupo de agricultores?

4.5 ¿Con quién más comparte(n) algo aprendido sobre el cuido de los cultivos y/o animales?

5. Sobre lo(s) terreno(s)

5.1 ¿Cuánto mide(n) su(s) terreno(s) dentro del casco urbano?

(1) Sitio:

(2)

(3)

5.2 ¿Quién cuida las plantas o animales en el traspatio del sitio?

5.3 ¿Cuántos hijos participan en cuidar las plantas o animales en el traspatio del sitio?

5.4 ¿Tienen terreno(s) fuera del casco urbano? Sí No *(siga en la pregunta 5.15).*

5.5 Sí →¿Cuánto mide(n) su(s) terreno(s) fuera del casco urbano? (la(s) parcela(s))

(1)

(2)

(3)

5.6 ¿A cuántos kilómetros está(n)?

(1)

(2)

(3)

5.7 ¿Cómo se llega su(s) parcela(s)?

a. Pasando por otro(s) terreno(s)
b. Por sendero o camino
c. Por una calle (donde puede pasar un vehículo)

5.8 La tierra es/tiene:

a. escritura
b. en tramites
c. comunal
d. familiar
e. municipal
f. alquilado de un privado
g. estatal con derecho de posesión

5.9 ¿Quién trabaja en su(s) terreno(s) fuera del casco urbano? (la(s) parcela(s))

5.10 ¿Cuántos hijos participan en su(s) terreno(s) fuera del casco urbano?

5.11	¿Buscan ayudantes/mozos?	Sí	No	Pocos días
5.12	¿Con qué frecuencia visita(n) su(s) terreno(s) fuera del casco urbano (la(s) parcelas)?			
5.13	¿Cuántas horas semanales trabajan en su(s) terreno(s) fuera del casco urbano (la(s) parcelas)?			
5.14	¿Cuántos meses tienen acceso?			
→	¿Está desnivelado su terreno? ¿Cuánto de su(s)terreno(s) se vea como…?			
5.15	a. Tierras altas o inclinadas: a. Tierras bajas:			
5.16	¿Construyo/eron **terrazas** o **curvas de nivel**?	Sí	No	
5.17	¿Ha(n) cuidado las terrazas o curvas de nivel desde mayo el año pasado? Algo	Sí	No	
5.18	¿Plantó/aron algo contra el aire/viento?	Sí	No	
5.19	¿Ha(n) cuidado las **barreras rompe vientos** desde mayo el año pasado? Algo	Sí	No	
5.20	En el transcurso del año pasado, ¿Cuántas manzanas tuvo/ieron de…?			

	Sitio	Terreno (1)	Terreno (2)	Terrer
jol o maíz y frijol (sólo)/ MILPA				
y/o forestales en asociación con de corto o mediano ciclo de vida				
y/o forestales en asociación con café, /o vainilla				
mezclados con forraje (y ganado)				
estales/ área de bosque				

Sólo frutales				
Sólo cultivos a corto o mediano plazo				
Sólo pasto y forraje con ganado*				
Sólo pasto y forraje (sin ganado)				
Guamil/Monte				

6. Organización interna

6.1 ¿Ustedes planifican y/o documentan la producción? ¿Usan…?

a. Plan de finca/ mapeo
b. Cronograma de actividades
c. Registro de compras y ventas
d. Cálculo de costos
e. Cálculo de ingresos
f. Otro. ¿Cuál(es)?:_____

7. Capacitación e innovación

7.1 ¿De dónde nacen nuevas ideas sobre como cultivar y/o criar animales?

a. Promotor(es)
b. Vecinos
c. Asociaciones/grupos de agricultores
d. Familiares
e. Asistencia técnica
f. Talleres
g. Reuniones
h. Investigación propia
i. Experimentación propia
j. Ningún lado
k. Otro. ¿Cuál(es)?:_____

7.2 e. → Aproximadamente, ¿cuántos talleres ha(n) recibido?

8. Disponibilidad de consejos y apoyo

8.1 ¿Quién les ayuda dentro el trascurso de una semana cuando tenga(n) algún problema y/o duda urgente sobre los cultivos y/o animales?

a. Promotor(es)
b. Un vecino, amigo o familiar
c. Un grupo local de agricultores
d. Un técnico/ experto de alguna organización
e. Nadie
f. Otro

9. Dependencia

9.1 Durante el año pasado ¿de dónde obtuvo/ieron sus semillas?

a. Las compró/aron
b. Del intercambio con otros agricultores
c. De un banco de semillas
d. Lo produjo/eron
e. De entregas de organizaciones (ej. del MAGA)
f. Las prestó/aron de organizaciones (ej. del MAGA)

10. Disponibilidad y uso de agua

10.1 ¿Cuántos meses tienen agua disponible para regar?

1. Dentro del casco urbano:
2. Fuera del casco urbano:

10.2 ¿De dónde captan el agua?:

1. Dentro del casco urbano:
2. Fuera del casco urbano:

10.3 ¿Qué estrategias usan para aprovechar mejor del agua?

