

*Is the community-based management
of natural resources inherently linked
to resilience? An analysis
of the Santiago Comaltepec
community (Mexico)*



María del Mar Delgado-Serrano*,
Roberto Escalante** and Saul Basurto***
University of Córdoba (Spain), UNAM (Mexico)***
*and University of Birmingham (United Kingdom)****

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***Is the community-based management of natural resources inherently linked to resilience?
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Abstract: The sustainable management of forests is a current pressing need. Many communities around the world manage common pool forests and base their livelihoods on forest products. The community-based management of natural resources approach has been often considered as a suitable approach to govern the commons. However, the application of these principles does not simply lead to harmonise development and conservation. We explore the links between community-based management of natural resources and social-ecological resilience in a Mexican indigenous community by: 1) analysing the trade-offs between environmentally sound forest management and socio-economic sustainability; 2) identifying the local strategies to face local, national and international challenges and analysing how they contribute to the social-ecological resilience; and 3) reflecting about how the current situation might affect future social-ecological resilience. The results showed that land and forests are sustainably managed from an environmental perspective, but current social and economic pressures, within and outside the community, represent a serious threat to the traditional common management and sustainability culture.

Keywords: socio-ecological systems, sustainability, indigenous communities, Latin America.

***¿Está el manejo comunitario de los recursos naturales inherentemente ligado a la resiliencia?
Análisis de la comunidad de Santiago Comaltepec (México)***

Resumen: El manejo sostenible de los bosques es hoy día más urgente que nunca. A nivel global existen muchos bosques gestionados por comunidades que dependen de ellos para su supervivencia. El manejo comunitario de recursos naturales es considerado como un enfoque adecuado para la gestión de bienes comunes. Sin embargo, la aplicación de estos principios no necesariamente ha conseguido aunar los principios de conservación de la naturaleza y desarrollo de las comunidades que realizan este manejo. En este artículo se analizan las relaciones entre la gestión comunitaria de los recursos naturales y la resiliencia socioecológica en una comunidad indígena mejicana. Para ello: 1) se exploran las relaciones entre gestión ambientalmente sostenible del bosque y sostenibilidad socioeconómica; 2) se identifican las estrategias locales frente a desafíos locales, nacionales e internacionales y se analiza como las mismas contribuyen a la resiliencia socioecológica y 3) se reflexiona sobre las principales amenazas a esta resiliencia socioecológica. Los resultados muestran que en la comunidad se está haciendo un manejo ambientalmente sostenible, pero que las actuales presiones sociales y económicas representan una seria amenaza al manejo tradicional colectivo y a la cultura de la sostenibilidad existente en la comunidad.

Palabras clave: sistemas socioecológicos, sostenibilidad, comunidades indígenas, América Latina.

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María del Mar Delgado-Serrano. University of Córdoba (Spain). Correspondence: mmdelgado@uco.es.

Roberto Escalante. UNAM (Mexico).

Saul Basurto. University of Birmingham (United Kingdom).

Introduction

Forests provide a wide range of ecosystem services and hold important economic activities (FAO, 2006). Approximately 1.6 billion people rely on forest resources for their livelihoods (World Bank, 2001). They have a key role in meeting basic human needs, making resources available for livelihoods and development, balancing the global climate through carbon sequestration, maintaining ecosystems and biodiversity, and addressing climate change mitigation and adaptation goals (Agrawal *et al.*, 2008). Forest commons are a particularly important class of forest generating these multiples benefits (Chhatre and Agrawal, 2009). Governance and sustainable management of forests are therefore current pressing needs at global and local levels.

Mexico is one of the mega-diverse countries of the world and the one with the biggest forest extension owned and managed by communities (18% of its 48 million ha). About 14 million people organized in 8,500 communities base their livelihoods in these forests (Merino-Pérez and Martínez-Romero, 2014). Collective ownership and access to use are major factors in the permanence and sustainable management of Mexican forests, but also is necessary to link conservation objectives with local development options.

The Community-Based Natural Resources Management (CBNRM) approach has evolved over the past three decades as an alternative to top-down strategies in natural resource management. There is no single definition of CBNRM, but the central idea in the concept is the coexistence of people and nature, as distinct from protectionism and the segregation of people and nature (Western and Wright, 1994). It is meant to combine local interests and socio-economic requirements with conservation by supporting environmentally sustainable natural resources uses. Its major components are: 1) local stakeholder involvement, 2) public participation, and 3) inter-organizational collaboration between top-down and bottom-up levels (Berkes, 2007).

