D3.2: "Stakeholder vision on problems and drivers related to environmental challenges in Mexico"

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Index

List of figures

List of graphs

List of tables

List of maps

Acronyms

BSR: Business for Social Responsibility
CCMSS: Civil Mexican Council for Sustainable Forestry
CDI: National Commission for the Development of the Indigenous People
CIDAC: Development Research Centre
CIESAS: Regional Centre for Social and Anthropological Research
CIIDIR: Interdisciplinary Research Centre for Integral and Regional Development
CONABIO: National Commission for Knowledge and Use of Biodiversity
COMET-LA: COmmunity-Based Management of EnvironmenTal Challenges in Latin America
CONAFOR: National Forestry Commission
CONAGUA: Water National Commission
CONANP: Committee on National Protected Areas
CPR: Common Pool Resources
CSO: Civil Society Organization
ECO: Related Ecosystems
ERA: Rural Studies and Consultation
FAPATUX: Paper bin
FSC: Forest Stewardship Council
GS: Governance system
I: Interactions
IEEO: Oaxaca State Institute of Ecology
INE: Ecological National Institute
INEGI: National Institute of Statistics and Geography
MDI: Matrix of Direct Influences

MICAMAC: Cross-Impact Matrix – Multiplication Applied to Classification
MII: Matrix of Indirect Influence
NGOs: Non-Governmental Organization
ODRENSIJ, A.C.: Organisation in Defence of the Natural Resources of la Sierra Juárez
Outcomes
PROCEDE: Communal and Ejidal Right Certification Programme
PSA: Prospective Structural Analysis
RS: Resource system
RU: Resource units
S: Economic, Social and Political Settings
SAO: Oaxaca Association for Environmental Services
SEDESOL: Ministry of Social Development
SEMARNAT: Ministry of Environment
SES's: Social-ecological systems
TDD: Total Direct Dependence
TDI: Total Direct Influence
TID: Total Indirect Dependence
TII: Total Indirect Influence
U: Users
UCO: University of Cordoba
UNAM: National Autonomous University of Mexico
UNSIJ: Sierra Juárez University
UZACHI: Zapotec-Chinantec Union
WS: Workshop
WWF: World Wildlife Fund
XEGLO Radio: Local radio station located in Guelatao, Oaxaca

Particular terms

Comisariado: Is the authority appointed by the Commoners' General Assembly to represent their interests. One of activities to be performed is to verify that rules of access are respected.

Caracterizados's group: This group is integrated by respectable community members appointed by the citizen's assembly due to their good cargos's performance.

Cargo: Employment, especially high responsibility or authority without payment

Radio Guelatao: Regional radio station

Sierra Norte: Northern Highlands

Tequio: Is an organized way to work in a collective benefit, consists of all the integrants of a community giving materials or work power to build a community facility without any payment

Cargos y comisiones: Unpaid labour for the community

Domestic labour: Household activities without any payment, generally it is carried out by women

Monitoring activities: Consist in the fact that commoners supervise the territory looking for some rule brokers or fire hazard

Usos y costumbres: The term customary practices refers to the culture attached to these kinds of communities, which indicates the manner that they are organized.

Ejido*:* means government land subrogated to agricultural producers. Generally, these producers are small land owners. Ejido lands can be sold, rented and lent.

Avecindados: Most of the times, they are non Chinantec people living in Comaltepec.

Executive summary

This document is part of the COMET-LA project financed by the European Community. In particular it refers to the Work Package 3 which deals with the Case Study of Mexico and corresponds to the deliverable entitled: D.3.2. Stakeholder vision on problems and drivers related to environmental challenges in Mexico.

The document refers to a community located in the Northern Highlands of Mexico: Santiago Comaltepec. This community, devoted mainly to forestry activities, has the characteristic of communally owing 18,366 ha. More important is that Comaltepec governs its territory and its natural assets in the same fashion. The commons and its destiny are in the hands of the whole community and a set of institutions have been developed to reflect such approach. Despite the relatively small territory and the number of people living in it, Comaltepec has become an example of using its territory for the purpose of preserving it, and using the communal property as the formula to achieve it.

The main objective of this document is to present and discuss the Stakeholders vision on problems and drivers of Comaltepec´s Socioecological system. The main goal is to show that within the complexity of the communal ownership and management of the forest resources of Comaltepec a set of variables, from the different types of stakeholders involved in the SES, play a different role and have a different capacity to influence it and move it.

Two instruments are used to present the above mentioned results. One is the *prospective structural analysis* (PSA) carried out in the Santiago Comaltepec's socio-ecological system. The second is based on the previous characterization of the SES under Ostrom's frame (deliverable D.3.1). In the case study of Mexico (Santiago Comaltepec), the PSA and Ostrom´s framework (SES) were used interactively. This means that Ostrom´s framework was followed to build and characterize the SES and the PSA was nourished with the information the SES offered. Ostrom's framework was used to describe and characterise our SES. In short, Ostrom (2007 and 2009) propose identifying and considering the users, leadership, norms, social capital, collective choice rules, knowledge of the SES interactions, importance of resources to users, resource size, mobility and productivity. This approach is useful to reveal and identify variables and interactions influencing the SES.

The characterization of Santiago Comaltepec's SES was prepared by UNAM and ERA members, which integrate the COMET-LA Project team in Mexico, in collaboration with community leaders and stakeholders as well as with external institutions working in the region, mainly the Zapotec-Chinantec Union (UZACHI for its acronym in Spanish). External stakeholders included members of such instances as the UZACHI, the Ministry of Environment (SEMARNAT), the Ministry of Social Development (SEDESOL, *Committee on National Protected Areas* (CONANP), the National Forestry Commission (CONAFOR), the National Commission for the Development of the Indigenous Peoples (CDI), the Oaxaca State Institute of Ecology (IEEO), the Oaxaca Association for Environmental Services (SAO), the Regional Centre for Social and Anthropological Research (CIESAS), the Sierra Juárez University (UNSIJ), the Committee of Comaltepec People in Oaxaca City and the Oaxaca Office of the National Polytechnic Institute Interdisciplinary Research Centre for Integral Regional Development.

Based on Ostrom´s frame of eight *subsystems* underlying robust institutions for collective action in CPR, the following lines analyse sets and subsets of variables related to the performance of the SES in our case study.

The sets and subsets of variables lead to a process of *diagnosis* of the system, in order to identify its key variables for facing environmental challenges.

SES Setting (S)

Comaltepec Community is in the Higher Chinantla or High Chinantec Area, which is part of the Mesoamerican bio-cultural region. In the American continent, landscapes have been shaped by long-standing management practices which have been perpetuated through a mix of techniques, myths, taboos and other cultural practices conforming bio-cultural complexes covering wide areas. Comaltepec community is part of the Mesoamerican bio-cultural region.

Resource System (RS)

The Resource System is a key aspect in the functioning of Comaltepec's SES. Being Comaltepec an example of communal management of a SES, and being governed by a direct participatory system, the resource system available in the SES will be intimately related to the Governance System.

The Resource System can be divided into five categories: agricultural land, commercially harvestable temperate forest, commercially harvestable rain forest, Wildlife/scenic areas, and micro watersheds.

Governance System (GS)

Since Santiago Comaltepec is a Chinantec (indigenous) community. Its *governance system* is based *on customary practices*. This system is a characteristic of most indigenous communities in Mexico. Comaltepec´s Governance System is characterized by having a direct participatory system. Everybody can be directly involved in the decision making process deciding about the community affairs. Two instances have been devised to exercise such democratic model: commoners 'and citizens' general assemblies. The General Assembly of Commoners sets the rules for access and use of natural resources.

Resource units (RU)

The Resource Units category is closely related to the Resource System. Due to the fact that the Resource System is a common pool governed by the commons, the relationships between them is very close. The common pool of agricultural lands is distributed amongst individuals or families to produce food staples and commercial temperate forests are used to produce wood and timber.

Users (U)

There is a first group of users. They are the commoners. A second group of users are the settlers. A third group of users are the outsiders. All commoners and settlers depend on forest resources for their construction materials, firewood, medicinal plants and fodder. The main sources of income are individual and communal.

Interactions (I)

The characteristics that Interactions adopt in the case of Comaltepec´s SES are very important. A first round of interactions takes place between the Governance System and Users. A second set of Interactions occur between the Governance System and the Resource System. A third set of Interactions are those between the Resource System and the Users.

Outcomes (O)

As a result of interactions inside the SES, the outcomes are overall indicators of general SES performance. It is highly efficient compared to other communities in the region. However, it could be stated that the institutional arrangements represent very strict constraints to individual entrepreneurship. It could even be argued that forces people out of the system. There is a constant flow of migrants.

Related Ecosystems (ECO)

Comaltepec's SES generates positive externalities, some of which benefit nearby SES. Watersheds protection, conservation of a large number of species of plants and animals as well as carbon capture and sink are some of these positive externalities. The magnitude of the negative externality is not significant.

Results of the PSA exercise in Comaltepec.

Prospective Structural Analysis was carried out using information provided by stakeholders (internal and external) which allows knowing what the behaviour of a SES, Comaltepec´s, This technique was applied using a specialized software MIcMac developed by Godel (1997).

Several workshops were carried out in May, 2013 and the output was a series of Direct Influence Matrices using a set of 15 variables, previously identified by the stakeholders, internal and external, as the most relevant.

Once the Direct Influence Matrices were obtained, it was possible to establish a hierarchy amongst SES´ variables by the following criteria:

Level of influence on the SES i.e., how much influence a variable I has on the remaining variables n-1, or;

By the level of dependence i.e., how much influence the n-1 variables have on variable 1.

By the theory of graphs showing de degree of influence on all the variables relations existing in the SES.

Moreover, using the influence –dependence MIC-MAC software produces different types of variables e.g., key, motor, autonomous and support variables, could be identified.

External stakeholders pointed out those variables such as History of use of the resources, governance system, non-paid activities, and collective-choice rules are Comaltepec´s SES support variables. In the case of internal stakeholders, Economic value, importance of the resources, monitoring and sanctions, non-paid activities, and the history of use of the resources, are the support variables.

The PSA exercise carried out with women stakeholders the most important variables are: collective decision making rules, history of the use of the resources, non paid activities and the governance system.

In terms of perceptions, there are differences amongst the different type of stakeholders about the importance and roles of the chosen variables for the PSA exercise. However, these differences are very strong. There is a coincidence that given the communal ownership and management of the SES in Comaltepec, the governance system based on non paid activities and clear rules of access and sanctions, keep the system working and any action exercise on them in the future will have a strong influence on the direction the whole SES might take.

Considering COMET-LA and community discussions and findings, Santiago Comaltepec's SES can be said to be environmentally sustainable, but its economic and social sustainability is not so certain due to it is not providing good opportunities for inhabitants. In contrast, in the case of institutional sustainability, the governance system is strong, but some future difficulties have been found. As a result of PSA application, a broader picture of the SES and its functioning has been obtained. It will be the input for the next phase of the Project: Scenario building.

1   Introduction

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The document refers to a community located in the Northern Highlands of Mexico: Santiago Comaltepec. This community, devoted mainly to forestry activities, has the characteristic of communally owing 18,366 ha. More important is that Comaltepec governs its territory and its natural assets in the same fashion. The commons and its destiny are in the hands of the whole community and a set of institutions has been developed to reflect such approach. Despite the relatively small territory and the number of people living in it, Comaltepec has become an example of using its territory for the purpose of preserving it, and using the communal property as the formula to achieve it.

The Nobel Prize laureate, Elinor Ostrom, drew attention to the fact that economic relations and processes are social relations and that, therefore, many issues regarding economics can be better understood in terms of how social agreements are built to address demand through production, transformation and distribution deals. Besides analyzing demand, supply and prices, Ostrom showed how an institutional analysis i.e. a description of the rules-in-use and the institutions created to enforce such rules can shed light to understand complex processes that have been difficult to explain under conventional economic frameworks (Ostrom, 2008).

In particular, in a more recent paper Ostrom (2009) proposed that natural resources-related issues can be better understood analyzing the relationships between a common pool of natural resources, such as irrigation water, fisheries or forests, and a range of users who demand these resources from that common pool for their wellbeing. Under a given *social, economic and political setting* (S), a *resource system* (RS) is directly or indirectly harvested or cultivated by a set of *users* (U) who extract some amount of *resource units* (RU) from it. This can be done in a sustainable way if extraction rates are lower than regeneration or reposition rates and the resource system is maintained. In Hardin's assumption of *the tragedy of the commons* (1968), no *governance system* is presented to regulate the *common pool resources* (CPR) use and access; to avoid over-harvesting as to ensure the proper maintenance activities are performed, a *governance system* (GS) is needed. With these elements, *social-ecological systems* (SES's) can be understood as the *interactions* (I) between all these components and may be evaluated by their *outcomes* (O). A socio-ecological system can also be analysed according to its impact over the *related ecosystems* (ECO) where it is embedded.

Thus, the main objective of this document is to present and discuss the Stakeholders vision on problems and drivers of Comaltepec´s Socioecological system. The main goal is to show that within the complexity of the communal ownership and management of the forest resources of Comaltepec a set of variables, from the different types of stakeholders involved in the SES, play a different role and have a different capacity to influence it and move it.

Two instruments are used to present the mentioned above results. One is the *prospective structural analysis* (PSA) carried out in the Santiago Comaltepec's socio-ecological system (SES). The second is based on the previous characterization of the SES under Ostrom's frame (deliverable D.3.1). In the case study of Mexico

(Santiago Comaltepec), the PSA and Ostrom´s framework (SES) were used interactively. This means that Ostrom´s framework was followed to build and characterize the SES and the PSA was nourished with the information the SES offered. Ostrom's framework was used to describe and characterise our SES. In short, Ostrom (2007 and 2009) propose identifying and considering the users, leadership, norms, social capital, collective choice rules, knowledge of the SES interactions, *importance of resources* to users, resource size, mobility and productivity. This approach is useful to reveal and identify variables and interactions influencing the SES.

Under Ostrom's scheme, the Chinantec Santiago Comaltepec SES can be described as a complex system where the Chinantec Mesoamerican stewardship tradition adapts to a harsh environment with steep slopes, sharp environmental variations and high diversity, to meet both internal and external social needs.

As in other places, human needs exert pressure over natural resources. Because of its comparatively good communications (a paved road running through its territory), Comaltepec exhibits stronger human needs pressures, both internal and external, over its resources than more isolated nearby communities. To deal with such complex situations, Comaltepec has a sophisticated Governance System (GS), mixing local ethnic traditions with legal agrarian and municipal frameworks, which, up to date, has been successful at giving basic *livelihoods* to its people, preventing deforestation and keeping an important biodiversity hotspot of national and regional importance.

Following Ostrom´s advice (Ostrom, 2007), that there are links among conceptual tiers of variables, a multitier frame with 132 variables organized in sets and subsets was defined. Once the SES was characterized, its content was presented to the local and external stakeholders in three workshops (external, local and women-only WS). According to their knowledge and experience on the SES, the different stakeholders were asked to choose the most relevant variables for the SES. They selected 15 principal variables as *drivers of the SES* that might be used as an input for PSA.

Then, once all the variables to use for the analysis were established, they were used as an input for PSA. This methodology is useful when dealing with a complex system, including not just the elements, but also the interactions among variables that play a significant role in the SES. Moreover, it can be useful to understand the SES' present and future situation (Ambrosio, A., et al. 2011).

The PSA analysis indicates that SES key variables are those short named *economic activities*; *non-paid activities*; *exclusion and extraction rights*; the *history of use*; *property rights system*; and the *importance of resources*. The interactions between these variables will be discussed. Detailed descriptions are provided in Annex I.

For the sake of clarity, in order to present PSA construction and results, this document has been divided into four sections. In the first one, a description of the study area under Ostrom's frame is provided. The second section deals with the use of prospective structural analysis (PSA) and the identification of the most relevant problems and drivers of the SES. The third section includes the results of PSA, some interpretations and their validation by the workshop participants. Finally, in the fourth section, the results and some conclusions drawn from the PSA are presented. All this information was collected through workshops, including local and external Stakeholders. It must be highlighted that in order to process the information gathered in the

workshops so as to weigh and analyse the roles of the variables and their interactions, MICMAC software was used[1].

2   Study area description according to Ostrom´s frame

Ostrom (1990) suggests that common pool resource (CPR) users may work together in order to avoid the overexploitation of their resources and the concomitant environmental damage and degradation. To make CPR use sustainable, CPR users should establish a GS effective enough. CPR systems that fail to develop such governance systems tend to overexploit the pool and eventually collapse. In contrast, robust systems survive for long periods of time because they are governed according to a certain set of effective rules (Ostrom, 1999). In this sense, Ostrom suggests a specific set of criteria to identify robust CPR use systems. After several years of research, Ostrom found that the successful cases of commons self-governance share eight common traits, which are named 'eight design principles' (Ostrom, 1999; Poteete et al., 2011), which have been defined as follows:

1. The Common Pool Resource has clearly defined boundaries. This means that the community has an effective manner to exclude external un-entitled parties.
2. There exists equilibrium regarding rules related to the assignment of benefits and costs. The system members should perceive such rules as fair and legitimate.
3. Community decisions are based on collective-choice arrangements so that those affected by the rules can modify them.
4. The monitoring process has an important role, because it is the way the community makes sure the rules are enforced. This process includes the resources conditions and each user's behaviour. Monitors are part of the appropriators.
5. A sanctioning system has to be designed in order to regulate members' behaviour; the system consists of gradual penalties, in order to allow dealing with exceptional circumstances.
6. It is important that there exist easy mechanisms on the local level to solve conflicts at a low cost.
7. Minimum rights recognition. The right of the participants to create and modify their own institutions is recognized by the government.
8. When we are dealing with a large Common Pool Resource, it is important that rules be designed and enforced through different tiers of nested enterprises.

When CPR are used by specific social groups and governance structures are developed, social-ecological system (SES) can be identified. A SES is defined as an ecological system that is linked and affected by at least one social system (Anderies et al. 2004). Moreover, an ecological system is defined as an interdependence of organisms; and a social system as a scheme 'tending to form cooperative and interdependent relationships with others of one's kind' (cited in Anderies, et al., 2004). But, when the link between both systems is

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[1] The MICMAC's aim, description, and software are available on http://en.laprospective.fr/methods-of-prospective/softwares/59-micmac.html. Consulted in June, 1st. 2013.

extremely close, the SES can be said to be a complex structure integrated by many subsystems, which cannot be understood standing alone, but within the network of social-environmental relationships that is possible.

The first aim of this document is to present the results of Comaltepec SES prospective structural analysis, which tries to capture SES's performance identifying key variables and their level of influence over other ones. To do so, the first step is to characterize the Santiago Comaltepec SES. As social and biophysical agents interact, the system becomes complex, and its problems involve non-linear relationships; therefore, time and space cross-scale approaches are needed and the system needs to be seen as a dynamic one (Janssen and Ostrom, 2006; Holling, et al, 1998). In order to analyse the SES, a method that might be able to identify combinations of several variables that are determining its performance, affecting incentives, actions and outcomes under a governance system has to be applied. Ostrom (2007) suggests that nested attributes of a *resource system* (RS), *resource units* (RU), users (U), *governance system* (GS), *interactions* (I) and *outcomes* (O) have to be considered into the analysis. Moreover, another kinds of variables such as *social, economic, and political settings* (S) and *related ecosystems* (ECO) have to be considered as well, as shown in *Figure 1:*

Figure 1 A multitier framework for analysing an SES
Social, economic, and political settings (S)

Resource system (RS)　　Governance system (GS)

Resource units (RU)　　Interactions (I)　　Users (U)

Outcomes (O)

Related ecosystems (ECO)
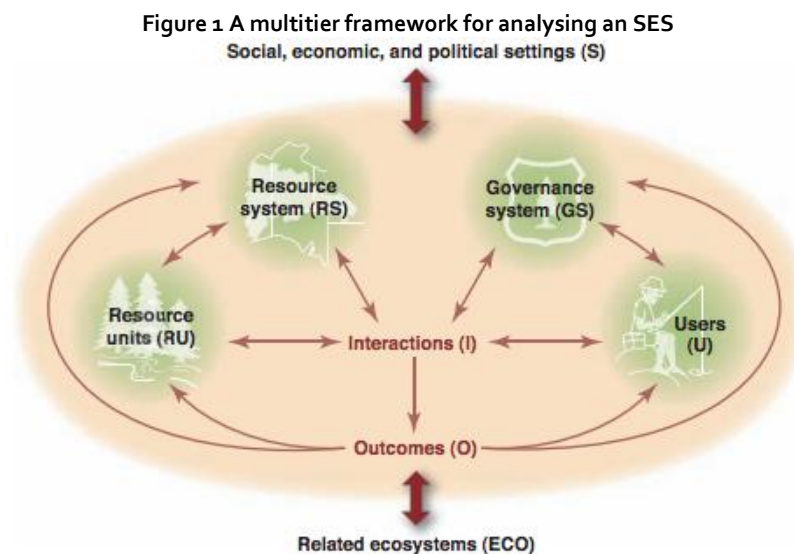
Source: Ostrom, E., 2009.

Figure 1 stresses a general framework capturing only general variables or highest tier variables, but these variables are unpacked in order to examine the SES such as a 'multicelular organism composed of organs, organs of tissues, tissues of cells' (Simon, H. 2000).

The general framework should be unpacked into the second tier variables, which are considered as an initial set of variables necessary to describe the SES, and then identify the causes of sustainable or unsustainable outcomes (Ostrom, 2007). Some authors, as Agrawal (2001) have identified as many as 30 variables as key factors to the organisation, adaptability and sustainability of a common property. In the study case that is presented in this document, a selection of the 53 second-tier variables described in Annex I was made. Once established the first and second tier variable sets, it was possible to perform a deeper analysis integrating third tier variables (132) as shown in table 1 in the annex I.

Attending Ostrom's framework, the characterization of Santiago Comaltepec's SES was prepared by UNAM and ERA members, who integrate the COMET-LA Project team in Mexico, in collaboration with community leaders and stakeholders as well as with external institutions working in the region, mainly the Zapotec-Chinantec Union (UZACHI for its acronym in Spanish). In a first approach, a description of the SES was built with information collected during field visits, workshops conducted within and outside the community, and using data from Comaltepec and ERA archives. Once the phase of the SES's characterization was completed, the results have to be devolved to the internal and external stakeholders to be revised. Internal stakeholders are those who live within the system, and indirect or external stakeholders are those who influence the system indirectly; they belong to external organizations. External stakeholders included members of such instances as the UZACHI, the Ministry of Environment (SEMARNAT), the Ministry of Social Development (SEDESOL, *Committee on National Protected Areas* (CONANP), the National Forestry Commission (CONAFOR), the National Commission for the Development of the Indigenous Peoples (CDI), the Oaxaca State Institute of Ecology (IEEO), the Oaxaca Association for Environmental Services (SAO), the Regional Centre for Social and Anthropological Research (CIESAS), the Sierra Juárez University (UNSIJ), the Committee of Comaltepec People in Oaxaca City and the Oaxaca Office of the National Polytechnic Institute Interdisciplinary Research Centre for Integral Regional Development. To obtain a description of the relevance of the stakeholders consulted and their relationships, a stakeholder mapping was done, as will be explained later. The most relevant characteristics of the SES, such as interactions, outcomes, settings and related ecosystems will be presented. Detailed information about the 132 third tier variables can be seen in the annex I to this document.