11. Ingresos adicionales

11.1 ¿Tienen alguna(s) fuente(s) adicional(es) de ingresos? Recibió/ieron…

a. Pensión(es); Jubilación(es)
b. Trabajo(s) con salario(s)
c. Ayuda(s) de familiares
d. Trabajo(s) con salario(s)
e. Ayuda(s) de familiares
f. Ayuda(s) estatal(es)
g. Otros. ¿Cuál(es)?:

11.2 ¿Cómo está compuesto el ingreso familiar?

$$Ingreso\ total\ familiar = Ingreso\ Act.agropecuaria + Ingresos\ adicionales$$

[100%] = [____%] + [____%]

12. Gastos en agroquímicos

12.1 Desde mayo el año pasado, ¿Aplican químicos contra pestes? Sí No Sólo MILPA

12.2 Sí → ¿Cuáles herbicidas/plaguicida necesita(n) aplicar? ¿Cuánto?

a. Paraquat alemán
b. Glifosato
c. Hedonal
d. Otro ¿Cuál(es)?:

12.3 ¿Cuánto gastó/aron desde mayo el año pasado en herbicidas y plaguicidas?

12.4 Desde mayo el año pasado, ¿aplicó/aron químicos para abonar el suelo?

Sí No Sólo MILPA

12.5 Sí → ¿Cuáles fertilizantes necesita(n) aplicar? ¿Cuánto?:

a. 151515
b. 2020
c. (Sal) urea
d. Bayfolan
e. Otro. ¿Cuál(es)?

12.6 ¿Cuánto gastó/aron desde mayo el año pasado en fertilizantes?

13. Conservación del suelo

13.1 ¿Cómo abonan el suelo **sin** usar fertilizantes químicos?

13.2 ¿Le(s) enseñaron aprovechar del **popo de gallina** o **estiércol maduro**? Sí No

13.3 ¿Aplicó/aron el popo de gallina o estiércol maduro desde mayo el año pasado? Sí No Algo

13.4 ¿Le(s) enseñaron aprovechar de **aserrín, la hojarasca o de la tierra del bosque**? Sí No Algo

13.5 ¿Aprovechan de aserrín, la hojarasca o de la tierra del bosque desde mayo el año pasado?

Sí No Algo

13.6 ¿Le(s) enseñaron ocupar el **bocashi y/o compost/**abonera? Sí No

13.7 ¿Ocupó/aron bocashi y/o compost desde mayo el año pasado? Sí No Algo

13.8 ¿Le(s) fue bien con esos **abonos orgánicos**? Sí No Con algunos

13.9 ¿Lo(s) usan en su(s) terreno(s) fuera del casco urbano? Sí No Algo

13.10 ¿Le(s) enseñaron ocupar **abonos verdes (ej. frijol abono**, gandul, cudzú, canavalia, …)

Sí No

13.11 ¿Ocupó/aron abonos verdes desde mayo el año pasado? (ej. frijol abono, gandul, cudzú, canavalia, …)

Sí No Algo

13.12 ¿Con qué cultivo(s) se llevan bien los abonos verdes?

13.13 ¿Le(s) fue bien con los **abonos verdes**? Sí No Algo

13.14 ¿Los usan en su(s) terreno(s) fuera del casco urbano? Sí No Algo

13.15	¿Le(s) enseñaron plantar **cultivos para retener la tierra** cuando hay mucha lluvia? (ej. frijol, ayote, pepitoria, camote, …)	Sí	No		
13.16	¿Plantó/aron cultivos para retener la tierra cuando hay mucha lluvia? (ej. frijol, ayote, pepitoria, camote, …)	Sí	No	Pocos	
13.17	¿Les fue bien con esos **cultivos de cobertura**?	Sí	No	Algo	
13.18	¿Los usan en su(s) terreno(s) fuera del casco urbano?	Sí	No	Algo	
13.19	¿Ocupan **biofertilizantes líquidos**? (ej. biol, madrifol té de estiércol, neemicid, supermagro, ensilaje de microorganismos, …)	Sí	No	Algo	
13.20	¿Ocupó/aron biofertilizantes líquidos? (ej. biol, madrifol té de estiércol, neemicid, supermagro, ensilaje de microorganismos, …) desde mayo el año pasado?	Sí	No	Algo	
13.21	¿Les fue bien con los **biofertilizantes líquidos**?	Sí	No	Algo	
13.22	¿Los usan en su(s) terreno(s) fuera del casco urbano?	Sí	No	Algo	
13.23	¿Dejan **descansar** el suelo?	Sí	No		
13.24	Sí →¿Cuántas manzanas descansan para cuánto tiempo?				
13.25	¿Cuándo **quemaron** por la última vez?	20___	Temporada pasada		
13.26	¿Cuándo volverán a quemar?	20___	Nunca		
14.	**Sanidad vegetal**				
14.1	¿Les enseñaron como preparar/aplicar **repelentes orgánicos**?	Sí	No		
	(ej. Chiltepol, la casal, flormortín, la bomba, extracto de ajo con apacin, caldo sulfocalcico)				

