

Enhancing social-ecological resilience in indigenous communities: the case of asaí berry harvesting in Carmen Alto

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Ruth Delgado Student Number: 3763668 ruth.delgado.marin@gmail.com; Marnixlaan 16, 3552 HD, Utrecht

Supervisor: Dr. Jeroen van der Sluijs, Associate Professor, Utrecht University

Second reader: Dr. Frank van Laerhoven, Assistant Professor, Utrecht University

External Supervisor: Dr. Daniel Larrea, Head of the Science Department, FAN-Bolivia (http://www.fan-bo.org)

Summary

Carmen Alto is a remarkable indigenous community, of the Bolivian Amazon, interested in the commercial use of the asaí fruit. The objective of this research is to establish a case study about the community, where this productive activity improves the social and ecological resilience. Two methodological frameworks are applied to achieve this purpose: Resilience Assessment and Success Factors of Commons-based Enterprises. Data were gathered through literature review, direct observation, semi-structured interviews to relevant actors and one validation workshop.

An assessment of the Carmen Alto resilience shows that the Amazon forest cover is an important source of productive activities, which means income to the community residents. The forest also provides key ecosystem services to the community, like water table homeostasis and nutrient cycling among others. Some activities that degrade the forest, like the palm heart extraction, seem to intensify the known disturbances: wildfires, drought, increase in temperature and disruption of the rainfall seasonality.

Carmen Alto is currently reorganizing its productive matrix, which opens the door to incentivize new activities to use the natural resources. Two very different states have been identified as likely for the future. The first one, when the sustainable use of the asaí fruit replaces the extraction of palm heart, promotes the regeneration and conservation of the forest cover, reducing threats to ecosystem services, providing a more profitable activity for both women and men, and increasing the social and ecological resilience of the system. A second, alternative state, promotes the deforestation and significant land use changes (crops and pastures), affecting negatively the ecosystems services of the forest.

The analysis of five status factors (Holistic vision, mission and values; Institutions, governing and managerial structures; Capitals and capacity building; Land and resource tenure; and Informed leadership) shows existing conditions for a successful establishment of a commons-based enterprise that uses asaí fruit.

Finally, the information from previous steps was applied to design a stewardship strategy to enhance resilience in the Carmen Alto community.

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ENHANCING SOCIAL-ECOLOGICAL RESILIENCE IN INDIGENOUS COMMUNITIES: THE CASE OF ASAÍ BERRY HARVESTING IN CARMEN ALTO

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List of Acronyms

ABT	National Forest and Land Authority of Bolivia
CIRABO	Indigenous Entity (Organization) of the Bolivian Amazon Region
FAN-Bolivia	Friends of Nature Foundation (NGO)
IPHAE	Institute for Human, Agriculture and Ecology (NGO)
LED	Low-(greenhouse gases) emission development
NGO	Non-government organization
NTFP	Non-timber forest product
тсіт	Tacana-Cavineño Indigenous Territory

1. Introduction

1.1 Background

Deforestation and forest degradation are major processes that influence climate change since they increase CO₂ emissions. Most of the tropical deforestation is caused by agricultural expansion (96%), wood extraction and infrastructure expansion. In most cases, these proximate causes are driven by the interplay of underlying causes like: economic, institutional, technological, socio-political and demographic factors. There are different patterns between proximate and underlying causes depending on specific characteristics of a region. Because of this, a detailed understanding of the set of causes is needed before starting a policy intervention (Geist & Lambin 2002).

It is broadly recognized that the use of non-timber forest products (NTFP) can be an answer to reduce deforestation while addressing rural poverty (Belcher et al. 2005). In Bolivia as in most of the tropics, land-use change activities are the main proximate causes of deforestation (Killeen et al. 2007). A combination of underlying causes is driving deforestation and forest degradation: cattle industry growth, soy bean expansion adapted to Amazon climate and human migration (Nepstad et al. 2006). The sustainable management of NTFP in Bolivian tropical forests represents an important opportunity to mitigate climate change while addressing economic and social needs of the local population. These actions can be part of a low-emission development (LED) strategy that contributes to the sustainable development of the region. The NTFP management in Bolivia has ecological and social issues and an uncertain and complex context. The resilience assessment framework can provide insight in the development of low emission development strategies (Resilience Alliance 2010; UNDP 2011).

Some studies are available on the contribution of NTFP to the sustainability of the Bolivian Amazon communities. Since most of those studies are focused on Brazil nut (Bojanic 2001; Stoian 2004; Wadt et al. 2008; Cronkleton et al. 2012), more research is needed on alternative NTFP, assuming that a diversified use of forest resources can help increase the resilience of these indigenous communities. The asaí berry is a promising NTFP, which important advantages compared to the extraction of palm heart of the same tree species (Euterpe precatoria). The latter activity used to be widely practiced in the 1990's, but it ended up being an unsustainable industry. The extraction of the palm heart, the inner core of the plant, resulted in a dead tree. Wild populations of palm trees close to settlements were significantly reduced, and the practice of extraction was banned by the indigenous authorities (Quiroga 2012; Stoian 2004). On the other hand, the harvesting of asaí berry does not damage the tree. Despite wide availability of the asaí berry throughout the Northern Bolivian Amazon forest, its use is minimal and generally limited to self-consumption by indigenous communities. The global market for asaí fruit is expanding because of a recent interest in its nutritional properties. There is a high potential to produce natural energetic drinks, which has attracted interest from several Bolivian and Brazilian companies (Altamirano 2012; Brondízio 2008).

This research is being conducted in partnership with Fundación Amigos de la Naturaleza (FAN-Bolivia), a large Bolivian environmental nonprofit organization, within the context of the "Forests, climate change and indigenous local economic development in the Bolivian Amazon" programme. The main goal of the programme is strengthening sustainable local socio-economic development of indigenous communities of Bolivia's Northern Amazon while reducing their vulnerability to climate change (FAN-Bolivia 2011). The research thesis will be a contribution to design strategies which enhance resilience to climate change, among other threats, and promote entrepreneurship in indigenous communities.

The researcher is following the Track Global Change and Ecosystems (TGCE) within the Master in Sustainable development. The research proposal is in line with one of the main TCGE's focuses, which is the sustainable use of land. As TCGE, the research is concerned with modeling ecosystems processes, evaluate the sustainability of scenarios, and propose solutions to improve sustainability of future human activities (UU 2012). The project also has a link with the research topics of the group of Environmental Sciences within the Copernicus Institute of Sustainable Development. The proposal is looking into interactions and feedbacks over time and space, as one of the themes of the Environmental sciences group (UU 2012b). Moreover, the research is relevant for the Annotation in Sustainable entrepreneurship and innovation. The project will focus on indigenous communities with potential to become a community-based enterprise, an emerging form of entrepreneurship (Peredo & Chrisman 2006). Besides that, a focal point of the proposal is the commercial harvesting of asaí berry, which is an innovative product in Bolivian indigenous communities.

1.2 Problem definition, aim, and research question

Nowadays there are indigenous communities dependent on ecosystem services of Bolivian Amazon forests that could be affected by the climate change. Their capacity to respond to ecological and anthropogenic disturbances in their system is limited, which increases the difficulty to fulfill their social and economic needs (Escalante 2012; Roca 2012c). An opportunity to enhance their resilience is to diversify their livelihoods by increasing the commercialization of asaí berries. Alternative activities to logging and cattle ranching can bring additional value to indigenous communities who want to transform forest management into a more transparent, participatory and inclusive activity. This is relevant for mitigation of climate change since tropical forests are an important carbon reservoir.

Several of these communities can become sustainable entrepreneurs, since they are aiming to resolve environmental challenges by creating or discovering new products, new markets, new production processes, new ways of organizing existing technologies (Dean & McMullen 2007; Baron & Shane 2007). Indigenous communities with natural and social capital can become a community-based enterprise, an emerging form of entrepreneurship. This kind of local organization would be more efficient for harvesting asaí berry and transferring value locally. Through a better organization and capacity-building, a community-based enterprise could sell a product with added value and not only raw material on the long term (Peredo & Chrisman 2006). Thus, it represents a promising strategy for fostering LED.

Although broadly developed in Brazil, asaí berry value chain is in a nascent stage in the Bolivian Amazon forest. Considering the difficulties to start a new economic activity, few communities have currently the conditions to become a pioneer in this area.

The aim of the research is to develop a case study in one of the communities inside the Tacana-Cavineño indigenous territory, which could increase the commercial asaí berry harvesting in order to enhance its resiliency. This leads to the main research question and sub-questions:

What stewardship strategy could enhance resilience in Carmen Alto indigenous community?

- What are the key resource uses, ecosystems services, and critical disturbances in this system? And what are their attributes?
- What are the main factors that drive change, the alternative states and the most critical thresholds in this system?
- > What are the main characteristics of governance and social networks in this system?
- What is the development stage of factors that contribute to establish a successful community-based enterprise dedicated to asaí harvesting in this system?
- Which stewardship actions can be taken for asaí berry harvesting to enhance resilience in this system?

To answer the main question it is necessary to apply a resilience assessment of Carmen Alto. The first three secondary questions will help identifying the components, the dynamics and the social aspects of the system. Because the use of the asaí fruit could increase the system resilience, the secondary question 4 looks for factors that could facilitate the setup of an initiative of commercial use of the fruit. Finally, the secondary question 5 looks for actions based on a better understanding of the system and entrepreneurship opportunities lead to an improved community resilience. These research questions will be better interpreted after presenting some key concepts in section 2.

This research has social, economic and scientific relevance. An important part of building a lowcarbon culture is engage producers to reduce GHG emissions in their activities without compromising their development expectations. The proposed research wants to explore the possible stewardship strategies in which Carmen Alto community can harvest asaí berry in the context of low-emission development. Although broadly developed in Brazil, this value chain is in a nascent stage in Bolivian Amazon forest. By designing resilience strategies, Carmen Alto community would become a pioneer on the asaí berry value chain and an example for the surrounding 89 communities. The asaí berry value chain is an innovation in Bolivian communities with potential to mitigate deforestation and degradation. The research is a pilot project to develop strategies that will contribute to remove innovation barriers in order to use the economic potential of standing forest.

This report is organized in five sections. After the introduction, it will be presented some of the key concepts about resilience assessment. In the next section, the methodological steps and the study site will be introduced; and then the data collection and analysis will be described. After this, the section results summarize the main findings about: the resilience assessment; the analysis of factors to establish a commons-based enterprise; and the design of a stewardship strategy to enhance resilience in Carmen Alto. Finally, the most significant conclusions about the conceptual model of Carmen Alto and the stewardship strategy will be presented followed by discussions, and suggestions for policy and future research.

2. Key concepts

In this section, key concepts are explained briefly in order to give context to the research questions and the Resilience assessment framework used in the next section.

Managing natural resources in a sustainable way requires understanding that human activities depend on ecosystem services and at the same time ecosystems are influenced by human activities. Therefore the concept social-ecological system is useful to describe both realities through an interdisciplinary approach (Berkes et al. 2003). Then, a **social-ecological system** can be defined as "An integrated system of ecosystems and human societies with reciprocal feedbacks and interdependence" (Resilience Alliance 2010).

Social-ecological systems do not tend toward an equilibrium state. Instead they go through an adaptive cycle over time (Gunderson 2001). The concept **adaptive cycle** explains the dynamic of social-ecological systems as "a sequence of four commonly occurring phases of change in complex systems: exploitation, conservation, creative destruction, and renewal". Understanding this phases of change can guide management actions and their timing (Resilience Alliance 2010).

Resilience is a property of systems, which can be useful for managing natural resources in socialecological systems. This concept is especially useful to take into account uncertain and complexity of systems where ecological and social components interact at multiple levels (Carpenter et al. 2001; Chapin 2009). In this context, the concept of **resilience** is defined as "the capacity of a system to absorb disturbances and reorganize while undergoing change so as to retain essentially the same function, structure, identity and feedbacks" (Resilience Alliance 2010).

In contrast to a resource management based on reaching an equilibrium state, **resilience-based stewardship** looks for responding and shaping change in order to "sustain the capacity of socialecological systems to provide benefits to society" (Chapin 2009; Resilience Alliance 2010). This kind of stewardship considers multiple potential states, fosters variability and diversity and assumes that people have responsibility to sustain future options (Chapin 2009). Under the conditions presented, **stewardship strategy** is a plan of action to enhance resilience of socialecological systems (Resilience Alliance 2010).

3. Methodological foundation

The research questions were addressed by performing a single case study, the case of the Carmen Alto indigenous community. The qualitative analysis used two frameworks as guidelines. The first one, the Resilience Assessment framework, is the core of the methodology. It guided the process for understanding resilience for Carmen Alto as a social-ecological system and for drawing the stewardship strategy (Resilience Alliance 2010). Resilience Alliance's methodology is complemented by applying an analytical framework about factors related to success of commons-based enterprises. This framework allowed a better understanding of a community-based enterprise emergence and formation, which were used to enrich the stewardship strategy (Orozco-Quintero & Davidson-Hunt 2010). The data necessary was

gathered from multiple sources of evidence, which included an extensive review of secondary data, semi-structured interviews and a workshop.

A case study had being chosen as research strategy because of limited data availability. Since commercial asaí berry harvesting is a new activity in Bolivia, the amount of research is small compared to levels of research in Brazil. Besides, the selected frameworks, Resilience Assessment and Success Factors of Commons-based Enterprises, are new approaches to management planning of natural resources in Bolivia. The Resilience Assessment framework has being chosen because it can provide insight into developing low emission development strategies when dealing with an uncertain and complex context, as the Bolivian Amazon. Regarding the second framework, it was included to complement the social system assessment with an analysis of the possibilities of successful entrepreneurship in Carmen Alto. This analysis was useful when designing the stewardship strategy to enhance resilience through asaí berry harvesting.

