



D2.2: “Stakeholder vision on problems and drivers related to environmental challenges in Colombia case study”

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Executive Summary

This document presents the second deliverable (D2.2) of Working Package 2 (WP2), entitled "Stakeholder vision on problems and drivers related to environmental challenges in Colombia case study." This deliverable focuses on two interrelated themes. The first is the description of the study area, based on the characterization of socio-ecological systems (SES) grounded in the Ostrom's approach (2009) presented in deliverable D1.1 ("Locally-adapted tools for the characterization of social-ecological system"). The second issue is the presentation and discussion of the results from part of the Prospective Structural Analysis (PSA) carried out with different stakeholders, in order to identify the variables (from the characterization) that are most relevant to the dynamics of the socio-ecological system in Colombia, specifically in relation to the behavior and state of biodiversity and water in the study area.

The work carried out in COMET-LA has a clearly participatory approach, which involves actively different stakeholders and especially members of the communities in the entire process of data collection, systematization and analysis. This commitment of the project to a research process with a participatory approach has meant the use of different tools to apply this approach in the field. Thus Participatory Rural Appraisal (PRA) tools have been used in workshops and forums. In the case of Colombia, the participatory methodological route also included the formation of a team that was called "co-researchers team", consisting of 25 men and women of both Community Councils, who were trained in relevant COMET-LA concepts (gender, socio-ecological systems, governance, planning, foresight) and participatory methodologies (participatory approaches to group work, moderation and facilitation techniques, and tools of PRA, systematization and analysis) and design and implementation of surveys (see Briefings: "Training Process for Co-Researchers from Community Councils of Black Communities in Alto y Medio Dagua and Bajo Calima" and "Participative Approaches to characterize socio-ecological systems and analyze governance of natural resources"). PUJ professors, with this co-researchers team, conducted several activities in both Community Councils to collect and analyze primary data for both the characterization and the PSA.

The application of Ostrom's approach (2009) requires a clear delimitation of the SES to be characterized and analyzed. In the case of Colombia, based on the review of secondary sources and primary data from the field, and from discussion with members of the Community Councils and other stakeholders close to these, four specific SES or case studies were selected (two in each Community Council): La Delfina and Zaragoza (in Dagua) and La Esperanza and Crucero (in Calima).

The main conclusions from this deliverable are:

1. The implementation of the matrix of variables proposed by Ostrom in 2009 was useful for testing of the validity of theoretical models developed for the study of SESs. It is recognized that locally, especially given the scale, many variables overlap and it is difficult to collect data for their characterization because of the novelty of some terms for communities.

2. It is recognized that the methodological combination proposed in this research was effective for recognizing the variations and mental models at local level that local inhabitants have about the interaction of the social, ecological and economic systems.
3. The process at local level was very useful to observe the importance of analyzing the local governance systems and to identify that not all activities are regulated locally, not just because inhabitants do not recognize this as necessary, but also because people recognize that extraction and new stakeholders have to be taken into account in the regulations design.
4. The combination of the characterization of the SES and PSA was important to identify variables such as resilience, strength and vulnerability that are needed to develop and to enhance the community participatory process.
5. The use of Mic-Mac methodology as an analysis tool in the context of socio-ecological systems proved useful, not only to identify variables that determine the evolution of the system, but also to enable a deeper understanding of the structure of socio-ecological system. It is important to make an educational effort in order to adapt the entire prospective methodology to local situations and stakeholders.
6. Since the SES analyzed are located in the Colombian Pacific context and in a special political and administrative division, 90% of the identified variables were common to SES selected in the territories of Dagua and Calima. However, the variables that are not common, play an important role in the behavior of the SES, so it is possible to say that the spatial proximity and similar socio-economic structure do not necessarily determine similar behaviors or structures, and their evolution can take different paths depending on the role played by key variables and their interactions within the system.
7. Within the overall set of variables, external variables play a key role in guiding the evolution of the SES. These variables, such as large infrastructure projects and illicit crops have a low level of influence, but generate, in turn, a high impact on the system structure such as pollution and deforestation.
8. The governance system of water resources and biodiversity in the SES studied is part of its social subsystem and is based on a process of social structuring that gradually has been including various stakeholders who have social, environmental, economic and political roles and have various forms of technical and institutional support. However, this external support is not sufficient and different dynamics hinder its orientation towards an ideal way in which consensus and local institutions are in the first level. It is therefore possible to consider that the governance system in this case is in the process of consolidation and has a polycentric character since the power is shared by multiple actors.
9. These difficulties prevent the possibility of Community Councils taking autonomous responsibility for the management of biodiversity and water. They need more support from public institutions. In this sense, it is important to consider both the effects of existing environmental conflicts, and the