14.2	¿Aplicó/aron algún **repelente orgánico** desde mayo el año pasado?	Sí	No
	Algo		
14.3	¿Les fue bien con los repelentes orgánicos?	Sí	No
	Algo		
14.4	¿Los usan en su(s) terreno(s) fuera del casco urbano?		Sí
	No Algo		
14.5	¿Le(s) enseñaron **técnica/s asociativa/s para repeler insectos**?		Sí
	No		
	a. Siembra de plantas aromáticas (ej. cilantro, flor del muerto)		Sí
	No		
	b. Cultivo como barrera (ej. maíz, tomate, pepino, etc.)		Sí
	No		
14.6	¿Usó/aron una/s **técnica/s asociativa/s para repeler insectos**?		
	a. Siembra de plantas aromáticas (ej. cilantro, flor del muerto)		Sí
	No		
	b. Cultivo como barrera (ej. maíz, tomate, pepino, etc.)		Sí
	No		
14.7	¿Les fue bien con estas técnicas de repeler insectos?		Sí
	No Algo		
14.8	¿Les usan en su(s) terreno(s) fuera del casco urbano?		Sí
	No		
15.	**Prácticas pecuarias**		
15.1	¿Les enseñaron preparar y/o ocupar concentrados?		Sí
	No		
15.2	¿Desde mayo, dio/aron algún concentrado preparado a los animales?	Sí	No
15.3	¿Les enseñaron desparasitar a los animales?		Sí
	No		
15.4	Desde mayo el año pasado, ¿desparasitaron a los animales?		Sí
	No		

6. Proyecto agroecológico

16.1 ¿Usted(es) puede(n) definir “Agroecología”?

Sí → aspectos mencionados:

No → *Explicar: Nuevas estrategias de cultivar y/o criar de la manera más ecológica, integral y diversa. Lo qu*
enseñaban en los talleres y de lo cual estábamos hablando.

16.2 ¿Hoy en día cultivar y/o criar animales les va mejor que en 2013/2014?

16.3 ¿Con qué le(s) fue bien?

16.4 ¿Con qué le(s) costó?

16.5	¿Todavía les falta conocimiento para cultivar suficiente?	Sí	No
16.6	¿Todavía les falta espacio para cultivar suficiente?	Sí	No
16.7	¿Todavía les falta dinero para cultivar suficiente?	Sí	No

16.8 ¿Qué más le(s) hace falta todavía?

16.9	Si la situación sigue así, ¿podría ser necesario vender su(s) terreno(s) a buen precio?	Sí	No

16.10 Si la situación sigue así, ¿podría ser necesario limpiar más espacio para cultivar? Sí No

17. Sobre el bosque

17.1 ¿Qué materiales obtiene(n) del bosque?

a. Leña
b. Madera
c. Hojarasca y/o tierra
d. Plantas comestibles
e. Plantas medicinales
f. Otro. ¿Cuál(es)?:

17.2 ¿Tiene(n) o solicitó/aron algún tipo de incentivos forestales?

Sí → ¿De qué tipo? ¿Desde hace/para cuánto tiempo? ¿Para cuánta área?:

No → ¿Por qué no?:

17.3 Personalmente, el bosque significa para usted(es)…

17.4 ¿Esa percepción ha cambiado? ¿Cuándo? ¿Por qué?

17.5 ¿Tienen más/menos área del bosque que en 2013/2014? ¿Por qué razón?

¡Muchas gracias por su participación!

¿Hay algo más que le(s) gustaría comentar?

4.2. English Version:

- **Nr.:**_____

Interviewer:_____

Date and Time:_____

Place:_____

Observations:

About the study:

- The survey takes on average one hour
- The survey forms part of a study to assess the impacts of the implementation of agroecological strategies in the region
- The results will be presented to all participants
- If you agree, the results will be communicated to the organizations involved
- If you agree, the results will be used in an academic work
- If you do not want to share any information, please feel free to not answer and let them know the interviewer
- The participation is voluntary
- The phrase "Last year," covers the period from May 2017 to April 2018:

May. 2017	Jun. 2017	Jul. 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Jan. 2018	Feb. 2018	Sea. 2018	Apr. 2018

1. General information

1.1 Name (1) full name and your partner (2)

(1)

(2)

1.2 What department were you born in?

(1)

(2)

1.3 How many years have you been living in the community?

(1)

(2)

1.4 How many years have you been cultivating and/or raising animals in northern Petén?

1.5 What is your main reason for growing and/or rearing animals?

Subsistence farming [<] [=] [>] generate income

1.6 Did you graduate from the "promoters' school"?

(1) Yes No

(2) Yes No

---

2. Changes regarding the quality of life

2.1 Are you happier than in 2013/2014? Better Worse The same

For what reason(s)?

---

3. Family composition

3. Who lives in your house?

1

Adults: F [ ] [] [] M [] [] []

Girls: F [ ] [] [] [] [] []

Boys: M [ ] [] [] [] [] []

4 Knowledge exchange and/or shared work

4. Do they participate in farmer groups? Yes No

1

---

4. Which group?

2

---

4. How often gather in groups to perform an activity together and / or speak to cultivate and

3 / or breed animals?

6. Hardly ever
7. Annually
8. Monthly
9. Weekly
10. Almost daily

---

4. What do farmers in the group?

4

---

4. Who else do you something something you have learned about the care of crops and/or

5 animals with?