3.1 Methodological steps

The following methodological steps have been adapted from two frameworks. The resilience assessment framework gave the tools to develop a conceptual model of Carmen Alto's social-ecological system, an indigenous community with the potential to harvest asaí berry. This is further explained in steps 1, 2, and 3. The second framework, Success factors of commons-based enterprises, provided insight into the entrepreneurial skills of Carmen Alto's residents. Step 4 provides more detail on that matter. Based on previous steps, a stewardship strategy is designed and explained in Step 5. For clarity, Carmen Alto will be known from now on as the focal system.

Step 1. Describe the focal system through the key resource uses, ecosystems services, and critical disturbances

The step 1 addresses two critical questions to define specified resilience of the focal system: "Resilience of what?" and "Resilience to what?"

First of all, the social-ecological boundaries and components of the focal system were defined to answer the first question. This was done by considering the main issues in the focal system, identifying system attributes that are valued by the stakeholders and then stating the main issue to be addressed in the assessment. After this, the appropriate temporal boundaries to examine the focal system were defined. Then, direct and indirect uses of key natural resources and ecosystem services supplied by the focal system and the stakeholder that rely on them were identified. Only key components are mentioned since the study area is part of natural tropical forests and a complete list could be too long and would be beyond the research scope.

Secondly, in order to answer the question "Resilience to what?" the critical causes of disruption of the focal system were identified. The disturbances, which can be natural or human-caused, were characterized by their frequency, severity and predictability. The key findings regarding resource uses, ecosystems services, and critical disturbances are summarized on a conceptual model of the focal system. The conceptual model is simple for the sake of clarity in the assessment and the design of the stewardship strategy. Finally, the space scale of the focal system was expanded by identifying the system operating at a scale above the focal system. After this, the most critical interactions between them were identified. Also the time scale of the focal system was expanded. A historical timeline from 1940 to 2013 was developed based on major events, where the trigger events that led to regime shifts were identified.

Step 2. Understand the system dynamics: change drivers, alternative states, thresholds

Based on the historic timeline obtained on the first step, the key factors that drive change in the focal system were named. Then, a key variable that could be used as indicator of change was determined. After this, it was identified in which phase of the adaptive cycle is the focal system: growth, maintenance, collapse or reorganization. Next, the current state of the focal system was described according to key components and the relationships among them. The same process was followed for describing the historical state and two potential future states. One of the potential future states included increasing the asaí harvesting activity in the focal system. Finally, the changes in key components that cause a shift to alternative states of the focal system were described.

Step 3. Describe governance and social networks in the focal system

Regarding governance, key formal and informal institutions involved on decision-making were identified in the context of the focal system. Then, the scale of the decision-making processes (local, municipal, provincial, national) was identified asking if this level is appropriate considering ecological process. Next, rule compliance and enforcement were described in terms of its effectiveness. Finally, the power relations were listed by naming those institutions with formal and informal power, existing conflicts and conflict resolution mechanisms.

The social networks were mapped by constructing a simplified sketch of the contacts between stakeholders involved with the focal system. Then a basic analysis was conducted regarding number of relations between groups, degree of centrality of groups and presence of clusters in the network.

Step 4. Describe status and trend of factors that contribute to establish a successful community-based enterprise dedicated to asaí harvesting in the focal system

There were five factors considered: Holistic vision, mission and values; Institutions and managerial structures; Capitals and capacity building; Land and resource tenure; and Informed leadership. The focal system was evaluated to know if it has developed the factors that increase chances of success for a community-based enterprise, with harvesting of asaí berry as the main activity. The status and trend of each factor were described according to characteristics related to the success of community-based enterprises (Table 1).

Table 1. Factors that contribute to establish a successful community-based enterprise.

FACTOR	CHARACTERISTICS ASSOCIATED WITH SUCCESS		
Holistic vision, mission	- Long-term holistic goals.		
and values	- Institutionalized vision and goals, independent of politics.		
	 Strong connections with land and traditions. 		
Institutions and	- Bodies overseeing community' political issues and long-term goals		
managerial structures	without interfering with management tasks.		
	- Clear, agreed upon verbal or written set of laws or constitutions.		
Capitals and capacity	- Community capital.		
building	- Management skills.		
	- Qualified workforce or improvement of labor skills.		
	 Ability to acquire external financial support. 		
	 Reaching new or established markets. 		
Land and resource tenure	- Jurisdiction and control over land and resources.		
	- Establishing legitimate land and resource use and management rules.		
Informed leadership	- Having an effective leadership.		
	- Establishing internal and external legitimacy.		

Source: Modified from (Orozco-Quintero & Davidson-Hunt 2010).

Step 5. Design a resilience-based stewardship strategy for the focal system

The findings of previous steps provided insight into options to enhance resilience. Based on that information a resilience-based stewardship strategy was drafted to sustain the capacity of the focal system to provide ecosystem services to Carmen Alto's residents within the context of LED. This was done by identifying opportunities and possible actions to seize those opportunities. Next, barriers were identified as limiting the implementation of actions where asaí berry harvesting contributes to enhance resilience in the focal system.

3.2 Description of the study site

The Tacana-Cavineño indigenous territory is located in Bolivia, South America (Figure 1). As part of the Amazon forests, the area is mostly covered by evergreen rainforests where trees grow between 30 and 45 m tall. The relief is generally flat (slope <10 m) to slightly rolling on the north (>20m). While the dry season only lasts two to three months, the average annual temperature is between 24 and 27 °C and the average annual rainfall is between 1500 and 2400 mm (Ibisch et al. 2003). Because of climate change, an increase in temperature (around 2 °C by 2030) and intensification of the rain cycle are expected (Seiler 2009). The Tacana-Cavineño indigenous territory is part of a highly biodiverse ecosystem, which has important ecological functions like carbon storage and hydrological regulation. Considering the above mentioned, it has a high priority for conservation and sustainable use in Bolivia (Ibisch et al. 2010).



Figure 1. Study area: location of the Tacana-Cavineño indigenous territory and the asaí forest distribution (Arroyo 2012).

This indigenous territory is a communal property of the Tacana and Cavineño people, recognized by law since 2010. The Tacana-Cavineño indigenous territory has 809 inhabitants and its territory covers 271,049 ha within the Bolivian Amazon forest. The population is scattered in 12 communities over a vast territory with few and poor roads. The population has a broad base, where more than half of the population is under 18 and a small amount of population is over 54 years. Subsistence activities include slash and burn shifting cultivation, raising animals, hunting and fishing. The major business activities are: Brazil nut harvesting, fishing and timber harvesting. The annual median household income is less than US\$ 3,000 (Escalante 2012; Roca 2012a).

The indigenous community selected for the case study, Carmen Alto, is located in the northern part of the Tacana-Cavineño indigenous territory. It has been selected because it has several conditions that could help it to become a pioneer on the asaí berry value chain in the context of LED. Carmen Alto is located in an area where the resource is abundant (Altamirano 2012; Arroyo 2012). It is part of an indigenous territory with social and political stability where the access and use of natural resources is guaranteed (Roca 2012b). Also, it is close to Riberalta, the largest city in the Bolivian Amazon with around 100 thousands inhabitants. Although this increases the pressure to change the land use, it also provides opportunities to commercialize NTFP like asaí berry and access to better transport to reach other markets (Arroyo 2012). Finally, it belongs to an area with a higher level of available information regarding asaí populations and profitability (Altamirano 2012; Quiroga 2012).

3.3 Data collection and analysis

In order to present a strong case study, the information was gathered from multiple sources of evidence. It included a review of secondary data, semi-structured interviews, observation, visit to the community and harvesting areas and a workshop. The methodological steps, section 3.1, was used as a guideline to determine what information was needed and then to analyze it.

The secondary data was obtained through an exhaustive review of relevant publications about: asaí palm ecology; livelihoods, structure and policies of indigenous community; and management of NTFP in the study area. It is important to note that the information for these topics is scarce and not always published in peer-reviewed journals, therefore grey literature was consulted as well (e.g. technical reports, thesis, and newspapers).

Regarding the semi-structured interviews, information was collected from a wide range of people who have first-hand knowledge about the focal system. Key informants of the indigenous communities, local experts, local authorities and local business owners willing to buy asaí berry were consulted. Their knowledge and understanding provided insight into social-ecological resilience of the focal system and give recommendations for stewardship strategies. This was done by selecting the key informants, and then preparing an interview guide.

The first day at Carmen Alto, a meeting with residents of the community was organized in coordination with the president of the community. It was explained in simple terms the research aim, those involved, the methodology and steps. The participants commented on the use of asaí and asked questions about the scope, which were answered. Finally, it was agreed that I would visit the houses to conduct individual interviews to gather information. It was also agreed to hold a workshop at the end of July for the joint review of the conceptual model and the proposed strategy.

The following days semi-structured interviews were conducted based on the availability of the residents. Twenty two people were interviewed: 13 men and 9 women of different ages. It was looked for those who were identified as key informants like: board members of the community, teachers, health center employees, older residents, residents who could participate harvesting or processing asaí fruit. In Riberalta, eleven semi-structured interviews with local authorities, local experts, and local business owners willing to buy asaí berry were conducted (see Appendix 1). Notes were taken during the interview, to record an answer, and after this activity. This approach was found to facilitate a more comfortable environment with the participants, when compared to the original idea of tape recording the interviews.

Observation is another source of data. The community was visited and there was a stay with residents (two visits, of 8 and 4 days), to observe their daily routine and struggles. The stay also offered a chance for spontaneous chat with people previously interviewed, which allowed improving the data collection. Additionally, areas were visited where Brazil nut is currently harvested, where palm heart used to be extracted and where asaí is expected to be collected. These visits permitted to record the time required to access the resources and the state of the trails to get there.

Finally, after processing the information, a workshop was organized at Carmen Alto to validate the proposed conceptual model and strategy. All community adults (men, women, both young and old) were invited and given a simplified presentation of the results. Three groups were then organized to express more openly an opinion about the accuracy of results and the feasibility of implementing the proposed strategy. They were also offered a chance to propose additional ideas for the strategy and complete data to the conceptual model. Each group presented its results to the plenary and those inputs were considered in this document.

The main tools to gather, organize and analyze the information on steps 1 to 3 were the worksheets provided by the workbook for practitioners "Assessing resilience in social-ecological systems" (Resilience Alliance 2010). Additionally, the Quasta software was used for step 1. This tool helps to represent the system in a comprehensive manner through cause-and-effect relationships (van Kouwen et al. 2009). It helped to draw a conceptual model of the system.

The semi-structured interviews and the workshop were organized in collaboration with FAN-Bolivia. This organization has partnerships with indigenous, local and national organizations. Besides, it has field technicians, an office, and means of transport in Riberalta, two hours from the study area. These conditions facilitated contacting key informants and logistics on the field.

A 30 ECTs thesis has been selected, because of several reasons. The scope of the research, established on the methodological steps, requires a moderate amount of empirical work. Also, the researcher is already familiar with conceptual models and the resilience assessment framework. Lastly, the partnership with FAN-Bolivia will facilitate obtaining the required empirical data.

4. Results

4.1 Carmen Alto: the focal system

4.1.1 Spatial and temporal boundaries

In order to define the spatial and temporal boundaries, the issues of the focal system were considered. After interviewing the stakeholders, two issues have been identified: Threatened ecosystem services, and Over-harvesting of resources (Table 2). The focal system provides many ecosystem services to their residents and even to external actors. The main relevant services for this system are: climate and water cycle regulation, CO₂ sequestration, and production of goods for human consumption. These services are threatened by the overuse of some products and climate change. For instance, the harvesting of palm heart has degraded many wetlands, which have become dry because of lack of vegetation cover. This affects water availability for the community. Streams, water sources and wells that used to provide enough water throughout the year have reduced their content and even vanish during the dry season.

People interviewed agree on a series of system attributes which are highly valued by the community. Residents of Carmen Alto value that the forests cover allow them to live in a dust-free and cooler environment when compared to the city of Riberalta. The forest also provides a source of income through products they can sell (e.g., Brazil nut and timber) and products they

can consume like bush meat and construction material. External actors, like small entrepreneurs, value that the focal system is a source of products they can process and commercialize. Local and indigenous leaders also value the focal system as a support to the resident's livelihoods and a driver of the regional economy. In summary, the most valued attributes are those related to ecosystem services provided by the Amazon forest that covers the focal system. For this reason, the threatened ecosystem services will be the main issue to be addressed in this assessment.

ISSUES	MAIN ISSUES OF CONCERN IN THE	VALUED ATTRIBUTES OF THE SYSTEM
	FOCAL SYSTEM	
Issue 1	Threatened ecosystem services	Source of income, fresh meat (bush meat and
		fish), construction materials (timber for walls
		and furniture, palm leaves for roof), fresh air,
		benign microclimate (cooler than the city)
Issue 2	Over-harvesting of resources	Native biodiversity

Гable 2. Summary с)f	assessment fo	cus	and	system	attributes.
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In view of threatened ecosystem services as the main concern, the following spatial and temporal boundaries have been defined for the system.

The focal system, Carmen Alto, is an indigenous community located in the north-eastern corner of the Tacana-Cavineño indigenous territory (latitude: 11° 42' 38" S; longitude: 66° 21' 46" W). It is 15 minutes away by car from one of the main roads of the Bolivian Amazon. This road connects with Riberalta, the largest city in the region, which is about two hours away by car. The influence of this road and Riberalta city over Carmen Alto will be further explained in section 4.1.6 (Scale above the focal system). From an administrative point of view, the community lies in the Riberalta municipality of the Beni department (state). However, historically it has received more economic support from the neighbor municipality of Reyes (Figure 2).



Figure 2. Location of the Carmen Alto community in the Tacana-Cavineño indigenous territory, the municipalities in the region and Bolivia.

As far as the oldest interviewee remembers, Carmen Alto started as a settlement of rubber tappers around the year 1946. Therefore the appropriate temporal boundaries to examine the focal system have been set from 1940 to the present. Therefore, the establishment of the community is included as a key change in the ecological dynamics of the area.