CBNRM seeks to encourage more sustainable practices that allow for conservation and local benefits by involving local communities in decision-making activities, and incorporating local institutions, customary practices, and knowledge systems in management, regulatory, and enforcement processes (Borrini-Feyerabend, 1996; Pomeroy, 1996; Barrett *et al.*, 2001). The approach emphasizes that place-based and contextualized analyses are required to build a better understanding of the socio-institutional conditions, risks, and interdependencies that shape prospects for adaptation and sustainable management (Armitage, 2005). Therefore, it assumes that communities and community-based organizations closely connected to natural resources are most likely to foster sustainable resource use and possess the knowledge required to do so (Blaikie, 2006). It proposes collaborative, deliberate, programmatic, decentralized, democratic, inter-disciplinary, adaptive and dynamic decision processes (Lane and McDonald, 2005; Lurie and Hibbard, 2008).

Several programmes and initiatives have supported CBNRM application. However, neither this approach nor government-based conservation are panaceas (Berkes, 2007). It is possible to find examples of effective and equitable outcomes of community-based conservation initiatives (e.g. Matzke and Nabane, 1996), but also unsuccessful results (e.g. Lund and Treue, 2008). Similarly, research has identified that the traditional top-down rational planning model is still playing a critical role in local conservation in certain contexts (Lane and McDonald, 2005; Balint and Mashinya, 2006; Lane, 2006; Tang, 2009). Despite the critics, CBNRM has been often considered as a suitable approach to govern the commons and it is an increasingly used approach. Several research contributions to provide the basis for its effective use can be found in the literature. However, its principles do not simply harmonise development and conservation, nor necessarily increase the sustainability or resilience of the system to undesirable disturbances (Agrawal and Gibson, 1999; Folk *et al.*, 2003).

This paper analyses the role that the community-based management of the forest in the community of Santiago Comaltepec in the Northern Sierra of Oaxaca has on the ecological and social resilience of the social-ecological system (SES). We used the concept of SES, to highlight the need of linking social and ecological systems for building resilience (Berkes and Folke, 1998). Janssen and Anderies (2007) proposed an interesting definition of SESs for this research: “a SES can be described as a structure composed of a common-pool resource (CPR), its users and an associated governance system”. This definition emphasizes that the separation between social and ecological systems is artificial and can only respond to arbitrary object study selection (Folke *et al.*, 2005). More comprehensively, SESs are defined as complex adaptive systems with key characteristics such as: 1) the integration of biogeophysical and socio-cultural processes, including mental processes, 2) non-linear and unpredictable dynamics, 3) emergent properties, 4) self-organization; 5) feedback flows between social and ecological processes, 6) changing behaviour in space (spatial thresholds) and time (time thresholds), 7) legacy effects in their behaviour with outcomes at very different time scales, and 8) the impossibility to extrapolate the information from one SES to every other (Holland, 1995; Berkes and Folke, 1998; Holling, 1998; Liu *et al.*, 2007; Du Plessis, 2008).

The concept of resilience has been widely used in ecology and can be defined in many ways. It is the ability of a system to absorb perturbations, or the magnitude of disturbance that can be absorbed, before a system changes its structure by changing the variables and processes that control behaviour (Holling *et al.*, 1995). Other definitions of ecological resilience emphasize the speed of recovery from a disturbance, highlighting the difference between resilience and resistance, where the latter is the extent to which disturbance is actually translated into impact (Adger, 2000). Thus, resilience increases the capacity to cope with stress and is hence a loose antonym for vulnerability.

Adger (2000) introduced the idea of *social resilience* as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change. Social resilience is an important component of the circumstances under which individuals and social groups adapt to environmental change. This definition positions social resilience in relation to ecological resilience. Ecological and social resilience may be linked through the dependence of communities and their economic activities on ecosystems. Institutional structures, such as property rights and markets, govern the use of natural resources creating incentives for sustainable or unsustainable management and thus affecting resilience.

Systems may be ecologically resilient but socially undesirable, or they might be socially resilient but degrade the environment (Folke *et al.*, 2003). Here is where social-ecological resilience raises interest, as a key property of sustainability. Resilience is understood as the capacity of a SES to take advantage of the opportunities that appear resulting not only from traumatic changes, but also by favourable circumstances under "normal" conditions, facing changes and uncertainties without shifting to another stable state controlled by different variables organized in a different structure (Gunderson and Holling, 2001; Olsson *et al.*, 2004; Folke, 2006; Walker *et al.*, 2006).