---

5. Land availability

5. What does your terrains within the town measure?

1

(1) Property:

(2)

---

(3)

5.2 Who takes care of plants or animals in the backyard of the property?

5.3 How many children are involved in the caring for plants and animals in the backyard of the property?

5.4 Do you owe land plots outside the village? Yes No *(Still in question 5.15).*

5.5 Yes →What do your land plot outside the city center measure?

(1)

(2)

(3)

5.6 How many kilometers away is it?

(1)

(2)

(3)

5.7 How do you access your land plots?

d. Passing through other field
e. On a trail or path
f. On a street (where a vehicle can pass)

5.8 The land is/has:

h. documentation
i. is in procedures
j. communal
k. the families'
l. municipal
m. rented by a private
n. state with right of possession

5.9 Who works in your land plots outside the village?

5.10 How many children are involved in activities in your land plots outside the village?

5.11 Are you employing assistants? Yes No Only days

5.12 How often do you visit your site outside the village?

5.13 How many hours per week do you work on your land plots outside the village (the (s) plots)?

5.14 How many months do you have access?

→ Is your land uneven? How much of your land plot looks like ...?

5.15
b. high or sloping land:
b. Lowlands:

5.16 Did you build terraces or level curves? Yes No

5.17 Have you cared for terraces or level curves since May last year? Yes No Somewhat

5.18 Have you planted something against the wind? Yes No

5.19 Have you cared for the windbreaks since May last year? Yes No Somewhat

5.20 During the past year, how many *manzanas* did you have of ...?

	Site	Land (1)	Land (2)	Land (
eans or corn and beans (only) / MILPA				

Fruit and/or forestry crops in association with short or medium life cycle				
Fruit and/or forestry in association with coffee, cocoa and/or vanilla				
Trees mixed with fodder				
Only forest/forest area				
Only fruit trees				
Only cultures short or medium term				
Only cattle pasture and forage *				
Only pasture and forage (without livestock)				
Secondary forest (*guamil*)				

6. Internal organization

6. Do you plan and/or document production? Do you use ...?

1

g. Plan of farm/mapping
h. Schedule of activities
i. Record purchases and sales
j. Cost calculation
k. Calculation of income
l. Other. (Which?):_____

7. Training and innovation

7.1 Where do you gain new ideas on how to cultivate and/or breed animals?

l. Promoter(s)
m. Neighbors
n. Associations/groups of farmers
o. Family
p. Technical assistance
q. Workshops
r. Meetings
s. Own research
t. Experimentation own
u. Nowhere
v. Other. Which)?:_____

7.2 e. → Approximately how many workshops have you received?

8. Availability of advice and support

8.1 Who helps you in the course of a week when you have any urgent problems and/or questions on crops and/or animals?

g. Promoter(s)
h. A neighbor, friend or relative
i. A local group of farmers
j. Technician/expert in any organization
k. No one
l. Other

9. Dependencies

9.1 Over the past year from how/where have you obtained your seeds?

g. Buying
h. Exchange with other farmers
i. A seed bank
j. You produced them
k. Deliveries of an organizations (Eg. MAGA)
l. Lent by an organizations (Eg. MAGA)

10. Availability and use of water

10.1 How many months do you have water available for irrigation?

3. Within the village:
4. Outside the village:

10.2 Where they capture the water?:

3. Within the village:
4. Outside the village:

10.3 What strategies did you use to get more water?

11. Additional income

11.1 Do you have any additional income source? Have you (received)…

h. Retirements

i. Salary of paid work
j. Support from family members
k. State payments
l. Others. (Which?):

11.2 How is you household's income composed?

$$Total\ family\ income = Agriculture + Additional\ income$$

[100%] = [____%] + [____%]

12. Agrochemicals

12.1 Since May last year, have you applied chemicals applied against pests? Yes No only on MILPA

12.2 Yes →Which herbicides/pesticides did you needed to apply? How much of each?

e. Paraquat German
f. Glyphosate
g. Hedonal
h. Other (Which?):

12.3 How much did spend on herbicides and pesticides since May last year?

12.4 Since May last year, have you applied chemicals to fertilize the soil?

Yes No only on MILPA

12.5 Yes →What fertilizer did you need to apply? How much of each?

f. 151515
g. 2020
h. (Sal)urea
i. Bayfolan
j. Other.(Which?)

12.6 How much did you spend on fertilizer since May last year?

13. Soil conservation

13.1 How do you treat the soil without using chemical fertilizers?

13.2	Were you taught how to use chicken poo or mature manure?	Yes	No
13.3	Have you applied chicken poo or mature manure since May last year? Somewhat	Yes	No
13.4	Were you taught how to use sawdust, litter or forest land? Somewhat	Yes	No
13.5	Have you used sawdust, litter or forest land since May last year? Yes No Somewhat		
13.6	Does (s) taught occupy the bokashi and/or compost? No		Yes
13.7	Have you used bokashi and/or compost since May last year? Somewhat	Yes	No
13.8	Did it go well with these organic fertilizers? Somewhat	Yes	No
13.9	Have you applied it in the land plots outside the village? No Somewhat		Yes
13.10	Were you taught how to use green manures (eg. Fertilizer bean, pigeon pea, cudzú, canavalia, ...) Yes No		
13.11	Have you applied green manures since May last year? Yes No		
13.12	Which crop get along with green manure?		
13.13	Has it gone well with green manure? Yes No Somewhat		