Based on Ostrom´s framework of eight *subsystems* described above, the following lines analyse sets and subsets of variables related to the performance of the SES in our case study. The sets and subsets of variables lead to a process of *diagnosis* of the system, in order to identify its key variables for facing environmental challenges.

2.1   SES Setting (S)

Social, economic and political settings play an important role in the SES. Comaltepec Community is in the Higher Chinantla or High Chinantec Area, which is part of the Mesoamerican bio-cultural region. In the American continent, landscapes have been shaped by long-standing management practices, which have been perpetuated through a mix of techniques, myths, taboos and other cultural practices conforming bio-cultural complexes covering wide areas. Comaltepec community is part of the Mesoamerican bio-cultural region, defined by Paul Kirhoff (2000) as the cultural area where the economy was based on corn agriculture. Societies were theocratically organized, used lithic technologies and lacked metalistery, among other traits. Their widespread use of what is known as slash-and-burn agriculture, shaped the structure and composition of the second most important tropical rainforest of the continent, besides the Amazon *(See Map 1).*

Map 1 The Mesoamerican bio-cultural region and sub-regions

Source: CC 2006 Wikimedia Commons. A formal description of Mesoamerica sub-regions, can be found at Whitmore, T. and Turner, B.: Cultivated landscapes of Middle America on the Eve of conquest. Oxford University Press, 2001, 2005.

In particular, Comaltepec community belongs to the Chinantec group, which is part of the Mesoamerican Gulf sub-region that hosts Oto-manguean cultural area core. Their territory is mostly located in the Higher Chinantec Area or Higher Chinantla. This ethnic group is characterized for its ability to produce under heavy rain weather. To do so, they adapt regular corn production techniques to their particular environment and have developed uses for many wild and semi-wild species that form an important part of their livelihoods. Therefore, traditional knowledge is vital for their living strategy *(See Map. 2 and 3)*.

Map 2 Otomanguean languages distribution*
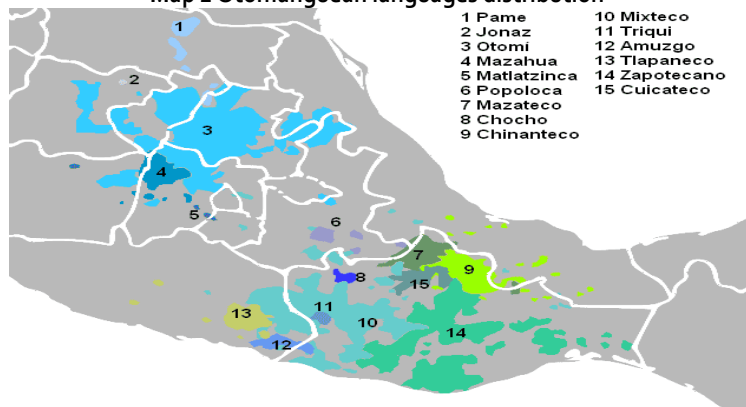
Source: Elaborated based on Instituto Nacional de Lenguas Indígenas: Catálogo de las lenguas indígenas nacionales.
http://www.inali.gob.mx/clin-inali/mapa.html#5

*Note: Chinantec is labeled as number 9.

Map 3 Higher and Lower Chinantla
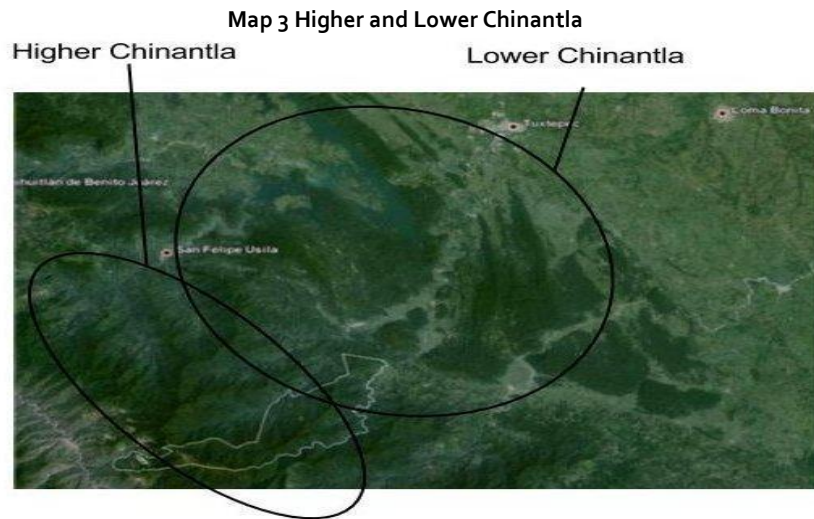
Due to the abrupt mountain topography, at the centre of its territory, Comaltepec´s boundaries include temperate forests on its highest altitudes (2200-3100 masl) Then, it has two gradients to lower and warmer places: (1) To the west climate changes to warm, semi-dry; (2) to the east climate gradient include semi-warm, humid climate where mesophyll vegetation grows and warm, humid climate in the lower, north-west where evergreen tropical rainforest grow *(see map 4)*. This makes natural resources sustainable management a complex task, but enables Comaltepec community access to a wide diversity of resources that contribute to increase their livelihood options *(See map 4)*.
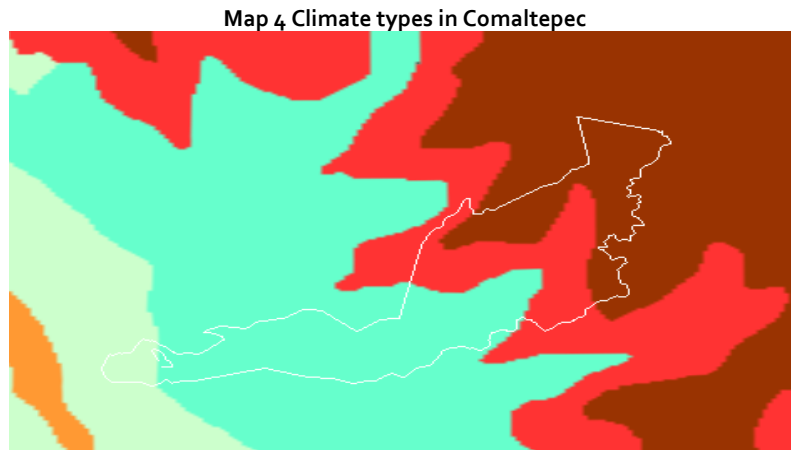
Map 4 Climate types in Comaltepec

Mexico´s prevailing legal framework is fundamental for the SES as it allows the community to have its own rules regarding social and ecological performance although a certain degree of autonomy is enjoyed. Local rules are embedded in state and federal laws. For example, communal property rights were ratified and

certified by *the Programme for the Certification of Ejido Rights and House Plots Ownership Titles (*PROCEDE for its acronym in Spanish) in 2008.

In Mexico, different national rules establish that inhabitants have the right to health and to a healthy environment, which encourages sustainable development and environmental protection. Likewise, environmental laws have been established by the Ministry of Environment and Natural Resources. Monitoring and control policies are robust because the community has the right to harvest the forest although the Ministry of the Environment has to grant permission to do it. Wood in Santiago Comaltepec is certified. However, such certification has no impact on wood price whatsoever. Wood is sold at considerably low market prices[2]. Moreover, commoners do not add value to wood products.

How trading activities influence Comaltepec´s SES is an important setting. Although Comaltepec produces a certain amount of its requirements[3], trade has become an increasing flow of goods, services, and job opportunities. Near the community are three main markets. Oaxaca's market, located 108 kilometres away from the community, is the place where people trade wood, coffee and pepper. Moreover, it is an important labour market where people from community search for jobs. It is also a place where educational opportunities are looked for. The second one is in Tuxtepec, located 123 kilometres away; wood, cattle and coffee are traded there. The third one is in Ixtlán, 45 kilometres away from the study area; there Comaltepec has usually traded wood. On the other hand, citizens from Comaltepec buy fast food, clothes, and machinery in Oaxaca and Ixtlán.

Another important variable in the settings is media organization. In the area a free television channel can be seen; there is also the option of a pre-paid service. Also, there are some radio stations, such as XEGLO Radio (local frequency in Spanish and indigenous languages) and private Internet access. These media very likely influence inhabitants' behaviour. Likewise, local radio is playing a role as a communicator of local news. So, the only media that is interested in the SES is the local radio, not the national media. In Comaltepec, these mass media means are a source of debate. On the one hand, some community voices agree with the need of being connected with the outside world. However, others hold the opinion that television and radio stations convey negative messages, which run against the customary practices, and values the community had held for decades. Being induced as an insatiable consumer is seen as a negative influence on children and the youth.

Regarding the degree of compliance of regional and national laws and insecurity, according to the Development Research Centre (CIDAC for its acronym in Spanish) index of security Oaxaca State has been affected by insecurity in the last years (CIDAC, 2012). At local level, the rise of insecurity in the Sierra Norte region is mainly related to the fact that delinquency has increased along Federal Road 175 (Papaloapan route).

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[2] Commoners are price takers. Wood markets have an oligopolistic structure.

[3] Maize, beans, vegetables and meat amongst other staples are produced for self-consumption.

2.2   Resource System (RS)

The Resource System is a key aspect in the functioning of Comaltepec's SES. As mentioned above, being Comaltepec an example of communal management of a SES, and being governed by a direct participatory system, the resource system available in the SES will be intimately related to the Governance System.

The Resource System can be divided into five categories. The first refers to the agricultural land where commoners spent most their endeavours to produce food for self-consumption. If the General Assembly agrees, these areas are allowed to crop them. The second type of land is the commercially harvestable temperate forest. They are harvested to produce wood. Both as wood logs and as processed timber, the community sells them to obtain income to be devoted to community ends. There is a third type of land, which is still waiting to be exploited. It is the commercially harvestable rain forest. Amongst other tropical species, stocks of cedar and mahogany are waiting for investments to be transformed into wood and/or added value goods. Other lands, which can be named as Wildlife/scenic areas, can be used for commercial purposes. They hold biological resources and natural value, which have begun to be commercially exploited. Infant communal firms have been established. However, a long list of requisites is still to be satisfied in order to be considered as a serious business able to generate revenue. Finally, micro watersheds are available which can affect hydrological performance.

Other *Resource System* variables include: system boundaries, size of resource system, human constructed facilities, productivity, equilibrium properties, predictability of system dynamics, storage characteristics and location. The ecological boundaries of the SES are: in the north, it is bounded by the San Pedro Yolox communal territory and the Guayabo River; in the west, it is limited by Soledad Tectitlán communal territory, the Guayabo River and the Carrizal Stream; in the southwest, San Pablo Macuiltianguis, which is located near the Araña Hill, bounds the SES; in the south, the biological boundaries are Ixtlán de Juárez territory and the Du River, Tarabundí, the Primavera Hill and the Soyolapam River; in the northeast, the SES is limited by Yetla municipality, the Soyolapam river and the Cacao Hill; in the east, the Santiago Progreso *ejido* and Soyolapam River bound the SES *(see map 5).*

Map 5 Resource System location
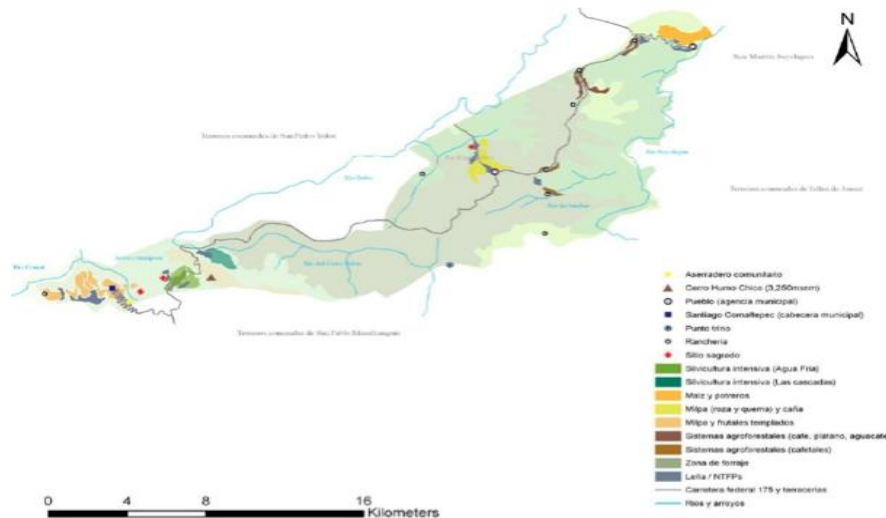
Socio-economic boundaries of the area of study are clearly defined. Physiographic and physical landmarks bound the territory. As mentioned, all the limits have been validated and registered by *the Programme for the Certification of Ejido Rights and House Plots Ownership Titles* (PROCEDE). In other words, the *property rights system* is clearly defined and recognized by the national government.

Within its boundaries, the SES territory is divided into several land use categories, including 1,726 ha allocated to forest production areas; 10,300 ha to forest protection; 127 ha to forest restoration; 6,108 ha to agricultural and agro-forestry uses; and, 108 ha to urban use. The total area of the SES covers 18,366 ha (according to the last Community Plan of Land Use elaborated in 2004), which include land, forest and water sources that were assigned to the community in 1953. By 2008, PROCEDE recognized a territory of 19,981 ha[4] as Santiago Comaltepec's territory considering an extra territory, which is in a legal conflict. So, under the communal regime, the community has total control and clear property rights to this territory.

There exists a conflict with the neighbouring community San Pedro Yólox regarding territorial limits; nevertheless, this conflict does not significantly affect Comaltepec territory and does not interfere with the system's performance.

It is important to highlight that *property rights system* and *extraction and exclusion rights* are clearly defined and that the community has the right to exclude external agents from harvesting the forest; likewise, internal commoners who want to use land for agriculture and other purposes have to ask for permission to do it. According to *extraction and exclusion rights*, commoners verify that any person harvesting the forest without permission given by the *Comisariado* is punished. Visitors have to pay a fixed fee to the ecotourism firm. The Commoners Assembly is the arena where the operational rules of the system are established and can be changed.

Human constructed facilities include a federal main motorway (Motorway 175), roads (which are used as the only access to the resource), water deposits, a pipeline network, public buildings (schools, Town Hall, basketball court, Council meeting room), electricity network, a clinic, and 307 houses.

Regarding the use of the resource system, the community has specific resource extraction periods. For instance, they usually cut down trees between July and February. Reforestation takes place from June to August (the rainfall period). Since the community approved the Land Use Plan and the Forest Management Programme in 1994, the forestry production has become very much under control. It could be stated that predictability is quite attainable. In contrast, agricultural production is not predictable because of weather variability. The environmental context might cause floods and droughts. These ecological factors and generational cultural changes impose a certain degree of uncertainty on the system's performance.

It is important to mention that commoners possess vast knowledge about wood and non-wood resources. They are conscious of the negative effects that would follow if they decided not to protect the forest. But they know that the system is vulnerable to some climate events as hurricanes, extreme rainfall, and drought. The latter has caused some fires over the past decades. At present, traces of such fires are still evident, and the community is investing 60% of its total annual expenditure in reforestation of the affected areas.

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[4] This size will not be considered because it includes an extra territory that is in a legal conflict.

2.3 Governance System (GS)

Since Santiago Comaltepec is a Chinantec (indigenous) community, its *governance system* is the one based in customary practices system, this system is a characteristic of most indigenous peoples in Mexico. The *Governance System* includes: *government organizations*, NGOs, network structure, property right systems, operational rules, collective choice rules, constitutional rules and *monitoring and sanctioning processes*.

Comaltepec´s Governance System is characterized by having a direct participatory system. Everybody can be directly involved in the decision-making process deciding about the community affairs. Two instances have been devised to exercise such democratic model: commoners 'and citizens' general assemblies.

The General Assembly of Commoners sets the rules for access and use of natural resources. All initiatives and projects related to the use of community´s natural capital have to be discussed and decided by those fully recognized as commoners. The same happens with decisions related to who is entitled to use them, under which conditions and what the punishments can be implemented if the rules are broken.

Regarding *Collective-choice rules*, all the collective agreements are taken by the general assembly, which is composed of commoners, and *caracterizados*. The assembly decides on the rules. Rules for monitoring processes are clearly established in the communal bylaw. Any commoner[5] is excluded of the SES benefits if they have not accomplished their duties. Some rules include that every commoner has to report any unauthorized use of resources. Local rules are of utmost relevance for the SES because they are consistent and have allowed for the maintenance of the system performance. Nevertheless, this kind of problems is never sanctioned on the federal level. According to sanctioning processes, there are differences in the administration of justice when the community sanctions a person who deliberately made an unauthorized use of the resource and a person who made it by mistake. Non-permitted use is punished with a fine, with imprisonment, or with both.

The Commoners General Assembly is the main arena in which the most important community affairs are decided. The General Assembly of Commoners elects an executive body in charge of implementing the decisions made in it. It is called the called the Communal property commissioner (CPC). Moreover, Overseeing Council is empowered by the general Assembly to check what the CPC really carries out and if it complies with the General Assembly´s decisions. This Overseeing Council depends on *non-paid activities* related with management of the territory such as assembly attendance, *tequios,* commissions, household labour, self-consumption agriculture, livestock, and monitoring activities. They are essential for the system's performance.

The second instance of decision is the Citizen´s General Assembly. It groups all community citizens, commoners and other people living in Comaltepec[6]. The Municipal Council authorities are in charge of implementing its decisions. This Council is responsible for implementing the citizens' assembly resolutions regarding public services, including public spaces, water, sanitation, health, education, roads, cemeteries and

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[5] The communal statute now establishes that men and women have the same rights, but it was not until 2010 that women were accepted as commoners.

[6] They are called *avecindados.* Most of the times, they are non Chinantec people living in Comaltepec.

market places. The *caracterizados' group* opinion is always important for every decision made in the assemblies.

With respect to the NGOs working in the area, Comaltepec receives support from different agencies. For example WWF, which is an international organization involved in conservation projects including fieldwork, research and environmental education. FSC is responsible for the promotion of sustainable forestry management. UZACHI, the regional communities' organization, plays an important role providing technical assistance to the community of Santiago Comaltepec regarding forest management and timber trade. The Civil Mexican Council for Sustainable Forestry (CCMSS) tries to improve the welfare of some communities located in this area by means of strengthening the governance systems and sustainable territorial management. Finally, there is *Estudios Rurales y Asesoría* (ERA), which is promoting the increase and improvement of opportunities for local people to achieve sustainable development within an egalitarian society in that region.

2.4 Resource units (RU)

The Resource Units category is closely related to the Resource System. Due to the fact that the Resource System is a common pool governed by the commons, the relationships between them are very close. Thus, the common pool of agricultural lands is distributed amongst individuals or families to produce food staples. Through a communal sawmill, commercial temperate forest units are used to produce timber for sale. In the SES, there are wildlife scenic areas and biological resources, which are trying to be used through the establishment of community businesses. Watersheds management is another resource unit, which plays a role. An area of 2,500 ha has been devoted to this purpose and the benefits are for the community.

Resource units also include: resource unit mobility, growth or replacement rate, interactions among resource units, *economic value*, the number of units, *distinctive markings*[7], and spatial and temporal distribution.

The forest is a static resource. In the last five years the community has harvested 2,500 cubic metres of round wood per year on average. The market value of the wood extracted is a bit more than 184.5 thousands of dollars, per year. The SES also has a high environmental value due to the biodiversity conservation practices Comaltepec community has undertaken ever since it took control of the territory from the FAPATUX paper bin. These practices include preserving species diversity, scenic beauty, carbon sink and, most importantly, conserving Mexico's cloud forest. Santiago Comaltepec, Oaxaca City and the Papaloapan basin are linked by a road that is used to transport timber and other wood products.

Commoners use a hammer with the legend UZC89 to stamp trees, which will be cut down. Products might be certified by FSC through a stamp and register. As mentioned before, the resource is extracted (harvested) from July to February of the next year, and the reforestation season occurs between June and August.

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[7] *Distinctive markings* are natural or artificial markings to distinguish categories in the forest resources.

2.5   Users (U)

A set of second tier variables is derived from the first tier variable U: number of users, socioeconomic attributes of users, *history of use*, location, leadership, norms and social capital, knowledge of SES, *importance of resources*, and technology used.

There is a first group of users. They are the commoners. As mentioned in the Governance System section, fully recognized commoners are entitled to use land for agriculture, to produce wood and timber and also use water. There are 279 agricultural and 83 forestry direct users.

For example, Users practice agriculture, livestock, forestry, ecotourism, trade and services. Agriculture and livestock satisfy food requirements within the community and only a small production amount is traded outside.

A second group of users are the settlers. These are people who live in Comaltepec but are not Chinantecs. Their rights to use the resources of the community are limited and have to be granted by the General Assembly. For instance they can use water, collect firewood. A third group of users are the outsiders who demand a variety of resources such as water and more intangible services like scenic beauty. There have also been a series of proposals from outside companies, which have offered the community to use its water resources to generate electricity. Outsiders also visit the community to enjoy areas with scenic value and others come to Comaltepec to take away biological resources.

All commoners and settlers depend on forest resources for their construction materials, firewood, medicinal plants and fodder. The main sources of income are individual and communal. The community produces most of its food, but the number of inhabitants that buy corn and beans from Valle Nacional City is increasing.

Other aspects of the living conditions of the inhabitants of the SES are, for instance, traditional healers who supply primary health care. The community has a clinic that gives secondary health care and refers difficult cases to Ixtlán's regional clinics or to specialty hospitals in Oaxaca City. The hospital that is closest to Comaltepec is in Ixtlán, 45 kilometres away.

It is compulsory to attend basic school. Junior high school only exists in Santiago Comaltepec. In La Esperanza there is a tele-high school[8]. Youngsters usually leave the community in order to access more and better education opportunities.

Even if development opportunities are limited, Santiago Comaltepec is not a highly marginalized community in terms of poverty. According to the Human Development Index, this community is classified as exhibiting medium marginality. Piped water is available to 85% of households. There are WC facilities and sewerage throughout the community, but there is no sewage treatment.

A brief chronology of the resources use is necessary to present some of the most important events in the history of the SES. Since 1953, by presidential resolution, lands ownership has been acknowledged in the area

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[8] This is a secondary school system created by the Mexico´s Ministry of Education to reach students living in faraway communities. It uses television to match students and teachers.

of the community of Comaltepec. In 1954, with the construction of the federal paved road, industrial processing of the wood started. There was no limit to extraction. A decree issued by the Federal Government, conceded a paper mill from the city of Tuxtepec in the Papaloapan Region (FAPATUX for its acronym in Spanish) the right to exploit the forest resources. FAPATUX systematically cut the adult trees, which disturbed the forest age pyramid. During the 1980-1982 period, Comaltepec participates in the Organisation in Defence of the Natural Resources of la Sierra Juárez (ODRENSIJ, A.C. for its acronym in Spanish); the community struggled to stop the renewal of FAPATUX forest concession and, after a long fight, they succeeded. Finally, in November 1st, 1982, the community founded its own forestry unit.