4.1.2 The ecosystem

ABIOTIC CHARACTERISTICS OF THE FOCAL SYSTEM

The focal system is marked by the presence of two kinds of landforms: uplands and lowlands. The first ones are rolling to hilly dissected lands, rounded hills with convex slopes and gently rolling plains, which have altitudinal intervals no greater than 200 meters. The uplands have red lateritic soils, which are deep to rather deep, well-drained, acidic, low in nutrients, and rich in

iron oxide and aluminum oxide. The lowlands are flat lands and inland wetlands (mainly floodplains, streams and springs) whit alluvial soils. The soils are predominantly acidic with clay minerals of lower activity. This landform is subject to seasonal flooding caused by precipitation or stream overflow. Its internal drainage conditions vary between moderately well drained and somewhat poorly drained (Sombroek 2000; Navarro & Maldonado 2002)

BIOTIC CHARACTERISTICS OF THE FOCAL SYSTEM

The focal system is part of the highly diverse Amazon region, which has at least 3,000 endemic plant species. It consists of largely undisturbed rainforest, where two kinds of vegetation can be identified: upland forest and flooded forest. The former is a closed-canopy forest, reaching 30-35m tall with emergent scattered trees which reach 45 m tall. It is also a semi deciduous seasonal forest since it is conditioned by 4 to 5 semiarid months. One of the characteristic species of this kind of vegetation is *Bertholletia excelsa* (Brazil nut). The above mentioned uplands are sustaining the upland forest (Navarrro & Maldonado 2002; Ibisch & Mérdia 2003).

The flooded forest, the second kind of vegetation founded in the focal system, is an open-canopy forest, reaching 20-25 m tall with isolated emergent trees 35 m tall (Navarrro & Maldonado 2002). Palm species like *Euterpe precatoria* (asaí) and *Oenocarpus bataua* are dominating the flooded forest. This kind of vegetation is sustained by the lowlands, where the hydrological regime limits tree growth (Sombroek 2000; Navarrro & Maldonado 2002; Ibisch & Mérdia 2003).

CONVERTED AREAS

A small portion of these natural areas, especially upland forest, has been converted to subsistence agriculture. It is customary in indigenous communities of the Bolivian Amazon to prepare land for food production through the clearing and burning of areas close to the human settlement. These areas are usually less than 5 hectares per household (Armijo 2012b).

Carmen Alto inhabitants report that the main crops are rice, cassava, plantain and sugar cane. Crop lands typically take advantage of limited soil fertility for 3 to 4 years, before being abandoned as fallow. Additional areas, closer to the community and smaller in extent have been planted with fruit trees, like cocoa (*Theobroma cacao*), grapefruit and a variety of lemon.

4.1.3 Key natural resources and ecosystem services

This assessment has identified the following natural resources as key: Brazil nut, timber, asaí palm heart, asaí berry, fresh water, and the soil. Some key ecosystem services have also been identified: provision of fresh water, nutrient cycling, local and regional climate regulation and carbon sequestration. A summary can be found in Table 3.

BRAZIL NUT

The Brazil nut tree (*Bertholletia excelsa*) is up to 45-50 meters tall, which makes it the tallest tree in the forest, and has a broad round canopy. The spherical fruit usually has 14 cm in diameter and contains between 20 and 30 angular woody shell nuts. The Brazil nuts are consumed as food and other products such as vegetal milk and vegetal oil. The fruit and nuts

shell are used as fuel in the production of ceramics and bricks in the Riberalta outskirts (Altamirano 2012).

The upland forest presents large patches of mature Brazil nut trees, which have high density in the focal system, about 27 ind. /ha. However, replacement of mature trees is low and natural regeneration of these kind of forests is slow (Altamirano 2012).

It is perceived that Brazil nut is a very abundant resource in the territory. Although users do not know the number and extent of productive trees in their territory, the Brazil nut areas are divided into several "*centros castañeros*" (Brazil nut harvesting units). Each "*centro castañero*" is aimed at a family. While Brazil nut grows without human intervention, users must spend time, manpower and money to harvest the fruits. The work begins with the cleaning of the roads that leads to the "*centros castañeros*". The harvesting is a family activity which typically involves an average of 2 people per family (Quiroga 2012).

In the Bolivian Amazon, rural communities' income is highly dependent on income coming from Brazil nut commercialization (Bojanic 2001). Some studies suggest that Brazil nut harvesting is social and economically more important for the indigenous communities than the harvesting of other non-timber forest products (Zenteno et al. 2013; Stoian 2004)

On 2011, each person collected 3 bags of nuts per day on average, and each family collected 69 bags of nuts during the harvesting season. Reforestation with Brazil nut is supported by internal regulations of the indigenous organization. Also, users think that they need to recover burned areas and increase production of Brazil nut. However, the reforestation of this specie is not practiced (Quiroga 2012).

TIMBER

The timber is used since the initial settlement in a community, to build houses for the resident people. As part of the Amazon forest, the focal system is rich in high-value timber species (Bojanic 2001). However, it has been only three years since the community started practicing commercial logging in a portion of its influence area (see Figure 6). It is important to mention that timber trees are located in the upland forest, where the Brazil nut trees are also found. According to Bolivian legislation, it is prohibited to cut Brazil nut trees, which makes the commercial logging focus only on allowed species, with the right size for logging. Young saplings and nursery trees are left to allow forest regrowth. Based on the current legislation, the community has a 20-year timber extraction management plan.

ASAÍ PALM HEART

The asaí palm heart is obtained from the inner core and growing sprout of *Euterpe precatoria*. This species grows mainly in the flooded forest, but it can be also found in the upland forest. As asaí is a single-stemmed palm, harvesting of palm heart kills adult reproductive individuals (Moraes 2004; Moreno & Moreno 2006).

According to the interviews to the community's residents, palm heart has been harvested on an off during the last 20 years. The last 3 years the activity has been reduced considerably because of resource accessibility. The community used to go to harvest palm heart in groups of 10 to 20

men following the pattern shown in Figure 3. The harvesting areas were up to 30 minutes away by motorcycle and 20 minutes walking from the community (according to my experience during the visit to the community and harvested areas). Each person could harvest around 20 pieces of palm heart (around 60 Kg) per day. Local intermediaries bought the product in the community and transport it to the processing plant in Riberalta city or Guayaramerín city. This activity started after crop harvesting and lasted for 3 months until the activities of slash and burn shifting cultivation initiated.



Figure 3. Pattern to harvest palm heart in groups.

ASAÍ BERRY

The asaí palm tree (*Euterpe precatoria*) has a rounded fruit, relatively hard, with a dark color, almost black. The palm trees have 3 to 4 infrutescences which mature at different times. The ripe fruits can be found in the forest around mid-year, however this stage varies based on soil types and humidity (Moraes 2004). Asaí palm trees grow notoriously taller and their infrutescences grow bigger when located in flooded forest when compared to upland forest. Therefore, the flooded individuals are favored for commercial use (Velarde & Moraes 2008).

In the Carmen Alto community, mature asaí fruits can be obtained starting in May until September. The months between June and August provide the largest amount of fruits. The community knows and consumes regularly the asaí fruit pulp, which is manually extracted to prepare a juice with banana, as a sweetener. This beverage, called "*payuje de asaí*", is known to be rich in nutrients and is commonly consumed to give strength to children and sick people.

Currently, the commercial exploitation of fruits is more opportunistic, when harvesting the palm hearts. Harvesters would only consider the collection and sale of fruits if they are ripe when the palm heart extraction is performed. However, this inconsistent approach makes for a low volume of collected fruits.

The fruits are usually sold to the same person buying the palm hearts. It seems that the buyers then sell their fruits to Madre Tierra Amazonia, an enterprise that does the processing of the pulp at an industrial scale. This enterprise declares a preference for buying asaí fruits collected from standing palm trees because this practice guarantees long-term resource availability. However, because the enterprise purchases the fruits in Riberalta, a large city, there is no way to verify any assertion on sustainable harvesting practices.

FRESH WATER

Water is also an important resource for the Carmen Alto community. There are two main water sources for human use: wells and the Geneshuaya River. Three common wells provide water for human consumption and for doing dishes. These wells, 10 to 15 meters deep, provide a water that is clean, not contaminated (does not cause health issues like diarrhea or similar illnesses), and is favored to drink because it is cold and pleasant.

The community borders the Geneshuaya River, which is around 50 meters wide. This river provides water to take a bath and wash clothes, but not for human consumption.

In recent years, the water level in wells have been decreasing, to the point of depletion, at least in one well during the 2012 dry season. Because of that, at the end of the dry season (August to September), the people only use the well's water to drink and cook, using river water to clean their cooking utensils.

SOIL – LAND

Even though the soil appears fertile because it supports a dense canopy, it is in reality very fragile and poor. The tree coverage relies on a very dynamic cycle of nutrients which supports the high biomass through constant renewal. Once the trees are cut and burned to make way for crops, the soil loses its fertility in a few years (Sombroek 2000).

However, the soil is clearly one of the main natural resources for Carmen Alto inhabitants. Thanks to the soil they can cultivate food for the family consumption, to exchange the surplus with neighbor families or other communities, and to sell a smaller part. Rice, cassava and plantain are the main cultivated food products. The rice is stored as a grain, at least half a year, for consumption, exchange or sale. The cassava is converted to *chivé*¹ for direct consumption or sale to neighbor communities or Riberalta.

Hence, access to arable lands makes an important contribution to food security. It is also a key support to family income for months outside of the Brazil nut harvesting season (December to April) and a key reason that people do not emigrate to urban areas.

CLIMATE REGULATION

The forest cover provides climate regulation as an ecosystem service, though the cooling of the local climate and as rain generator. Once this cover is degraded or removed (deforestation), there is less absorption of heat, less moisture is transferred to the air and hence less rain is available (Spracklen et al. 2012).

Carmen Alto residents perceive a clear difference between their local climate, considered cooler and more pleasant than the one observed in the city of Riberalta. This difference is attributed by them to the forest surrounding the community and the fact that most of the houses were built under the shadow of large trees, remaining from the original forest or planted long time

¹ Cassava that has been grated and toasted.

ago. This clever placement of the human settlement maximizes the benefit provided by the forest.

Table 3. Direct and indirect uses of key natural resources supplied by the system and the stakeholder that rely on
them.

KEY NATURAL	PRACTICES	NATURAL RESOURCES USES	STAKEHOLDERS
RESOURCES			
		Direct uses	Inside focal system
Brazil nut	Wild collection	Commercialization	All residents
Timber	Timber logging	Subsistence and	All residents,
		commercialization	FABOLMA (timber
			company)
Asaí palm heart	Wild harvesting	Commercialization	Few residents
Asaí berry	Wild harvesting	Commercialization	Few residents
Fresh water	Well drilled until	Subsistence	All residents
	reaching the		
	water table		
Soil - land	Slash and burn	Subsistence and	All residents
	shifting	commercialization at a	
	cultivation of rice,	smaller scale	
	cassava, banana		
	and sugar cane		
KEY NATURAL		ECOSYSTEM SERVICES	STAKEHOLDERS
RESOURCES			
		Direct uses	Inside focal system
Upland forest and		Fresh water provisioning	All residents
flooded forest		Nutrient cycling	All residents
		Local climate regulation	All residents
		Indirect uses	Outside focal system
Upland forest and		Climate regulation	Amazon forest region
flooded forest		Carbon sequestration	Amazon forest region

CARBON SEQUESTRATION

Another ecosystem service related with forest cover is the sequestration of carbon. Forest covert is important for carbon sequestration since woody plants, usually accumulate more carbon, live longer, and decompose slower than shrubs and grasses. Conserve or restore forest could lead to improve carbon sequestration along with other ecosystem services like climate regulation, nutrient cycling and fresh water provisioning (Millenium Ecosystem Assessment 2005).

In the case of Carmen alto area, the forest sequestrates more than 150 Mg/Ha of aboveground woody carbon (Baccini et al. 2012). This ecosystem service is less known to Carmen Alto residents. Awareness of this important ecosystem service of the Amazon forest is more prevalent with authorities of the Riberalta municipality and leaders of indigenous organizations.

CALENDAR NATURAL RESOURSE USE

The use of natural resources in the focal system can be summarized through a calendar (Table 4). Primary activities are the ones that take most of the resident's time. Secondary activities take only a marginal time of each family.

Palm heart harvesting is included as a main activity because of its high importance until recent years. However, because of the decline in income derived from this activity, male members of the family tend to seek a job outside the community, especially between July and September. For instance, they work as motorcycle taxi drivers in Riberalta, which still allow them to keep more profitable activities like Brazil nut harvesting or activities that ensure their food security.

SEASON	MONTH	ΜΑΙΝ ΑCTIVITY	SECONDARY ACTIVITIES	OBSERVATIONS
Wet	January	Brazil nut harvesting		
season	February	Brazil nut harvesting		
	March	Brazil nut harvesting	Crop harvesting	
			(cassava and	
			plantain)	
	April	Brazil nut harvesting	Crop harvesting	Small harvest
			(cassava and	
			plantain)	
Dry	May	Crop harvesting (rice)	Crop harvesting	
season		and cultivate	(cassava and	
		(cassava)	plantain)	
	June	Crop harvesting	Crop harvesting	
			(cassava and	
			plantain)	
	July	Asaí palm heart	Crop harvesting	The extraction is
		harvesting	(cassava and	not directly
			plantain) and timber	performed,
			extraction	leaving this
	August	Asaí palm heart	Crop harvesting	activity to timber
		harvesting	(cassava and	company.
			plantain) and timber	
			extraction	
	September	Asaí palm heart	Crop harvesting	
		harvesting, Prepare	(cassava) and timber	
		new land for	extraction	
		cultivation and		
		cultivate (cassava and		
		plantain)		

Table 4. Calendar of activities in the focal system.