13.14	Were they used in the land plots outside the village?			Yes	No
	Somewhat				
1315	Were you taught how to plant crops to retain the land when there is a lot of rain? (Eg. Beans, squash, fricassee, sweet potato, ...)			Yes	No
13.16	Have you planted crops to retain soil when there is a lot of rain? (Eg. Beans, squash, fricassee, sweet potato, ...)		Yes	No	A lillte bits
13.17	Has it gone well with those cover crops?			Yes	No Somewhat
13.18	Were they used in your land plots outside the village?			Yes	No
	Somewhat				
13.19	Were you taught how to use liquid biofertilizers (e.g. *biol*, *badrifol manure tea*, *neemicid*, *supermagro*, silage of microorganisms, ...)			Yes	No
	Somewhat				
13.20	Have you used liquid biofertilizers?[11] since May last year?				Yes No
	Somewhat				
13.21	Has in gone well with the liquid biofertilizers?			Yes	No Somewhat
13.22	Were they used outside the village center?			Yes	No Somewhat
13.23	Do you allow the soil to rest?		Yes	No	
13.24	Yes →How many *manzana*s lie for how long?				
13.25	When did you burn last?	20___		Last season	
13.26	When do you burn again?	20___		Never	
14.	**Plant health**				
14.1	Were you taught how to prepare/apply organic repellent?				Yes No
	(Eg. *Chiltepol*, *la casal*, *flormortín*, *la bomba*, garlic extract with apacin, lime sulfur broth)				
14.2	Have you applied some organic repellent since May last year?			Yes	No
	Somewhat				

[11] Changed on the fly, as in the Spanish version, the question before was repeated by mistake

14.3	Has it gone well with organic repellents? Somewhat		Yes	No
14.4	Were they used in your land plots outside the village? No Somewhat			Yes
14.5	Were you taught associative techniques to repell insects?		Yes	No
	c. Planting aromatic herbs (eg. Cilantro, *flor del muerto*)		Yes	No
	d. Crop barriers (eg. Corn, tomato, cucumber, etc.)		Yes	No
14.6	Have you used associative techniques to repel insects?			
	c. Planting herbs Yes No			
	d. Cultivation barrier Yes No			
14.7	Did it go well with these techniques repel insects? No Somewhat			Yes
14.8	Were they used in your land plots outside the village? No			Yes
15.	**Livestock practices**			
15.1	Were you taught how to prepare and/or use concentrates?		Yes	No
15.2	Since May, have you prepared concentrate for the animals?		Yes	No
15.3	Were you taught how to deworm <u>vaccinate</u>[12] animals?	Yes	No	
15.4	Since May last year, have you dewormed <u>vaccinate</u> animals?	Yes	No	

16 Agroecological project

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16 Can you define "Agroecology"?

.1

Yes → mentioned aspects:

[12] Changed on the fly from “deworm” to “vaccinate”

No →*Explain: New strategies to cultivate and / or breed of the most environmentally friendly, comprehensive and diverse way. What they taught in workshops and which were talking about.*

16.2 Do you do better with the cultivation and/or breeding of animals than in 2013/2014?

16.3 What has gone well?

16.4 What has been hard?

16.5 Do you still lack knowledge to grow enough? Yes No

16.6 Do you still lack space to grow enough? Yes No

16.7 Do you still lack money to grow enough? Yes No

16.8 What else is still needed?

16.9 If the current situation persists, could it be necessary to sell your land at a good price?

Yes No

16.10 If the current situation persists, could it be necessary to clean more space to grow?

Yes No

17. About the forest

17.1 What materials were obtained from the forest?

g. Firewood
h. Timber
i. Foliage and/or soil
j. Edible plants
k. Medicinal plants
l. Other. (Which?):

17.2 Have you requested any kind of forest incentives?

Yes →What type? For how long? For how much area?:

Do not → Why not?

17.3 Personally, the forest means to you ...

17.4 Has this perception changed? When? Why?

17.5 Do they have more or less forest area in 2013/2014? For what reason?

Thank you for your participation!

Is there anything else you would like to comment on?

4.3. Production sheet: Spanish Version

Nr.:_____ **Nombre(s) y apellido(s):** _____

Monitoreo abril 2018: 13.1 Hoja de diversidad y producción (de mayo 2017 a abril 2018)

Categoría 1: Maíz y frijol

- Maíz
- Frijol

Categoría 2: Cultivos bianuales

Musáceas
- Banano
- Guineo
- Majunche
- Pacaya

- Papaya
- Plátano
- Piña
- Rosa jamaica
- ¿Otro?

Categoría 3: Cultivos a largo plazo

- Achiote
- Aguacate
- Anonas
- Cacao
- Café
- Coco
- Caña
- Chico zapote
- Guanábana
- Guano
- Guayaba
- Jocote
- Limón
- Mandarina
- Mango
- Maracuyá
- Nance
- Naranja
- Paterna
- Pimienta
- Pitahaya
- Ramón
- Vainilla
- Zapote
- ¿Otro?