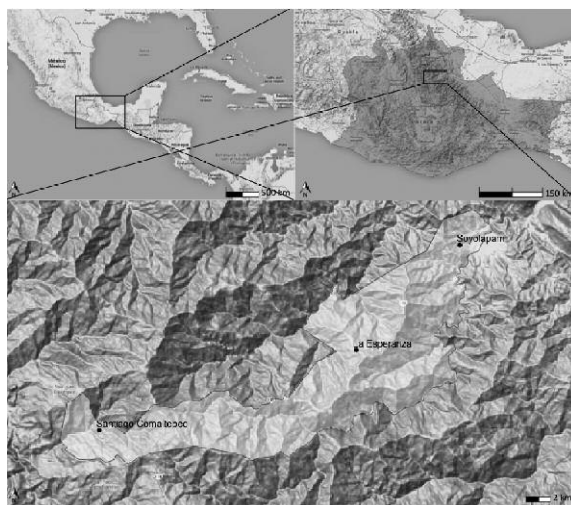
Santiago Comaltepec community has practiced, for centuries, a community-based management of their forest and natural resources, through a nationally and internationally recognized governance system. The social and economic pressures within and outside the community currently represent a serious threat to the traditional common management and sustainability culture. In this contribution we: 1) explore the trade-offs between environmentally sound land management and socio-economic sustainability in this community, 2) identify local strategies to face local, national and international challenges and analyse how these strategies contribute to the social and ecological resilience, and 3) reflect about how the current situation might affect future ecological and social resilience.

The paper is organized as follows: section 2 describes the case study, section 3 the methods and section 4 presents the results. In section 5 we discuss the main results analysing the social and ecological resilience of the SES. Finally, section 6 presents the main insights and conclusions.

Case study description

Santiago Comaltepec is a Chinantec community located in the Higher Chinantla, which is part of the Mesoamerican bio-cultural region (Figure 1). This territory is internationally acknowledged for the good conservation of its temperate forest, rainforest and mountainous cloud forest. The annual average precipitation rate (around 4,000 mm) and the altitude gradient (from 0 to 3,200 masl) sustain one of the most diverse regions in Mexico.

Figure 1.
Geographical location of Santiago Comaltepec, Oaxaca.



Source: Own elaboration.

The two main ethnic groups in the area are Chinantec and Zapotec, who speak their own indigenous languages and manage their natural resources according to the so-called 'customary practices' system (*usos y costumbres* by its Spanish name), described in detail in Section 4.1. The community has communal property rights over 18,366 ha of land and forest entitled in 1953 by the Mexican Government and ratified and certified in 2008 by PROCEDE (the Programme for the Certification of Ejido Rights and House Plot Ownership). This territory is divided into several land use categories, namely 1,726 ha are allocated to forest production, 10,300 ha to forest protection, 127 ha to forest restoration, 6,108 ha to agricultural and agro-forestry uses and finally 108 ha to urban use.

According to the 2010 population census elaborated by INEGI (Mexican Geographical and Statistical Institute), there are 1,115 inhabitants, distributed in three settlements along the territory: a principal nucleus, Santiago Comaltepec and two small villages, La Esperanza and San Martín Soyolapam. These settlements are located at very different altitude ranging from more than 3000 masl in Comaltepec to around 200 masl in Soyolapam. That creates a rich variety of landscapes, forest systems and livelihood options.

The main activities in the territory are related to forest production and agriculture (mainly subsistence agriculture with eventual surpluses traded in the local markets). The community owns very diverse and well conserved forests, ranging from mountainous cloud forests in Comaltepec to mesophyll forest in La Esperanza and tropical forests in Soyolapam. To manage the forest, since 1994 the community has Land Use Plans and Forest Management Programmes, approved each ten years by the Mexican environmental authorities. These plans are developed by the UZACHI, a technical organization hosted by four Chinantec and Zapotec communities, that plays an important role providing technical assistance to these communities in forest management and timber trade.

Incomes come mainly from two sources: communal and individual. The first one involves all collective benefits from forest and other communal economic activities (i.e. ecotourism, transport and services). In the last five years, the community has harvested an average of 2,500 cubic metres of round wood per year (mainly pine wood). This is well below the natural growth rate, hence logging has little impact on the renewability of the main natural resource of the SES. To add value to this wood, the community has built a sawmill where they process the logs. They also buy and market wood produced by other nearby communities. The mill provides some jobs and income to the inhabitants directly working in it. However, the economic benefits of the activity are not transferred directly to commoners; rather they are invested in community's infrastructure and projects or in forest maintenance. The community forest management system is certified as Smart and Sustainable Wood under the international standards of FSC (Forest Stewardship Council). Even if the low production does not allow to access international markets and to get higher prices, for the community is important to have this sustainability label.

On the other hand, individuals and families earn some money from small-scale economic activities such as agriculture, livestock, agro-forestry and services. The remittances that migrants send from Oaxaca, Mexico D.F. and the United States are an important income source. Migration is a key issue to understand the community situation and evolution. Around 50–60% of the total population have emigrated at least once. Some years ago to migrate for short periods (1–3 years) several times were usual practices. However, the stricter USA migration laws are forcing more permanent migrations. The lack of economic opportunities, the tight community rules that block individual actions and the absence of jobs for qualified people create a constant draining of people and are a main vulnerability of the SES.