	October	Prepare new land for	Crop harvesting	
		cultivation and	(cassava) and timber	
		cultivate (rice,	extraction	
		cassava and plantain)		
Wet	November	Brazil nut harvesting	cultivate (rice)	
season	December	Brazil nut harvesting	cultivate (rice)	

Based on observations, interviews and Roca (2012a)

4.1.4 Disturbances

The focal system has the following main disturbances: wildfire, drought, increase in temperature and disruption (intensification) of the rain cycle (Table 5). Although floods are a very common problem in the surroundings, it is not an important disturbance in the focal system. The area lies above the level affected by flooding coming from the river. Only ecological disturbances are included, which leaves economic disturbances out because of the current scope of the study. The Discussion section will provide some comments on the importance and research opportunities for economic disturbances.

WILDFIRE

The focal system, as the Amazonian forest in general, is impoverished by fire from time to time. However, incidental surface fires, which burn standing forest, remain as commonly undocumented fires. Severe droughts, or drought intensifications because of a changing climate, increase flammability, which makes even undisturbed forest vulnerable to fire during the dry season. The fire also increases forest vulnerability to future burning and releases CO₂ to the atmosphere, which have the potential to increase net carbon emissions from regional land-use (Nepstad et al. 1999).

Fires happen during the dry season, mainly between the months of August to September. These events are mainly caused by humans, even though they have been intensified by environmental conditions. (Armijo 2012a; Roca 2012c)

During the past 30 years, forest fires have affected the area with low intensity cases, with an annual periodicity. It is expected that climate change will intensify and make more frequents these fire events (Gonzales & Zalles 2009).

The need to prepare new land for cultivation is a main cause of fires in Carmen Alto. The residents cut and then burn the trees to open new crop fields, between October and November each year. The fire is a useful tool and it comes almost free for people that do not have any machinery, or resources like pesticides or fertilizers. Even though they usually wait to burn until after the first rainfall, sometimes the fires run out of control and impact an area larger than expected.

The worst fire incident in people's memory happened on year 2005 when an area of 40 hectares (estimate) was burned with planted trees devoted to logging and cocoa. At the time, the trees were 7-year old and the cocoa trees provided fruits. The cocoa production, which was starting in Carmen Alto, declined to almost zero after this incident.

DROUGHT (DECREASE OF RAIN IN THE DRY SEASON)

The past 25 years, the Bolivian Amazon has experienced a trend of decreasing rainfall during the dry season. This phenomena increase the risk of droughts, especially between June and August (Espinoza Villar et al. 2009; Seiler et al. 2013a). An increase in droughts could have a major impact in subsistence crops, which depend entirely on rainfall (Spracklen et al. 2012). This trend is expected to continue as climate models predict that the Bolivian Amazon could become drier and warmer in the near future (Seiler et al. 2013a).

In the focal system, residents claim that the dry season has intensified in recent years. There are some signals of this phenomenon in the reduction of creeks flow, water sources and wells. The city of Riberalta, less than two hours away by road, has long-term climate records of this decrease in rain in the dry season, suggesting that it could be a regional phenomenon (Figure 4).

Some people relate this problem to the overharvesting of palm heart in the past two decades. There are some suggestions that flooded forest areas, where palm trees were present, have become increasingly dry at the peak of the palm heart extraction. Because the flooded forest is an important component of a system that keeps and filter the water, it may explain that the volume of water bodies were more affected during the dry season.

In 2011 a significant drought was reported in the focal system and for the first time one of the three wells became completely dry. Esto tuvo un impacto en la disponibilidad de agua para beber en el sistema focal.

INCREASE IN TEMPERATURE

It is known that tropical forests are highly sensitive to climate change, and recently it has been demonstrated that small increases in temperature (1 to 4 °C) can affect its growth and reproductive health of the forest (Pau et al. 2013). The temperature in the Bolivian Amazon is currently increasing at a rate of 0.1 °C per year, which adds up to at least 0.4 °C during the past fifty years (Seiler et al. 2013a). A significant increase in the temperature is projected by regional climate models for the Bolivian Amazon region. Temperatures could potentially increase in a range between 1.3 °C and 1.6 °C for year 2030 and 2.5 °C to 5.9 °C for year 2070 (Seiler et al. 2013b; Seiler 2009). There is a perception that temperature has been increasing recently. Elder people report warmer years in recent times in the focal system.

INTENSIFICATION OF THE RAIN CYCLE

Climate models for the Bolivian Amazon project less rainfall (a decrease of 19%) during the dry season (April to September) due to climate change (Seiler et al. 2013b).

Extreme occurrences of this water stress could impact on tree mortality in a similar way that has occurred in other portions of the Amazon biome (Rammig et al. 2010; Lewis et al. 2011).

Deforestation also reduces significantly rainfall during the dry season (April to September) in the Amazon region. The air in a forested area produces twice the rainfall when compared to a deforested area. Activities that decrease deforestation rates could reduce and even avoid the negative impacts on the rainfall (Spracklen et al. 2012).

There is also a local perception that the rainfall regime has changed. For instance, the rain seems to fall later in the year than before, closer to November. This change is visible because traditionally the first rains are expected before preparing (slash and burn) the cultivation areas. It also seems that the dry season has extended in time and there is less rain than before in this season.

This perception seems to be confirmed with records for the city of Riberalta, the closest location with climate records covering at least 30 years. When comparing average monthly records between two series of the past 30 years, the most recent one (1995-2011) shows an increase in precipitation for the wet season, especially December to April, compared to the previous series (1974-1995). In the dry season, the precipitation decreased in the most recent series, mainly between June and July (Figure 4) (Armijo 2012a). This shift in occurrence of rainfall is consistent with forecasts made for the future (Seiler et al. 2013b).



Figure 4. Intensification of rainfall in the city of Riberalta, the Bolivian Amazon. Comparison of average monthly records for two temporal series (1974-1995 and 1995-2011). Source: (Armijo 2012a).

DISTURBANCE		SINGULAR EVENTS OR EVENTS THAT OCCUR CONTINUALLY	FREQUENCY OF OCCURRENCE (IF IT IS A SINGULAR EVENT)	TIME FOR RECOVERY (SHORT-TERM TO LONG- TERM)	Most Affected Components	MAGNITUDE OF IMPACT (MINOR TO SEVERE)	CHANGE IN PAST YEARS OR FUTURE TREND
Past	Wildfire Drought	Singular events Singular events	Annually (during dry season) Annually (during dry	Short-term Short-term	Forest cover and soil Crops, fresh water	Moderate Moderate	more intense more intense*
Present or Future	Wildfire	Singular events	season) Annually (during dry season)	Long-term	Forest cover and soil	Moderate to Severe*	more intense*
	Drought	Singular events	Annually (during dry season)	Long-term	Fresh water, crops	Moderate to Severe*	more intense*

Temperature	Events that occur	n/a	Long-term	Forest cover	Moderate	more
increase	continually				to Severe*	intense*
Rain cycle	Events that occur	n/a	Long-term	Forest cover	Moderate	more
intensified	continually		-		to Severe*	intense*

* If no mitigation actions are taken

4.1.5 Conceptual model of the focal system

Critical disturbances, resource uses, and ecosystems services are summarized on a conceptual model of the focal system. It is presented a simplified model and a model which include the sub-system in Carmen Alto (Figure 5).

SIMPLIFIED MODEL OF THE FOCAL SYSTEM

The simplified model of the focal system shows the negative relationship of the disturbances over the Amazon forest and the positive relationship between the Amazon forest and the ecosystem services.

The Quasta program allows the analysis of the effect of a change in the model. Figure 5.A shows that to increase drinking water, it is necessary to increase ecosystem services and reduce the disturbances. However, a close look over the Amazon forest is needed to understand better the focal system. Therefore, the next section will explore the relationship between resource uses, disturbances and ecosystem services.

MODEL OF THE FOCAL SYSTEM INCLUDING SUB-SYSTEMS

A more detailed conceptual model shows the subsystems within the Amazon forest in the area of the focal system, which are: flooded forest, upland forest and converted areas. It is shown the key uses of resources in each subsystem, how they relate to ecosystem services and are affected by disturbances (Figure 5.B).

For example, the use of asaí palm heart has a negative relationship with all environmental services represented in the model. By cutting the palm, to harvest the heart, the carbon stocks are reduced; the flooded forest dries out and causing a reduction on the depth of the water table which provides drinking water. Likewise it has a negative relationship with local climate regulation and nutrient cycling that maintain soil fertility. Asaí palm heart harvesting also increases the negative effects of the disturbances over the Amazon forest. The harvested areas are more vulnerable to wildfire, droughts, temperature increase and intensification of the raincycle. An analysis with Quasta program shows the effect of increasing asaí berry harvesting (Fig. 3.B). In that case, there is an increase of all environmental services and a decrease of the disturbances without affecting Brazil nut harvesting, timber extraction, and slash and burn shifting cultivation.





Figure 5. Critical disturbances, resource uses, and ecosystems services are summarized on a conceptual model of the focal system. A. Simplified model of the focal system. B. Focal system including sub-systems.

Change

4.1.6 Scale above de focal system

SURROUNDING COMMUNITIES, PRIVATE OWNERS

The focal system is bordered by indigenous communities and private owners. The closest indigenous communities are Recreo, to the north and La Esperanza, to the south; both are also part of the same indigenous territory. The private owners are Mr. Medina who owns San Antonio, a cattle ranch to the east of Carmen Alto; and Mr. Alpirez who owns El Descargadero, a horse ranch to the west of the focal system (Figure 6).



Figure 6. Extent of the Carmen Alto community (dotted yellow line), neighboring communities (white points) and private properties (light green polygons).

The delimitation between indigenous communities come from verbal agreements between the residents, to organize the use of natural resources. These agreements were necessary because an indigenous territory is defined as a collective ownership of land, which cannot be formally partitioned or transferred to third parties. On the other side, private properties neighboring an indigenous territory are defined by boundaries clearly delineated and supported by land rights

issued by a national agency. According to interviews with Carmen Alto inhabitants, the community estimates direct access to an area that covers around 16,900 ha (Figure 6). The agreements make the community the exclusive user of natural resources inside this area.

In general the informal boundary agreements inside an indigenous territory have worked well in the past. However at least one conflict, with a private owner (El Descargadero) has been reported. A formal demand has been submitted to the national forest authority (ABT) on an unauthorized harvesting of Brazil nut inside the indigenous territory.

ROADS

The Carmen Alto community is relatively close (less than 15 Km) to a major national road, that connects the largest city of the Bolivian Amazon (Riberalta) to the Beni savannah and Andean regions. Access of community residents to the main market (Riberalta) is done by an unpaved road and takes less than two hours by motorcycle.

There are plans to pave the main road (national route 8) as a part of a major infrastructure investment (the "Northern Corridor" project) to connect the Bolivian Amazon to the central part of the country (SNC 2005). The improvement of the existing gravel road will allow an all-year transportation² and will likely attract economic activities along the highway. The pressure of agriculture activities near the indigenous territory could happen as a result of an increased profitability of land linked to an improved access to larger markets as Riberalta and the highlands.

Carmen Alto inhabitants can also use a waterway as a transportation alternative to roads. The Geneshuaya River, around 50 meters wide, borders the community and connect it to small settlements along the river. Small boats are used for this purpose.

RIBERALTA

Riberalta (population ~ 100,000, 2012 estimate), is the largest city in the Bolivian Amazon. It is also the largest city in the Beni department (state) and the seat of the municipality of the same name (population ~ 160,000). Located in the Northeastern portion of the country (11° 00' 18"S, 66° 03' 58"W), it lies far from the main urban centers of Bolivia. The transportation of goods and people is made through unpaved roads that connect to neighbor states of the country and Brazil. There are also regular flight services to the city.

The local economy is based on the extraction and processing of Amazon forest products (Brazil nut³, timber, cupuazú, rubber) and the provision of services to the city and surrounding towns. As the biggest and wealthiest urban center of a large, sparsely populated region, Riberalta is a major market for agriculture products and a magnet for unskilled migrants or part-time laborers from surrounding towns and other states.

² The existing road is temporary closed in the rainy season.

³ Bolivia is the largest exporter of Brazil nut in the world and Riberalta is the largest processing and exporting site of this product in the country. The annual Brazil nut business in the country is worth US\$ 146 million in exports (La Razon 2013).

4.1.7 Historical timeline of the focal system

In this section, a timeline for the study area is presented with a focus in the management periods and system crisis. As stated before, the analysis covers from year 1940 to the present.

It has been identified three main management periods: Not used, Commercial forest product extraction without planning and Planning (Figure 7).

The first era, *Not Used*, is assumed to lack human settlements in the focal system area. Even though there is evidence of human occupation of the Bolivian Amazon by nomad groups (Stoian 2005), there is no record or oral memory of a settlement previous to the Carmen Alto foundation for the current location of the community.

The consolidation of this human settlement becomes the first recorded crisis, associated with the rubber extraction in the focal system.

The second period, Commercial forest product extraction without planning (or wild rubber and Brazil nut era), started with wild rubber extraction (Hevea brasiliensis) and later continued with Brazil nut (Bertholletia excelsa) and Palm heart extraction (Euterpe precatoria). The tacana, the indigenous ethnic group that lives in the Carmen Alto community, seems to have migrated from a neighbor area in the Amazon, in the northern portion of the La Paz department (state). This migration was related to the rubber extraction, which was the main economic activity of the community during almost four decades. In the beginning, the settlement did not look like an organized community. People used to work for a landlord and were dependent on this person to get their house supplies. At the time, the cultivation of food near the settlement was discouraged by the landlords to keep the dependence condition. The rubber exploitation lasted until 1986, based on the memories of the eldest member of the community. This crash in the regional rubber industry was caused by a significant decrease of the price of the product. As an aftermath, this economic outcome would break the relationship between landlords and workers. Around 1990, the Tacana-Cavineño indigenous territory is officially created and the Carmen Alto residents become organized as an indigenous community, with an elected board. The subsistence agriculture increased to add up to the main activities of Brazil nut and palm heart harvesting. However, activities that make use of natural resources were still not entirely planned.

A new crisis defines the change to an era of increased planning in the use of the resource. In year 2010, the palm heart harvesting is significantly reduced due to diminished profitability associated with long distances to collect the resource.