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relationships between the stakeholders in the system and in particular between the public institutions and the Community Councils, the role played by these in the territory, and the difficulties present in this.

1 Introduction

This document presents the second deliverable (D2.2) of Working Package 2 (WP2), entitled "Stakeholder vision on problems and drivers related to environmental challenges in Colombia case study." This deliverable focuses on two interrelated themes. The first is the description of the study area, based on the characterization of socio-ecological systems (SES) grounded in the Ostrom's approach (2009) presented in deliverable D1.1 ("Locally-adapted tools for the characterization of social-ecological system"). The second issue is the presentation and discussion of the results from part of the Prospective Structural Analysis (PSA) carried out with different stakeholders, in order to identify the variables (from the characterization) that are most relevant to the dynamics of the socio-ecological system in Colombia, specifically in relation to the behavior and state of biodiversity and water in the study area.

It is worth repeating that the Colombian case study is located in the territory of two Community Councils of Black Communities within the municipality of Buenaventura (Valle del Cauca): Alto y Medio Dagua (AMDA) and Bajo Calilma (BC). As mentioned in the first deliverable D2.1 (September 2012), the inhabitants of both Community Councils are mostly black communities, mainly settled along the river banks of Calilma and Dagua rivers. The Councils have a heritage and collective cosmology, what constitutes a human group with a common history, from its origins as slaves brought from Africa to America in colonial times. Their concept of territoriality is a key issue to understanding, not just their philosophy and community action, but also the process of territorial and environmental organization in the Pacific area. Both Community Councils are located in the Chocó biogeographic region. This region has been recognized internationally as one of the most biologically diverse on the planet. It covers the northwestern corner of South America, from south of Panama to northwestern of Ecuador, and limits to the east with the western slope of the Andean Zone and to the west with the Pacific Ocean.

The work carried out in COMET-LA has a clearly participatory approach, which involves actively different stakeholders and especially members of the communities in the entire process of data collection, systematization and analysis. This commitment of the project to a research process with a participatory approach has meant the use of different tools to apply this approach in the field. Thus Participatory Rural Appraisal (PRA) tools have been used in workshops and forums. In the case of Colombia, the participatory methodological route also included the formation of a team that was called "co-researchers team", consisting of 25 men and women of both Community Councils, who were trained in relevant COMET-LA concepts (gender, socio-ecological systems, governance, planning, foresight) and participatory methodologies (participatory approaches to group work, moderation and facilitation techniques, and tools of PRA, systematization and analysis) and design and implementation of surveys (see Briefings: "Training Process for Co-Researchers from Community Councils of Black Communities in Alto y Medio Dagua and Bajo Calilma" and "Participative Approaches to characterize socio-ecological systems and analyze governance of natural resources"). PUJ professors, with this co-researchers team, conducted several activities in both Community Councils to collect and analyze primary data for both the characterization and the PSA.

The training of a local team has been vital in this process, since it has enabled local capacity building in order to have greater depth and closeness to reality in the analysis.

The application of Ostrom's approach (2009) requires a clear delimitation of the SES to be characterized and analyzed. In the case of Colombia, based on the review of secondary sources and primary data from the field, and from discussion with members of the Community Councils and other stakeholders close to these, four specific SES or case studies were selected (two in each Community Council): La Delfina and Zaragoza (in Dagua) and La Esperanza and Crucero (in Calima) (see Briefing "Socio-ecological Systems Characterization: Some aspects from Colombia Case study" and section 2.2 of this document). The elements that characterize these four case studies are:

- Dagua:
 - La Delfina: town, aqueduct, river, agriculture, forest and road.
 - Zaragoza: town, river, mining, aqueduct and forest.
- Calima:
 - La Esperanza: town, river, agriculture
 - Crucero: town, river, road and aqueduct.