Even if development opportunities are limited, Santiago Comaltepec is not a highly marginalized community in terms of poverty. Its Human Development Index is

0.6773, placing the community in the 803th position out of 2,419 municipalities what is considered as a medium level of marginality. There are primary schools in the three villages. Secondary school only exists in Santiago Comaltepec, even if in La Esperanza there is a tele-secondary school. However, to access higher education levels, youngsters need to migrate. Traditional healers supply primary health care. There is also a rudimentary clinic in the community, which does not work continuously and people have to displace to Tuxtepec (the nearest village provided with better health facilities).

With respect to the infrastructures and facilities, all the houses have access to electricity, even if the service can be very deficient. Piped water is available to 85% of households and there are WC facilities and sewage infrastructures throughout the community, but no sewage treatment. Finally, there is a paved road that connects Oaxaca city to Tuxtepec region. It was built in 1957 to transport the timber extracted from the area and it facilitates the relationships and the commercial flows of the community with the external world.

Methods

This research has been developed within a near to completion 3-years project COMET-LA (www.comet-la.eu) whose main aim is to identify sustainable community-based governance models for the management of environmental challenges in common pool resources (water, biodiversity, forest and marine and coastal areas). It is developed around 3 case studies in Colombia, Mexico and Argentina, dealing with environmental challenges in specific SES. All the case studies have, to a higher or lesser extent, a community-based management of common pool resources and face internal or external pressures for a sustainable management. To improve the integration of conservation and socio-economic objectives the analysis have been based on the following premises: i) the need to rethinking conservation by using a complexity perspective; ii) the ability to deal with multiple objectives and trade-offs between the interests of different actors involved in the management of natural resources; iii) the creation of partnerships and the use of deliberative processes, and iv) the development of locally-adapted management tools.

To reach the objective, the project is organised in three phases, namely: 1) characterisation of the SESs under analysis; 2) identification of the main variables and drivers in the evolution of the SESs using prospective analysis techniques, and 3)

scenario building. The working method is based on the use of participatory techniques within a learning arena where scientific and local knowledge are shared and integrated. In this way, the project has been developed to ensure the involvement of the local communities within the project itself, hopefully leading to a higher level of appropriateness of the outcomes to their needs.

This paper presents results of the Mexican case study, focused on forest management. To analyse the links between CBNRM and resilience the research was organized in 3 steps: 1) the description of de CBNRM in the community; 2) the history of use of the forest to identify the main disturbances and the adaptations undertaken and 3) the analysis of the social-ecological resilience. For the first two steps we used part of the information collected in the first phase of COMET-LA. In this phase, we characterized the Santiago Comaltepec SES using an adaptation of the Ostrom's framework to analyse the sustainability of SES (Ostrom, 2009). This framework proposes second level variables to analyse 8 subsystems in SES: social, economic and political settings (S), resource system (RS), resource units (RU), governance system (GS), users (U), interactions (I), outcomes (O) and related ecosystems (ECO). In the adaptation, more than 130 third-level variables were defined, leading to an exhaustive description of the SES (see Delgado-Serrano *et al.* (2013) for a full description). Many of these variables have been used to describe the case study, as presented in section 2. The variables included in the governance system and the history of use of forest in the community served to describe the rules and regulations of the management system and the time history of the forest. As mentioned, this task was developed through several participatory workshops with the community developed in the last two years. In these workshops the scientific and the local knowledge were shared to build an accurate characterization of the SES. Some aspects were analysed more in-depth through personal interviews or talks with the commoners.

To analyse the social-ecological resilience of the SES we used the adaptation by Gómez-Baggethun *et al.* (2012) of the approach proposed by Agrawal (2008) for the analysis of adaptive strategies. They proposed different categories to understand how the community had faced different situations: mobility, forecasting, storage, rationing, selection, communal pooling, market exchanges and diversification. This framework was used to identify and discuss the local community-based management strategies in Santiago Comaltepec. Finally, the capacity of these strategies to enhance or block the social and the ecological resilience of the SES was analysed.

Results

The results are presented following the three steps proposed in the previous section.

The community-based management of Comaltepec's forest

The community-based management of the area is organized through a complex governance system that is key to analyse the sustainability and resilience of the SES. As mentioned before, the community governance system is based in customary practices. Mexico's prevailing legal framework (*Constitución Política de los Estados Unidos Mexicanos*) allows indigenous communities to have its own rules regarding social and ecological performance with a certain degree of autonomy. Local rules are embedded in state and federal laws, but the administrative management of the territory is organised by their inhabitants in a direct democracy model where members of the community play the different roles from administrative issues and natural resource management to police functions.