In the current and third period (Planning), some activities start to be planned. Timber extraction, an activity that requires management plans under the Bolivian legislation, increased in importance.

Some important additional crises, which did not force a change of the period, were caused by large wildfires (2005) and droughts (2012), as reported by Carmen Alto residents.



Figure 7. Historical timeline from 1940 to 2013 based on major events that led to regime shifts.

4.2 The system dynamics

4.2.1 Change drivers

Even though the above mentioned disturbances have a significant role in the system dynamics, the largest changes have been driven by socio-economic factors (Stoian 2000; Stoian 2005). The two identified crises in the history of the focal system, which changed the era, were caused by socioeconomic factors, as explained in the previous section.

During the last system change, there has also been a significant loss of natural capital. The flooded forest close to the human settlement experienced an extinction of adult individuals of asaí, which forced a halt on the exploitation activity and a need to consider a substitute source of income.

4.2.2 Indicator of change

Deforestation is one of the change indicators, as stated in the above mentioned history of the focal system. During the first era, it is assumed that there was no deforestation because no significant human population has been recorded for the area. With the rubber and Brazil nut era following, the deforestation was slightly increased. The forest provided timber for construction and fuel, to the rubber tappers. Only a more recent extraction of palm heart and timber, with low-scale agriculture, has increased the deforestation during the third era.

4.2.3 Phase of the adaptive cycle

Based on our analysis, the system is currently in a reorganization phase. The year 2010 exposed the system to an unexpected disturbance. The areas close to the human settlement of Carmen Alto were already exploited in previous years and no adult tree individuals were left for harvesting. Not having planned the use of the resource, it came as a surprise for the residents the need to invest more time and effort to reach palm trees that were now distant. "There was supposed to be so much palm tree (for palm heart harvesting) in the community that we thought it would never end", they said. Nevertheless, the palm heart price did not increase per unit,

staying at Bs. 2 (\notin 0.22). At this point, the cost of extraction was considered higher than the income. Because of that, most of the residents decided to stop harvesting; this created an income gap for the months between July and September.

By then, the people started to extract timber and seek alternative activities to fill the gap left by the palm heart harvesting. The collection of asaí fruits became one of these alternative sources of income.

It is under this context that the system is considered under reorganization phase. It is also a good time to propose a strategy that promotes resilience of the focal system.

Four states have been identified for the focal system: historical, current and two potential future developments (Figure 8). Each state is described in the following sections.

4.2.4 Historical state

The historical state is dominated by extractive activities where wild rubber and Brazilian nut were the main species harvested. Those activities were not subject to any kind of planning and depended only on market opportunities.

The good conservation status of the Amazon forest allowed sustaining the extractive activities. There were also two types of vegetation: upland forest and flooded forest. The rubber and Brazil nut were extracted from the upland forest and the palm heart was extracted from the flooded forest. The wood was only used as fuel or construction material, without any commercial exploitation. Asaí fruits were only consumed by the community residents, when they were ripe and ready for harvesting. There was no subsistence agriculture and this practice was even discouraged. Both types of vegetation provided ecosystem services as water supply, nutrient regulation, climate regulation and carbon sequestration. About disturbances, there was no perception of an increase in temperature, modification of rainfall regime and deforestation. Fires and droughts were milder, less affected by land use change or climate change.

In the historical state, the relationship was mainly landlord-laborer. The Carmen Alto settlement was composed of individual families, not organized as a community. Hence, the group of people was directly dependent on the landlord to get their basic supplies in exchange of rubber, Brazil nut and later, palm heart. At the time, there was no indigenous organization that could represent the people of the area. The presence of the national government was almost inexistent. The roads to Riberalta and surrounding towns were few, narrow and hard to navigate during the rainy season.



Figure 8. System dynamics: alternative states.

4.2.5 Current state

The current state has been widely described in sections 4.1.1 to 4.1.5. However, in this section a summary will provide a better understanding for the analysis and comparison with other states.

The current state is centered on extractive activities, with a focus on extraction of Brazil nut and timber, with subsistence agriculture.

The conservation status of the Amazon forest in the focal system is still good, which allows for applying extractive activities. There are two types of vegetation upland forest and flooded forest. The Brazil nut and timber are extracted from upland forest. However, the flooded forest surrounding Carmen Alto is partially degraded, because adult trees were cut to extract palm heart, leaving mostly young saplings. The extent of planning the use natural resources is improving in different ways. For the Brazil nut, some community members have joined Muije and there is a trend of more joining. Muije is a new association of Brazil nut harvesters, which helps them improve the harvesting practices, the direct selling of Brazil nut to processing plants and to get better prices. Including the timber extraction, this initiative is organized around a 20-year management plan. Some additional activities, like subsistence agriculture, do not have planning. The main crops are rice, cassava, corn and sugar cane.

Both types of vegetation provide the following ecosystem services: freshwater provision, nutrient cycling and carbon sequestration. The main disturbances include fires and droughts, both intensified by deforestation (to open agriculture fields) and forest degradation (palm heart extraction). There are two additional disturbances related to climate change: increase of temperature and disruption of rainfall seasonality.

At the current status, the Carmen Alto residents are organized as an indigenous community, with a board, and with common property toward the resources. The former landowner-laborer relationship is gone. However, there are still some middlemen that buy Brazil nut at lower prices to some residents, in exchange to giving advance money to people that have lower income and job opportunities (before the Brazil nut harvesting starts). Residents that are members of Muije avoid those middlemen and obtain better profits.

The community has a dynamic relationship with the regional indigenous organizations and the municipal governments (Riberalta and Reyes). The road connecting Carmen Alto to the main road (linking Riberalta to Rurrenabaque) has been improved (expanded and covered with gravel), which makes it easier to use most of the year, except the rainy season.

4.2.6 Potential future states

It has been identified two potential future states, which are: Sustainable asaí berry harvesting and Declining supply of ecosystem services. Following there is a description of both states.

STATE: SUSTAINABLE HARVESTING OF ASAÍ BERRY

This potential future state will show an important increase in asaí berry harvesting. This activity will help to diversify the activities of Carmen Alto residents, regenerate the flooded forest and preserve the forest cover; therefore, it will help to increase their resilience.

The conservation status of the Amazon forest in the focal system is good and the degraded areas start to recover. There are still two types of vegetation: upland and flooded forest. Brazil nut and timber are still extracted from upland forest. The extraction of palm heart has stopped completely and the degraded flooded forest recovers, allowing the harvesting of asaí fruit in areas closer to the community. The use of the main resources of the focal system (Brazil nut, timber and asaí) is planned.

Because the upland forest remains in good health and the flooded forest is recovering, the system as a whole maintains its main ecosystem services (water provision, nutrient cycling, climate regulation and carbon sequestration).

The resilience of the focal system is increased toward the main disturbances: fires, droughts, increase in temperature and rainfall disruption. The system has a forest in good conservation status, which keeps more water in the system y therefore slows the expansion of wildfires. The recovery of the flooded forest allows the replenishment of the water table, assuring reserves for the system and allowing water use in the dry season. Most of the productive activities keep the forest cover, helping the focal system to better adapt to disturbances caused by the climate change: increase in temperature and rainfall disruption.

In this potential future state, sustainable harvesting of asaí Berry, Carmen Alto residents are organized as an indigenous community with a board. A community-based enterprise helps to organize the use and sale of asaí fruit. The dealing with middlemen is decreased to almost zero. The harvesting of asaí provides income to residents during the months of June, July and August, keeping them from adding debt from middlemen, until the Brazil nut harvesting starts. Associates to Muije avoid middlemen and obtain better profits.

The community has a dynamic interaction with regional indigenous entities, municipal governments (Riberalta and Reyes) and buyers of asaí fruit.

The resilience-based stewardship strategy to reach this desirable state is presented in section 4.5 of the document.

STATE: DECLINING SUPLY OF ECOSYSTEM SERVICES

This state is characterized by an increase of transformed areas, especially monocultures. Also activities like asaí palm heart harvesting will continue. As a consequence, water table is affected and reduced. Also because of loss of soil fertility, crops will need fertilizers.

The conservation status of the Amazon forest in the focal system is bad; the deforested and degraded areas expand rapidly. The two types of vegetation, upland and flooded forest, are clearly receding. Low height, savannah-like, vegetation prevails, with reduced species diversity. The upland forest has been cleared by unplanned timber extraction, which strongly affects productivity and regeneration of Brazil nut trees. The flooded forest becomes dry, probably linked to the overharvesting of palm heart. Activities in the system are reduced: the forest degradation prevents the extraction of palm heart, and even asaí fruit harvesting is limited because of a lack of adult trees that assure a viable commercial use.

The high loss of forest cover affects the capacity of the system to provide ecosystem services. The focal system loses humidity fast, especially in the flooded forest, which affects the water table replenishment and capacity to attract rain. The provision of water for human consumption will become compromised in the dry season. The local climate tends to be drier and warmer without the forest cover that regulates it. A loss of soil fertility is also expected, which will affect crops and make them more reliant on additional inputs like fertilizers. Finally, the capacity of the system to sequester carbon will be drastically reduced.

The focal system resilience will be severely affected, reducing the capacity to adapt to disturbances: fires, droughts, increase of temperature and disruption of the rain regime. Deforested and degraded areas will become more prone to fires, which will expand faster and affect larger areas than now. The reduced forest cover will influence less rainfall and impact the homeostasis of the water table, especially during the dry season. The increase in temperature will continue and the rainfall seasonality will be disrupted, drastically limiting options to adapt to climate change.

In this plausible future state, declining supply of ecosystem services, the organization of Carmen Alto residents as an indigenous community is weakened, with some members leaving the settlement. The remaining inhabitants would require migrating during the dry season, to neighbor cities or ranches, to sell their work as cheap labor and add income. The stability of families will be affected. The interaction with middlemen will be reduced because fewer resources from the forest will be available for extraction.

The community interacts with regional indigenous organizations and more marginally to the municipal governments of Reyes and Riberalta.

A resilience-based stewardship strategy is drawn in Section 4.5 to avoid this state, considered undesirable.

4.2.7 Drivers that cause shift to future alternative states and critical thresholds

As in the past, the focal system could transition to potential future states led by drivers mainly of socioeconomic nature. At the current spatial (one indigenous community) and temporal (short term) scale of this research, the changes in the ecological aspects of the system would be a consequence of a change in state and not a source of change.

At a much larger spatial (the Amazon biome) and temporal (more than 30 years) scale, an increase in temperature could cross a critical threshold. This would derive in a negative impact on the primary production (Doughty & Goulden 2008; Pau et al. 2013), which would affect the growth and sustaining functions of the forest cover.

FROM CURRENT STATE TO A STATE OF ASAÍ BERRY HARVESTING

In the case of the transition from the current state to a state of sustainable use of the asaí berry, the main driver could come from an additional economic benefit. An improved profit of harvesting could attract people which currently rely on low skilled jobs like ranch laborer or motorcycle-taxi driver in Riberalta.

Carmen Alto, as an indigenous community of the Amazon, has a cultural preference to use the standing forest. The collection of NTFP is compatible with acquired knowledge on forest use and traditional cultural practices. For instance, the harvesting Brazil nut has been practiced for many decades. A recent experience with Muije, shows the potential to organize a community-based enterprise that generates additional capacities to add value to a NTFP (organic and fair trade certification) and provide more benefits to the community. The existing competence to collect NTFP can maximize entrepreneurship when looking for compatibility with traditional uses and practices of Carmen Alto residents.

Looking at a higher scale, this state change could be supported by indigenous organizations (TCIT and CIRABO) that favor forest conversation and the use of resources of a standing forest.

External actors, like potential buyers of asaí fruit and pulp, could facilitate the transition to the future state if they offer competitive prices that provide profitability to Carmen Alto residents. This approach could be based on the buyers' need to diversify their provider base. It is also known that the demand coming from the national market is so big (Oliva 2012) that there should be no concern of new enterprises entering the business.

FROM CURRENT STATE TO A STATE OF DECLINING SUPPLY OF ECOSYSTEM SERVICES

The main driver to a future state of declining supply of ecosystem services could come from a significant increase in public investment in agriculture and cattle ranching projects inside indigenous territories.

As most of the indigenous communities in the Bolivian Amazon, Carmen Alto practices subsistence small scale agriculture (less than 5 hectares per family) and has no experience in cattle ranching (Killeen et al. 2008).

The community residents reported an attempt to raise cattle (50 individuals) a couple of years ago. However, a lack of knowledge on how to manage this activity resulted in damages to crops and houses. The livestock was later sold to meat markets and provided a source of savings.

Therefore, a change to an increased area of crops and pastures would require a significant investment in time, money and training. This indigenous community has no tradition or knowledge for commercial agricultural activities.

At a higher scale, this state change could be driven by national development agencies or municipal governments, which aim to generate job opportunities and benefit the indigenous communities. The prevailing development paradigm of these actors is that a standing forest has no economic or social function. Without agriculture or timber extraction, these forest lands are considered unproductive (Villegas & Martínez 2009). The forest ecosystem services are not considered important and therefore can be ignored when the main objective is to improve the economic conditions of indigenous families. Short term benefits are favored and long-term negative impacts are usually overlooked.

There is a risk that indigenous organizations (TCIT and CIRABO) embrace this paradigm and support these types of projects because they are officially called to improve the communities' livelihoods. The question will remain on how compatible is this development vision to the traditional indigenous beliefs and lifestyles.

4.3 Governance and social networks among stakeholders

This section covers the main institutions influencing the governance and social networks of the system, under the context of the main problem analyzed 'the threatened ecosystem services'. A summary can be found in table 5 and figure 6.

4.3.1 Key formal and informal institutions

Six institutions, formal and informal, have been identified as relevant to the decision making process in the focal system: Carmen Alto, the Tacana-Cavineño indigenous territory, CIRABO, the municipalities of Riberalta and Reyes, and the ABT. In this section, each institution is described in its role to facilitate or restrict the flexibility of the focal system, influencing the resilience of the system. A detailed role of these institutions in the decision making process, enforcement of rules, power relations and conflicts is presented in section 4.3.2.