To characterize the socio-ecological systems (with co-investigators) four transects and a workshop with PRA tools were carried out in each of these sites. Also, secondary sources of information were reviewed. Furthermore, some of the elements from the deliverable D2.1 were revisited. The results of the characterization is reflected in Chapter 2 of this document (Description of the study area), which was made using local adaptation of the Ostrom framework (see deliverable D1.1) applied also to the other two COMET-LA case studies (Argentina and Mexico - View deliverables D3.2 and D4.2). This characterization focuses on the eight first tier variables of Ostrom framework.

Chapters 3, 4 and 5 present the results, discussion and analysis of the PSA (until the matrix of direct influences). As explained below, there were five workshops of PSA in the communities: the first one with the co-investigators of the Alto y Medio Dagua, the second one with the co-investigators of Bajo Calima, the third with public officials and members of other entities for the municipality of Buenaventura, the fourth with people in the communities of Zaragoza and La Delfina (AMDA), and the fifth with community members of El Crucero and La Esperanza (Calima). The results of these workshops were processed and analyzed with the MIC-MAC software and the results were presented and discussed in two forums with stakeholders, one with local people in Buenaventura and other at regional and national level in Cali.

Finally, chapters 6 and 7 present discussion and conclusions on the problems and drivers of the environmental challenges associated with socio-ecological systems of the two Community Councils.

2 Study area description

The study area description is based on eight first tier variables of the Ostrom framework (2009) (See Annex 2 and deliverable D1.1), which are listed below to clarify the characterization:

1. Social, economic and political setting (S)
2. Resource Systems (RS), Resource units (RU) and Related Ecosystems (ECO)
3. Governance Systems (GS)
4. Users (U)
5. Interactions (I)
6. Outcomes (O)

2.1 Social, economic and political setting (S)

The context in which the Community Councils of Black Communities of Alto y Medio Dagua and Bajo Calima is very important in terms of their economic, demographic and political dynamics, since these dynamics are influenced not just by national, regional and local policy decisions, but also by various market signals and messages received from different media. Also, the context is influenced by processes occurring in the Community Councils. Next an overview of the social, economic and political environment in which both councils are acting is presented. For details of this characterization see Annex 2.

As mentioned in the introduction, the two Community Councils are part of the Chocó biogeographic eco-region. In demographic terms, the majority of the population is of African descent or black, but there are also indigenous and “colonos” inhabiting the territory. The settlements are located mainly along rivers and roads. There is a growing increase in population from increasing birth rate and the migration of new actors into the territory, especially those related to natural resource extraction. Population growth is increasing despite the relatively high migration of youth to adjacent cities in search of better educational and employment opportunities.

The main economic activities in this eco-region are wood extraction, agriculture, artisanal mining, artisanal fishing and tourism, all of which are highly dependent on natural resources in the region, especially the biodiversity and water. Since none of these activities itself generates enough income for a family to live properly, people distribute their time in various economic activities, which seek to have diversified sources of income to meet their needs. The average monthly income of a person and a family in the region are below the national average and overall living conditions of the inhabitants of the Pacific Coast are much lower than those of the Colombian population, being the region with higher poverty rates in the country. In the Community Councils of Pacific black communities, members of the boards and the legal representative carry out activities related to the management and decision making of the territory, which are not remunerated, and therefore these inhabitants share their time between their community and leadership work with economic activities that generate income to support themselves and their families.

In a context in which communities have been inhabiting the territory for a long time and have been generating their own dynamics for decision making and use of natural resources, it is important the State recognizes these processes and the right of these communities to control their territories. In this sense, the 1991 Colombian Constitution in several articles explicitly recognizes and seeks to promote the rights of indigenous peoples and Afro-Colombians to their territory and the preservation of their customs. In order to promote these constitutional principles, Law 70 of 1993 was issued i to recognize the right of black communities to

collective ownership of the territories that have been occupied by them in the rural areas encompassing the rivers of the Pacific Basin, according to traditional production practices. Also, the law seeks to establish mechanisms for the protection of cultural identity and the rights of Colombian black communities as an ethnic group, and to promote economic and social development, in order to ensure real conditions of equal opportunity in relation to the rest of Colombian society. Under these criteria, as part of the regulation of the law, the decree 1745 of 1995 was issued. This states that a black community may become a Community Council as a legal entity that holds the highest authority within the internal management of territories of black communities. One of the issues that still is demanded by black communities is the regulation of some of the articles of the law 70, in order that the legal framework is much clearer and provides legal guidance in the territories of black communities for its inhabitants and for other local, regional, national, and even international stakeholders.