Due to this hard struggle, many commoners, who are now elder, still vote against any extraction of wood from the forest. Between 1992 and 1993, with the collaboration of the CSO ERA A.C., a forest management plan was developed for Comaltepec and the other three communities integrated in the Zapotec-Chinantec Union (UZACHI). In December 1993, Comaltepec was granted a forest management permit. In July 22, 1994, the community approved the Land Use Plan and the forest operations with the new management programme. The community agreed to extract only 2,500 m3 from the forest of Comaltepec and leave most of the forest in reserve. In 1997, the Smart Wood Program certified UZACHI's forest management system as *sustainable* under the Forest Stewardship Council international standards. In 2004, Comaltepec received the first payment for the provision of environmental services, mainly water catchment. This government programme offers and stimulus i.e, 58 dollars per ha/per year to maintain 2,524 ha under conservation. The conservation area is in the Agency of La Esperanza where a mesophyll forest exists.

In 2009, an evaluation (Bonnart, 2009) considered that the trend of Santiago Comaltepec was lower its extraction rate. This rate may increase if several development projects are launched, but this should go through a proper consultation. As recently as November 2012, an ecotourism firm started being operated by the community. Nowadays, a study of CO_2 absorption is presently carried out so the community can benefit from REDD+ funds. However, the feasibility of the project is not certain, because of it depends on different factors that will be considered when this programme will be applied.

2.6   Interactions

The characteristics that Interactions adopt in the case of Comaltepec's SES are very important. Being a communally owned and governed SES a series of interactions take place amongst different key aspects of it. Let us describe them.

A first round of interactions takes place between the Governance System and Users. As has been examined above, the Governance System decides who can be the Users of the resources; under which rules they can be used and in case of not being followed what the punishments would be implemented. As has been described, the kind of interactions between the Governance System and the variety of Users changes. Something similar occurs with the technological aspects the use of the resources may imply. A case in point is the project of producing electricity using water.

Interactions among all biophysical and social agents mentioned above are represented in the sixth first-tier set of variables. This set includes*: harvesting levels* of diverse users, *information sharing among users*, *deliberation processes*, *conflicts among users*, *investment activities*, *lobbying activities*, *self-organizing activities*, and *networking activities*. The harvesting level is low (2,500 m3), well below the natural growth, so logging does not

really pose a hazard to the SES. Logging has little impact on the SES, and due to replanting processes its effects are minimized.

A second set of Interactions occurs between the Governance System and the Resource System. This relationship is extremely important because one of the main values of Comaltepec´s SES is that through communal ownership and management sustainability is guaranteed. So, for example, how the different resources systems will be exploited, managed and protected are crucial issues. Related to that is the community's deliberation process. Deliberation is conducted through general assemblies, where the authority calls for the meeting, ensuring that each member of the community has been informed. There is a list of support and approval of the agenda of the day. Then, each point on the agenda is discussed and analysed. Every assembly member may speak. After each topic is considered, sufficiently discussed and analysed, the Assembly proceeds to make a decision by vote. The final decision is obtained by a simple majority rule. We should highlight that these decisions directly affect the SES.

Lobbying activities are carried out before the meetings and during them. Small groups expose their communities' needs to the Assembly. Moreover, external influences arise from state and national governments, which exert their influence by means of projects and financial support. Some general assembly activities are self-organizing; community celebrations, and creation of committees (for instance, the Drinking Water Committee. the Municipal Committee of the music band, or parents committees at each educational level. The assembly mechanism is also used to assign barn raisings or collective tasks.

A third set of Interactions is between the Resource System and the Users. The different types of Users relate to the different Resource Systems available. In this relationship what the cropping decisions taken and how maintenance is kept are a very important function of the umbrella principal guiding the SES i.e, sustainability.

Other kinds of interactions have to do with the role the General Assembly plays. As mentioned before, the general assembly is the main arena for internal conflict resolution of issues related to users and resources. The mechanism is to solve a conflict face to face that is why it happens to be effective. The meetings are usually a very long process, which imposes high costs to the participants.

Internal and external networks play a relevant role in the SES. In the first case, the assembly of commoners and citizens appoint committees. These committees are an important link between the authorities and the rest of the community. External networks allow Comaltepec's inhabitants to keep in touch with friends and relatives living outside the community through community radio (Radio Guelatao), phone, and e-mail; moreover, there are associations of Comaltepec citizens living in the United States and in Oaxaca City. Also there are some ties between international communities through NGOs. Comaltepec also maintains linkages with state and federal government agencies such as CONAFOR, CONABIO, SEMARNAT, and CDI. UZACHI, the regional communities' organization, collaborates to solve technical issues related to the forest and also fosters relationships with other groups like SAO.

2.7   Outcomes (O)

As a result of interactions inside the SES, the outcomes are overall indicators of general SES performance. The system is efficient from the social point of view. The community recognizes the rules as legitimate and fair and this acknowledgment ensures a high degree of compliance. The system is robust if we consider Ostrom (1990, 1999) design principles. It exhibits most of these principles. In addition, if Comaltepec´s system is compared

the system with others, it can be noticed that Comaltepec's environmental robustness, social and organizational structure shows strengths but also 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. Comaltepec has been able to preserve its forest. This has not been the case of other regions such the Mazatec Highlands or Rincon Bajo. Sustainable forest management has not been possible there. In the case of the Mazatec region, the agricultural strategy has been to produce annual crops.. At the Rincon Bajo, pig raising has been the option *(see map 6)*.

Map 6 Mazatec and Rincon Bajo regions
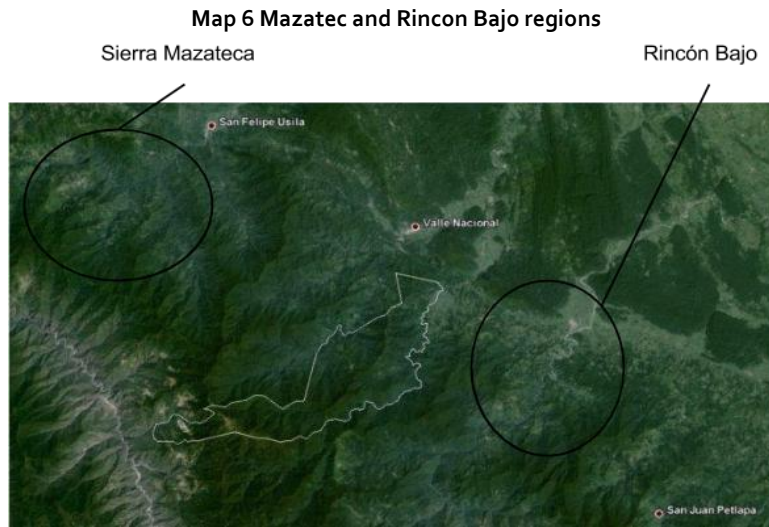
Source: Drawn over a Google/Earth image, consulted on Sep 8th. 2006

Other examples of unsustainability are Comaltepec's neighbouring communities of Santiago Progreso, Ozumacin and Ayozintepec. At the hands of livestock activieties, they have lost most of their forests. They are located in the northern section of Comaltepec's territory.

However, it could be stated that the institutional arrangements represent very strict constraints to individual entrepreneurship. It could even be argued that forces people out of the system. There is a constant flow of migrants, mainly to the United States of America and Oaxaca City. *Migration trends* seem to be related to cultural issues. Young people's migration might result either from the need to search for better job opportunities or from a escaping from community´s rules.

Measured by its socioeconomic performance, Comaltepec's SES enjoys a debatable sustainability. Such sustainability is based on the following aspects: egalitarian opportunities; fair assessment of charges; and the benefits of common resources. These benefits include the sale of wood, hydrological environmental services, land leasing for telecommunications antennas and project management, and are always agreed on by the General Assembly of commoners. Customary practices and traditions are inherited generation after generation, and the system seems to have a response capacity to meet the community's specific needs. Each villager has expectations regarding reciprocity from their fellow commoners. However, the villages of La Esperanza and Soyolapam perceive deficiencies in the fairness of the system. This feeling relates mainly to the distribution of the benefits obtained from the resources and the weak influence these villages have due to

their small number of representatives in the General Assembly. So far, these differences have not threatened the sustainability of the system. In sum, in the socioeconomic arena, Comaltepec´s SES is capable of satisfying a set of basic need to its owners. However, it has strong difficulties to enlarge them. The economic sustainability is not as strong as the environmental sustainability. Comaltepec´s commoners recognize that the living standards could be improved. However, they fear such aspiration could mean the ecological deterioration of their SES.

With respect to environmental sustainability, it is possible to say that the SES is environmentally sustainable. Projects that are thought of as potentially harmful to the ecosystem (such as a proposed medium-sized dam for hydroelectric generation or an agro-forestry project based on exotic invasive species) were rejected. The 2003 forest inventory shows that the forest area has been preserved. Records showed that timber stocks were growing with respect to 1993 inventories. A new forest inventory is planned for 2013-2014. These are robust indicators of sustainable forest management. On the other hand, the existence of a well-defined land use plan, which has been enforced by the community since 1993, is also a robust indicator of sustainability. Logging rates are well below natural forest regeneration rate and natural primary production. UZACHI technicians think that after 20 years of logging at such conservative rates, and after restoration of degraded forests has succeeded, it will be possible and safe to think of increasing logging rates by 20-30%. There is no significant pollution evidence.

2.8   Related Ecosystems (ECO)

Comaltepec's SES generates positive externalities, some of which benefit nearby SES. Watersheds protection, conservation of a large number of species of plants and animals as well as carbon capture and sink are some of these positive externalities. Paddocks opening and slash-and-burn practices generate CO_2. However, the magnitude of the negative externality is not significant, because 33% of the territory is used for agriculture and agro-forestry. Except for the agency of Soyolapam, the proportion used for grazing is not relevant.

RE also include second tier variables such as climate patterns, pollution patterns, and input and output flows of local SES. There is no evidence of significant climate variability in the Sierra Norte region regarding temperature, extreme events of rainfall variation and season changes on the local level. Such climate variability needs to be monitored and analysed on a proper, possibly higher, scale. In 2011, a strong rain season threatened Comaltepec lowlands with flooding and hills with landslides, but fortunately Comaltepec did not experience losses in property or human lives as other communities in the Sierra did, notably the Mixe Tlahuitoltepec Community, about 120 km NE from Comaltepec.

Evidence suggests that there are no relevant patterns of contamination in the SES caused by other ecosystems. In the communities that are located near Santiago Comaltepec, there are some local water pollution problems due to untreated sewage. Water catchment for the watersheds of the region has a positive effect on nearby communities (Yolox, Valle Nacional, Santiago ¨Progreso San Mateo Ayetla, and San Pablo Macuiltianguis). Comaltepec is "the" positive example in the area for its good forest management and strong organizational structure. It generates positive flows into communities thanks to the conservation of the biodiversity and because it serves as a refuge for species such as the jaguar (which probably migrated from the Papaloapan basin, whose systems have been heavily degraded by industrial rice, corn, tobacco and sugarcane agriculture). Livestock farming activities of the Papaloapan region affect Comaltepec´s ecosystem. Soyolapam inhabitants are dedicated to livestock in part influenced by nearby communities. Forest pests

come from communities and nearby regions (e.g. San Pablo Macuiltianguis) that have poor conservation practices. All the information provided above could be synthesized in figure 2, which illustrates the SES of Santiago Comaltepec.

Figure 2 The Chinantec Santiago Comaltepec Social-Ecological System

(S) Setting: The **High Chinantec area**, wich is part of the **Mesoamerican** bio-cultural region. A mountain ecosystem with steep slopes and biological communities ranging from ever-green rainforest at 100 masl high paramo at 3000 masl. 80% of the land is covered by forests

(GS) Governance System

A direct participatory system, where the General Commoners **Assembly** sets the rules for access and use of natural resources and an executive body, the community **Commissariat** executes Assembly-agreed plans and enforces rules and an **Overseeing Council** checks that the commissariat do what the Assembly commanded.

For civil issues, such as security, education, communications and health, a **municipal council** is directly appointed, with no parties involved, under the legal figure of costumary law (*usos y costumbres*)

(I) Interaction: rules setting and enforcement, Technologies dev.

(I) Interaction: Management practices, protection

(I) Interaction: cropping, maintenance

(U) Users:

Commoners with rights to use land, forest and water
Settlers (avecindados) with limited rights to use common resources
Ousiders demanding water resources, runoff mitigation, scenic beauty and biological resources

(RU) Resource Units: agriculture lands

(RU) Resource Units: commercial temperate timber production

(RU) Resource Units: wildlife/scenic places, biological resources

(RU) Resource Units: watershed management

(RS) Resource system common pool:

Agriculture land where commoners devote most of their labor and address most of their food needs.
Commercially harvestable temperate forest from where Comaltepec community gets its main cash income
Commercially harvestable warm rainforest to be developed in the future
Wildlife/scenic areas where outsiders recreate and biological resources are hosted
Micro watersheds that can affect hidrologic performance.

(O) Outcomes: Livelihoods, primary production

(ECO) Ecological Impacts: Biodiversity conservation, watershed management

Source: Own elaboration based on collected information by ERA and UNAM.

The SES of Comaltepec is an important example of autonomy. Once the Mexican Constitution recognised the right of indigenous communities to preserve their governance system and allowed it to occur under the protection of national law, the community reinforced its autonomy. The process of making decisions and changing rules occurs only under assembly agreements. According to Ostrom's framework, as SES involves a large CPR, rules are designed and enforced through different tiers of nested instances, including formal governing bodies, commissions and enterprises. Most community members abide by them and monitor that external people to the SES and community members do the same. In this sense, there exists an arena

(assembly), where face-to-face communication can be used for solving conflicts (Ostrom, 1999). Moreover, there are nested instances that allow for multi-scale conflict solution.

3 Prospective Structural Analysis. Problems and drivers related to environmental challenges

Once SES's characterization has been carried out and taking into account that the main objective of Deliverable 3.2 is to identify key variables (or drivers) in the SES's performance, Prospective Structural Analysis methodology has been chosen. PSA technique tries to observe interrelations between variables in a complex system, so once influences have been identified, it provides a classification that should be helpful to understand SES's functioning.

Godet (1985; 1994; 1998) applied this methodology in different research exercises. It is based on the construction of future scenarios using historic and present tendencies of the system. One of the most important advantages of applying PSA is that uncertainty about the future can be reduced through promoting viable scenarios. The method does not deal with cause-effect relations as other techniques do. It deals with influences- relationships using a double entrance matrix, as it will be presented in the following part. Then, once that matrix is fulfilled through valid participatory methods, Markov chains properties will be applied in order to obtain hierarchies and variables classification according to influence and dependence levels. The analysis is carried out using MICMAC software, which is able to include properties and routines mentioned above (Godet and Bourse, 1989; Godet, 1994).

As PSA method for analysing complex systems based on Ostrom's framework SES characterisation suggests, the most important variables have to be identified by representative stakeholders. So, in order to corroborate that WSs' participants really know the SES performance and their views are trustable, this part of the document begins describing stakeholders mapping process, proposed by Business for Social Responsibility (BSR). After this mapping, workshops developed[9], in which participants chose the most significant variables for the SES functioning.

3.1 Stakeholders mapping

Based on the SES characterisation under Ostrom's framework, three workshops were organised in which internal and external stakeholders participated. During the WS, the stakeholder mapping methodology suggested by UCO and other members of COMET-LA was used. These actors were invited as stakeholders to select variables that they consider the most relevant in the SES performance.

In order to validate workshops' results, all participants have to be representatives providing substantial information about the SES functioning. Stakeholders mapping technique is required to identify them. BSR suggests a mechanism that should be used for this purpose.

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[9] How workshops worked will be described below.

BSR proposes a stakeholder mapping in order to identify and classify the relevance of each workshop participant. This technique (mapping phase) consists of four secondary phases and allows detecting individuals who can provide meaningful information about the SES.

Identifying is step one of Stakeholder mapping phase and, consists of making a participants list and then trying to identify each of them and represent their ties, for instance, using a mind map. It is important to mention that this list is dynamic and may change throughout time. In this case, Stakeholders were divided into internal and external. Some aspects that had to be considered are:

- ¬ The community (interest groups such as commoners, teachers, migrants, and the parish priest)
- ¬ Sawmill and ecotourism staff
- ¬ Ecologically concerned groups (NGO's, ecologists, naturalists, researchers and university staff)
- ¬ Government organisations (National Commission for Forests (CONAFOR), National Commission for Water (CONAGUA), National Institute of Ecology (INE), Ministry of the Environment (SEMARNAT)
- ¬ The civil society (e. g. University of the Sierra Norte Region SAO, UZACHI)

The phase 2 is *Analysing*. It is important to understand stakeholders' interests and their perspectives they offer in order to identify their usefulness for the SES. The BSR methodology suggests that the following criteria have to be taken into account:

- ¬ Contribution: how much information and knowledge participants have about their community, and if their opinion is general or particular about a specific issue.
- ¬ Legitimacy: legitimacy of the stakeholder´s claim for engagement.
- ¬ Willingness to participate: How willing the stakeholder is to participate and provide information
- ¬ Influence: how much influence the stakeholder has over SES policies
- ¬ Necessity of involvement: the potential for a participant to deviate or delegitimise a project when he/she is (or feels) excluded

Phase 3 is the also named *Mapping*. It consists in evaluating the influence stakeholders exert on each other (unidirectional or bidirectional and the magnitude of each one's influence). In order to describe this, two axes quadrant is used, where the vertical axis represents expertise level and the horizontal one the willingness to participate.

Prioritizing is the last phase of Stakeholders mapping and it consists of an analysis of the stakeholders in the sense of looking into their issues and defining if their participation matches the engagement objectives.

This categorisation supports later results; stakeholder mapping allows identifying key people for participating in the workshops, so they will provide the best information about the SES. As mentioned before, three stakeholder's WS: external, internal (women and men) and women were organized. It was confirmed that the

stakeholders' distribution initially identified was correct; therefore, the information gathered could be considered valid for later use in the PSA.

External stakeholders included, among others, agents from public institutions, NGO's, the Comisión para el Desarrollo de Pueblos Indígenas, the Sierra Juárez University, and the Chinantec and Zapotec Organisation (UZACHI), as well as others externally involved in the SES *(see table 1 and figure 3).*

Table 1 External Stakeholders workshops participants

Institution
1. Sierra de Juarez University lecturer
2. Lecturer of the Interdisciplinary Research Centre for Integral and Regional Development, Oaxaca office (CIIDIR for its acronym in Spanish) and the National Pedagogical University
3. Rain Forest Alliance manager
4. Researcher from the Research and Higher Studies Centre on Social Anthropology (CIESAS for its acronym in Spanish), Oaxaca
5. National Forestry Commission (CONAFOR for its acronym in Spanish)
6. Ministry of Environment and Natural Resources (SEMARNAT for its acronym in Spanish) Oaxaca
7 .National Commission for Natural Protected Areas (CONANP for its acronym in Spanish)
8. Ministry of Social Development (SEDESOL for its acronym in Spanish)
9. State Ecological Institute
10. National Commission for the Indigenous Peoples' Development, Coordination Centre, Guelatao, Oaxaca
11. UZACHI's Administration Council's President
12. UZACHI's Forestry Technical Director
13. UZACHI's Protected Areas Manager
14. UZACHI's Training and Organisation Manager
15. President of Oaxaca's Environmental Services Administration Council (SAO for its acronym in Spanish)

Source: Own elaboration based on WS, UNAM-ERA A.C.

Figure 3 External Stakeholders workshops

Source: Own photographs.

In spite of their personal activities, internal stakeholders such as community authorities and commoners participated in the WS *(See table 2 and figure 4).*

Table 2 Local Stakeholders workshops' participants

Institution
1. President of the *Comisariado*
2 Treasurer of the *Comisariado*
3. Secretary of the *Comisariado*
4. Mayor
5. Municipal authorities
6. A long standing council member
7. A Comaltepec's farmer
8. Livestock breeders representative
9. Communal Enterprises General Coordinator
10 and 11. Two Comalcatepec's female citizens

Source: Own elaboration based on WS, UNAM-ERA A.C.

Figure 4 Local Stakeholder workshops

As a result of stakeholders mapping external stakeholder, most of them were identified as valid representatives. In the case of internal stakeholders, most of participants were classified into the *desirable area* (high levels of expertise and willingness), and had strong ties with other stakeholders, forming a solid group. So, all of them have to be kept as informants. Female stakeholders mapping suggests that participants have high levels of expertise and willingness to participate in the SES characterisation and in the identification of the key variables of the SES. Graph 1 shows that the stakeholders involved in workshops supplied vast information and that they were willing to participate in this process. Likewise, most stakeholders seem to be linked through bidirectional relationships *(see graph 1)*.