Categoría 4: Cultivos a corto o medino plazo

Chiles
- Chile cobanero
- Chile habanero
- Chile dulce

- Acelga
- Ajo
- Ayote
- Berenjena
- Calabaza melocotón
- Camote
- Cardamomo
- Chaya
- Chipilín
- Cebolla
- Cebollín
- Cilantro
- Espinaca malabar
- Gandul
- Hierba mora
- Güisquil
- Lechuga
- Macal
- Melón
- Mostaza
- Hocro
- Repollo
- Sandía
- Pepitoria
- Tomate
- Tomate criollo
- Yuca
- Yame
- Zanahoria
- ¿Otro?

Categoría 5: Madera

- Caoba
- Cedro
- Chico zapote
- Jobillo
- Madre cacao
- Melina
- Pimienta
- Plumajillo
- Ramón
- Rosul
- Santa María
- Selillón
- Teca
- ¿Otro?

Categoría 6: Forraje

- Botón de oro
- Brizantha
- Canabalias
- Caulote
- Gandul
- Humedicola
- Leucaena
- Macedero
- Maraalfalfa
- Mombasa
- Morera
- Nappier
- Tanzania
- ¿Otro?

Categoría 7: Animales

- Cabra
- Cerdo
- Gallina
- Pato
- Res
- Pavo
- Peces
- ¿Otro?

Categoría 8: Otros productos (procesados)

- Harinas
- Hongos
- Hojas de plátano
- Huevos
- Leche
- Jugos/Aguas
- Tortillas
- Hojas de xate
- Semillas
- Plantas ornamentales
- ¿Otro?

Nr.:_____**Nombre(s) y apellido(s):** _____

Monitoreo abril 2018: 13.1 Hoja de diversidad y producción (de mayo 2017 a abril 2018)

Posición	Producto	Número de plantas o extensión del cultivo		Desde mayo el año pasado, ¿cuánto produjo?	Unidad de medida	Pérdidas de cosechas[1]	Causa(s) de pérdidas de cosecha[2]	¿La producción alcanza para el consumo de la familia?	Ventas[1]	Precio (venta)	Comentario	¿Lo produjo antes de 2013/2014?
		Sitio	Terreno(s)									
1	Maíz				U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
2	Frijol				U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
3	Leña y/o madera				U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
4	Forraje				U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
5	Musáceas*				U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
6					U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
7					U/Q/L	***a b c d e***		S/N	***a b c d e***			S/N
8												
….	…	…	…	…	…	…	…	…	…	…	…	…

1: a) (casi) nada b) menos de la mitad c) la mitad d) más de la mitad e) (casi) todo

2: Aire/Viento (V), Falta de agua (FA), Frío (F), Ganado (G), Inundación (I), Plaga (P), Robo (R), Otro (O) *(comentario)*

4.4. Production sheet: English Version

Nr .:_____ **Names and surnames:**_____

Monitoring April 2018: 13.1 Sheet regarding diversity and production (period May 2017 to April 2018)

Category 1: Corn and beans

- Corn
- Bean

Category 2: biannual crops

musaceas
- Banana
- guineo
- majunche
- Pacaya

- Papaya
- Platain
- Pineapple
- Rosa jamaica
- Other?

Category 3: long-term cultures

- Annie
- Avocado
- Anonas
- Cocoa
- Coffee
- Coconut
- Sugar cane
- Sapodilla
- Soursop
- Guano
- Guava
- Jocote
- Lemon
- Tangerine
- Mango
- Passion fruit
- Nance
- Orange
- Paterna
- Pepper
- Pitahaya
- Breadnut
- Vanilla
- Sapodilla
- Other?

Category 4: Crops short-term or Medino

Chillies
- Chard
- Garlic
- Ayote
- Eggplant
- peach pumpkin
- Sweet potato
- Cardamom
- Chaya
- Chile Cobanero
- Habañero pepper
- Cweet pepper
- chipilín
- Onion
- scallion
- Coriander
- Malabar spinach
- Slacker
- Nightshade
- Guisquil
- Lettuce
- Macal
- Cantaloupe
- Mustard
- Hocro
- Cabbage
- Watermelon
- Pumkin
- Tomato
- Creole tomato
- Yucca
- Yame

Category 5: Wood

- Mahogany
- Cedar
- sapodilla
- Jobillo
- mother cocoa
- Melina
- Pepper
- Plumajillo
- Ramón
- Rosul
- Santa Maria
- Selillón
- Teak
- Other?

Category 6: Fodder

- Gold button
- brizantha
- Canabalias
- Caulote
- Slacker
- Humedicola
- Leucaena
- Macedero
- Maraalfalfa
- Mombasa
- Mulberry
- Nappier
- Tanzania
- Other?

Category 7: Animals

- Goat
- Pork
- Chicken
- Duck
- Beef
- Turkey
- Fishes
- Other?

Category 8: Other products (processed)

- flours
- Mushrooms
- Banana leaves
- eggs
- Milk
- Juices / Water
- Tortillas
- Xate leaves
- Seeds
- ornamentals
- Other?

- Carrot
- Other?