Eight additional institutions were identified to build the social network of the focal system: Muije, Madre Tierra Amazonia, Berlin, Asaí-manía, ADEMAF, IPHAE, CIPCA and FAN-Bolivia. This section briefly covers these actors. A mapping of the social network can be found in section 4.3.3.

In this section, the main stakeholders are described based on its relation to the Carmen Alto community and the exploitation of asaí fruit in the Bolivian Amazon.

TACANA-CAVINEÑO INDIGENOUS TERRITORY (Local indigenous organization)

The Tacana-Cavineño indigenous territory (TCIT) has a collective property, which cannot be divided or transferred outside the Tacana and Cavineño people. This property allows for the exclusive use of renewable natural resources inside their territory. There are 12 indigenous communities inside the territory, which are represented by an elected board (Roca 2012b). The main political unit of the indigenous territory is based in Carmen Alto.

As main objectives, this local indigenous organization follows-up the main project and demands of the member communities and mediates in conflicts between communities or outsiders (private owners) (Roca 2012b).

In an interview, the TCIT president acknowledged the opportunity offered by the asaí fruit, as a profitable alternative to activities that degrade the forest, like the palm heart extraction. He also expressed an interest of the TCIT leadership to support future initiatives that make a sustainable use of the asaí fruit (Roca 2012b).

CARMEN ALTO (indigenous community)

Carmen Alto is a community inside the TCIT. Because its existence is strongly linked to the indigenous territory, it is considered an informal, loosely-defined organization. Many of its residents have leadership skills and seek better living conditions for their families and the community. For instance, the community president is also the leader of the 12 communities inside the TCIT. The principal of school center, which covers 9 schools including Carmen Alto, is a woman with many skills and strong leadership in the community.

Because the asaí palm is widespread in communal land, there is interest in using the asaí fruit as an alternative to the extraction of palm heart, which degraded the surrounding palm forest. The fruit harvesting is seen as an opportunity to diversify the productive activities.

This actor facilitates flexibility of the focal system because it is open to take advantage of new opportunities and change activities that limit its adaptation options toward the system disturbances.

CIRABO (Regional indigenous organization)

The CIRABO (Indigenous Entity of the Bolivian Amazon Region, *Central Indígena de la Región Amazónica Boliviana*) is an organization that groups and represents people in 8 indigenous territories of the Bolivian Amazon, including the Tacana-Cavineño territory.

Its mission is to defend the territories and seek projects that improve the livelihoods of the people inside the indigenous territories (Roca 2012b).

Based on the interviews, CIRABO deals with Carmen Alto only through the Tacana-Cavineño representatives. However, in cases when Carmen Alto wants to solve a conflict involving a project in the community, they address their concerns both to CIRABO and the indigenous territory leaders. In the same way that TCIT, CIRABO is also interested in attracting productive projects that improve local livelihoods of its members. The use of asaí fruit is therefore well regarded by CIRABO.

However, the operation of CIRABO is limited by a lack of a stable source of funding. This limitation causes that this organization do not facilitate the flexibility of the focal system. Their leeway becomes limited because of the lack of resources.

MUNICIPALITY OF RIBERALTA (Local government)

The municipality of Riberalta is located in the southern portion of the Bolivian Amazon, in the Beni department (state). A portion of the municipality overlaps the Tacana-Cavineño indigenous territory, even though there is no overlap with the Carmen Alto community. Because Riberalta is the closest large city in the region, the communities of the indigenous territory rely on the municipality for technical and economic support.

The Brazil nut business is the main economic driver of the municipality. The main processing plants of this product in the country are based in Riberalta. Bolivia is the largest exporter of Brazil nut in the world, in a business worth US\$ 146 million per year (La Razon 2013).

The Riberalta municipality has been supporting the production of asaí saplings to recover areas where palm was exploited. This interest opens a chance for collaboration with Carmen Alto.

Because Carmen Alto is not officially inside the municipal boundaries of Riberalta, it is assumed that the municipality has a neutral influence in the focal system flexibility.

MUNICIPALITY OF REYES (Local government)

The Reyes municipality is located in the southeastern portion of the Bolivian Amazon, in the Beni department. Part of the Tacana-Cavineño indigenous territory falls in this municipality, which makes many communities, including Carmen Alto, request economic support.

Even though the municipal boundaries for Reyes, Santa Rosa and Riberalta are not established, Carmen Alto residents identify themselves as based in the former municipality. They were in fact considered part of the Reyes municipality in the recent 2012 census. It is this municipality that provides basic facilities, support small productive projects, and pay education and health centers.

The wide economic support provided by the Reyes municipality, even though the municipal capital is far from Carmen Alto, increases the flexibility of the focal system.

ABT - National Forest and Land Authority (National government)

The ABT is a national government agency in Bolivia in charge of controlling activities related to the use of the forest, mainly timber extraction.

Current interaction of ABT with Carmen Alto involves the review and approval of timber management plans. That makes the agency have a neutral role in terms of flexibility of the focal system.

MUIJE (Community-based enterprise of Brazilian nut)

Muije, which means Brazil nut in Tacana language, is a community-based enterprise inside the Tacana-Cavineño indigenous territory. This enterprise, founded in 2009, has 110 members from

the Tacana-Cavineño indigenous territory, and 20% of those members are women. This community-based enterprise was established to make a sustainable use of local natural resources. Their main activity is Brazil nut harvesting and they also intend to harvest and commercialize other non-timber forest products, like asaí.

The association collected more than 36 tons of Brazil nut in 2011 with the involvement of members and nonmembers. Since this production received organic certification, the income shared among the members represented a 5% increase in revenues (Escalante 2012).

Many Carmen Alto residents are associates of Muije and have been trained on best practices of storage.

MADRE TIERRA AMAZONÍA (Local Amazon fruit processing enterprise)

Madre Tierra Amazonía is a company based in the city of Riberalta and oriented toward the processing of tropical fruits, like cupuazú (*Theobroma grandiflorum*), asaí, cayú (*Anacardium occidentale*) and carambola (*Averrhoa carambola*). The company started working in 2002 thanks to the support of IPHAE. They aim to improve the livelihoods of farmer and indigenous families through the production of high quality fruit pulp and oils.

Based on an interview with the company manager, some farmer communities around Riberalta, co-owners of the enterprise, are the main providers of Madre Tierra Amazonía. However, because of a high demand in the national market (a lyophilizer company from the city of Santa Cruz buys the product) and the existing capacity of the processing plant, they are seeking new providers from indigenous communities near Riberalta, like Carmen Alto. They offer to pay Bs. 3 (€ 0.33) per kilogram of unprocessed fruit.

BERLIN (Community-based enterprise of asaí and majo)

Berlin is the short name of an association of community producers of eco-friendly majo and asaí (known by its Spanish acronym, ACOPEMA). Based on information provided by the Riberalta municipality, it is a young organization, with less than two years. The association is led by a board with representation of families coming from a farmer community called Berlin (28 families) and 8 neighbor communities located in the Riberalta municipality.

This association was created to harvest and process the asaí fruit leaving the palm tree standing. With economic and technical support of the Riberalta municipality, they have been able to set a processing plant where 6 members of the community work when fruit is available.

The associates harvest fruits in the forest that surround the communities and bring the product to the processing plant in the Berlin community. Because the plant has an unused capacity, the association is willing to coordinate with additional communities to collect more fruit. They offer to pay Bs. 5 (≤ 0.55) per kilogram of unprocessed fruit. The direct sale of the processed fruit is done in the city of Riberalta.

ASAÍ-MANIA (Smoothie store)

Asaí-manía is a small store based in the city of Riberalta. The store specializes in selling all kind of juices which include processed asaí. The owner, a resident born in the city, was interviewed. Because of its success in three years of life, the owner opened an additional store in the neighbor city of Guayaramerín. The store buys its processed asaí from Brazilian cities close in the region, like Porto Velho. The suppliers are well-established companies that export to the U.S. and Canada, like Andrade Exportadores.

They buy the kilogram of fruit pulp at Bs. 11 (\leq 1.21), which is cheaper that the price asked by local providers in Riberalta (Madre Tierra Amazonía and Berlin), when they are able to buy in large quantities from Brazilian providers. However, there are additional time and monetary costs needed for the transportation of this input to Riberalta. The owner reports a purchase of around 7 tons of fruit pulp the past year and expects for this year a purchase of 10 tons because of the recent opening of a new store.

ADEMAF (Agency of development, National government)

ADEMAF is a national government agency in Bolivia in charge of the development of the rural areas. It provides basic facilities and support small and large productive projects. Because of those activities it has eventual interaction with Carmen Alto.

IPHAE (Local NGO)

The Institute for the Man, Agriculture and Ecology (IPHAE, from the Spanish acronym) is a NGO (http://iphae.org.bo) devoted to strengthening capacities toward an integrated management of community forests. They have been providing technical support to farmer communities and small enterprises in the Northern Bolivian Amazon. The Madre Tierra Amazonia Enterprise, above mentioned, came as an initiative of IPHAE.

Currently, IPHAE does not have a direct relationship with Carmen Alto.

CIPCA (National NGO)

The Center for the Research and Promotion of Farmers (CIPCA, from the Spanish acronym) is an NGO devoted to strengthen farmer and indigenous communities in their productive practices (http://cipca.org.bo/).

Based on an interview, it seems that this NGO has been supporting for more than a decade the Carmen Alto residents. The technical support aims to improve agriculture practices and establish agroforestry systems in areas close the houses. However, the support has decreased and the visits currently happen sporadically, mainly during the sowing months.

FAN-BOLIVIA (Regional NGO)

Friends of the Nature (FAN-Bolivia) is a non-governmental organization of regional level that has been working in biodiversity conservation with indigenous communities, peasants and local and national government (http://www.fan-bo.org/). As a result of this collaboration, FAN-Bolivia has supported the creation of Muije, the community enterprise described above.

4.3.2 Governance

DECISION-MAKING LEVEL

Interviews to indigenous leaders and Carmen Alto residents report that most of the decisions about the use of natural resources are taken at the local, community level. However, before implementing these decisions they request the approval of the territory (TCIT) level.

Based on the ecological level of processes, this seems to be an adequate level of decision. Decisions can be taken fast when there are first symptoms of system disturbances (like a drought). It is assumed that some actions could be taken to change people's practices and adapt to the system changes in a more effective way.

However, some important decisions are also taken at the regional and municipal level, affecting the access to natural resources and trade opportunities. For instance, there is a decision to develop an important transportation corridor that will connect Riberalta to the central part of the country. This paved highway will be built close to Carmen Alto.

The decision making process could be improved if more information is provided to the focal system about use alternatives and impact of different practices to the system.

For instance, during interviews and the workshop, the community residents expressed that they could have decided different about palm heart extraction had they know about the more profitable alternative of asaí fruit harvesting. Even though the price was low, they favored the palm heart extraction because they did not know about alternative activities or the possibility of depleting the resource. They also did not know about the impact on water provision of cutting the palm trees (see section 4.1.4). At the time, the water seemed an abundant resource.

RULE ENFORCEMENT AND COMPLIANCE

The formal rule enforcement and compliance is not effective in the focal system. The authorities are in charge of vast extensions of land, they have limited staff and resources that can go to the ground to control a sparse population. An agency like ABT, the national forest and land authority, has limited reach to small communities like Carmen Alto.

In contrast, the informal rule enforcement and compliance is more effective in the focal system. The social control inside the community, and from the community toward neighbors, provides better results. This is because they have property rights on the area where they live, they are users of the natural resources, they benefit from the ecosystem services and hence area directly affected when the rules are not observed.

The palm heart extraction provides a good example of this situation. This activity should be planned and the national forest authority (ABT) should approve management plans and enforce⁴ extraction rules. Unfortunately, this control does not occur. The trade of palm heart is relatively small compared to timber, the main focus of ABT control. By the year 2010, when the palm heart extraction was in crisis, this activity was banned in the whole Tacana-Cavineño indigenous territory (TCIT). Even though the TCIT did not have enough officials in charge of enforcing the

⁴ The ABT has staff in the main road checkpoints between Carmen Alto and Riberalta.

ban, at the community level, the Carmen Alto residents were well aware of the ban and the need for a local control, applying pressure to the few ones still extracting palm heart. This local control has proved more effective to enforce the regulation than any action by national or regional authorities.

It is recommended to better inform the people on the damages caused by an unsustainable use of natural resources and the benefits of obeying the regulations. A combination of a command and control approach with market incentives, when legal activities can be profitable, could help a more effective enforcement of regulations.

POWER RELATIONS AND CONFLICTS

The formal power attribution of Carmen Alto is weak because official decisions need to be taken by the board of the TCIT. However, the informal power is more intermediate because community leaders know how to approach people and organizations to accelerate decisions, start and follow up projects.

The leadership that represents the TCIT and CIRABO have an intermediate level of formal and informal power. They have a mandate to represent the indigenous communities of the territory but have limited economic and staff resources to implement any decision.

The municipalities of Riberalta and Reyes have an intermediate formal power. They have economic resources to invest in projects that use natural resources. However, their informal power is weak, with limited action inside indigenous territories that overlap their jurisdiction.

ABT has a strong formal power aimed at the timber extraction, with a mandate to control. However, its informal power is intermediate because of limited staff resources to implement this mandate.

The only reported conflict in the use of natural resources is the encroachment of a private owner, from El Descargadero. He has repeatedly entered the TCIT, including the indigenous community, to harvest Brazil nut. The indigenous authorities have formally demanded this person for invading their territory.

KEY FORMAL AND INFORMAL INSTITUTIONS					
MAIN ISSUE	LIST OF INSTITUTIONS	ENHANCE FLEXIBILITY			
		(YES/NEUTRAL/NO)			
Threatened	Carmen Alto (indigenous community)	Yes			
ecosystem	TIOC Tacana-Cavineño (Local indigenous	No			
services	organization)				
	CIRABO (Regional indigenous organization)	No			
	Municipality of Riberalta (Local government)	Neutral			
Municipality of Reyes (Local government) ABT – National Forest and Land Authority (National		Yes			
		Neutral			
	government)				
LEVEL OF DECISION-MAKING					

Table 6. Institutions, decision making and power relations and conflicts.