Graph 1 Stakeholder's maps

Workshop: Prospective Structural Analysis-Internal Stakeholders (Men and women)

Workshop: Prospective Structural Analysis-Internal Stakeholders (women)
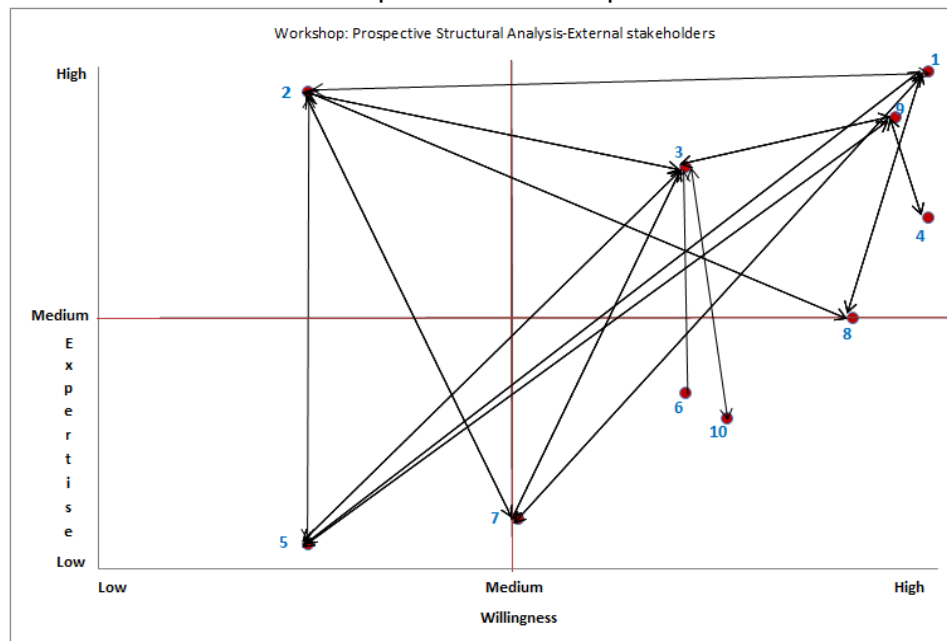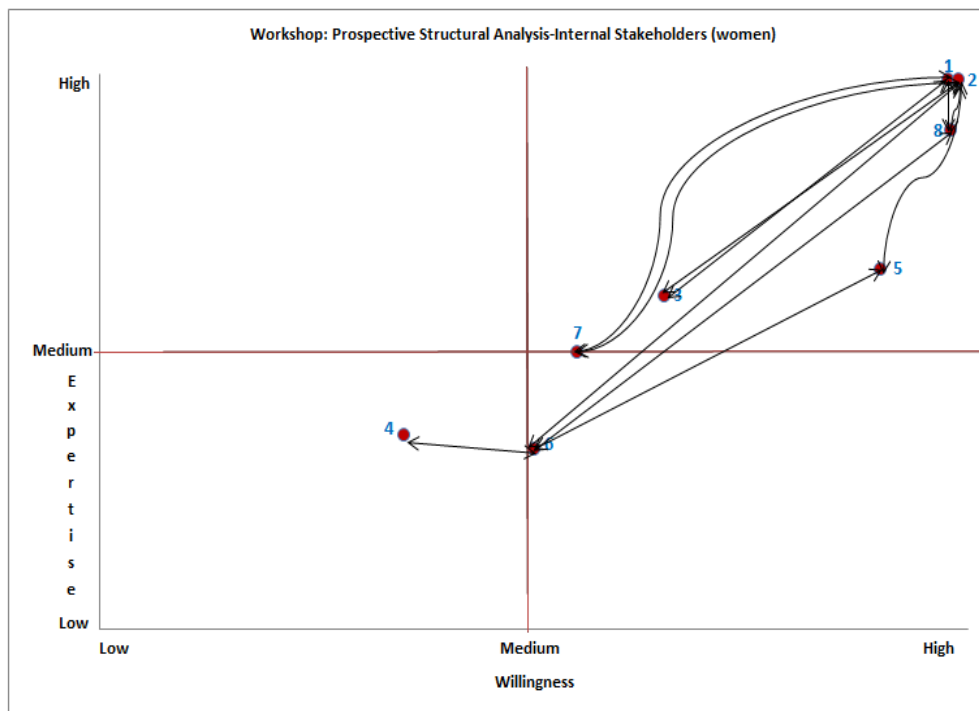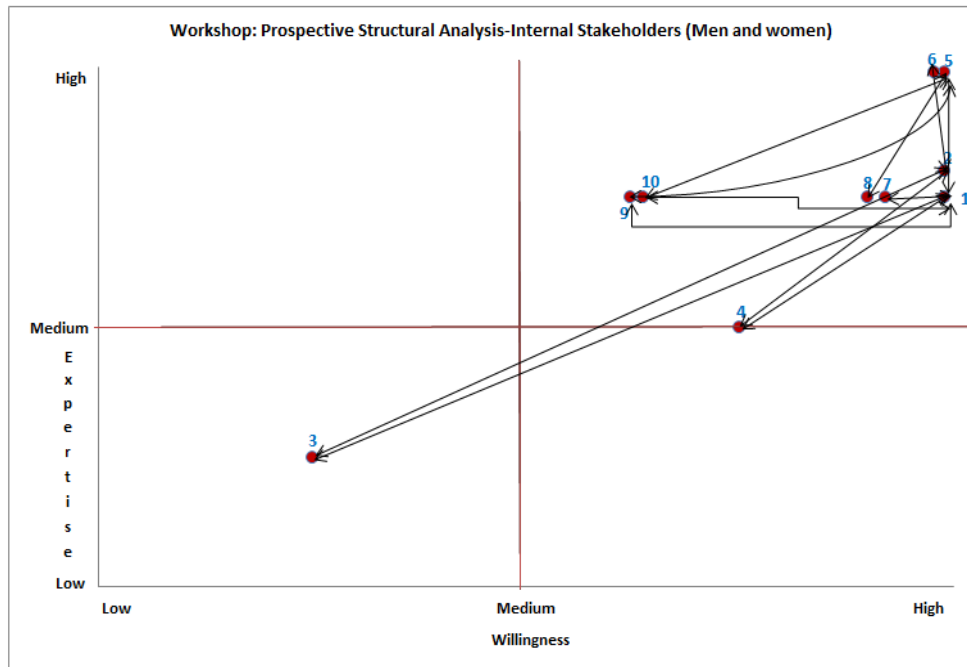
Source: Own elaboration based on BSR methodology and Stakeholders' workshops.

Mapping actors suggests the validity of our PSA, in the sense that WS's participants were representative and they know the SES's performance. However, it should be considered as a necessary condition but not sufficient for results validation. Most of the participants are in the desirable area (high levels of willingness and expertise); only a few are not there. As a lesson learnt from this process, internal stakeholders have proposed the creation of a semi-permanent PSA commission to attend these workshops in the future, which may

contribute prospective insights for the Assembly to consider. Only stakeholders with a high level of expertise and willingness would be included, with the few exceptions that have been mentioned above. The General Assembly should appoint them. Their main task would be to train themselves in the use of these research techniques e.g., SES and PSA, and examine future possibilities for community development. This is an important contribution of COMET-LA project. As s a result of it, internal stakeholders have suggested to be part of such committee indicating that one of the main aims of the project has been achieved: the learning arena could lead to community's capacity building and it should impact in a positive way at local level in the future.

3.2   Workshops' development

The first phase of PSA methodology includes a process in which key variables have to be identified by people who are interacting with the system. In order to carry out it, participatory methods were organized and developed such as workshops and personal meetings in which the most informed participants were invited based on stakeholders mapping.

Once the description and characterisation of the SES was finished using all the information related to the set of variables of each of the categories and sub-categories (first and second tier variables, respectively) required for the SES analysis and PSA (this description is explained in the second part of this document and in annex I), the exercise started. All the WS participants received this information (132 variable descriptions). Once they understood all variables' definitions, they were asked to expose the variables that they consider the most essential ones to the present and future SES performance. During the selection process the definitions of each variable had to be explained again in order to be sure that everyone understood the correct concept of them. Some of the controversial variables were *livelihoods*, p*olitical stability* and *Resource importance*. At the end of that discussion, internal, external and women stakeholders had to choose the key variables of the SES.

Once the internal stakeholders selected the key variables of the SES, an influence and dependence matrix was generated integrating 14 variables. Later, the participants of external Stakeholders added a new variable, which they considered relevant, *monitoring and sanctioning process*, which was then included as it is explained below *(see table 3)*.

Table 3 SES key variable matrix obtained during local and external stakeholder workshops

Variable	
1. Economic activities	8. Exclusion and extraction rights
2. Monitoring and sanctioning process	9. Government organisations
3. Livelihoods	10. Property right system
4. Activities without payment	11. Collective choice rules
5. Migration trends	12. Economic value
6. Political stability	13. Resource importance
7. Type of environmental laws	14. Sanitary conditions
	15. Use history

Source: Own elaboration based on UNAM-ERA A.C's WS

*Note: External Stakeholders added an extra variable: monitoring and sanctioning process.

The first step of the second round of WS was an explanation about the general purpose of the project COMET-LA and the key issues and objectives of its deliverables. An ample explanation was given about what was about to do be done; i.e., the PSA exercise. Later, COMET-LA team and WS participants reviewed each variable listed in order to identify any missing information or any other relevant variable.

As PSA analysis indicates, stakeholders have to fulfil a double entrance matrix of influences between key variables. Then, when the participants were assigning values to the matrix of interrelations an interesting debate emerged. They suggested that *monitoring and sanctioning process* had to be included as an important variable for the PSA because it is a fundamental variable in what refers to future environmental challenges. In contrast, they considered that the most controversial variables are the impact of *non-paid activities* on *economic activities* and *livelihoods*. They also pointed out that the interrelations between *migration trends* and *non-paid activities*, *livelihoods* and *government organisations* are relevant.

This debate concluded that external stakeholders are aware of the relevance of the activities without payment and of the impossibility for most community members to circumvent them. To a great extent, these activities are responsible for the system robustness. Commoners know that the complying with those duties has an impact on their *livelihoods* of the one who is performing a *cargo* and on the economy of the community as a whole. Generally speaking, the household economy is impaired while the economy of the community improves.

In the case of *migration trends*, both their positive and negative effects were discussed. Most of them concluded that the *migration trends* are harmful to the community. There was a long and heated discussion about some variables, such as *non-paid activities* and the *government organisations*, and their impact on migration. Of course, they admitted *non-paid activities* and *government organisations* are not the only factors playing a role in this phenomenon. They acknowledge family traditions, youth educational patterns and even fashions as relevant contributors to migration.

As in the case of external stakeholders, internal stakeholders had the opportunity to revise the SES characterization and to make suggestions both about the SES´s variables and about their definitions. They were also given an explanation by the research team members concerning to our tasks and goals. As for the PSA exercise, the objectives of it and all the variables that have to be considered were presented to the workshops participants. In this specific case, an important difficulty came out when some complicated terms appeared. However, once the WS facilitators provided some simple examples applied to the community, the stakeholders got the idea of this method and they could provide all the necessary information to fill in the matrix that would be used as input for PSA. It is important to highlight that all participants understood each variable clearly.

As was the case in the external stakeholder WS, *migration trends* turned out to be a controversial variable because of the complex interactions it has with several other variables. Although migration has not left the community completely depopulated, it represents an important threat. Internal stakeholders also highlighted the importance of the government structure and its influence on the SES. In the second round of WS, participants assigned values to the matrix taking into account the intensity of each relation among variables. Moreover, they considered present and potential relations.

3.3 Variables identified and their short description

In the workshops conducted for the PSA process, internal and external stakeholders groups through an analysis of SES data identified fifteen principal variables. Remember that internal ones selected 14 variables and the external stakeholders corroborated them, but the last ones added an extra variable, so both groups chose 15. In order to identify relations between them, these variables will be used as input for the next phase of PSA.

These variables influence and define the system's performance; therefore, they can be used to understand and analyse the system dynamics. A short description of this set of variables is shown below (the detailed explanation and the specific case study description can be seen in Annex II).

S1a Economic activities

Economic activities (S1a) represent a third-tier variable according to Ostrom's framework, derived from the second-tier variable Economic development (S1). These *Economic activities* are those that represent a source of income for the community members.

S1d Livelihoods

The variable *Livelihoods*, according to the framework for analysing SES is originally labelled as *Subsistence Activities*. The name was changed to *Livelihoods* due to the fact that the research team considered this concept more consistent with the case study. *Livelihoods* are the day-to-day activities performed by all inhabitants for the subsistence of the families and the community regardless of whether or not they generate monetary income.

S1e Non-paid activities

Non-paid activities are those held by the commoners without payment and on mandatory basis. These activities strengthen the community ties. Some of the most important activities in this category are: service to the community (*cargos* and commissions), unpaid labour for the community (*tequios*), domestic labour, and monitoring activities.

S2f Migration trends

Migration trends refer to changes in the migration patterns and to the nature of such changes over the years, as well as to the reasons for the changes. This variable also includes identifying who migrates, why and where to. In the case study, migration started in the eighties and nineties and there has been a stable trend since then, showing some declining tendency in the last few years.

S3 Political stability

Political stability is related to the political conditions on the regional, national and local levels, (if) whether stability or conflict (either current or potential) prevails. It also refers to the degree of compliance with the rules due to the knowledge that community members have of them and to the community's enforcing power. The trust and predictability of behaviour and reciprocity among commoners is important for *migration trends* and *political stability*. The same can be said about the trust in the authorities' performance.

S4b Types of environmental laws

This variable includes environmental laws affecting the interrelations among the resource units on the regional, national and local levels; for instance, if the community performs or stops performing certain activities related to the natural resource management due to regional environmental laws.

GS8 Monitoring and sanctioning processes

These processes allow the strengthening of operational rules within the system. The commoners monitor the correct use of the system resources and verify compliance with the established rules. When compliance with the rules is not effective or the resources are used inappropriately, the authority imposes sanctions (monetary, community labour, imprisonment).

GS1 Government Organisations

Government organisations (GS1) are a second-tier variable that refers to the multilevel organisations affecting the system, its performance and its structure; for instance, the Commoners' Assembly, the Citizens Assembly, the municipal authorities, the Communal Property Commissioner, and the Surveillance Council.

GS4a Property Rights System

The *Property Rights System* (GS4a) describes the existence or absence of formal property rights regarding the resource system and the common pool resources.

GS6 Collective-choice rules

The *Collective-choice rules consist on* rules for collective action and community-based management of resources.

RS6b Exclusion and extraction rights

This variable refers to the rights to define who has access to the resources and to its management. The assembly of commoners defines who can use the resources and how and intervenes in the decision making process related to *exclusion and extraction rights*. It makes a lot of difference when these rules are clear or not.

RU4 Economic value

Economic value (RU4) refers to the prices of the natural resources, for instance, timber and forest prices.

U8 Importance of resources

This variable is related to how important the resources are for the lives and economy of the commoners and how much they depend on such resources.

U3 History of use

It is the history of the community, regarding land use and natural resource management. It also comprises how the interactions among the resource units have changed over the years.

U₂i Sanitary conditions

A sanitary condition (U₂i) is related to the infrastructure and services that improve health conditions in the community.

3.4 Matrix of direct influences

In order to achieve the Deliverable 3.2 objective, which consists of identifying key variables (drivers) of the SES and following the steps indicated by PSA, a double entrance matrix had to be fulfilled using stakeholders' views. So, once WS participants identified the key variables of their SES, a new WS was conducted including internal and external stakeholders. Separately, a women workshop was organised.

These WS´s had the objective of linking the *n* variables selected by the WS participants during the first round (in this case study n=15), but now relating them to one another in a matrix of order *n x n* called *matrix of direct influences,* where each column represents the influence of a specific variable over each one of the other 14 variables. Stakeholders assign values depending on their assessment of such influence, according to the following code:

0: given current conditions, there is **no** influence of this variable over other variables;

1: given current conditions, there is a **weak i**nfluence over other variables;

2: given current conditions, there is a **medium** influence over other variables;

3: given current conditions, there is a **strong** influence over other variables; and

P: It means that this variable can have **potential** influence over other variables in the future, if some circumstances change.

The sum of any column represents the influence that a variable has over the whole system. Likewise, the sum of values in a given row can be interpreted as how dependent the variable in that row is on all the other variables in the matrix. The principal diagonal was filled with null elements because of the influence of a variable over itself must be zero. As additional information provided by PSA, the Total Direct Influence (TDI) and Total Direct Dependence (TDD) of a variable can be obtained.

In order to simplify the analysis, the Total direct influence of a variable *j* (TDI*j*) over other n-1 variables might be defined as follows:

$$\text{TDI}\,i = \sum_{j=1}^{n} a_{ij} \; ; \; \forall\, i : \; i = 1 \dots n$$

Where, a_{ij} represents each entrance of the matrix, and i is the row number and j the column number. The Total direct dependence or total direct influence received from a variable i (TDDi) is defined as follows:

$$\text{TDD } i = \sum_{i=1}^{n} a_{ij} \, ; \; \forall j : \; j = 1 \dots n$$

So, the next section will present three direct influences matrixes, TDI and TDD levels according to each group of stakeholders.

3.4.1   Matrix of direct influence according to external stakeholders' views

A prospective structural analysis WS with external stakeholders was conducted on May 24th, 2013. After being carefully explained the notions of the method, the matrix, the variables and their influence, the participants clearly understood each variable concept and were able to fill in the matrix of direct influences knowing the meaning of each element.

Table 4 shows direct influences between 15 variables or 'possible system drivers', where each entry of the matrix {*aij*} represents the influence of variable *i* over the variable *j*. With a 15 x 15 matrix the number of matrix elements; i.e. relations between variables, is 225.

For instance, in the case of *government organisations* variable, named GS1 and positioned in the ninth row and column, the data can be interpreted as follows:

1. The *government organisations* (GS1) variable has a strong influence over the main *Economic activities* (S1a), (a_{91}=3). This is so because governance structure, which includes community and citizen assemblies, municipal and communal councils, commissions and enterprises, influences the community's main *Economic activities* (forestry and agriculture).
2. In contrast, *Economic activities*, is a variable with null influence over *government organisations* (a_{19}=0). This can illustrate the fact that these two variables do not influence one another reciprocally.
3. *Government organisations* has a medium influence (a_{95}=2) over *Migration trends* (S2f). Stakeholders assert that *cargos* assigned in the General Assembly are compulsory; but at the same time they know such duties can be avoided if the individual with a *cargo* migrates in order to avoid that responsibility;
4. *P* represents a potential variable. For example, *Migration trends*, does not affect the SES functioning, given current situation. However, if *Migration trends* augments it may have an impact over the *Government Organisations* in the future.

Table 3 Matrix of direct influence based on external stakeholders' views

	1 : S1a	2 : GS8	3 : S1d	4 : S1e	5 : S2f	6 : S3	7 : S4b	8 : RS6b	9 : GS1	10 : GS4a	11 : GS6	12 : RU4	13 : U8	14 : U2i	15 : U3
1 : S1a	0	1	3	0	1	1	0	0	0	0	0	3	2	1	0
2 : GS8	3	0	2	0	0	0	3	0	3	3	P	3	0	0	0
3 : S1d	3	2	0	2	3	3	0	1	0	0	1	2	3	0	0
4 : S1e	3	3	2	0	3	2	0	3	3	0	0	3	2	2	0
5 : S2f	1	0	2	2	0	2	0	0	P	0	0	0	2	1	0
6 : S3	3	2	P	3	0	0	1	2	3	P	P	3	0	0	0
7 : S4b	3	2	2	0	0	P	0	2	2	P	P	3	3	2	0
8 : RS6b	3	3	2	0	0	P	0	0	0	0	0	3	1	1	0
9 : GS1	3	3	1	3	2	3	1	3	0	2	3	2	1	2	0
10 : GS4a	3	2	3	3	1	P	2	3	1	0	3	1	P	0	0
11 : GS6	3	3	3	1	0	3	1	3	0	P	0	1	3	1	0
12 : RU4	3	0	2	0	2	2	0	0	0	0	P	0	0	P	0
13 : U8	3	P	3	0	1	2	P	3	0	0	P	2	0	0	0
14 : U2i	P	0	2	0	0	0	1	0	0	0	0	0	P	0	0
15 : U3	3	3	2	3	1	3	1	3	3	3	3	0	0	0	0

Source: Own elaboration based on external Stakeholders perception WS and MICMAC software outcomes

As has been defined at the beginning of this section, TDI of a variable is the sum of all values in a row labelled with that variable. On the other hand, the TDD, with respect to other variables, is the sum of all values located in the respective column. Once the TDI and TDD have been calculated, these values should be used to rank the importance of each variable over the SES's performance. This will be done in the following section *(see the results in table 5)*.

If the rows are considered as the TDI, the most significant variable, which has the largest impact over the other 14, is g*overnment organisations*. It has a TDI of 29. It is followed by *history of use, non-paid activities, property rights system, and collective-choice rules* with associated TDIs 28, 26, 22 and 22, respectively. In contrast, the lowest value was placed to the *sanitary conditions*.

On the other hand, if analysing columns instead of rows, it is possible to obtain the total direct dependency (TDD). In this sense, the most influenced variable by the other 14 variables is *economic activities* with a TDD of 37, followed by *livelihoods (29), economic value (26), monitoring and sanctioning processes (24),* and *extraction and exclusion rights (23).* The lowest value was attributed to *history of use* with 0 TDD. According to external stakeholders' views these variables represent factors that have significant influence upon and dependence on the SES.

Table 4 Direct influences based on external stakeholder's views

N°	VARIABLE	SHORT LABEL	TOTAL DIRECT INFLUENCE	TOTAL DIRECT DEPENDENCE
1	Economic activities (forestry and agriculture)	S1a	12	37
2	Monitoring and sanctioning processes	GS8	17	24
3	Livelihoods	S1d	20	29
4	Non-paid activities	S1e	26	17
5	Migration trends	S2f	10	14
6	Political stability	S3	17	21
7	Type of environmental laws	S4b	19	10
8	Extraction and exclusion rights of natural resource	RS6b	13	23
9	Government organisations	GS1	29	15
10	Property rights system	GS4a	22	8
11	Collective-choice rules	GS6	22	10
12	Economic value	RU4	9	26
13	Importance of resources	U8	14	17
14	Sanitary conditions	U2l	3	10
15	History of use	U3	28	0
	Totals		261	261

Source: Own elaboration based on external Stakeholders perception WS and MICMAC software outcomes.

3.4.2   Matrix of direct influence according to internal stakeholders' views

The internal stakeholders' WS was conducted in the same manner as the external Stakeholder WS. So, all participants understood the methodology and filled in the Matrix of Direct Influences using 15 variables selected in the first round of WS. In this particular case is important to emphasize the fact that the process in which each stakeholder understood all variables definitions was more complicated than for external stakeholders. But after some exercises they did it. As a result, the matrix of direct influences was filled in as is shown below *(see table 6).*

As can be seen from the matrix *(see table 6)*, *government organisations* (GS1) variable interacts with other variables to a different extent. The internal stakeholders' view of the influence of this variable can be read as follows:

1. *Government organizations* (GS1) has a *strong* influence on main *economic activities* (S1a), as in the external stakeholder's WS, so, $a_{91}=3$.
2. Conversely, the main *economic activities* (S1a), are perceived as having a potential effect on *government organisations*. This is because if there existed a significant change in *economic activities*, the government structure might be affected as well. So, $a_{19}=P$. In contrast, external stakeholders consider this relation is null.
3. GS1 is also seen as having a strong influence over *migration trends* (S2f) because this governance system requires people to participate in the *cargos system*; however, some young people prefer to leave the community rather than comply with that duty, so, ($a_{95}=3$).
4. S2f has no influence on *government organisations*, so, ($a_{59}=0$). This view differs from external stakeholders', who assigned a potential value to this relation. It seems that for internal stakeholders *government organisations* have priority over *migration trends* due to the fact that the *Governance system* is an essential component of the way of life for most indigenous people in Mexico.

Table 5 Matrix of direct influence based on internal Stakeholders' views

	1 : S1a	2 : GS8	3 : S1d	4 : S1e	5 : S2f	6 : S3	7 : S4b	8 : RS6b	9 : GS1	10 : GS4a	11 : GS6	12 : RU4	13 : U8	14 : U2i	15 : U3
1 : S1a	0	0	3	1	2	3	P	0	P	0	3	0	0	3	P
2 : GS8	2	0	3	1	0	3	P	2	P	0	0	3	2	3	3
3 : S1d	3	1	0	0	3	2	0	0	P	0	0	3	2	3	P
4 : S1e	2	0	2	0	1	2	0	3	1	0	0	2	1	1	3
5 : S2f	3	0	2	0	0	1	0	0	0	0	1	0	3	1	0
6 : S3	2	2	1	2	1	0	0	P	P	1	3	2	2	1	2
7 : S4b	3	P	3	0	0	P	0	3	P	P	2	2	3	3	P
8 : RS6b	3	2	2	3	1	3	0	0	0	1	1	2	2	0	3
9 : GS1	3	3	2	3	3	3	2	3	0	2	3	2	2	3	3
10 : GS4a	3	3	2	2	0	3	2	3	3	0	2	2	1	0	3
11 : GS6	3	3	2	3	1	3	1	2	3	0	0	1	2	P	3
12 : RU4	3	3	3	P	3	3	P	P	0	P	P	0	3	3	3
13 : U8	3	3	2	P	2	2	0	0	2	0	0	3	0	2	3
14 : U2i	2	0	1	0	0	2	2	0	0	0	0	P	0	0	P
15 : U3	3	3	3	3	2	3	1	3	3	3	2	1	2	2	0

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Source: Own elaboration based on internal Stakeholders perception WS and MICMAC software outcomes.