Nr .:_____**Names and surnames:**_____

Monitoring April 2018: 13.1 Sheet regarding diversity and production (period May 2017 to April 2018)

Position	Product	Number of plants or área used for cultivation		How much were produced since May?	Unit of measurement	Harvest losses	Cause of losses[2]	Is the production reaches for family consumption?	Sales	Price	Comments	Planted before 2013/2014?
		Site	Field (s)									
1	Corn				U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
2	Bean				U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
3	Timber and/ or firewood				U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
4	Forage				U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
5	Musaceas *				U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
6					U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
7					U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
8					U / Q / L	***a b c d e***		S / N	***a B C D E***			Y / N
…	…	…	…	…	…	…	…	…	…	…	…	…

1: a) (almost) nothing b) less than half c) half d) more than half e) (almost) everything

2: Air / wind (V), Lack of water (FA), Cold (F), Livestock (G), Flood (I), Plague (P), Burglary (R), Other (O) (comment)

4.5. Results of the survey study

-

4.5.1.General

General				
	EC	SP	LT	Total
Participants	13	17	2	32
Promotors	3	9	0	12
Years in Community	28.58	19.50	30.00	23.83
Av. household size	6.42	6.00	8.00	6.29
Number of participants with only property	1	3	0	4

NV General	EC	SP	LT	Total
Years in Community	1	1	0	2
Av. household size	1	0	0	1

4.5.2.Land availability

Land area					
Number of participants with availability of	EC	SP	LT	Total	NV
Only the household's property	1	3	0	4	0
Number of terrains including property	28	29	3	13	1
Number of participants with more than one terrain	10	7	1	18	1
Number of participants with land plot	9	12	2	23	1
Number of participants without land plot	3	5	0	8	1
Number of participants with more than one land plot	1	1	2	4	1
Estimated area of land plots	225	205.5	377.5	808	0

4.5.3.Workforce

Workforce					
	EC	SP	LT	Total	
Workforce backyard	5.636363636	4	7	4.827586207	
Workforce land plot	3.111111111	2.5	3	2.782608696	
Female workforce in land plot	0	3	0	3	

NV Workforce				
	EC	SP	LT	Total

Workforce backyard	2	1	0	3
Workforce land plot	4	5	0	9
Female workforce in land plot	4	5	0	9

4.5.4.Group organization

Group-organization					
	EC	SP	LT	Total	
In Group	10	8	2	20	
Only CADER	5	1	2	8	

NV Group-organization				
	EC	SP	LT	Total
In Group	1	0	0	1

4.5.5.Use of planning instruments

Use of planification instruments					
	EC	SP	LT	Total	
Farm map	2	2	0	4	
Cost calculation	1	2	0	3	

NV Use of planning instruments				
	EC	SP	LT	Total
Farm map	2	0	0	2
Cost calculation	2	0	0	2

4.5.6.Income

Income					
	EC	SP	LT	Total	
Only farm	4	5	0	9	
No income farm	0	4	0	4	
Family members	2	4	1	7	

NV Income				
	EC	SP	LT	Total
Only farm	2	0	0	2
No income farm	2	0	0	2
Family members	2	0	0	2

4.5.7.Application of chemicals

Application of chemicals					
	EC	SP	LT	Total	
Fertilizer	8	3	0	11	
Pest control	9	12	2	23	

NV Application of chemicals				
	EC	SP	LT	Total
Fertilizer	1	0	0	1
Pest control	1	0	0	1

4.5.8.Received formation in soil conservation

Received formation in soil conservation					
	EC	SP	LT	Total	
Green manure	8	14	2	24	
Manure	8	11	2	21	
Forest materials	10	11	1	22	
Boakashi	9	8	2	19	
Liquid biofertilizer	8	6	2	16	

NV Received formation in soil conservation				
	EC	SP	LT	Total
Green manure	1	0	0	1
Manure	2	0	0	2
Forest materials	3	0	0	3
Boakshi	2	0	0	2
Liquid biofertilizer	2	1	0	3

4.5.9.Applied measures in soil conservation

Applied measures in soil conservation					
	EC	SP	LT	Total	
Green manure	6	10	0	16	
Manure	6	5	1	12	
Forest materials	8	5	0	13	
Bokashi	7	4	0	11	
Liquid biofertilizer	5	6	0	11	

NV Applied measures in soil conservation				
	EC	SP	LT	Total
Green manure	2	0	0	2
Popo	2	0	0	2
Bosque	1	0	0	1
Bokashi	1	0	0	1
Liquid biofertilizer	1	2	0	3

4.5.10. Received formation regarding agroecological pest managements

Received formation regarding agroecological pest managements					
	EC	SP	LT	Total	
Liquid repellents	8	9	2	19	
Associations	7	9	2	18	

NV Received formation regarding agroecological pest management				
	EC	SP	LT	Total
Liquid repellents	2	0	0	2
Associations	3	0	0	3

4.5.11. Application agroecological pest management measures

Application agroecological pest management measures					
	EC	SP	LT	Total	
Liquid repellents	5	2	0	7	
Associations	6	5	0	11	

NV Application of agroecological pest management				
	EC	SP	LT	Total
Liquid repellents	1	0	0	1