LO		CAL, REGIONAL,	APPROPRIATE	SUGGESTED IMPROVEMENTS			
	NATIONAL		GIVEN ECOLOGICAL				
			PROCESSES?				
Threatened Local (al (with	Yes	More information on alternative uses of natural			
ecosystem	app	roval of the		resources and impact	resources and impact on the system		
services	boa	rd of the					
	indig	genous					
	terri	tory)					
		Ru	LE ENFORCEMENT AN	ID COMPLIANCE			
	IS I	T EFFECTIVE?	SUGGESTED IMPROVEMENTS				
Threatened	No		More information on the regulations to use natural resources				
ecosystem			Market incentives				
services							
		MAPP	NG POWER RELATIO	NS AND CONFLICTS			
LIST OF		Formal	INFORMAL	CONFLICTS WITH	CONFLICT RESOLUTION		
STAKEHOLDER	S	POWER	POWER	OTHER STAKEHOLDERS	MECHANISM IN PLACE		
		(STRONG TO	(STRONG TO				
		WEAK)	WEAK)				
Carmen	Alto	Weak	Intermediate	Conflict with El	The indigenous		
(indigenous				Descargadero	authorities have		
community)				(private owner) for	formally demanded the		
TIOC Taca	ana-	Intermediate	Intermediate	territory invasion	private owner		
Cavineño (L	ocal						
indigenous							
organization)							
CIRABO (Regi	onal	Intermediate	Intermediate	No conflict reported	n/a		
indigenous							
organization)							
Municipality	of	Intermediate	Weak	No conflict reported	n/a		
Riberalta (L	ocal						
government)							
Municipality	of	Intermediate	Weak	No conflict reported	n/a		
Reyes (L	ocal						
government)							
ABT - Supervis	sory	Strong	Intermediate	No conflict reported	n/a		
and social control							
authority of forests							
and territory							
(National							
government)							

4.3.3 Social networks among stakeholders

In this section the social network of previously described stakeholders (section 4.3.1) is mapped. A simple graphic has been prepared to summarize the connections reported by people interviewed during the data collection activity (Figure 9). The following lines will describe how the network structure can facilitate governance and resilience in the system. There will be an

analysis of the number of relations, centrality level and the existence of subgroups and their cohesion.

The social network of actors does not show subgroups that can be clearly identified. Carmen Alto is well connected to indigenous authorities (TCIT and CIRABO), local governments (Riberalta and Reyes municipality) and a community-based enterprise (Muije); it has weak links to national enforcement and development agencies, and an NGO (ABT, ADEMAF and CIPCA); and there a possibility of establishing relations with asaí buyers (Madre Tierra Amazonía, Berlin and Asaímanía) and a regional NGO (FAN-Bolivia). The periphery of the graphics shows groups that share an interest on improving indigenous life conditions. However, these groups have different development paradigms on how to achieve this improvement, from the "business-as-usual" (i.e., agrarian) approach to a more forest-oriented use with a conservation approach. This significant divergence hinders a consensus on management strategies and conflict resolution about resource use. However, the recent empowerment of indigenous stakeholders has promoted an acceptance of an "indigenous" vision of development toward the use of natural resources in their territory.



----> Intended relationship

Figure 9. Social networks among stakeholders.

4.4 Status and trend of factors that contribute to establish a successful community-based enterprise dedicated to asaí harvesting in the focal system

Carmen Alto is interested in reaching a state of sustainable use of asaí, as described in section 4.2.6. The residents want to organize an enterprise that take advantage of the fruit in a

sustainable way and improves the community resilience. However, because the initiative is yet to be established, in this section we will review if conditions are in place for a successful set up. A special consideration will be made on the existing indigenous structure and a similar enterprise, Muije.

4.4.1 Holistic vision, mission and values

LONG-TERM HOLISTIC GOALS

According to recent interviews and CIDOB (2013), the Carmen Alto community, as part of the TCIT, has a long-term goal of managing its territory and use its natural resources in a sustainable way to offer benefits to its families.

These goals support initiatives that organize people toward the use of a resource, facilitate its sale and promote an equitable distribution of benefits. As a positive previous experience, the indigenous enterprise Muije shows that it is possible to benefit from Brazil nut, improve finances of member families and protect the forest, especially groups of Brazil nut trees.

INSTITUTIONALIZED VISION AND GOALS, INDEPENDENT OF POLITICS

An indigenous community has as a key principle an independent nonpartisan approach toward politics (CIDOB 2013). Recent interviews to actors agree that, organizations like the TCIT and CIRABO have supported the establishing of Muije with no interference to its management. The implementation of the vision and goals of the enterprise rely on the convention and board of members. These directives have been include in the statutes and operating rules of the enterprise, which are compatible with rules of the territory where it is based.

In interviews with leaders of the TCIT and CIRABO, they expressed an interest in supporting new initiatives that make a sustainable use of asaí. Carmen Alto residents also perceive that a community level organization that uses the resource could be supported by a territory-wide leadership, without interfering in the management.

STRONG CONNECTIONS WITH LAND AND TRADITIONS

Native inhabitants of the Bolivian Amazon, among them the Tacana group; show a strong connection to their territory. As a reflection, they fought for a long time (1996-2008) to get common property titles for the land where they live (Fundación Tierra 2011).

Even though there has been temporal migration, many of these migrants reported that they returned to Carmen Alto because of a strong connection to the place where they were born. For instance, many community leaders (e.g., the board president and the principal of the school center) studied or worked outside the community, but decided at the end to come back to promote the community development. Other residents have considered the possibility of moving to Riberalta or a larger populated center, but decided to stay in the community because of their family or their preference for living near the forest.

According to interviews to Carmen Alto residents and Roca (2012), the inhabitants identify themselves as Tacana. However, during the rubber extraction period many of their cultural practices and native language were lost. Since the obtaining of land property titles, they have

expressed an increased interest in rescuing their cultural identity and keep traditions (Roca 2012b).

Carmen Alto's residents share values relative to the territory where they live. Their values and cultural practices recognize that the forest provides high diversity and many natural resources for their livelihoods. There is an interest in establishing enterprises that help them conserve the forest and the ecosystem services.

4.4.2 Institutions and managerial structures

BODIES OVERSEEING COMMUNITY'S POLITICAL ISSUES AND LONG-TERM GOALS WITHOUT INTERFERING WITH MANAGEMENT TASKS

The Tacana-Cavineño authorities oversee all commercial activities inside their territory, including the Muije activities. However, this oversight does not interfere with the operational activities of the enterprise. The enterprise was founded as an independent organization. So far the political organization of the indigenous territory has not intervened in management affairs. The Muije has had freedom of decision and action in the context of its statute. This is a good antecedent for futures entrepreneurial efforts within the TIOC.

CLEAR, AGREED UPON VERBAL OR WRITTEN SET OF LAWS OR CONSTITUTIONS

The TCIT has formal statutes and rules, approved in 2009, which guarantee the use and access to natural resources for its inhabitants. There are also specific regulations to use timber and non-timber forest products and distribute the economic resources generated by these activities. The mentioned regulations provide the basis for the Muije internal regulation approved in 2010 by the members and accepted by authorities of the indigenous territory (Suárez & Delgado 2011; Roca 2012b). This is good precedent to establish a regulation for a new community enterprise that uses NTFP.

However, the interviews to Carmen Alto residents showed a limited knowledge of the Muije regulations. This may explain why fewer people understand the advantages of benefit-sharing of an association, and why they did not join Muije. Members of the board of Muije and FAN acknowledged that, even though regulations are clear and have been approved, less effort has been made to communicate the rights that members get with the association. They hope to address this shortcoming soon, and recommend considering this on future initiatives.

4.4.3 Capitals and capacity building

COMMUNITY CAPITAL

Carmen Alto still has an important natural capital. The flooded forest contains significant populations of asaí that can provide a commercial use of the fruit. Even though the surroundings of the settlement have populations of asaí that have been degraded with the palm heart

extraction, there additional healthy populations in the remaining area assigned to the community (for more information, see section 4.1.3).

The community has a trail that connects the human settlement with the Brazil nut harvesting areas. This dirt road was opened by community inhabitants and allows for transportation on foot or motorcycle. This trail allows visiting the healthy populations of asaí, which can only be reached on foot. Carmen Alto residents report that with communal work they could open a road to these areas. The opening of these areas through an improved road could allow the use of motorcycle, reducing time and effort required by the activity.

The community also has an open space which includes nearby trees to extract wood. This space could be used to build storage or processing center for the asaí fruit. There is previous example of Muije, which built a storage center in Carmen Alto to gather Brazil nut.

The conditions of roads between Carmen Alto and Riberalta are bad and transportation is expensive (as described in section 4.1.6). However, indigenous families from Carmen Alto usually have motorcycles. In this way, a limited amount of products can be transported from the community to the city and vice versa.

MANAGEMENT SKILLS

There are no Carmen Alto residents involved in Muije management. However, many of them (at least 6 persons, 3 women and 3 men) have participated in trainings provided by the indigenous organization or different NGOs. The management skills have improved thanks to personal experience and frequent interaction with businesses in a larger city like Riberalta. There is in fact social capital to fill management positions in an association.

QUALIFIED WORKFORCE OR LABOR SKILL IMPROVEMENT

The Muije has successfully organized its members to implement and assess best practices during the last year. These best practices are described in the Quality Management manual that establishes guidelines and procedures on how to harvest and store Brazil nut and how to take care of the Brazil nut trees. The members are starting to realize that because of these practices they are able to make more profit that can be shared among members of the enterprise. This represents a positive experience to build new associations that commercializes semitransformed NTFP.

ABILITY TO ACCESS EXTERNAL FINANCIAL SUPPORT

The past four years the steering boards of Carmen Alto have gained experience to obtain financial support. Thanks to their negotiations, projects have been implemented with funds coming from the municipalities of Riberalta and Reyes. These projects include the construction of a new building for the school (4 new rooms), the acquisition of a power generator with increased capacity to provide electricity to the community and a small rice peeler.

REACHING NEW OR ESTABLISHED MARKETS

The continuous interaction of Carmen Alto residents with Riberalta allows them trade products like rice, Brazil nut (at a large scale, both as individuals and through Muije) and *chivé* (at a smaller scale). This experience could allow them to enter the market with asaí fruit and even asaí pulp.

4.4.4 Land and resource tenure

JURISDICTION AND CONTROL OVER LAND AND RESOURCES

The Tacana-Cavineño indigenous territory is a communal property since 2010. Starting this year, plans to control the territory have been implemented to prevent conflicts and better control the use of natural resources. The indigenous inhabitants use the natural resources, including Brazil nut, according to a combination of traditions and new regulations. Current regulations secure the inhabitants with accession and use of natural resources in the territory. In general, the domestic use of the resources is free and any commercial use must benefit the whole community and the indigenous structure (Roca 2012b; Roca 2012a). It is the indigenous structure that regulates the resource access and each community can have its own rules.

Carmen Alto has then control over the land and resources under the assigned area (see map 2). The resident can make commercial use of the resources as long as they obey the regulations of the indigenous territory.

ESTABLISHING LEGITIMATE LAND AND RESOURCE USE AND MANAGEMENT RULES

Muije established two internal regulations for Brazil nut harvesting: quality control and benefit sharing. The first one establishes an internal system of quality management for harvesting of wild Brazil nut. The second regulation defines the distribution of benefits from commercialization of Brazil nut. According to this regulation, the benefits should be distributed among the members (60%), capital (30%), social benefits (5%) and organizational costs (5%). It is important to consider that better prices obtained by Muije, because of organic and fair trade certifications allow improved incomes to associates and set aside some savings for the capital. This policy has been agreed and approved by the assembly of members and by the indigenous organization of the Tacana-Cavineño territory. The regulation also seeks to increase the involvement of indigenous families in a community-based enterprise through a better benefit distribution. This approach has provided an increased legitimacy in the use of Brazil nut in the TCIT. This is a good antecedent to set regulations for another NTFP like the asaí fruit.

4.4.5 Informed leadership

HAVING AN EFFECTIVE LEADERSHIP

Carmen Alto has many potential people that could lead a new enterprise. These are people that already lead other initiatives like timber extraction, education and subsistence agriculture. Their efforts have allowed many projects to be implemented in the community: execution of a timber extraction plan, family groves to improve the school meal, saplings to enrich the subsistence crops.

ESTABLISHING INTERNAL AND EXTERNAL LEGITIMACY

These leaders already have internal legitimacy because they share the values embraced by the community residents. The leaders were born and raised in the community and have their own family. They also know the community matters, verbal and written regulations of the indigenous territory, agreed boundaries with other communities and communication channels with the indigenous organization and local governments. About the external legitimacy, they are people recognized by the indigenous authorities and actors they interact in their projects. However, there is a need to build a relationship with private sector actors to make business.

4.5 Resilience-based stewardship strategy for the focal system

After the resilience analysis of the focal system and an analysis of possibilities to establish a successful community initiative to use asaí, it was identified that a stewardship strategy to ensure that the system continues to provide ecosystem services is one that fosters biological and economic diversity through entrepreneurship.

The Carmen Alto community has a high potential to use asaí fruits and has an interest and potential to organize a community-based enterprise to achieve this activity. The substitution of palm heart extraction with fruit harvesting could promote resilience. This is because it would avoid degradation of the flooded forest coming from the cutting of asaí palm trees. It would in fact facilitate the regeneration of this type of forest because of an increased care of the asaí palm associated with an added appreciation of the tree as economically beneficial. There is then a double impact that contributes to keep the biological diversity and provide incentives to diversify the economic activities of the community residents.

The harvesting of the asaí fruit is compatible with the current calendar of productive activities in Carmen Alto. The fruit can be harvested between July and September, when it is ripe, filling the gap of months when palm heart was formerly extracted. This would foster resilience at the social level, keeping family members together the whole year, providing a job to household heads that would otherwise migrate temporally to Riberalta to earn money.