The maximum authority to exercise such democratic model is the General Assembly of Commoners. This Assembly is the arena where the operational rules of the system are established and can be changed. Every commoner (as far as he accomplish his duties) can be directly involved in the decision-making process and decide about the community affairs. However, only since 2010 women are accepted as commoners and still the representation is far from equal. The General Assembly sets the rules for the access and use of natural resources and takes all the decisions related to rights of use, conditions to use and sanctions to rules-breakers. It is also the space for internal conflict resolution. Normally, the mechanism to solve conflicts is a face-to-face confrontation that happens to be effective.

The General Assembly also elects the executive body in charge of implementing the decisions: the Communal Property Commissioner (CPC). Moreover, an Overseeing Council is empowered by the General Assembly to check the actions of the CPC and his compliance of the General Assembly's decisions. This Overseeing Council also watches the commoners activities related to the management of the territory such as assembly

attendance, participation in *tequios* (organized work for a collective benefit consisting of all community members providing materials or work power to build a community facility without any payment), commissions, household labour, self-consumption agriculture, livestock, and monitoring activities. Finally, there are different commissions in charge of the administrative and management functions in the territory.

All these functions are developed under a *non-paid system* basis, what means that every commoner has to devote between 6 and 9 years (in periods of 1-2 years) of his working life to work for the community without receiving any payment. It is considered as a return for collectively owning the land. These yearlong duties are called *cargos*. *Cargos* are elected 2-3 years in advance to allow the commoners to organise their livelihood options in order to subsist during these periods. Their role is essential to maintain the community-based management.

A second instance of decision is the Citizen's General Assembly. It groups all community citizens, commoners and other people living in Comaltepec. The Municipal Council authorities are in charge of implementing decisions regarding public services (including public spaces), water, sanitation, health, education, roads, cemeteries and market places.

In the community, the *property, extraction and exclusion rights* are clearly defined. Commoners have to ask for permission to use land for agriculture and other purposes and they can be excluded of the SES benefits if do not accomplish their duties. The community has the right to exclude external agents from harvesting the forest and every commoner has to report any unauthorized use of resources. Non-permitted use is punished with a fine, with imprisonment, or with both. Rules for monitoring processes are also clearly established in the communal bylaw. These rules have allowed the maintenance of the system performance and its good conservation status, but are nowadays more contested specially by younger and better-qualified people.

The customary practices and traditions are inherited generation after generation, the community recognizes the rules as legitimate and fair and this acknowledgment ensures a high degree of compliance. Furthermore, reciprocity plays a key role in the social system. This social and organizational structure shows strengths and weaknesses. It is highly efficient compared to other communities in the region, in which the lack of organization in terms of management of their resources derives in deforestation and pollution. However, the villages of La Esperanza and Soyolapam perceive deficiencies in the fairness of the system, mainly because of the lower access to the benefits obtained from the forest resources and the weak influence these villages have in the General Assembly due to their smaller number of representatives.

Furthermore, these institutional arrangements represent very strict constraints to individual entrepreneurship. The General Assembly decides on the use of natural resources. Communal views prevail among the commoners and individual or entrepreneurial initiatives tend to be systematically blocked. This is seen as a major cause for migration (mainly to the United States of America and Oaxaca City). Young people migrates either searching for better job opportunities or for escaping from the rigid community's rules.

The history of use of Comaltepec's forests

A brief chronology of the history of this community in the use of its resources is presented, since it is essential to understand the actual situation and the future challenges. As mentioned, in 1953, a presidential resolution acknowledged the land ownership to the community of Santiago Comaltepec. However, in 1956 a Federal Government decree conceded a paper mill (FAPATUX for its acronym in Spanish) the right to exploit the forest resources. Afterwards, the construction of the federal paved road allowed the industrial processing of the wood. No limit to extraction was established and FAPATUX systematically cut the adult trees, disturbing the forest age pyramid. During this time, the community profoundly suffer the destruction that this exploitation caused to the natural resources they have inherited from their ancestors.

Between 1980-1982, Comaltepec participated in the Organisation for the Defence of the Natural Resources of Sierra Juárez (ODRENASIJ, A.C. for its Spanish acronym) whose main aim was to stop the renewal of FAPATUX forest concession. After several and long struggles, in 1984 the communities succeeded and the concession was not renewed. They regained the control of the territory and reinstalled the common management use of their forests. Due to this hard struggle, many commoners, who are now elder, still vote against any increase in the extraction of wood from the forest and are very conservative to accept any external investment or company in the SES. In 1989, the community joined other three neighbour communities to found its own forestry unit, UZACHI, to manage their forest. UZACHI was the first to be certified as a sustainable forest technical unit in Mexico. It has also received several national and international awards for their sustainable forestry management.

In 1983, a forest fire burnt more than 2,000 ha. In 1998 and 2003, other fires led to forest management plan modifications. In December 1993, Comaltepec was granted its first forest management permit. In 1994, the first Land Use Plan and Forest

Management Programme elaborated by UZACHI were approved. The community agreed to extract only 2,500 m³ from the forest of Comaltepec and leave most of the forest as a preservation area. In 1997, the Smart Wood Program certified UZACHI's forest management system as sustainable under the FSC international standards.