Associations	3	0	0	3

4.5.12. Lack of Knowledge, area and money for investments

Lack of…					
	EC	SP	LT	Total	
Knowledge	8	15	2	25	
Area	6	5	0	11	
Money for investments	11	16	2	29	

NV Lack of…				
	EC	SP	LT	Total
Knowledge	3	0	0	3
Area	2	0	0	2
Money for investments	2	0	0	2

4.5.13. Definition of agroecology

Definition of agroecology					
	EC	SP	LT	Total	
	1	1	0	2	

NV Definition of agroecology				
	EC	SP	LT	Total
	4	3	0	7

4.5.14. Shifting agriculture

Shifting agriculture					
	EC	SP	LT	Total	NV
Let soil rest	8	12	2	22	8
Burn	5	5	2	12	6

4.5.15. Forest incentives

Forest incentives					
	EC	SP	LT	Total	
Paid	7	0	0	7	
Applied	1	0	0	1	

NV Forest incentives				
	EC	SP	LT	Total
Paid	4	4	0	8
Applied	4	0	0	8

4.5.16. It might be necessary to sell

It might be necessary to sell					
	EC	SP	LT	Total	
	5	4	2	11	

NV It might be necessary to sell				
	EC	SP	LT	Total
	3	3	0	6

4.5.17. Plant species diversity

Average number of plant species					
	EC	SP	LT	Total	
Total	30.92	29.73	34.00	30.52	
Biannual	2.58	2.60	2.00	2.55	
Perennials	14.75	13.87	17.00	14.45	
Medium-term	12.17	11.93	12.50	12.07	
Perennials and biannual					

Max diversity					
	EC	SP	LT	Total	
Total	55	50	36	55	
Biannual	5	2.6	2	5	
Perennials	21	23	19	23	
Medium-term	27	22	13	27	
Perennials and biannual	21	23	19	23	

Min diversity					
	EC	SP	LT	Total	
Total	10	16	32	10	
Biannual	1	1	2	1	
Perennials	2	7	15	2	

Medium-term	2	4	12	2	
Perennials and biannual	1	1	2	1	

NV plant species diversity				
	EC	SP	LT	Total
Total	1	2	0	3
Biannual	1	2	0	3
Perennials	1	2	0	3
Medium-term	1	2	0	3
Perennials and biannual	2	4	0	3

4.5.18. Presence of subsystems

Presence of subsystems					
	EC	SP	LT	Total	
Maize	10	12	2	24	
Beans	8	5	2	15	
Poultry	10	13	2	25	
Livestock	6	8	2	16	
Cattle	2	4	2	8	
Fish	4	1	2	7	
Shadow species	4	6	0	10	
Fodder	1	2	0	3	

NV Presence of subsystems				
	EC	SP	LT	Total
Maize	1	2	0	3
Beans	1	2	0	3
Poultry	1	2	0	3
Livestock	1	2	0	3
Cattle	1	2	0	3
Fish	1	2	0	3
Shadow species	1	2	0	3
Fodder	1	2	0	3

4.5.19. Land availability

Land					

	EC	SP	LT	Total	NV
No land	1	3	0	4	1
More than one terrain in city center	10	7	1	18	1
Without land plot	3	5	0	8	1
With more than one land plot	1	1	2	4	1

Land plot sizes

Land plot size [mz]					
	EC	SP	LT	Total	NV
<= 5	0	3	0	3	0
6 - 10	4	2	0	6	0
11 - 20	1	3	0	4	0
21 - 40	0	3	0	3	0
41 - 80	3	1	0	4	0
81 - 100	0	0	1	1	0
> 100	0	0	1	1	0
	EC	SP	LT	Total	
Minimum size [mz]	8	0.5	91.5	0.5	0
Maximum size [mz]	64	64	286	286	0
Average size [mz]	28.13	19.29	188.75	37.91	0
Total [mz]	225	205.5	377.5	808	0

Land plot size [ha]					
	EC	SP	LT	Total	NV
3.53	0	3	0	3	0
7.06	4	2	0	6	0
14.11	1	3	0	4	0
28.22	0	3	0	3	0
56.45	3	1	0	4	0
70.56	0	0	1	1	0
70.56	0	0	1	1	0
Minimum size	5.64	0.35	64.56	0.35	0
Maximum size	45.16	45.16	201.80	201.80	0
Average size	19.85	13.61	133.18	26.75	0
Total	158.76	145.00	266.36	570.12	0

4.5.20. Plant species diversity

NV Average plant species diversity				
	EC	SP	LT	Total
Total	1	2	0	3
Biannual	1	2	0	3
Perennials	1	2	0	3
Medium-term	1	2	0	3
Perennial and biannual	2	4	0	3

Max/Min				
	Max	Min	Average	
Total	55	10	30.52	
Biannual	5	1	2.55	
Perennials	23	2	14.45	
Medium-term	27	2	12.07	
Perennial and biannual	23	1		

[i] ("Agroecology is the integrated use of the resources and mechanisms of nature for the purpose of agricultural production. It combines the ecological, economic and social dimensions and aims to better exploit interactions between plants, animals, humans and the environment.")