The sum of the relations between the 15 variables selected as possible key variables of the SES is presented below as a matrix of direct influences, from the internal stakeholders' standpoint. This summarises the direct dependences each variable has from the rest as well as the influences it is subjected to, according to internal stakeholders *(see table 7)*

As can be seen in table 7, in the case of TDI, which measures the influence each variable exerts on the others, government organisations is the most relevant variable with an associated TDI of 37, followed by history of use

(34), property rights system (29), collective-choice rules (27), economic value (24) and extraction and exclusion rights of natural resource (23) The lowest value was attached to sanitary conditions with a TDI of 7.

On the other hand, observing the TDD, it can be seen that the variable most influenced by the other 14 variables is economic activities with a TDD of 38, followed by political stability (33), livelihoods (31), history of use (26), and natural resource importance (25) The lowest value corresponds to property rights system, which means that, from the internal stakeholders' point of view, this is the least influenced variable, that can be attributed to the strong and clear property rights system and its importance in the history of the SES.

Table 6 Direct influences based on internal stakeholders' views

N°	VARIABLE	SHORT LABEL	TOTAL DIRECT INFLUENCE	TOTAL DIRECT DEPENDENCE
1	Economic activities (forestry and agriculture)	S1a	15	38
2	Monitoring and sanctioning processes	GS8	22	23
3	Livelihoods	S1d	17	31
4	Non-paid activities	S1e	18	18
5	Migration trends	S2f	11	19
6	Political stability	S3	19	33
7	Type of environmental laws	S4b	19	8
8	Extraction and exclusion rights of natural resource	RS6b	23	19
9	Government organisations	GS1	37	12
10	Property rights system	GS4a	29	7
11	Collective-choice rules	GS6	27	17
12	Economic value	RU4	24	23
13	Importance of resources	U8	22	25
14	Sanitary conditions	U2i	7	25
15	History of use	U3	34	26
	Totals		324	324

Source: Own elaboration based on external Stakeholders perception WS and MICMAC software outcomes.

Similarly to the previous section, the TDI and TDD have been calculated; these values should be used to rank the importance of each variable over the SES's performance.

3.4.3 Matrix of direct influences according to female internal stakeholders' views

As in the cases of the two other types of stakeholders, in what follows the matrix of direct influences is presented, as female stakeholders perceived these. Later, there are examples to illustrate how to interpret the data in the matrix. Finally, the results of TDI and TDD and discussion about them are presented as well. As will be seen in the results' section, women perceptions differ from the other ones.

Table 8 shows the matrix of all 15 direct influences selected in the previous WS based on women's perceptions. Some interesting relations that resulted from this WS include *(see table 8)*:

1. For this group of stakeholders, the *government organisations* variable has null influence on *economic activities* (a_{91}=0). This view differs from internal stakeholders' and external stakeholders' viewpoints.
2. Conversely, *economic activities* (S1a), according to women's arguments, has medium influence on *government organisations*, so, (a_{19}=2). Internal stakeholders suggest that this relation only has a potential effect while external stakeholders asserted that this variable has null influence on *government organisations*.
3. Regarding *migration trends*, women think that *government organisations* has medium influence on *migration trends*, so, (a_{95}=2). It is important to remember that, in contrast, internal stakeholders attributed a high level of TDI to this variable. Even women suggest that *government organisations* have influence on *migration trends*, they, they do not think *government organisations* determine migration;
4. In contrast, women suggest that *government organisations* is strongly influenced by *Migration trends*, so, (a_{59}=3). This statement differs from internal and external WS, because they assign values of potential and null effects.

Table 7 Matrix of direct influence based on female internal stakeholders' views

	1 : S1a	2 : GS8	3 : S1d	4 : S1e	5 : S2f	6 : S3	7 : S4b	8 : RS6b	9 : GS1	10 : GS4a	11 : GS6	12 : RU4	13 : U8	14 : U2i	15 : U3
1 : S1a	0	0	1	0	2	2	P	P	2	0	0	2	2	2	P
2 : GS8	1	0	2	3	0	3	0	0	0	0	0	3	2	0	3
3 : S1d	0	0	0	0	3	2	P	0	0	0	0	0	2	2	1
4 : S1e	3	3	2	0	2	3	0	2	3	0	0	0	0	3	3
5 : S2f	2	0	2	2	0	1	0	3	3	0	P	0	2	2	0
6 : S3	3	3	2	3	2	0	2	3	3	3	3	0	0	2	2
7 : S4b	3	3	3	3	3	3	0	3	0	2	0	2	3	2	P
8 : RS6b	2	3	3	3	0	3	0	0	0	0	0	0	0	0	3
9 : GS1	0	3	2	3	2	3	3	3	0	3	3	0	1	3	3
10 : GS4a	3	2	2	0	1	3	0	3	3	0	3	0	3	0	3
11 : GS6	3	3	2	3	2	3	P	3	3	0	0	1	2	2	3
12 : RU4	3	2	2	0	3	1	P	2	0	0	0	0	3	0	0
13 : U8	0	3	2	0	0	0	3	3	2	0	3	1	0	1	3
14 : U2i	0	2	1	1	0	2	2	0	2	0	0	0	2	0	0
15 : U3	3	3	2	P	1	3	3	3	3	3	2	2	3	2	0

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Source: Own elaboration based on women internal Stakeholders perception WS and MICMAC software outcomes.

As in the other stakeholders¨ cases, the matrix below summarises all the effects, total direct influences and dependences, each variable has on one another, as assessed by women. According to the women WS results, the variables with most direct influence on other variables are the following (the TDI sum is indicated in parentheses): *history of use* (33), *government organisations* (32), *political stability* (31), *type of environmental laws* (30), *collective-choice rules* (30) and *property rights system* (26). The least influential variable is *livelihoods*, with a TDI of 10.

Regarding the TDD of the variables considered for this SES, female stakeholders identified the following as the most relevant ones: *political stability* (32), *monitoring and sanctioning processes* (30), *extraction and exclusion rights of natural resources* (28), *livelihoods* (28), *economic activities* (26) and *importance of resources* (25). Meanwhile, the lowest values correspond to *property rights system* and *economic value (see table 9)*.

Table 8 Direct influences based female internal stakeholders' views

N°	VARIABLE	SHORT LABEL	TOTAL DIRECT INFLUENCE	TOTAL DIRECT DEPENDENCE
1	Economic activities (forestry and agriculture)	S1a	13	26
2	Monitoring and sanctioning processes	GS8	17	30
3	Livelihoods	S1d	10	28
4	Non-paid activities	S1e	24	21
5	Migration trends	S2f	17	21
6	Political stability	S3	31	32

N°	VARIABLE	SHORT LABEL	TOTAL DIRECT INFLUENCE	TOTAL DIRECT DEPENDENCE
7	Type of environmental laws	S4b	30	13
8	Extraction and exclusion rights of natural resource	RS6b	17	28
9	Government organisations	GS1	32	24
10	Property rights system	GS4a	26	11
11	Collective-choice rules	GS6	30	14
12	Economic value	RU4	16	11
13	Importance of resources	U8	21	25
14	Sanitary conditions	U2i	12	21
15	History of use	U3	33	24
	Totals		329	329

Source: Own elaboration based on external Stakeholders perception WS and MICMAC software outcomes.

In sum, the matrix of direct influences of each case could be used as an input for PSA due to the most relevant variables and their relations have been captured. In the next part of this document, PSA results will be presented and show how participants validated them and added more information, which may be used in the next COMET-LA project phase.

4   Identification of the role played by the different variables

One of the objectives of this document is to identify key variables for the SES analysed. In order to achieve it, several workshops have been carried out. So far, key variables and double entrances matrixes have been identified and fulfilled, respectively; both are inputs for PSA analysis and MICMAC software. Remembering that MICMAC software takes the matrix of direct influences and through Marcov chains properties direct and indirect variables' relationships, roles and rankings can be identified. In order to present PSA results influences/dependences maps and some graphs will be shown. These results were obtained by the PSA application based on stakeholder's views.

4.1   Variables of the system identified by PSA

Aiming at identifying the 'drivers of the system', i.e., the variables that determine Santiago Comaltepec's SES performance, the results of each of the three WS will be compared with one another. In order to present them, influences/dependences maps, influences graphs, and rankings of different matrices have to be shown[10].

If the influences/dependences graph is observed on a Cartesian plane associating level of dependence and influence of each variable generating ordered pairs, the basis of PSA can be understood. According to Ambrosio (2009), it is possible to identify in these graphs four kinds of variables:

1. Determinants (usually named drivers): these variables have a significant influence (over) on the SES performance. These variables affect others, but they are not influenced.
2. Development variables: these have a medium influence on the SES, and at the same time, they are slightly influenced by others.
3. Objective variables: these are considered as a community and SES´s aims.
4. Result variables: these have an irrelevant influence on other variables. However, they are dependent on the evolution of others, and are considered a rigid and weak element of the SES.

Another aspect to be considered for PSA analysis is the result of a strategic logic and the capability of generating multiplied effects, as a function of the position of a variable with respect to the strategic diagonal (the diagonal from the origin of the Cartesian plane to the opposite side). The farther on the diagonal, the more capable a variable is of generating and receiving multiplied effects.

Four types of strategic variables may be distinguished:

1. Key variables: they have a high level of total influence and dependence at the same time.
2. Regulators: they have medium influence and dependence on the performance of the SES
3. Secondary variables: they have or had little influence on the SES. However, other variables have medium influence on them.
4. Autonomous variables: they have a low impact on the SES; i.e. their influence and dependence is not significant.

Graph 2 shows the influence/dependence map classifying variables according to the categories above. Notice that the SES key variables (red oval) are located in the first quadrant (far away from the origin), thus implying they have a high level of dependence and influence.

The SES secondary variables are located in the centre of the graph 2 (yellow oval). Result variables are in the second quadrant (green oval), which means they are highly dependent on others but are of little influence to them. Autonomous variables (grey oval) are in the third quadrant, which means they have a low level of influence and dependence. Finally, in the fourth quadrant we can see Determinants (blue oval) with a high level of influence, but low level of dependence. In general, it can be said that *key variables* (red oval) support

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[10] MICMAC software allows obtaining indirect variables' relationships of complex systems. This document is limited to present direct relations because they will be the main input for the next phase of COMET-LA project.

the SES and, at the same time, receive feedback from it. In other words, they are responsible for SES cohesion[11].

Graph 2 Influence and dependence relations
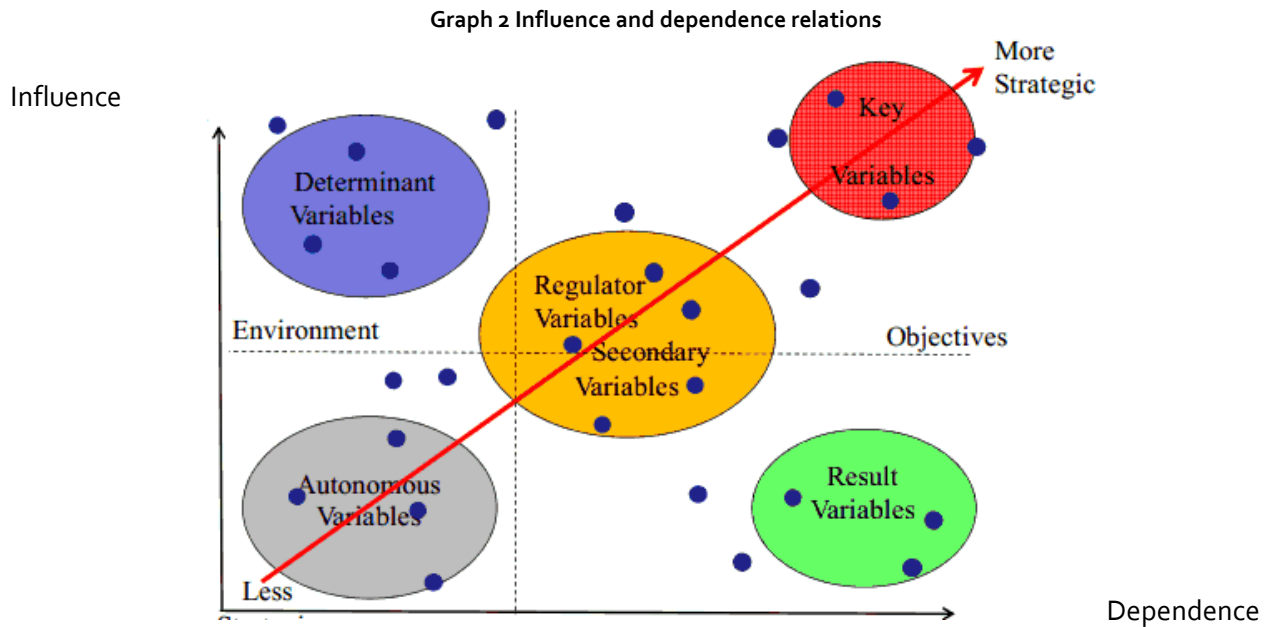
It is important to indicate that framework described above (variables' classification) is still incomplete in the sense that COMET-LA scientific team is working on the definition and names of each type of variables considering particular contexts and scientific aspects. That discussion is planned for next phase of the project, specifically in February 2014, during the next methodological meeting, which can be developed in Faro.

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[11] [11]Blanco (2009) and Ambrosio and Delgado (2008) defined key sectors as a function of each case study, but supported on previous maps. Blanco (2009) suggests the following classification:

i)   In red: key variables, which have high level of influence and medium or high level of dependence as in the previous definition.

ii)   In green: result variables, which have medium-high level of (dependence) influence, but medium-low level of dependence

iii)   In grey: autonomous variables, which have both low level of influence and dependence.

iv)   In blue: determinants, which have medium-high influence, but low dependence

v)   In orange: Regulators, which have medium-high level of influence and medium dependence level.

vi)   In yellow: Secondary variables, which have low-medium level of both influence and dependence.

As a part of PSA, Godet (2001) suggests that some variable rankings should be helpful for this analysis in the sense that it illustrates the relevance of each variable in the SES; so, the MICMAC software provides these rankings. The first one is based on the direct influences, but due to the complexity of relations provided by the graph, a binary matrix is used in which a unit value represents that variable has an influence over the another one (specified by the row and column number), and zero otherwise; the second and the third one are based on TDI and TDD values, respectively, in other words the more value is attached to a variable the more important is in this ranking.

In the following part direct influences and dependences maps will be described in order to illustrate SES's performance. Fifteen variables selected by internal and external stakeholders as has been described before will be used into the PSA. Likewise, the variables classification and different rankings suggested by MICMAC software based on influences graph, TDI and TDD, will be presented.

4.1.1   Outcomes of External Stakeholders

Based on the previous analysis, graph 3 shows the results corresponding to the external stakeholders' views. Graph 3 shows that there seems to be just one *key variable* in this SES: *livelihoods* (S1d). In other words, *livelihoods* can be interpreted as it influences and is influenced by most other variables of the SES. So, it is a cohesive system variable. However, variables as *government organisations* and *non-paid activities* might also be considered 'key variables' because they have a high level of influence upon and a medium level of dependence on other variables.

In the category of regulators, we identified property rights system (GS4a), collective-choice rules (GS6), political stability (S3), and monitoring and sanctioning processes (GS8). Importance of resources (U8), migration trends (S2f) and exclusion and extraction rights (RS6b) turned out to be secondary variables. Another finding of our analysis is that there are two result variables: economic activities, and economic value. Sanitary conditions (U2i) is the only autonomous variable. Lastly, the determinants, according to the external stakeholders' vision, include collective-choice rules (GS6), property rights system (GS4a) and history of use (U3).

Graph 3 Influence/dependence graph based on the matrix of direct influences. External Stakeholders' views

S1a	Economic activities (forestry and agriculture)
GS8	Monitoring and sanctioning processes
S1d	Livelihoods
S1e	Non-paid activities
S2f	Migration trends
S3	Political stability
S4b	Type of environmental laws
RS6b	Extraction and exclusion rights of natural resource
GS1	Government Organisations
GS4a	Property rights system
GS6	Collective-choice rules
RU4	Economic value
U8	Importance of resources
U2i	Sanitary conditions
U3	History of use.
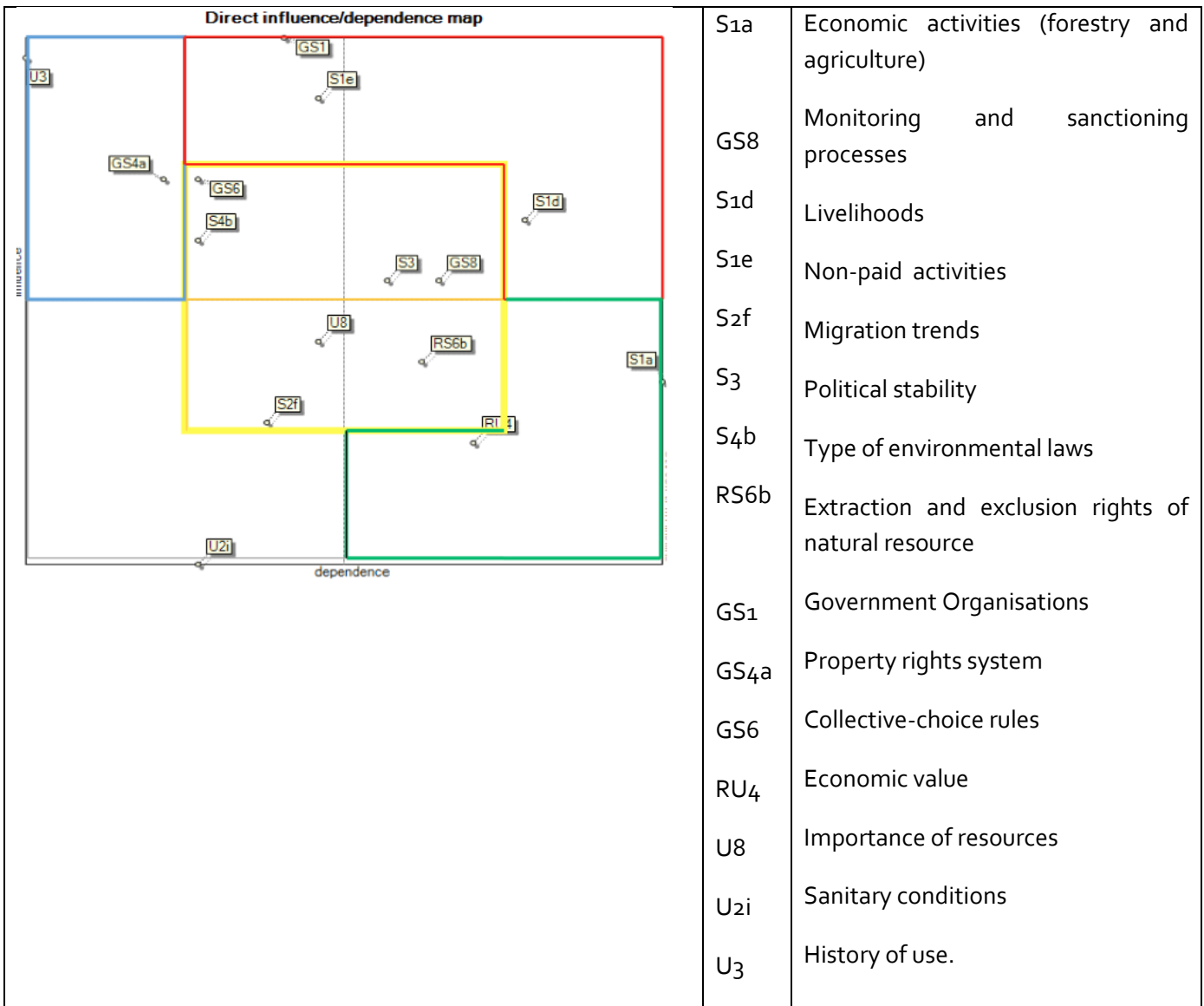
The analysis should be completed through identification of the most relevant variables, which are playing a relevant role in the SES performance including the influences graph. This graph generates a substructure that gives system cohesion. According to the external stakeholder's view, Graph 4 shows relations network.

In order to illustrate the role that some key variables play in the SES, it is necessary to analyse in detail the influence graph. This graph shows the most important relations and connections that support the SES functioning. Moreover, it is possible to identify the magnitude and direction of each influence relation. For example, if the number attached to a line is 3, it means that this variable is strongly influenced and the arrows indicate the direction of the influence. For instance, the relation between governance system and non-paid activities is really close because they are strongly influencing each other. However, as networks theory suggests, the history of use is a pole or key variable due to the fact that it influences four principal

relationships: governance system, types of environmental laws, property rights system, and collective choice rules. Another key or pole variable is collective choice rules, which has three associated relations.