The organizing of residents in an association would allow a better planning of the forest use, which would benefit the environmental sustainability of the resource. On the other hand, if residents associate, they could directly negotiate with the processor or final consumer, cutting the middlemen and getting a better share of profits. Therefore, entrepreneurship based on asaí berry could also increase the community resilience.

Four actions were identified to implement the proposed strategy: (1) harvest berry and sell it as raw product in Riberalta; (2) reforest degraded areas with asaí; (3) acquire a pulper to process asaí berry and sell the pulp in Riberalta; and (4) prepare asaí smoothies for the school in Carmen Alto.

The following sections explain the actions, opportunities and potential constraints (see Table 7 for a summary).

4.5.1 Harvest berry and sell it as raw material in Riberalta

This action proposes that a first phase of the Carmen Alto community-based enterprise collects asaí fruit and sell it as raw material in Riberalta, where there are to potential buyers, Madre Tierra Amazonía and Berlin.

According to profitability studies (Quiroga 2012), and based on observations and interviews, a positive effect in the resilience is expected with an increase in income coming from the substitution of palm heart extraction with asaí fruit. An asaí tree can only be used once for palm heart extraction, because the tree dies, and gives 3 to 5 Kg of product that can be sold at Bs. 2 ($\notin 0.22$). The same palm can provide every year at least 5 Kg of asaí fruit that can be sold between Bs. 15 ($\notin 1.65$ to Madre Tierra Amazonía) and Bs. 25 ($\notin 2.76$ to Berlin). This means that by selling only the fruit as raw material in Carmen Alto, they can get at least seven times the price they get for palm heart. Both products can be collected at the community by the buyers as long as there is enough to fill a small truck, around 400 Kg. The economic benefits may look thin, but compared to the average income of families in the community (\notin 192 per month), the income coming from selling the fruit as raw material would be important.

The harvesting of asaí fruit would require the same or less effort because the same areas can be visited every year. This compared to the palm heart extraction which requires increasingly longer distances because the closest trees are cut first.

The only identified constraint is that few residents know how to climb the asaí palm tree to harvest the fruit bunch. However, they became interested when they knew that other indigenous communities developed a safe and practical system to harvest using only a rope (García & Mariaca 2012).

4.5.2 Reforestation of degraded areas with asaí

As a parallel activity to the harvesting of asaí fruit in better conserved areas, a recovery of flooded forest is proposed in areas closer to the community, degraded by palm heart extraction. This would allow the improvement of community resilience toward disturbances like drought, described in section 4.1.4, which affects the provision of water for human consumption.

The plantation of asaí provides an opportunity to recover degraded areas. Because these degraded areas are likely close to the community, there is an additional benefit of approaching the resource to the people. The municipality of Riberalta, with 10,000 one-year old asaí saplings, offers an opportunity to materialize this reforestation. Those saplings could be provided without cost to any person willing to take them to the reforestation site. The available one-year saplings would accelerate the recovery of production areas for palm trees that require 5 to 7 years to produce fruits. The reduction in time would increase the chance of the community to consume the fruit because the resource would be available sooner. It would also increase the family income, coming from palm trees which would be closer to the houses, more abundant and easier to harvest.

4.5.3 Acquire a pulper to process asaí berry and sell pulp in Riberalta

In addition to harvesting asaí fruit, the processing to obtain pulp is proposed. According to interviews, this type of product has a market in Riberalta, if done under good manufacture practices. There are at least two potential pulp buyers: Madre Tierra Amazonía and Asaí-manía. The value added product would get a better price: around Bs. 11 per Kg (€ 1.21/Kg). From an interview with Madre Tierra Amazonía manager, one kilogram of pulp can be obtained from three kilograms of asaí fruit.

The Carmen Alto residents suggest that the collection of asaí fruit should be done by men, who have the strength to climb trees. The processing of the fruit could be left to women, who have experience extracting manually the pulp, and could combine this activity with child care and other house tasks.

Increased income from the asaí fruit harvesting would discourage activities like the palm heart extraction. This would help conserve the flooded forest, benefit the biodiversity and promote the environmental resilience of the system. Additionally, this action would increase the social resilience through an improvement of the social environment, with empowered women which diversify their activities, add new skills and have a change to get cash income.

Two main constraints have been identified: investment capital and a limited knowledge of good manufacturing practices. The acquisition of a pulper, a refrigerator and the funding of operations would require an amount of money above the capacity of the community. A stay in the Carmen Alto community allowed verifying that women have basic knowledge of food production hygiene, based on their experience producing *chivé* for sale in Riberalta. However, this knowledge would need to be adapted to a product that decomposes fast if not adequately handled.

Based on interviews to community inhabitants, the municipal government and NGOS, there is possibility that Carmen Alto residents negotiate projects to help fund the initial investment and training in good manufacturing practices.

4.5.4 Prepare asaí smoothies for the school in Carmen Alto

A final action identified requires the preparation of asaí smoothies for the breakfast at the Carmen Alto School, which has 55 students. This would add even more value to the product and would promote the environment and social resilience, based on the previously described action. It would also increase the local consumption of asaí, providing nutritional benefits to the School children.

Based on an interview to the School center principal, the Reyes municipality has a budget to fund the school breakfast in Carmen Alto, and could be interested on contracting a community initiative instead of providers from Riberalta. The breakfast would include asaí during the months when it is available.

The constraints for this action are similar to the previous action. However, based on the way this activity is organized, there is a chance that it might require less investment. The reduced volume would allow the pulp to be manually processed (using a mortar), saving the need for a pulper.

STEWARDSHIP STRATEGY: FOSTER BIOLOGICAL AND ECONOMIC DIVERSITY THROUGH ENTREPRENEURSHIP				
Opportunities	Actions Barriers/constraints			
Asaí abundance and local	Harvest berry and sell it as	Do not know how to climb		
market for asaí berry [Madre	raw material in Riberalta	the palm trees		
Tierra Amazonía and Berlin]				
Municipality willing to give	Reforest degraded areas with	n/a		
away 10,000 1-year-old	asaí			
saplings				
Local market for asaí berry	Acquire a pulper to process	- Investment		
pulp [Madre Tierra Amazonía	asaí berry and sell pulp in	- Limited knowledge of good		
and Asaí-manía]	Riberalta	manufacturing practices		
Municipality hires breakfast	Prepare asaí smoothies for	- Investment		
for children at school	the school in Carmen Alto	- Limited knowledge of good		
		manufacturing practices		

Table 7. Resilience-based stewardship strategy for the focal system.

5. Conclusions and discussions

The research found that a stewardship strategy to improve social and ecological resilience in Carmen Alto requires fostering biological and economic diversity through entrepreneurship. One way of implementing this strategy is organizing a community-based enterprise to take advantage of the asaí fruit provided by a healthy forest. The asaí is a widespread palm in areas assigned for community use. The community is also well suited to organize an initiative that implements an innovative business idea.

The results of the research show that even if the asaí is sold as raw material, it would still provide benefits that increase social and ecological resilience of the system. These findings concur with Stoian (2000) who demonstrated that NTFP industries, like Brazil nut, provide benefits to a wide range of actors, from laborers and gatherers to the owners of the processing plants and intermediaries.

On the other hand, the research agrees with studies by Ostrom (1990) who found that selfcontrol from actors allows for a long-term use of a natural resource. This research identified that external control can be less effective, because authorities have limited economic and staff resources to monitor use. The user awareness about the negative impacts of over exploitation ended up being more effective as a measure.

This case study agrees with Anderson and colleagues (2006) who propose that a strong connection between indigenous communities and their territories are the basis to improve their socio-economic conditions in the long term and thus build sustainability. In the case of Carmen Alto, sustainable use of asaí berry is possible because of the strong cultural attachment of the community to the Amazon forests.

It is clear that community-based enterprise's success would not be possible without a legitimate access to the land and resources as Cornell and colleagues stated (2004). The present research suggests the importance of connecting the community-based enterprise to the indigenous territory leadership, because the latter have a saying on the control of land and resources.

Cornell & Kalt (1992) highlighted the importance of capacity building for the success of a community-based enterprise. They identified that skillful management and qualified workforce increase the chances of successful development. However, the gender question has not been openly addressed, maintaining some degree of marginalization of women in indigenous communities. In the case of Carmen Alto, the asaí berry harvesting could offer an opportunity to involve more women in the enterprise through the transformation process. Therefore, especial considerations must be taken to encourage gender equality, through activities that enhance knowledge and skills.

The present research was based on a qualitative methodology. Within the time constraints, enough information was gathered to feed the analysis. The assessment of the focal system (Carmen Alto) resilience permitted analyzing complex ecological and social issues the use of natural resources of an indigenous community involves. The new acquired understanding facilitated the design of actions toward the sustainability of the system, operationalizing two key components of the sustainable development paradigm: environmental and social. The proposed methodology provided tools to organize unstructured data collected in the field, supported the building of conceptual models and summary tables that simplified a complex reality.

The combination of two methodological approaches, resilience assessment and entrepreneurship assessment⁵ proved useful. The analysis of social components of the system was carried out in more depth to identify if there was a basis in the community to implement an idea for an innovative business. This analysis is key to recommend next steps that allow to achieve success in the enterprise, because it identifies factors that need to be developed.

The implemented field work and data collection were considered sufficient to answer the research questions in a general way and provide recommendations. However, there was a need to reduce depth in the analysis and even take off part of the study after realizing that the initial scope of the research proved too ambitious for the allocated time. Among the topics not considered there is the general assessment of the system resilience. The study covered only an assessment of a specific resilience, leaving for future research initiatives the consideration of a broader range of disturbances. It is also suggested that future assessment efforts cover the following attributes of the system: diversity, openness, reserves, tightness of feedbacks and modularity.

The chosen research approach, ecological and social, described only environmental disturbances, leaving out the economic disturbances that also affect the system. A literature review identified that previous research by Stoian (2000) provide a basis to incorporate the

⁵ Factors related to success in commons-based enterprises.

economic component. However, regional dynamics of the past decade call for an updated review of the impact of economic growth, migration and new public projects.

Another element not considered touches the critical thresholds between potential states of the system. Because changes are mainly driven by socioeconomic factors, there is a need for future research in the economic realm to determine the conditions that tip the scale toward a given state of the system.

This research shows how the commercial use of a NTFP, like the asaí fruit, can improve the resilience of indigenous communities in a way compatible with their traditional knowledge and practices. Even though this may appear self-evident, the link is not always understood by residents and the indigenous leadership. The activities of doing individual interviews and then using a workshop to share results of the research facilitated the understanding of residents about the threats to the forest. Structured data, summarized in a conceptual model, helped analyze the system and discuss action alternatives.

A resilience analysis that precedes the implementation of a change in the use of resources, could help the indigenous organizations to take better decisions. A better understanding of the local reality could ensure a priority for projects more suitable to the local development vision, seeking partners to implement them. In this research, the results were reported and discussed, calling the attention of community members and leaders, who expressed an interest in implementing the recommendations.

The findings of this research show that indigenous organizations are implementing measures that make a better control of the use of resources in the territory. When a regulation is shared with community people, an informal control takes place at the local level. For instance, a ban on palm heart extraction has been successfully enforced through an open communication of the measure with community members. This evidence call for formal local and national governments, which have control attributions, to coordinate efforts with indigenous organizations for a more effective outcome.

In opposition to the current agrarian paradigm of development, there is a need for municipal and national entities to provide incentives to initiatives that make a sustainable use of the forest. An inspiring case can be seen in the technical and economic support provided by the Riberalta municipality to the Berlin initiative, which collect and process two NTFP (majo and asaí).

It is also expected that NGOs can benefit from this research, using this case study to expand their activities with indigenous communities. The implemented analyses suggest concrete actions that have been adapted to the local context, increasing the chance for a successful outcome. The inclusion of climate change adaptation measures, increasingly required by agencies that fund development, has also been exemplified in this research.

6. Literature

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Appendix 1 - Respondents

Carmen Alto (focal system)

- 1. Yildo Ayala, President
- 2. Fanny Subirana, Vice-president
- 3. Lorenzo Ortiz, Secretary of economy
- 4. Luisa Cordero, Secretary of land and territory
- 5. Jorge Chamaro, Secretary Minnute
- 6. Liliana Velasco, School principal
- 7. Elias Soto, School teacher
- 8. Jeyson Alvarado, Chief and nurse of the Health center
- 9. Abraham Marigua
- 10. Ada Cachari
- 11. Alejandro Ayala
- 12. Fabiola Camaconi
- 13. Felix Velasco
- 14. Francisca Cachari
- 15. Guillermo Idacua
- 16. Lorena Duran
- 17. Lucio Marupa
- 18. Mirtha Duran
- 19. Rubén Idacua
- 20. Teresa Cachari
- 21. Victor Marupa
- 22. Wilfredo Subirana

Riberalta (scale above the focal system)

- 1. Grace Orellana, Asaí-manía's owner (Smoothie shop)
- 2. Alvaro Suárez, Manager of Madre Tierra Amazonia (Local Enterprise of Amazon fruits)
- 3. Alejandro Chamas, Manager of AIR-Muije (Community-based enterprise of Brazilian nut)
- 4. Herlan Eguez, AIR-Muije's Secretary of economy and resident of Carmen Alto
- 5. Alberto Ortiz, President of CIRABO (Regional indigenous organization)
- 6. Pedro Sanjinez, President of TCO Tacana-Cavineño (Local indigenous organization)
- 7. Humberto Suarez Díaz, Senior Officer of Economic development, Municipality of Riberalta (Local government)
- 8. Wilber Melgar, Head of Agricultural development, handicrafts and tourism, Municipality of Riberalta
- 9. Miguel Campusano, ADEMAF (Agency of development, National government)
- 10. Anahi Llanque, IPHAE (Local NGO)
- 11. Ronald Justiniano, FAN-Bolivia (Regional NGO)