In 2004, Comaltepec received the first payment for the provision of ecosystem services, mainly water catchment, from the Government. This programme offers 58 USD ha/year to maintain 2,524 ha under a preservation scheme in the very well preserved mesophyll forest located in La Esperanza. Nowadays, a study of the forest CO₂ absorption capacity is carried out so the community could benefit from REDD+ funds. However, the feasibility of the project is not certain yet. Finally, in November 2012, an ecotourism firm started being operated by the community.

Comaltepec's resilience

The main disturbances and drivers of change currently affecting Comaltepec are: 1) climate variability; 2) globalization and the new models of consumption and incomes that it imposes; 3) migration of the youngest and better qualified. The first two are external drivers and the community has few options to face them. The last one is internal, even if highly influenced by globalization and the new development models. The main practices and processes in the community for each of the strategies proposed by Agrawal (2008) and Gómez-Baggethun *et al.* (2012) are displayed in Table 1.

Table 1.
Adaptive practices to cope with disturbance

Strategy	Description
Forecasting	<ul style="list-style-type: none"> • Observation of meteorological indicators to forecast changes in weather • Participation in research to improve the understanding of the SES dynamics, including the participatory development of scenario building process
Mobility	<ul style="list-style-type: none"> • People migration to find better jobs and guarantee a diversity of income sources to many families
Storage	<ul style="list-style-type: none"> • Physical infrastructures for wood storage, like a saw mill • Customary devices for storing traditional ecological knowledge and collective memory such as local histories and tales
Rationing	<ul style="list-style-type: none"> • System based on frugality, where inhabitants need very few to subsist • Very limited wood cutting to allow forest regeneration
Common pooling	<ul style="list-style-type: none"> • All the resources (including labour) are community-owned, except houses and agriculture subsistence land • Benefits of resource exploitations invested in collective goods and services • Long-term reciprocity
Market exchanges	<ul style="list-style-type: none"> • Timber, even if FSC certificated, traded in local and regional markets due to the low production • The sawmill buys some wood to the neighbour communities to increase the marketed volume • Only raw pinewood is sold, a commodity with relatively low prices and added value. The sawmill has not the technology to process other types of wood present in the forest, such as some quercus species
Diversification	<ul style="list-style-type: none"> • Diversification of income sources and skills to spread disturbance-related risks at household level • Development of new activities at the community level: payments for ecosystem services, ecotourism, buy of wood to neighbour communities • Natural diversification of cultivated and harvested products because of the altitude gradient that produce different microclimates and livelihood options • Subsistence farming based on policulture to produce staple food

Source: Own elaboration based on Agrawal (2008) and Gómez-Baggethun *et al.* (2012)

Discussion of results

This section discusses the impact of the different adaptive strategies on the SES socio-ecological resilience and how the CBNRM rules and institutions influence it.

Forecasting. Farmers and pastoralists can predict weather conditions in the short term. In La Esperanza inhabitants predict climate conditions observing how the sky is clouded. For instance, they have detected warmer seasons than in the past due to the fact that the number of cloudy days has diminished. People involved in forest exploitation have detected the same modifications on rainfall season patterns. All these season changes have led to delays or advancements on harvest plans. This local knowledge about short-term forecasting has allowed some adaptation process.

On the other hand, the community's General Assembly approved to be part of COMET-LA as a strategy to be linked with universities and to have a better understanding of the dynamics of the SES and of the options to overcome the present challenges. One of the tasks in the project is an analysis of scenarios. Currently, the community is conducting a scenario building process to think about how the future could look like and how prepared they are to respond to potential disturbances. These strategies increase both the social and the ecological resilience.

Mobility. The governance rules and institutions on community life proved to be effective in the past, but seems now to be discouraging individual entrepreneurship and innovation, therefore fostering migration of youngsters. Even if this governance system might ensure ecological sustainability and possibly resilience by decreasing the pressure on natural resources use, from a social perspective the outcome might be contradictory. While migration is the strategy that young people adopt to have better education, income and job opportunities, it might also be seen as a family and community strategy to diversify sources of income and knowledge. In fact, on one hand, the remittances represent a survival option for most of the families and contribute to the economic sustainability of the community. On the other hand, it might also be seen as a loss of social capital, a challenge to generational turnover and a process that might increase family and community dependence on global economy, therefore enhancing social vulnerability. Additionally, this strategy has an important influence on the continuity of the community-based management since the migrants do not always have the option or the willingness to fulfil the *cargos* responsibilities. Sometimes they come back to the

community to accomplish this obligation. Other times they pay someone to do it for them (this option is mainly used by the migrants in the United States). However, when none of these options are available to them, they lose the condition of commoners.