Graph 4 Direct influences graph according to external stakeholders' views (10% filter)

S1a	Economic activities (forestry and agriculture)
GS8	Monitoring and sanctioning processes
S1d	Livelihoods
S1e	Non-paid activities
S2f	Migration trends
S3	Political stability
S4b	Type of environmental laws
RS6b	Extraction and exclusion rights of natural resource
GS1	Government Organisations
GS4a	Property rights system
GS6	Collective-choice rules
RU4	Economic value
U8	Importance of resources
U2i	Sanitary conditions
U3	History of use.
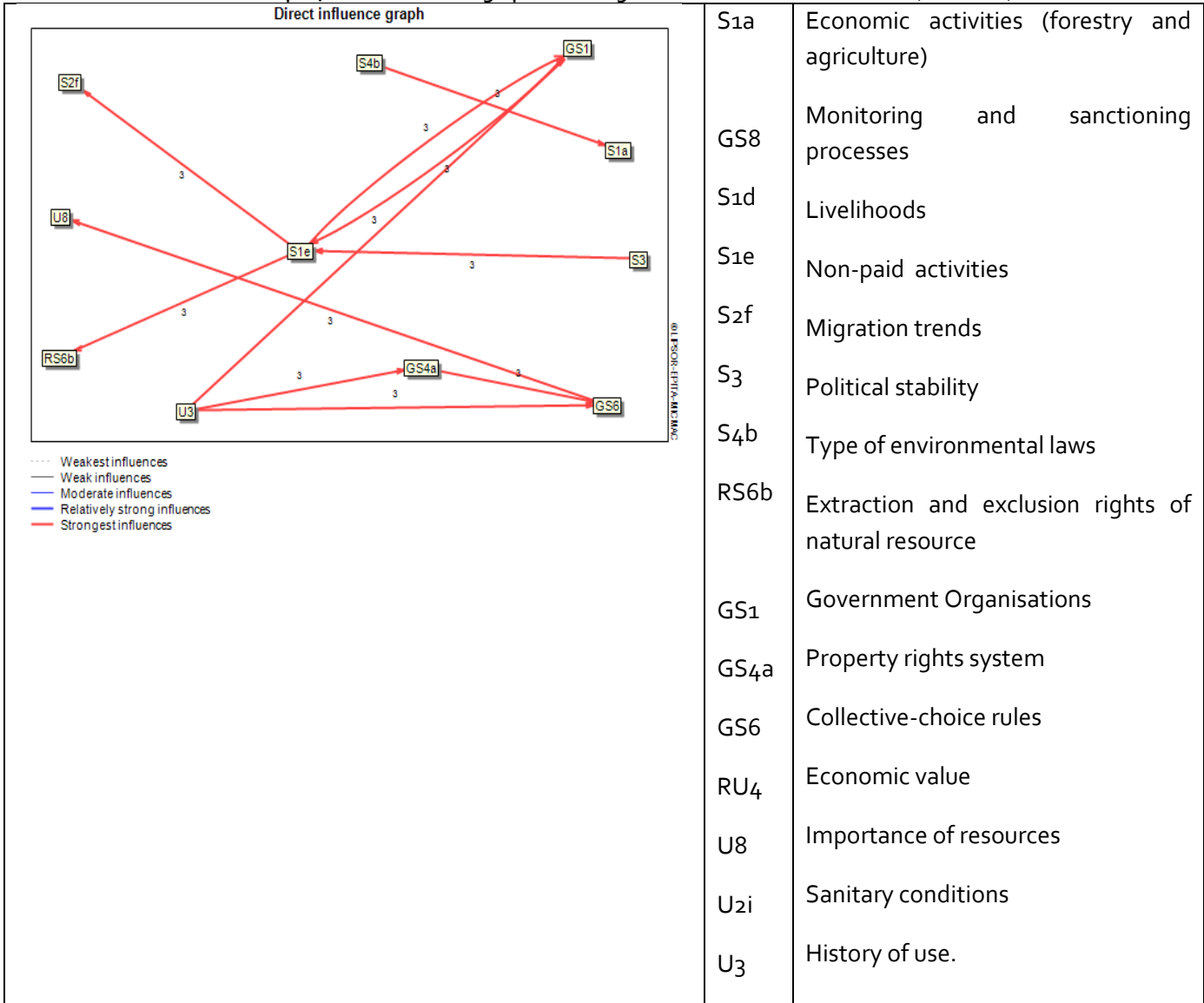
Source: Own elaboration based on MICMAC outcomes.

According to the last description, a ranking can be derived with the direct relations associated to the influence graph. This classification coincides with the ranking obtained through influence and dependence relations. So, these rankings are based on influence graph, TDI and TDD *(see the following classification)*:

Variables hierarchy based on graph according to external stakeholders´ views:

1. History of use
2. Non-paid activities
3. Government organisations

4. Collective-choice rules
5. Property rights system

Variables hierarchy based on Total Direct Influence TDI according to external stakeholders´ views:

1. Government organisations
2. History of use
3. Non-paid activities
4. Collective choice rules
5. Property rights system

Variables hierarchy based on Total Direct Dependence TDD according to external stakeholders´ views:

1. History of use
2. Government organisations
3. Property rights system
4. Non-paid activities
5. Collective choice rules

4.1.2 Outcomes of Internal Stakeholders

To expose the results of the internal stakeholders' WS, the same order that has been used in the previous section will be followed. The map of direct influence and dependence relations indicates that *collective-choice rules,* and *extraction and exclusion rights economic value, sanction and monitoring processes and the importance of resources* can be considered *regulators*. All of these variables have medium level of influence and dependence and are susceptible to manipulation in order to affect the SES functioning. As for secondary variables, the only in this category was *non-paid activities*.

After processing the data gathered in the internal stakeholders' workshops, it turned out that *political stability, economic activities, livelihoods* and *migration trends* were considered *outcomes* variables because they exhibit a high level of dependence and low influence. MicMac outcomes suggest that *sanitary conditions* and *types of environmental laws* are regarded as *autonomous variables* that have both low levels of dependence and influence. It is important to highlight the fact that the *history of use* is a *key variable* in the SES' performance. Moreover, this variable shows the way in which Comaltepec´s commoners have managed their forest sustainably and defended it against the paper mill three decades ago. The variables that have a high level of influence, *determinants or drivers*, are *government organisations* and *property rights system (see graph 5)*.

Graph 5 Direct relations map based on Internal Stakeholders´ workshops

S1a	Economic activities (forestry and agriculture)
GS8	Monitoring and sanctioning processes
S1d	Livelihoods
S1e	Non-paid activities
S2f	Migration trends
S3	Political stability
S4b	Type of environmental laws
RS6b	Extraction and exclusion rights of natural resource
GS1	Government Organisations
GS4a	Property rights system
GS6	Collective-choice rules
RU4	Economic value
U8	Importance of resources
U2i	Sanitary conditions
U3	History of use.
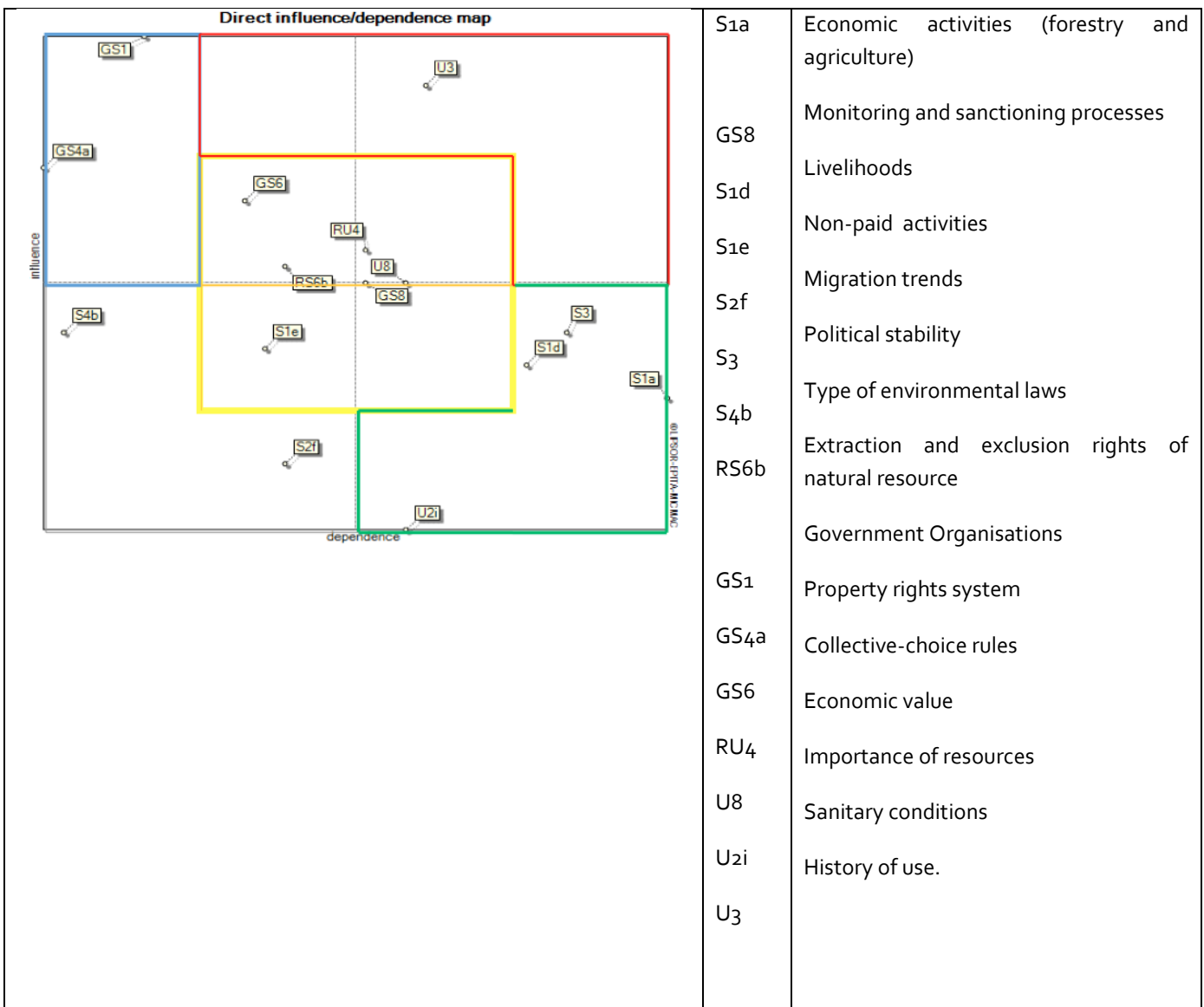
Source: Own elaboration based on MICMAC outcomes.

According to direct influences graph of internal stakeholders, *Economic value* RU4 has a strong bidirectional relation with *Monitoring and sanctioning processes* GS8 and the *Importance of resources* U8. It means that if the *Economic value* increases, *Monitoring and sanctioning processes* GS8 will be improved in order to preserve the forest, and vice versa. Likewise, when the *Economic value* RU4 is affected, the pressure over the resource will be modified in the same direction *(see graph 6).*

Graph 6 Direct influences graph according to internal stakeholders' views

S1a	Economic activities (forestry and agriculture)
GS8	Monitoring and sanctioning processes
S1d	Livelihoods
S1e	Non-paid activities
S2f	Migration trends
S3	Political stability
S4b	Type of environmental laws
RS6b	Extraction and exclusion rights of natural resource
	Government Organisations
GS1	Property rights system
GS4a	Collective-choice rules
GS6	Economic value
RU4	Importance of resources
U8	Sanitary conditions
U2i	History of use.
U3	

Source: Own elaboration based on MICMAC outcomes

As in the previous section, a ranking can be derived with the direct and indirect relations associated to the direct influences graph. This classification coincides with the ranking obtained through influence and dependence relations. So, these rankings are based on direct influences graph, TDI and TDD (see the following classification):

Variables hierarchy based on graph according to internal stakeholders´ views:

1. Economic value
2. Importance of resources
3. Monitoring and sanctioning processes
4. History of use
5. Non-paid activities

Hierarchy of total direct influences TID according to Internal Stakeholders:

1. Government organisations
2. History of use
3. Property rights system
4. Collective-choice rules
5. Economic value

Hierarchy of total direct dependences TDD according to Internal Stakeholders:

1. Economic activities
2. Political stability
3. Livelihoods
4. History of use
5. Importance of resources

4.1.3   Outcomes of Female Internal Stakeholders

The results of the Structural Analysis based on the information gathered in the female workshops will be presented in the same way as in the previous two sections, showing the direct influence and direct dependence maps, influence graphs, and the displacement map.

First, we have to highlight the fact that women participated very actively in the workshops we organised with them. They discussed carefully every detail in Ostrom's framework and the construction process of the matrix of influences.

As can be seen from the following graph, *non-paid activities* is a *regulator* variable. The *importance of resources* and *migration trends* are considered *secondary variables*. *Economic activities, extraction and exclusion rights, monitoring and sanctioning processes*, as well as *livelihoods* turned out to be *result* variables. They are measuring the SES performance. Women consider that *sanitary conditions* and *economic value* have little influence and dependence on the SES functioning, which is defined by *autonomous variables*. This is because resource price is not important for *economic value* and is not under community control. In contrast, the *history of use, government organisations,* and *political sta*bility have a high level of both dependence and influence; therefore, they can be regarded as *key variables* of the SES. Lastly, *collective-choice rules, property right system*, and *types of environmental laws* have a high level of influence, so they are located in the quadrant of determinants *(see graph 7).*

Graph 7 Direct relations map based on female internal stakeholders' workshops

S1a	Economic activities (forestry and agriculture)
GS8	Monitoring and sanctioning processes
S1d	Livelihoods
S1e	Non-paid activities
S2f	Migration trends
S3	Political stability
S4b	Type of environmental laws
RS6b	Extraction and exclusion rights of natural resource
GS1	Government Organisations
GS4a	Property rights system
GS6	Collective-choice rules
RU4	Economic value
U8	Importance of resources
U2i	Sanitary conditions
U3	History of use.

Source: Own elaboration based on MICMAC outcomes.

When indirect influences are incorporated into the analysis, ranking and characterisations can be observed in the graph 8. In this case, the variables do not change. In other words, direct and indirect influence rankings are almost the same, only *sanitary conditions* moved from *autonomous* to *result* variables. So, through indirect influences, *sanitary conditions* seems to increase its level of dependence. Likewise, *extraction and exclusion rights* moved from *result* to *secondary* variables: it increased its level of influence. These movements can be observed in the displacements graph *(see graph 8).*

Graph 8 Direct influences graph according to female internal stakeholders' views (10% filter)

S1a	Economic activities (forestry and agriculture)
GS8	Monitoring and sanctioning processes
S1d	Livelihoods
S1e	Non-paid activities
S2f	Migration trends
S3	Political stability
S4b	Type of environmental laws
RS6b	Extraction and exclusion rights of natural resource
	Government Organisations
GS1	Property rights system
GS4a	Collective-choice rules
GS6	Economic value
RU4	Importance of resources
U8	Sanitary conditions
U2i	History of use.
U3	
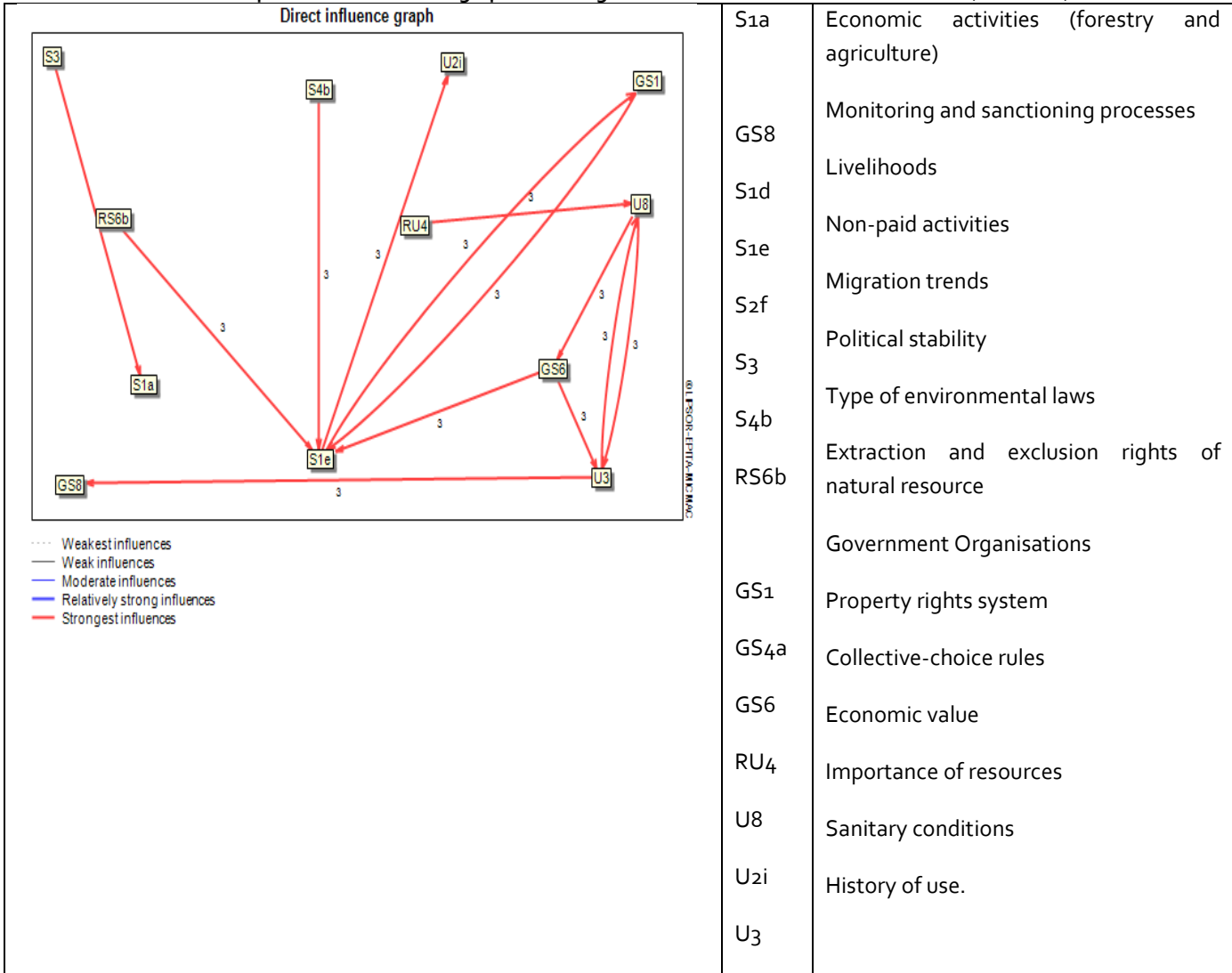
Source: Own elaboration based on MICMAC outcomes.

According to direct influences graph, TID and TDD, a ranking can be derived. This classification coincides with the ranking obtained through influence and dependence relations *(see the following classification)*:

Variables hierarchy based on graph according to women internal Stakeholders

1. Collective-choice rules
2. History of use
3. Importance of resources
4. Non-paid activities
5. Government organisations

Hierarchy of total direct influences TID according to women Internal Stakeholders :

1. History of use
2. Government organisations
3. Political stability
4. Type of environmental laws
5. Collective-choice rules and property rights system

Hierarchy of total direct dependences TDD according to women Internal Stakeholders:

1. Political stability
2. Monitoring and sanctioning processes
3. Extraction and exclusion rights of natural resources
4. Livelihoods and Economic activities
5. Importance of resources[12]

In this section direct influence and dependence graphs and rankings based on direct influences, TDI and TDD have been described, but in the next section, those findings will be discussed in a deeper manner. Once these PSA outcomes were presented to each group of stakeholders, they added information and generated a discussion in which some issues completed the PSA. According to the outcomes presentation and that discussion, the next section will deal with SES's performance.

5   Results of the PSA analysis: interpretation and validation by stakeholders

The Deliverable 3.2's aim is to identify key variables in the SES through the application of PSA methodology. Once PSA has been carried out these variables were observed and their role in the SES functioning. As COMET-LA Project establishes the learning arena has to take place into the analysis, so in order to devolve PSA results two workshops were organized and developed in which COMET-LA team interpreted and presented them and participants (internal and external stakeholders, respectively) suggested additional information for the PSA that has not been included. Moreover, participants' validation of the PSA results was carried out by all of them.

5.1   Prospective Structure Analysis results and discussion

As explained above, external stakeholders' results indicate that *history of use* and *property rights system* are the most influential variables in this SES. This means that they have a high level of influence but at the same time, if their behaviour were modified, it would be risky. On the other hand, *livelihoods*, *government organisations* and *non-paid activities* represent *key* variables of the SES, and they connect *determinants* with

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[12] All the workshops results were validated by each group of stakeholders signing the "ethical guidelines" form at the end of each one.

result variables. *Economic activities* and *economic value* were identified as *result* variables or system functioning indicators that measure the system's performance, showing a high level of dependence but a low level of influence. Likewise, *regulators* and *secondary variables* represent an opportunity of action for modifying the SES performance. For this reason, according to internal stakeholder's perception, *collective-choice rules, political stability, monitoring and sanctioning process, types of environmental laws, the importance of resources, migration trends* and *extraction and exclusion rights* should be used in the policy making design. *Sanitary conditions* is considered an *autonomous* variable, with the lowest level of dependence and influence over the SES.

Once the results were obtained and systematised, COMET-LA team presented them at a meeting with external stakeholders in Oaxaca City (July 16th, 2013). A variety of presentation materials was used, such as flipcharts, cards, and large blankets in order to represent influence and dependence maps and influence graphs, as is shown in figure 5.

Figure 5 Structural Analysis results presentation: external stakeholders

After the Structural Analysis results presentation, a discussion process started in order to validate the results. It is important to highlight that these results are supported by external stakeholders' views. However, in the validation process, discrepancies came up. For instance, one of the participants suggested that some variables had not been classified as he believed they should have been. From his point of view, *government organisations* and Collective choice rules should be classified as determinants of the SES. Moreover, it was suggested that some cultural identity issues related to the SES should be incorporated into the analysis. Examples of such cultural identity issues are: religious traditions, promises made at the beginning of the year, the arrival of political parties in the community (which is governed by *ways and customs* system) and the interests they represent. One stakeholder urged the team to go deeper into the community's alternatives to maintain its governance system and into the SES' capacity to adapt (or to be modified) for forest management to improve. Once all these comments were collected, the COMET-LA team offered to organise further workshops in order to strengthen these results.

On the other hand, to internal stakeholders, *property rights system* and *government organisations* are the *determinants* of the SES. *History of use* of the resource is the only *key* variable. This means that *history of use* works as an unstable factor with a high level of dependence on and influence over the SES. As *result,* variables or functioning system indicators *economic activities, sanitary conditions, livelihoods,* and *political stability were*

found. These variables have a high level of dependence on but low level of influence over the SES. Methodologically, *regulators* and *secondary variables* represent an opportunity to modify the SES functioning applying some policies by means of variables such as *collective-choice rules, economic value, monitoring and sanctioning processes, the importance of resources* for the community, and *extraction and exclusion rights*. It is important to highlight the fact that *autonomous* variables such as *migration trends* and *types of environmental laws* are part of the SES but have the lowest level of influence and dependence.

The community of Santiago Comaltepec is characterised by male participation in the General Assembly and in several relevant activities, but women's role is also vital for the SES' performance. So, as it was underscored above, women's vision is fundamental due to their traditional role and to their increasing participation in activities performed only by men in the past. In their view, the *property right system, collective-choice rules,* and *types of environmental laws* move the SES, i.e. they are *determinants*. As was the case of internal and external stakeholders, women also considered *history of use, government organisations and political stability work* as linking variables in the sense that they have a high level of influence and dependence but, due to their instability, they cannot be used to change SES' performance. On the other hand, *economic activities, livelihoods, monitoring and sanctioning processes,* and *extraction and exclusion rights* can all be considered outcomes or *result* variables that are an indicator of the SES performance. The capacity of modifying the SES functioning, according to women, is attached to *non-paid activities*, *migration trends* and *importance of resources* for the community. Finally, women consider that *sanitary conditions* and *economic value* have the lowest level of influence over and dependence on the SES although both variables are part of it.

Figure 6 Prospective Structural Analysis results presentation

Source: Own photographs.