Storage. Three kinds of storage have been identified: wood, traditional knowledge and collective memory. The sawmill gives the community the capacity to store sawn wood. This activity diversifies livelihood opportunities and the storage of wood allows the community to have some chances of bargaining with wood buyers and to better manage the extraction of wood, even if the community is not very efficient in its management due to the lack of skills and technologies.

Although young people are increasingly embedded in new globalisation stereotypes coming from outside the community, local traditional knowledge is being transmitted through generations. Likewise, collective memory is one of the most controversial topics in community's discussions. For community members, the collective memory represents a robust response to face future environmental, economic and social challenges. They consider collective memory to be the most important and potent antidote to face negative externalities: globalisation and national and state policies that foster individualism and neoliberal approaches. Information and data collected during workshops with the community point out that collective memory has framed the culture, the value system and the sense of belonging, and as such has been essential to overcome disturbances. For instance, when Comaltepec defended its property and management rights over the forest three decades ago, the collective memory of living in community and the social cohesion it generated became the main asset and strength. It made possible the community's current status.

The combination of practicing a particular relationship with nature became knowledge and has been taught. Elders and parents taught youngsters that communality is the way to live and see the world. But most importantly, such vision became institutions. Through time, people of Comaltepec have learnt that collective decision works better than individual acting. That is why community issues are discussed and decided through the commonship of the Commoners Assembly. This institution has maintained not only a particular ethos but also a discipline. Comaltepec's commoners not only are convinced of commonship but also accept the rules it implies. Wood storage, traditional knowledge and collective memory contribute to social and ecological resilience. The CBNRM strengthens these strategies. The investment of the incomes derived of the forest exploitation in common infrastructures permitted the building and improvement of the sawmill among others. The importance of culture, traditions and ancestral knowledge is stored and transmitted by the CBNRM institutions.

Rationing. These strategies are found both in forest management and in the households' economies. The rationing in the use of natural resources, particularly after the great disturbance of the long-lasting unsustainable extraction of wood and the struggle to avoid perpetuating that management, has produced an environmentally sustainable model of natural resources use. However, while Comaltepec preserves the forest and the biodiversity associated to it, commoners have a limited welfare level and cannot aspire to have current levels of consumption and luxuries. Local livelihoods are based on a frugal poverty: subsistence is guaranteed by producing one's food and having access to basic education and medical care, but other goods and services today considered as a need for living are lacking. While this frugality and rationing of forest resources might be good for ecological resilience, social resilience is being affected. Some commoners, especially the young question the prevalence of these ideas among the elder and will welcome livelihood opportunities derived of the exploitation of natural resources.

Selection strategies are not relevant in this community.

Common pooling. Pooling of resources, incomes, and welfare might also be considered an adaptive strategy to cope with disturbances and changes. The income generated by communal enterprises are not distributed to the inhabitants, but invested in town's infrastructure, frequently misallocating resources. The existing governance system, therefore, seems to be on one hand, not making the best of community's revenues, and on the other hand not providing enough individual benefits. Different responses such as the creation of a local financial institution supported by communal resources or to grant individual/familiar concessions for production purposes (generating individual sources of income) have been appointed during this research, but the Assembly is reluctant to go further. We believe an important challenge is finding manners about how to link individual and collective projects so that adapting it to external drivers of change increases social resilience. The long-term reciprocity has also been an efficient strategy to manage risks and shocks, like those derived of forest fire, and enhance social and ecologic resilience. The lack of individual and familiar benefits due to the community-based management is a raising concern in the community and a threat for the social resilience.

Market exchanges. The community trades a very low wood quantity and does it in local markets or in Oaxaca. Even if they maintain the FSC certificate as a guarantee of their sustainable management, they do not have the production volume necessary to access fair trade markets. Recently, they translated the sawmill closer to a main road, and thanks to that they can now buy some wood to neighbour communities and increase the timber they process and market, but still it is a small quantity. Furthermore,

they only trade pine logs that do not have high prices. In the forests are *quercus* species, producing higher quality wood, but the handling and the adding value is more complex and need other technologies and capacities to process it. The social resilience of the community is negatively affected by these strategies. The tight decision methods in the General Assembly and the risk aversion of most of its member block the options to entrepreneurship and adding value schemes.

Diversification. This type of strategies can be found at household level (incomes, skills, policulture farming) and at community level (new activities). Although traditional crops are being cultivated in Santiago Comaltepec, peasants are exploring the possibility of developing agro-forestry projects and improving crops diversification. In fact, crops such as fruits, vegetables and orchids, which have a higher market value, are being produced or being considered for production. In addition, after the collapse of the coffee as a result of the North American Free Trade Agreement (NAFTA) signed in 1994, these products are being cultivated again and changes in weather conditions have allowed cultivating "*café de altura*" (gourmet coffee). Another strategy that is implemented by commoners is improving the infrastructure to prevent and fight fire hazards. It is based on a firewall system and on training of local inhabitants. For the future, the community is reflecting about other responses such as economic activities diversification and new production processes. These strategies contribute positively to enhance social and ecological resilience.

Final insights and conclusions

The first reflection from this research is that the CBNRM is not providing conservation and development. The forest has been restored and is in better conditions since the community regain full rights of access and management, but this management provides limited development and socioeconomic wellbeing opportunities. As a result, forest and land are sustainably managed and resilient from an environmental perspective, but social and economic sustainability and resilience lag behind.

There are several adaptive strategies of Santiago Comaltepec that can be seen as social and/or ecological resilience enhancers and that are therefore critical for sustainability in the mid and long term. However, the future of Comaltepec's SES is at

stake: the community faces important socio-economic challenges. Some undesired outcomes of the community-based governance system, such as the lack of individual income sources and the rigidity towards innovation, together with external pressures, are stirring migration of youngsters. The current situation might be considered an example of the frequent and central dilemma of environmental conservation versus development. Sustainability and resilience are based on communality and poorly compensated. The low prices received for the efforts of common conservation makes individual alternatives appear as more profitable. So far, sustainability and resilience have been guaranteed, but this reality seems to be uncertain in the mid-long term. On the one hand, social resilience is at risk. On the other external drivers might interfere with the current governance and resource management system. The system is hence confronted from both flanks: internal and external. The community is aware of these issues and is exploring ways out.

Looking into the past, the several shocks that have affected Santiago Comaltepec had both positive and negative effects. For instance, the entry of FAPATUX and the 1983 forest fire pushed the community to reflect about the internal organization in order to face and overcome external forces. These experiences led to the strengthening of a self-organising institutional structure, the development and implementation of a forest management model that is more respectful towards natural resources and has helped restoring natural capital. However, the CBNRM that facilitated this recovery and seems a successful example of social-ecological resilience presents important limitations. In fact, the governance system has a high capacity to cope with forest management, but a medium-low capacity to cope with people, since it does not provide enough welfare and development for community members and the system is not necessarily fair, particularly for youngsters and women, whose participation is largely limited by the governance system. Therefore, even if the SES, as we have seen, to a certain extent is resilient, the state of the SES cannot be considered fully "desirable". This situation (high resilience of a partially undesirable state) is making the community face the challenge of modernizing its governance system without losing its ethos, i.e. changing some rules and instruments but not its essence, and working on new *diversification* strategies. For instance, peasants are considering crop diversification to handle diverse challenges as climate change and traditional crop prices downward.

However, even if new possibilities to sustainably improve outcomes from the local biodiverse natural capital were properly developed, the context in which such initiatives are embedded is adverse. To Comaltepec's sustainability model based on communality use of resources, another important barrier lives outside the SES. The

globalization macroeconomic setting largely forces the suppliers of natural resources (goods and services) to behave as price takers. National and international commercial and financial agreements and markets are set so that consumption is largely subsidized and production is penalized, so that intermediate links of the chain gain most of surplus. The most evident effects, at local scale, derived from such arrangement, are: 1) that the quality of life of the local population guarantying and depending on the supply of natural resources that supports global markets, continuously declines, and 2) that a kind of social deception spreads among the communities. In this way, the message seems to be that, maintaining the natural capital means both being poor and naive. Comaltepec's system requires taking initiatives to build new transformational paths and grab the advantages of globalization, but global worldviews should also value commonship and sustainability for the benefits they provide.

As we have seen, both internal and external factors are currently pressing on the SES: climate change, high levels of migration and the lack of individual benefits –and hence impoverishment- derived from the forest management are some of them. However, even large disturbances such as droughts, elimination of the self-organised governance system, or the potential entry of violent, drug-related groups in the zone as happens in other parts of the country, need to be taken into consideration as possible future challenges. Reviewing and improving development and forest management plans as well as strengthening the links between the community and external institutions (such as universities and technical advice specialized institutions) might be, and currently are, thought as strategic responses in the sense that they may be useful to cope this kind of phenomena.

If Comaltepec is unable to transform itself and the macro context is not modified, the SES will likely be overwhelmed and externally transformed. The future of both trends is uncertain. Outside the system, the scenario seems pessimistic. Mexico's government present preoccupations and initiatives to transform the economy and the society are antipode to what Comaltepec's essence is all about. Commonship is considered as a fancy, but an out of date strategy. However, within the system some awareness exists about the need of change. It requires knowledge, financing and public policies. Even if the last two seem difficult to achieve, past experience on coping with crises has taught Comaltepec's community that knowledge, both local and external, is important. Preserving and transmitting the first to the next generations, and seeking for the second with external partners such as universities, are among the steps that the community is already taking to sustain their SES.

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