During the discussion held after the research team presented the Prospective Structural Analysis results to internal stakeholders, participants considered that the most relevant community's issues are migration, commonality, economic issues and the way commoners manage their forest. As they said, communal goods have been the product of both the community history and a learning process. They also pointed out that there is a high level of dependence on remittances sent by migrants. Another issue they focused on was the fact that their *usos y costumbres* (customary practices) represent a crucial variable for analysing Santiago Comaltepec's SES. One of the community's principal worries is that the SES is exclusionary, in the sense that community members cannot find economic opportunities to increase their welfare.

Moreover, they recognize some SES' problems as they do not know if the *governance system* will be sustainable in the future given current political, economic, social and environmental conditions. Likewise, it is not possible to know exactly how long this governance system will work. From internal stakeholders' point of view, there will be some changes coming from outside the community, which will exert some pressures over the SES, and they are not well prepared to face those changes. That is why COMET-LA and the community are working together (as a learning arena) in order to provide the community with tools for the analysis of the system's performance.

Workshops participants have suggested some points that have to be taken into account. For example, some of them realise the importance of having preserved the forest but are unsure about the next steps they should take to obtain better opportunities. For example, should they increase harvest rates by using a better technology while maintaining sustainability? Another issue is their economic welfare. They consider that the preservation of the forest does not necessarily imply welfare improvement. Therefore, one of the most significant worries is how to manage the forest creating better economic and social opportunities for young people, thus reducing *migration trends*.

As have been already mentioned, the results of prospective structural analysis done using information provided by Comaltepec's external and internal stakeholders through several workshops show similarities and divergences. In the first case, both types of stakeholder agree that system of *property rights* is a key variable which exerts strong influence on the SES but whose dependence on it is very low. In both stakeholders' views, the *economic activities* variable represents an outcome of this system due to the fact that it exhibits a high level of dependence, but exerts a very low level of influence over it. Moreover, *non-paid activities, collective-choice rules, monitoring and sanctioning processes* and *extraction and exclusion rights* support the SES because they have a medium level of dependence and influence on it. As for the divergences, external stakeholders, for example, consider that the *migration trends* have a medium influence on the SES while they receive a similar amount of influence from the other variables of the system. However, internal stakeholders believe that *migration trends* have both little influence and low dependence on the SES. The reason for these differing views lies in the fact that external stakeholders think that the *migration trends* occur because Comaltepec´s SES is incapable of generating enough jobs, pushing people, particularly the youth, to migrate. In contrast, internal stakeholders believe that people migrate because they do not want to comply with their community duties, which implies getting involved in *non-paid activities* i.e., *tequios* and *cargos*; or because it is a fashion initiated by other youngsters who have migrated before.

6   Conclusions

As a conclusion, this experience allows to have a broader *picture* of Santiago Comaltepec's SES and its functioning. Once analysis results were presented to the stakeholders, they agreed with them in general, but new issues and particularities emerged from this process, which will be used in the next phase of the project: Scenario building.

This picture of Comaltepec's SES performance suggests that SES does have clearly defined boundaries, in the sense that community has an effective way to exclude external unentitled parties. It seems to Comaltepec's commoners do not match the *customary practices* governing rules with local needs and context because some

commoners have mentioned that the SES is not providing enough economic and social opportunities to increase everybody's welfare.

All commoners participate in the decision-making process. Likewise, the community has a well-prepared mechanism to monitor its territory. Governance structure and cultural factors contribute to ensure that the rules are enforced. Moreover, it is important to highlight the fact that geographical and location characteristics also contribute to make that enforcement possible. The community has designed a sanction system, which has proved to be able to regulate its members' behaviour and is accompanied by a penalty scheme. Also, the SES does not have an efficient and low-cost mechanism to solve conflicts or issues related to Comaltepec. The community spends a lot of time solving SES' problems because they have to elucidate all of them through a General Assembly, and sometimes this may take more than two months. Local authorities have a solid influence on their territory and governance system, even if external *government organisations* are present in the community. Commoners really govern their territory. Moreover, the SES has some obstacles to overcome designing and enforcing rules through different tiers of nested enterprises.

Finally, considering what has been exposed, the SES of Santiago Comaltepec can be said to be environmentally sustainable, but its economic and social sustainability is not so certain. In the case of institutional sustainability, this community has a strong governance system, but the community could face some difficulties in the future. Likewise, social sustainability is not guaranteed at all because female and young community members do not find real opportunities to participate as equals in the current SES performance. Youngsters cannot find job and development opportunities within the SES and they may change their vision of the future of the community due to external influences such as television and migration. The *cargos* system is also an important source of worries for the community members, because *non-paid activities* mind severely the familiar economy and commoners are worried about the sustainability of the system in this regard.

Another feature that has been identified is that the SES's performance sustainability is complex. It is observed by each group of stakeholders (internal and external ones), but each group's views differ. The sustainability of the SES is supported by its governance system based on non-paid activities. The most relevant aspect is that institutional sustainability supports the environmental system due to most of local institutions have strong and effective influence over the SES. But, it has negative effects at the same time because of community welfare improvements are limited by this inflexibility. The institutional system rigidity limits that SES provides better opportunities for young people, so they are locking outside the community in order to find them.

As has been shown, the Prospective Structural Analysis allows to have a characterisation of the SES, but this phase of the project will be the just the input for the next phase, in the sense that some probable scenarios of the SES performance will be built identifying and up-scaling a governance sustainable model.

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Annex I. Socio Ecological System (SES)

Table 1. Socio Ecological System (SES) characterization

First tier		Second tier			Third tier		
Social, Economic and Political Setting (S)	Describes how all SES may affect and be affected by the larger socioeconomic, political, and ecological settings in which they are embedded	S1	Economic development	Sustained, concerted actions of communities and policymakers improving the standard of living and economic health of a specific area / the quantitative and qualitative changes in an existing economy	S1a	Economic activities	Principal activities: agriculture, livestock, forestry. natural resources management, services, and commerce.
					S1b	Income per capita	• Income per-capita in the Oaxaca state USD 3257/year (INEGI and CEFP, 2008)
					S1c	Employment per sector (% and trends)	• Employment per sector in Oaxaca: primary sector 32.41%, secondary sector 19%, services sector 47.60% .
					S1d	Livelihoods	• The livelihoods in the Sierra Juarez Region are mainly agriculture, livestock, trade, forestry and ecotourism.
					S1e	Non-paid activities (related to land management)	(The customary practices system is the governance system of the indigenous communities in the Sierra Juarez and it is based on non-paid activities, therefore attendance at community meetings, *cargos*, *tequios* and *commissions* are mandatory.
					S1f	Income dispersion	The GINI index for the Sierra Juárez region is 0.36 (based on Ruiz and Campechano, 2006), this indicator suggests a low income concentration compared with the National Mexico's coefficient, which is 0.47.
					S1g	Time allocation among the different economic activities carried out in the area	According to agriculture seasonality (summer-winter). Varies in the different economic activities.

First tier	Second tier			Third tier		
				S1h	Specialization of stakeholders (in one of different economic activities)	Forest management (harvesting timber and wood processing), agriculture, and livestock.
	S2	Demographic trends	Development, changes and status of the human population	S2a	Number of inhabitants	Oaxaca state population: 3,801,962. Sierra Juarez total population: 176,489 (INEGI, 2010).
				S2b	Density of population	The Sierra Juarez has 176,489/ 8972.39 km² = *19.67 Pop. Per/km2* . (Municipal Information Centre of the Oaxaca State, based on INEGI, 2010).
				S2c	Gender ratio	In the region, 48.19% of the inhabitants are men and 51.81 are woman (Municipal Information Centre of the Oaxaca State, based on INEGI, 2010).
				S2d	Demographic structure	Population between 6 and 24 years: 68,204, 15 and more age group: 103, 296 (Municipal Information Centre of the Oaxaca State, based on UNDP, 2005).
				S2e	Population growth rate	Oaxaca state: 1.00 (INEGI, 2010).
				S2f	Migration trends	Move for work or for higher education. Migrants age range: 18-45 years. Destinations: United States of America and Oaxaca city.
				S2g	Ethnical diversity (in % per group)	• 85% Chinanteco (indigenous language). There are also Zapotecs (15%)
				S2h	Settlement patterns	Communities in the Sierra Juárez are settled according to ecological patterns and population centres such as Ixtlán de Juárez.
	S3	Political stability -	Eventual existence of a core regulatory framework for the country or area / eventual existence of defined laws / the regularity of the democratic processes	S3a	Core legal framework (national constitution and core laws)	Mexico's Constitution and the Constitution of the State of Oaxaca.
				S3b	Level of norm compliance (norm stability, capacity of reinforcement, knowledge of norms)	Regional and internal differences. Local regulations are well known and most respected.
				S3c	Type of conflict	No information available about

First tier	Second tier			Third tier		
						conflicts.
				S3d	Security Indexes (UN Security Risk Rating Index…)	The state of Oaxaca is listed in those severely affected by insecurity. According to crime rate CIDAC (Research Center for Development, 2012) Oaxaca ranks 22 32 with an index of 77.3.
				S3e	Respect for democratic values (human rights, corruption, etc.)	There is great respect for democratic values at a local level. Corruption is apparent at regional and national levels.
	S4	Government resource policies -	Type of resource policies adopted by the national, regional and local governments (top-down approach)	S4a	Governmental regulatory framework for natural resources management and use	-Mexican constitution: Article 4 recognizes the right that the public health protection and a healthy environment-Article 25 promotes the sustainable development of the economy and protecting the environment; article 27 assigns responsibility to the Federal, State and municipal levels of Government for the development and conservation of natural resources and to achieve the sustainable development of the country; article 73 States those federal, state and local governments can issue laws and regulations for the protection, preservation and restoration of the ecological balance.
				S4b	Environmental policies at national, regional and local levels and the implementation level (including climate change mitigation strategies)	Hydrological Environmental Services Programme promoted by CONAFOR . Community conserved areas network promoted by WWF Mexico. The communal statute establishes the sustainable forest management.
				S4c	Environmental regulatory and policy frameworks compliance	There is high compliance at the local level.
	S5	Market incentives	Market functioning for natural resource management and conservation	S5a	Influence of global/local markets in the area (e.g. levels of dependency of external markets, price definition)	The study area is linked to local markets and regional markets.

First tier	Second tier			Third tier		
				S5b	Type of products (e.g. commodities, certified products, other kind of labelling)	Wood is certified, but certification is not reflected in its price.
				S5c	Access to markets (distance, commercialisation channels and networks, marketing)	Oaxaca 108 km, Tuxtepec 123 km and Ixtlán 45 km :
				S5d	Demand for natural resources from local, regional, national and international markets	There is low dependence on regional and national markets. Regional dependency on fuel is strong.
				S5e	Market incentives for natural resource conservation (e.g. existence of taxes, fees and charges, tradable permits, eco-labelling, financial mechanisms, liability and compensation schemes)	There are Environmental services programs for water catchment and carbon scuestration. Payment received by the communities is low, therefore it is not a strong incentive.
	S6	Media organization -	Number, diversity, freedom… of private and public media	S6a	Existence of communication networks	Broadcast open television, private satellite television, radio (open access), internet access (private).
				S6b	Media deterrence capability	National television, internet and local radio.
				S6c	Interest of media in socio-environmental issues	Local media show significant interest on environmental issues.
				S6d	External support for denunciation	Weak support of Mexican civil society. In the region, the local radio (Guelatao) is an important support for denunciation.
Resource Systems (RS)	Comprises the environment where the resource is produced/found	RS1	Sector(s) (e.g. water, forest, pasture, fish)	Specific biological-production related classification	RS1	Sectors	Agriculture and forestry.
		RS2	Clarity of system boundaries -	Clarity of system geographical, social, legal and access boundaries (Description if the boundaries of the resource system under study are clear or fuzzy and cannot be defined.)	RS2a	Ecological boundaries (spatial distribution, natural boundaries as rivers, biomass, specific vegetation, climate patterns, etc.)	Ecological boundaries: río Guayabo, Arroyo Carrizal., Cerro Araña, Río la Du, Tarabundí, Cerro la Primavera, Río Soyolapam. The boundaries are clearly defined.
					RS2b	Anthropogenic boundaries (e.g. land use distribution, conservation areas)	The land use distribution and conservation areas are clearly defined by the Land Use Programme.

First tier	Second tier			Third tier		
				RS2c	Extraction access and property boundaries	Property boundaries are clearly defined by the PROCEDE. Extraction access is established by the communal statute.
	RS3	Size of resource system	Size based on type of resources classification (e.g. CPR, Private, Club, Open access, etc.)	RS3	Size	The community of Santiago Comaltepec covers a territory of 19,360 hectares.
	RS4	Human constructed facilities	Constructed facilities such as roads, enclosures, field systems, boundary banks and ditches, ponds, parks and woods, wind and water mills, manor houses, moats and churches	RS4	Human constructed facilities (infrastructure, buildings...)	Federal highway 175, rural roads, access to production areas, 307 private homes habited
	RS5	Productivity of system -	Productivity of system - General estimation of the resource system productivity	RS5a	Productivity of the resource system (high, medium, low, exhausted)	Low productivity
				RS5b	Resource regeneration period	
						The forest management programme for pine-oak forest establishes a final harvest in 40 and 60 years for areas of low and high slope, respectively. The annual growth rate per individual (tree) in the low slope: height (up to 90 cm) and diameter (up to 1.2 cm), in the case of high slope areas: height (60 cm) diameter (0.6 cm).
				RS5c	Resource extraction period	Santiago Comaltepec only exploits a forest area of 739 ha (87,977 m3). In this area, a variety of forestry practices can be found. The average intervention area is 73 ha per year, out of which 2,500 m3 of total tree volume are harvested.
	RS6	Equilibrium properties -	Equilibrium properties - Influences (positive and negative) on the equilibrium of the resource system	RS6a	Equilibrium properties	The rate of forest regeneration is positive (average cutting intensity is 10% leaving standing 90%).

First tier	Second tier			Third tier		
			(interaction between species, in social systems, or between biological and antropological systems)	RS6b	Natural hazards occurrence (frequency and magnitude): e.g. flooding, fires, drought	Massive forest fires. Every year coincide with the "El Niño" phenomenon.
				RS6c	History, evidence of impacts in sub-systems and its effects	In forested areas the wildlife has been regenerated. Presence of jaguar.
	RS7	Predictability of system dynamics	Predictability of system dynamics - Capacity to estimate the evolution and dynamics of the resource system and the impact of interventions or external influences on them	RS7	Predictability of system dynamics	Forestry production is highly predictable due to the Land Use Programme and the Forest Management Programme. The sustainable management and the *governance system* strength increase the predictability of the system dynamics.
	RS8	Storage characteristics	Storage characteristics - Retention of information about the system dynamics	RS8	Storage (memory) of the effects of disturbances on a system or sub-systems	There are no traces by climatic events. Storage of fire events exists, but all the affected areas have been reforested.
	RS9	Location	Geographic location	RS9	Geographical location, distribution and distribution patterns	Resources are clearly located.

First tier		Second tier			Third tier		
Governance Systems (GS)	Describes the governance system jointly affected and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place	GS1	Government organizations	Government organizations - Permanent or semi-permanent organizations (or systems of rules) controlled by national, regional and local regulation institutions	GS1	Government Organizations	The customary practices system of indigenous people is recognized by the Mexican Federal Government and by the Constitution of the Oaxaca State. Even indigenous communities have a certain degree of autonomy, the federal and state regulations are respected.
		GS2	NGOs	Describe (social, environmental, technical, development) NGOs interacting with the SES being analyzed	GS2	NGOs	International: WWF, AMERICAN FOUNDATION. National: UZACHI CCMS, UNOSJO
		GS3	Network structure - Networks related to the management and use of resources inside the socio-ecological system	Describe the type of networks related and or embedded to the management and use of resources inside of the governance system.	GS3a	Social networks	UNOSJO (Union of Organizations of the Sierra Juárez of Oaxaca):its purpose is to manage projects of interest to their members before government bodies and also to be an instance that creates mechanisms for financing productive projects with funds from Government Institutions (mainly the National Commission for the Development of Indigenous Peoples and the Ministry of Social Development. The Union of communities of the Sierra Juárez (UCOSIJ) : brings together approximately 42 communities of the Sierra Juarez. Its main activities are identifying regional problems and manage projects that contribute to the sustainable management of natural resources.
					GS3b	Environmental networks	SAO, UCOSIJ, The Rainforest Alliance. • Environmental services of Oaxaca (SAO): second level organiambios en zation comprising various State organizations; generate alternatives to the development of communities possessing natural resources, with emphasis on the carbon market and other environmental services. • The Rainforest Alliance: It is a non-profit global organization

First tier	Second tier			Third tier		
						dedicated to promoting responsible forest management. One of its activities is to develop forest certification standards in communities.
				GS3c	Market networks	UZACHI: consulting for the network of ecotourism of the Sierra Juárez and the network of ecotourism of la Chinantla, sale of sawn timber.
	GS4	Property-rights systems	Property-rights systems - Presence or absence of formal property right systems for the resources (e.g. land property, exclusive fishing rights)	GS4a	Property-rights systems	Communal property rights of 18,366 ha are recognized by the Article 27 of the Mexican Constitution.
				GS4b	Excludability (i.e. possibility to exclude potential users from using the good)	It does not exclude any commoner who complied with their obligations to the benefits generated by the SES. But external users are excluded and can only access the resources under certain circumstances an permissions.
				GS4c	Substractability (i.e. whether resource appropriation by one user reduce availability to others)	The wood is subtracted. The agricultural and livestock use of common lands is substractable.
	GS5	Operational rules -	Operational rules (local rules for defining Who, How, Where, When, and Why have access to local natural resources)	GS5	Operational rules (local rules for defining Who, How, Where, When, and Why have access to local natural resources)	Self consumption use of the resources (timber, land, water): access for every commoner who complies with their duties; permission must be given by the communal authorities. Commercial use of the resources (timber, land, water, biodiversity): only under federal law framework and under assemblies' permission; communal statute establishes that to access the resources is necessary to be Chinantec, live in the community, have accomplished the mandatory non-paid activities and having committed no offense against the community.

First tier		Second tier			Third tier		
		GS6	Collective-choice rules -	Collective-choice rules - Collective-choice rules used to change the day-to-day operational rules related to the resource management	GS6	Collective-choice Rules	Collective agreements by commoners and citizens reached in assemblies. If there are proposals about changes in the use of the natural resources, in the first place, the group of the *caracterizados* has to be consulted. Once the proposal is accepted by this group, it is transferred to the Commoners´ Assembly to be considered.
		GS7	Constitutional rules	Constitutional rules - The background rules set at the beginning of the common use of resource organization (e.g. the constitutional or core rules of the community)	GS7	Constitutional rules	The communal statute, approved by the assembly of commoners, is also recognized by the Government and the Mexican Constitution as the constitutional rules set of the community
		GS8	Monitoring and sanctioning processes	Present a set of ways to monitor and enforce the operational rules (GS5). The system should be cost-effective, that means its costs should not be higher than possible damage infringed by intruders. (adopted from Basurto & Ostrom, 2009)	GS8a	Monitoring processes	The rules for monitoring are established in the communal statute and the *comisariado* is the authority an charge for monitoring the use of the resources and it is supported by the *surveillance council* and by all the commoners as monitors
					GS8b	Sanctioning processes	There exists a strong internal sanctioning process which is stronger when a deliberated violation of the rules occurs than when the infringer ignores the rules or uses the resource inappropriately by mistake (mostly external agents). Those who deliberately violate the rules must be punished with fines, imprisonment or both. Sanctions establishing process: Commoner's Assembly and communal authority. Sanctions implementing process: Municipal Authority through the trustee, or ultimately by the Public Prosecution Office in the district (Ixtlán de Juárez)

First tier		Second tier			Third tier		
Resource Units (RU)	Describes the natural resource units generated by the resource system (e.g. fish, water, fodder)	RU1	Resource unit mobility)	Describes if resource units are mobile or static. (E.g. fish is a mobile resource, while molluscs are static resource, etc.)	RU1	Resource unit mobility	Forest is static
		RU2	Growth or replacement rate	Describes the life cycle of the resource units: how long it takes to reach a reproductive age, harvesting age, how long it takes to bring up a new generation of resources.	RU2	Growth or replacement rate	During the past five years the community has extracted, on average, 2,500 m3 total roll tree per year. Logging rate is lower than replacement and growth rates.
		RU3	Interaction among resource units	How does resource units interact: competition, collaboration, etc.	RU3	Interaction among resource units	To some extent agricultural areas compete with wooded areas. Agricultural activities move into forested areas in some places and in others the forest has been established in areas that previously were agricultural. Competition with livestock is given mainly because agents seek to increase their income. When competition is in areas under protection there is an impact on municipal revenues.
		RU4	Economic value	Explanation of the economic value of the resources	RU4a	Market value	Wood price is low. The removable wood from the forest has a value of 184,514 USD (UZACHI, 2004)
					RU4b	Environmental value	High environmental value due to conservation of biodiversity, species, scenic beauty, carbon sinks.
					RU4c	Strategic value	Water catchment for the watersheds of the region. Refuge of species.
		RU5	Number of units	Number of units - Total volume or amount of resource (e.g. wood volume, agriculture production volume, number of fish)	RU5	Number of resource units / amount of resource	Forest production areas 1,726 ha Intensive forestry 453 ha Low intensity forestry 292 ha Domestic forestry use 982 ha Forest protection areas 10,300 ha Watershed protection 517 ha Protection of wildlife 4,421 ha Forest reserve 5,068 ha Seed area 5 ha

First tier	Second tier			Third tier		
						Natural regeneration 289 ha Forest restoration area 127 ha Agricultural areas and urban agro-forestry 6,108 ha Agriculture 144 ha Agro-forestry 5,954 ha Urban use 108 ha TOTAL AREA 18,366 ha
	RU6	Distinctive markings	Distinctive markings - Natural or artificial markings to distinguish categories in the resource.	RU6	Distinctive markings	Trees to be harvested are marked by the UZACHI in order to leave the younger trees.
	RU7	Spatial and temporal distribution	Spatial and temporal distribution - Availability of the resource in space and time.	RU7	Spatial and temporal distribution	The wood is extracted by the company of the community with an agenda as follows: period of harvest between July and February; from June to August reforestation (rainy season), from July to May application of treatments; October-January preventive activities and pest eradication. November to January maintenance of forest roads.
Users (U)	Describes users of the resource system under consideration	U1	Number of users	describe the number of the direct users of the social-ecological system	U1	Number of users	Direct users: community members who work directly with the SES • Agriculture and livestock: 279 users • Forestry and natural resource management: 83 users Indirect: All the community members who are not commoners

First tier	Second tier			Third tier		
						and visitors.
						"
	U2	Socio-economic attributes of users	Describes the socioeconomic characteristic of the resource system users.	U2a	Sources of income	The main sources of income are agriculture, livestock, retail trade, forestry and remittances.
				U2b	Consumption patterns (e.g. local resources, local/imported food, shopping)	Most of the foodstuff consumed in the community: produced within the community.
				U2c	Women rights (e.g. land tenure, empowerment, gender equity, private-public roles, health, education)	The communal statute recognizes the right of women to be commoners, but it was recently (2010) when the first woman became a commoner. Women are increasing their participation in the assemblies; this trend is related to migration of men. Heads of households: Women: 25.73%. Women are not elected for public cargos because of the customary practices and traditions. However, they are the majority in the committees. In the commissions the participation distribution among males and females is equal. Public cargos held by women: 0; women with post-primary education: 27.93%; illiterate women: 17.38%; participation in total labour force: 14%. In sum, women's rights in Comaltepec's SES are limited in practice. In paper, there is not such discrimination. Culture is a very strong restriction for women to exercise their rights
				U2d	Access to health	Primary health care: supplied by traditional healers. One clinic in the community.
				U2e	Access to education	High school only exists in Santiago Comaltepec. In La Esperanza there is a tele-secondary school. 73.24% of 15 or more years old female population reads and writes; 88.94% of male population, 80.34%

First tier	Second tier			Third tier		
						in average.
						School attendance ratio is 73.35 for females, 74.23 for males, 75.16 in average. Youngsters emigrate to access better and/or higher education levels.
				U2f	Poverty (e.g. income, life cost, access to food)	Comaltepec has an index of medium marginality. There is no food shortage problem.
				U2g	Vulnerability (e.g. social, economic, institutional, environmental)	Environmental vulnerability is not to see, with exception of rivers pollution. Social vulnerability exists due to migration (possible changes of life patterns in future generations). Non-paid activities impose vulnerability because they imply high costs for commoners when they have to leave their income sources in order to accomplish them.
				U2h	Cultural identities (e.g. language, food, celebrations, traditions)	The cultural identity is expressed in the indigenous language and ways (e.g. celebrations, dances and food). The governance system is also distinctive for cultural identity. The majority of people speak the chinantec language; elderly people perform an activity in the woods to ask for the welfare of the community; in January the community gather to ask for good health; in June elderly people gather to thank god that authorities have made the right decisions; in every celebration traditional food is prepared (the yellow *mole* sauce is preferred); a music band performs in the celebrations ; special celebrations are carried out to say good bye to outgoing authorities and welcome the new ones.
				U2i	Sanitary conditions	Most of houses have WC facilities. There is sewage throughout the community; there is no treatment of black waters.; piped water is

First tier	Second tier			Third tier		
						available.
				U2j	Access to drinking water	The community has access to piped water, which is not always drinkable
				U2k	Access to electricity	The three localities are connected to the electrical network of the Federal Electricity Commission.
				U2l	Home gadgets (e.g. TV, washing machine, computer, telephone)	31.92% of 307 houses in the community has refrigerator, 25.08% washing machine, 11.73% a car, 64.17% television, 68.40% radio, 5.21% computer.
	U3	History of use	History of use - Chronological description of resource extracting methods	U3	History of use	The community and UZACHI fought in the eighties to remove the forest concession given to a paper company. The Community approved the Plan of land use and management forest in 1994 under federal law framework.
	U4	Location	Location - Geographical location of users of the resource system (e.g. settlements, villages, dispersion).	U4	Location/dispersion patterns	Agricultural land and irrigation water users are located near to the rivers resource;.

Forest resource users (timber, other products from the forest and tourism), are located 4-20 km far from their resources, so on many occasions, motor transportation is needed. Traders are located in the urban zone. |
	U5	Leadership/entrepreneurship	Leadership/entrepreneurship - Existence of, and attitude towards leadership and entrepreneurship among users.	U5a	Leadership patterns (e.g. level of acceptance, prominence, leadership models)	Commoners with some leadership qualities are elected to serve at several positions of increasing responsibility.
				U5b	Attitudes toward conservation (e.g. entrepreneurship, maintenance, sustainable use)	There is a high consensus of supporting all activities to preserve the forest. Even youngsters who express their desire of modernity, they support forest conservation.
	U6	Norms/social capital	Norms/social capital - Levels of social interaction, reciprocity and trust among	U6a	Social capital	Social capital is strong in Comaltepec

First tier	Second tier			Third tier		
			users	U6b	Traditional forms of collaboration among users (e.g. norms, habits, traditions, customs)	A set of norms and regulations are established in the communal by-laws statute
	U7	Knowledge of SES/mental models - Level of knowledge among the users of the SES conditions, perturbation patterns and possible effects	Level of knowledge among the users of the social ecological system conditions and perturbation patterns and possible effects	U7a	Local knowledge on SES (based on traditional or scientific knowledge)	Agriculture, cattle rising and forestry are based mostly on traditional knowledge systems.
				U7b	Knowledge of the effect of over-harvesting	High level of knowledge
				U7c	Knowledge of the effect of social attitudes toward resource management on the SES	High level of knowledge
				U7d	Knowledge of the effect of biological shocks on the SES	High level of knowledge
				U7e	Mental models related to SES management (e.g. conservation, exploitation, human-nature relationships)	Chinantecs recognize their dependence from nature
	U8	Importance of resources - Users dependence on resources for livelihood		U8	Importance of resources for livelihood	The natural resources of Santiago Comaltepec are the basis of the livelihoods in the community. Dependency decreases with migration and remittances.
	U9	Technology used - Type of technology used to extract, harvest and manage the resource, as well as differences in access among users based on access to		U9	Type of technologies used on the SES	International certified technology is used. Electric saw is being used.

First tier	Second tier			Third tier	
			different technologies		
Interactions (I) — Describes interactions among all before mentioned variables		I1	Harvesting levels of diverse users	Describes quantity of the resource(s) harvested by different users.	I1a	Harvesting level and effects on SES	. Harvested volume is 2500m3 out of 8,000 allowed. No negative effects of harvesting.
					I1b	Free-riding	There are no free riders due to monitoring and sanctioning process. However, occasionally some appear. Moreover, commoners who haven't completed non-paid activities profit from the forest resources in some circumstances. Travel agencies benefited from scenic value and do not pay any fee.
		I2	Information sharing among users	Describes any present scheme of information sharing among users.	I2a	Knowledge dissemination on the SES	The knowledge about the SES is inherited from generation to generation and is also acquired by performing non-paid activities related to the resources.
					I2b	Information/knowhow sharing about the SES variations	Conducting regular meetings and home visits by authorities are the main bodies of interaction.
		I3	Deliberation processes - Deliberation process used among users	Comprises description of deliberation process used among users	I3a	Deliberation processes among users	Trough Assemblies: 1)The authorities organize assemblies, guaranteeing that every community member is informed. 2) Roll call and approval of the day planning. 3) The municipal president officially installs the assembly end the president of the Comisariado

First tier	Second tier			Third tier		
						coordinates it.
						4) Every aspect is discussed according to the day's agenda. Every member can speak to the assembly.
						5) Ones the assembly decides that every aspect is covered, the decision making process starts and all the members vote.
						6) The decision is the one supported by the majority.
				I3b	Knowledge about participation mechanisms and rights	There is high knowledge about the participation mechanism. Every commoner an citizen is aware of the process and of their rights.
	I4	Conflicts among users	Description of any existing conflict among users on resource´s ground.	I4	Type of conflict (e.g. conflict based on greed, grievance, scarcity, technology, access, power, information)	Conflicts among the 3 localities about the distribution of the financial resources obtained from the use and management of the resources.
	I5	Investment activities	Investment activities - Investments for improving and managing the resources (investor, amount invested and destination of investment)	I5	Investment activities (actors involved, changes of the local conditions...)	Different sources: Government institutions, such as SAGARPA carry out productive projects. The CDI invests in projects such as the regional indigenous fund and the women's support programme. The CONAFOR invests in reforestation, soil preservation and maintenance of reforested areas. Roads and air strips of Oaxaca, the Ministry of Roads and Communications SCT and the SAI invest in construction and maintenance of roads. The Ministry of Finances of the State of Oaxaca contributes to the municipal strengthening and social infrastructure. The community invests in the communal enterprises (Forest Management Unit, sawmill, restaurant, ecotourism infrastructure).

First tier		Second tier			Third tier		
		I6	Lobbying activities	Description of lobbying activities (internal, external, influence capacity).	I6	Lobbying activities (actors involved, expected outcomes)	Influence in decision-making activities is made in the assemblies.
		I7	Self-organizing activities - Self-organization activities among users for extracting resources	Description of self-organization activities among users for extraction of resources. Description of any solidarity activities carried out.	I7	Self-organizing activities	Celebrations, *tequios* to preserve and clean the forest, forest fire fighting and care of public buildings.
		I8	Networking activities - Networking activities of the users within and outside the community	Networking activities of the users within and outside of the community	I8a	Internal networks	Committees appointed by the assembly of commoners and citizens. The committees often link authorities, commoners and citizens.
					I8b	External networks	Links between the community inhabitants and emigrated community members. They are in touch by telephone, e mail or the local radio (Radio Guelatao). Linkages with migrants trough the Union of community members living in the United States of America. Links between the communities and international agencies trough the NGOs. Representation of federal and state agencies (e. g. CONAFOR, SEMARNAT and CDI) . The UZACHI to solve technical issues related to the forest; also to solve problems with other ethnic groups.
					I8c	Partnership and cooperation	Partnership and cooperation is widespread among indigenous people
					I8d	External communication channels	NGOs and governmental dependencies, state and federal level

First tier	Second tier			Third tier		
Outcomes (O)	Comprises results of the interactions among aforementioned variables	O1	Social performance measures (e.g. efficiency, equity, accountability, sustainability) - Impact of different activities on social performance	Measure the social performance and impact of different activities within the community, taking into account the welfare of all the local actors.	O1a	Efficiency	The system, compared with others in the region shows strengths but also some weaknesses in its social and organizational structure. There are worries about the sustainability of the cargos system because it imposes high costs to the commoners. Even they want to preserve the governance system and cargos system, they express their difficulties on accomplishing them.).
					O1b	Equity (distribution of benefits between SES users)	1.- Distribution of the benefits of forest management is equitable between the community members. 2./Participation in decision-making is equitable for the community members. 3. La Esperanza and Soyolapam, suffer of limited capacity of decision making capacity, since they account for a low proportion of participants in the assembly.
					O1c	Socio-economical sustainability	The socio-economical sustainability of the system is in danger; youngsters have to migrate for better job opportunities and the difficulties for the accomplishment of non-paid activities increase.
					O1d	Accountability	The Commoner's Assembly of communal property is responsible for these activities
					O1e	Effects of deliberation processes on the SES. Conditions/ change	The decision making on the assemblies have direct influence in all residents.

First tier	Second tier			Third tier	
				O1f	Empowerment (including gender analysis)	The users of the SES are empowered through the strong organizational structure to fight the system´s weaknesses, but this process is in its first stage. Women are increasing their participation in the discussion of the community problems and probably soon they can enter the cargos system. However, if so, institutional changes would have to be introduced.
				O1g	Adaptation strategies to climate change	Special Climate Change Program 2009-2012. Alternative communication routes.
	O2	Ecological performance measures (e.g. overharvesting, resilience, biodiversity, sustainability)	Ecological performance measures (e.g. overharvesting, resilience, biodiversity, sustainability) - Impact of different activities on ecological performance	O2a	Environmental sustainability	There is evidence of environmental sustainability, but future pressures on the water resource are expected.
				O2b	Pressure on resources (e.g. increasing demand, new actors, overharvesting)	There is no pressure on the ecosystem of timber production.
				O2c	Natural habitat (e.g. biodiversity indexes, species richness, connectivity, habitat conservation/degradation/fragmentation)	The richness of plant species has been maintained and the richness of mammals has increased, because watershed protection and wildlife protection areas have formed biological corridors (percentages no available).Conservation of the SES has led the forests to serve as a refuge for species from near deforested systems. There is no evidence of strong erosion and fragmentation.
				O2d	Effect of SES management on natural hazards (e.g. changes in type, frequency, pattern)	There is a real risk of fire during dry periods. However, there is no regular pattern in its occurrence. The fire events are due to external factors and are always controlled by the community members.
				O2e	Structure and function of resources (e.g. changes, interactions among resource units, trophic chains)	The interactions among resource units are maintained. The presence of the jaguar could be a sign of the complete trophic chain.

First tier	Second tier			Third tier		
				O2f	Soil (e.g. erosion, degradation, improvement)	The tropical forest shows signs of deforestation due to the practice of farming and the opening of new pastures.
				O2g	Water (e.g. quality, availability)	The water sheds are of strategic value for the community and the whole region, state and land. The water availability is not a problem in the SES, but distribution channels, for example for agriculture are not developed. Water is available for drinking and bathing. Rivers pollution by waste water.
				O2h	Air (e.g. quality)	Forest fires. Every year coincide with the "El Niño" phenomenon
				O2i	Pollution (e.g. waste generation, frecuency of ocurrence)	There are no signs of pollution as a result of the system performance, but waste and wastewater are not treated.
				O2j	Resilience	The system has been resilient in its ecological performance due to conservation and sustainable forest management.
				O2k	Vulnerability	The vulnerability of the ecological performance increases with the lack of sources that generate income to the community members and with the migration of youngsters in age of performing cargos. Future pressures on the water resources could affect the ecological performance.
	O3	Externalities to other SES - Positive or negative impacts on other SESs without previous agreement or request	Costs of benefits transmitted to another SES without previous agreement or request	O3a	Positive externalities (e.g. CO_2 capture, water protection, biodiversity conservation)	Areas of protection of watersheds, protection and forestry to wildlife preserve a large number of species of plants and animals.
				O3b	Negative externalities (e.g. CO_2 emissions, pollution)	Livestock generates methane emissions but is not significant.

First tier	Second tier			Third tier		
Related Ecosystems (ECO) / Describes the connection of the considered ecosystem with the surrounding ecosystems	ECO1	Climate patterns -	Description of climate patterns affecting the considered ecosystem.	ECO1	Climate patterns (e.g. precipitation, temperature, sea level, extreme events, seasonal changes)	There is no evidence of significant climate variability.
	ECO2	Pollution patterns (water, waste, soil, air, other)	Description of pollution patterns affecting the considered ecosystem and produces by it (water, waste, soil, air, others).	ECO2	Pollution patterns (water, waste, soil, air, other)	There are not relevant patterns of contamination in the SES
	ECO3	Flows into and out of focal SES - Flows from other SESs affecting the considered SES and vice versa	Comprises into and out of flows of different type affecting the focal SES and flows created by focal SES affecting surrounding SESs	ECO3	Flows from other SESs affecting the considered SES and viceversa (economic pressures, environmental effects and social effects)	It generates positive flows into communities by the conservation of the biodiversity and because it serves as a refuge for species such as the Jaguar, that probably migrated from the region of the Papaloapan, whose systems have been degraded in great magnitude. Pests eradication helps to the health maintenance of nearby systems. Comaltepec' community pour their wastewater and contaminated nearby communities.

Annex II. Principal variables

S1a Economic activities

Economic activities (S1a) represent a third-tier variable according to Ostrom's framework, derived from the second-tier variable Economic development (S1). These *Economic activities* are those that represent a source of income for the community members.

- ¬ • Agriculture and livestock
- ¬ • Forestry and natural resources (including ecotourism)
- ¬ • Trade (mainly retail trade)
- ¬ • Services

S1d Livelihoods

The variable *Livelihoods*, according to the framework for analysing SES is originally labelled as *Subsistence Activities*. The name was changed to *Livelihoods* due to the fact that the research team considered this concept more consistent with the study unit. *Livelihoods* are the day-to-day activities performed by all inhabitants for the subsistence of the families and the community regardless of whether or not they generate monetary income.

- ¬ • Agriculture and livestock: Activity held to satisfy food requirements within the community. Only a small amount of the production is traded outside the community.
- ¬ • Forestry and natural resources (including ecotourism)

S1e Non-paid activities

Non-paid activities are those held by the commoners without payment and on mandatory basis. These activities strengthen the community ties. Some of the most important activities in this category are: service to the community (*cargos* and commissions), unpaid labour for the community (*tequios*), domestic labour, and monitoring activities.

- ¬ -Public offices (Cargos)
- ¬ -Attendance at community meetings
- ¬ -Tequios and commissions
- ¬ -Domestic work.
- ¬ -Subsistence agriculture
- ¬ -Livestock
- ¬ -Collection of wood chips
- ¬ -Establishment of limits of the territory through trenches, location mojoneras and physiographic limits.
- ¬ -Collection
- ¬ -Management and community activities
- ¬ -Monitor socio-ecological system permanently

S2f Migration trends

Migration trends refer to changes in the migration patterns and to the nature of such changes over the years, as well as to the reasons for the changes. This variable also includes identifying who migrates, why and where to.

In the case study, migration started in the eighties and nineties and there has been a stable trend since then, showing some declining tendency in the last few years.

Migration due to cultural issues. Relevant to move for a time, either for work or for higher education. Indistinct genre, from 1982 to date, have migrated 450 individuals at ages older than 18. Migrants age range: 18-45 years.

S3 Political stability

Political stability is related to the political conditions on the regional, national and local levels, (if) whether stability or conflict (either current or potential) prevails. It also refers to the degree of compliance with the rules due to the knowledge that community members have of them and to the community's enforcing power. The trust and predictability of behaviour and reciprocity among commoners is important for *migration trends* and *political stability*. The same can be said about the trust in the authorities' performance.

The state of Oaxaca is listed in those severely affected by insecurity. Regional and internal differences on regulation and compliance. Local regulations are the most important in the study area, those are well known and most respected. Local regulation compliance occurs parallel to federal framework compliance. There is great respect for democratic values at a local level. Corruption is apparent at regional and national levels.

S4b Types of environmental laws

This variable includes environmental laws affecting the interrelations among the resource units on the regional, national and local levels; for instance, if the community performs or stops performing certain activities related to the natural resource management due to regional environmental laws.

The control and monitoring policies by Mexico's federal Ministry of the Environment and Natural Resources SEMARNAT. There exist diverse federal programmes for natural resources protection, sometimes these programmes do not consider, respect or combine local practices.

GS8 Monitoring and sanctioning processes

These processes allow the strengthening of operational rules within the system. The commoners monitor the correct use of the system resources and verify compliance with the established rules. When compliance with the rules is not effective or the resources are used inappropriately, the authority imposes sanctions (monetary, community labour, imprisonment).

The rules for monitoring are established in the communal status. All Community Member is obliged to report any incident or misuse of resources and, if possible, should solve the problem at the moment through dialogue with who has violated the rules of for avoiding going to Federal sanctions.

GS1 Government Organisations

Government organisations (GS1) are a second-tier variable that refers to the multilevel organisations affecting the system, its performance and its structure; for instance, the Commoners' Assembly, the Citizens Assembly, the municipal authorities, the Communal Property Commissioner, and the Surveillance Council.

The community has the maximum authority in this system by its assemblies. There are two kinds of assemblies: commoners' and citizens' assemblies. The commoners' assembly is the main authority regarding the use of the resources. The Community Council does the implementation of agreements; this Council divides into two structures: the communal property commissioner (or Comisariado) and the surveillance committee. Another implementing body is the Municipality Council. This takes the responsibility of implementing the citizens' assembly agreements, regarding public services, including public spaces, water, sanitation, health, education, roads, cemeteries and market places. The *caracterizados* group is important for the decision making process in the community, it is integrated by respectable community members designed by the citizens' assembly (due to their good cargos' performance). Additionally, there are committees for diverse activities in the community and also an organization named supporting group (or cuerpo de apoyo), which functions as an emergency body, for example in case of fire events.

GS4a Property Rights System

The *Property Rights System* (GS4a) describes the existence or absence of formal property rights regarding the resource system and the common pool resources.

In 1953 the community acquired the land property rights of 18,366 Has. In 1982 the community achieved to revoke the 25 year concession that had been given to FAPATUX (paper enterprise) by the government. In 2008 PROCEDE by its Spanish acronym recognized the property rights of the community over 19,981 Has. The use of goods for self-consumption requires permission of the *Comisariado* and authorization of the municipal authority. According to Article 27 of the Federal Constitution all land belongs to the Mexican State. The agricultural plots assigned to each commoner never cease to be common property.

GS6 Collective-choice rules

The *Collective-choice rules* (GS6) rules for collective action and community-based management of resources

All the collective agreements are taken during by the general assembly, which is composed by commoners, and citizens. The assembly decides on the rules. The advice of the group of the *Caracterizados* is fundamental for the decision making process.

RS6b Exclusion and extraction rights

This variable refers to the rights to define who has access to the resources and to its management. The assembly of commoners defines who can use the resources and how and intervenes in the decision making process related to *exclusion and extraction rights*. It makes a lot of difference when these rules are clear or not.

Exclusion and extraction rights are only discussed in the commoners' assembly. All the community landholders check unauthorized exploitation, while doing farm work. Visitors must pay a fixed fee to the community Ecotourism Company. The exploitation of forest resources are commercially only through curatorial or

communal enterprises are formed by assembly agreement. Trees that are cut should be marked for the address marker technique with his hammer.

RU4 Economic value

Economic value (RU4) refers to the prices of the natural resources, for instance, timber and forest prices.

The removable wood from the forest has a value of $184,514.00. See RU4. Price of purchase with other communities of roundwood: primary $1,350 per m3; secondary $1,150; cellulosic $750 per m3. Thousand room $950 m3. Wood transformed: wood of class $12.50 Board by thousands, secondary $11.20 foot foot table. Fourth $9.50. Quinta $5.00. By-products: $5.00 cubic meter. The *economic value* is higher than the market value, whereas the *economic value* includes use values and non-use (these last capture and sink of carbon, scenic beauty and other hydrological services)

U8 Importance of resources

This variable is related to how important the resources are for the lives and economy of the commoners and how much they depend on such resources.

The natural resources of Santiago Comaltepec are generating some incomes. Ecotourism industry and starting to enter to the REDD+ programmes. USA remittances are important for less dependence of the forest.

U3 History of use

It is the history of the community, regarding land use and natural resource management. It also comprises how the interactions among the resource units have changed over the years.

- ¬ 1603 October 20 Community Foundation
- ¬ 1954 with the pavement of the highway, the wood products industry began. There was no limit of extraction, by which the company FAPATUX caused problems in the pyramid of age of the forest.
- ¬ 1980-1982, the community and UZACHI fought to remove the forest concession to the trash, he was accomplished, but there was no clear vision about what would be done with the forest.
- ¬ 1992-1993, with the collaboration of was A. C. developed the forest management plan
- ¬ 1993, December, was awarded the forest management to the community. July 22, 1994, the Community approves the Plan of land use and management forest.
- ¬ 1997, UZACHI forest management system was certified by Smart as sustainable Wood under international standards of FSC.
- ¬ 2004, the community receives the first payment for environmental services
- ¬ 2009, Bonnart (2009) evaluation considered that the trend in the rate of extraction is low. This may be higher if new projects, taking care not to violate the principles of sustentability
- ¬ November 2012, the ecotourism company is established. Currently, a study on absorption of CO2 is carried out with the purpose of joining the REDD+ program.

U2i Sanitary conditions

Sanitary conditions (U2i) variable is related to the infrastructure and services that improve health conditions in the community.

- ¬ Most of houses have WC facilities.
- ¬ Sewage throughout the community.
- ¬ No treatment of black waters.
- ¬ Piped water available