The right and responsibility of Community Councils of black communities in the management of their territories, are put in practice under the national legal framework, which main principles are in the 1991 Colombia Constitution, and according to which the State has the responsibility to "protect the diversity and integrity of the environment" and "conserve areas of special ecological importance" (Article 79, inc.2). Following these constitutional mandates, in 1993 the National Environmental System was created, and one of its main elements is the management of biodiversity and the need for research and increased knowledge about biodiversity in the country. In this sense, in that same year, the Alexander von Humboldt Institute for Biological Resources Research was created, in order, first, to carry out processes of scientific research on biodiversity in Colombia, including aquatic and genetic resources, and moreover, to coordinate the National System of biodiversity information and the formation of the national inventory of biodiversity in Colombia. In 1995, the National Biodiversity Policy was published by the Colombian state. Currently, this policy is in the process of being updated and discussed with various institutions and civil society. As part of this process, since 2009 the Von Humboldt Institute has been building an agenda for institutional research on biodiversity, and in 2011, the Four Year Plan for Environmental Research Institution (2011-2014) was established as the primary corporate strategy to guide and support the management of biodiversity in the country, in the context of productive activities.

At the national level, the level of compliance with environmental regulations is between medium and low. In the case of Buenaventura, the environmental regulation at the national and departmental levels, are applied by government environmental authorities. Locally, knowledge of legislation relating to the management and governance of the territories of black communities is very good. Community leaders always have the need to apply this legislation for the benefit of their communities. Therefore, there is a difference in perception of the importance of standards and compliance with these among the representatives of the communities and the communities themselves.

The councils of black communities have to manage their collective territories within a context of armed conflict, which is present in several areas of Colombia, among which are the geographic areas of the two Community Councils. Locally, the conflict occurs primarily by access to resources such as gold, which can affect water conditions and biodiversity. This and

the presence of illicit crops (coca), provide challenges for the governance of natural resources by the communities.

In addition to the legal framework and the context of conflict that significantly influence Community Councils, market signals are relevant to environmental dynamics of the region. Thus, wood extraction is fueled mainly by domestic and regional markets, while the activity of fishing, river sand mining and agriculture respond especially to local markets or subsistence needs. Meanwhile, international markets influence the gold activity and illicit crops (coca) in the region. Most products are sold mainly in the local market, with Buenaventura as the main center for for distribution. The influence of the market depends largely on the distance to the centers of demand. Both Community Councils are located relatively close, by road, to Buenaventura city and between 3 and 5 hours from Cali. This road connects the country center with Buenaventura, the main port on the Colombian Pacific coast. In addition, there are three weekly return flights between Bogota and Buenaventura.

The media have a significant influence on how people manage their territory and especially on the environmental consciousness of the people. Although there are no community radio stations in the area, there are several stations broadcasting from Buenaventura. There is a TV channel that although it does not have a close relationship with the Community Councils, it produces programs with environmental content that seeks to highlight the value of biodiversity and overall environmental wealth of the Colombian Pacific territory. Community Councils have little influence on the content of radio and television programs, although possibilities have been opened recently and there is an increased interest from the local media to cover the successes for the protection of natural resources by Community Councils.

The analysis of official documentation, plans of municipal development and territorial planning, among others, reflects a strong emphasis on the development of the urban zone of Buenaventura and its related infrastructure and port. Rural development in turn has not had sufficient support on key issues such as wastewater treatment, solid waste disposal, drinking water supply, improved housing and rural electrification. For example, municipal investment in agricultural development and the environment does not exceed 0.2% and 0.3%, respectively, of the total municipal budget for 2012. Linked to this problem is the limited capacity of intervention of public institutions to control problems such as illegal mining, wood extraction and cultivation of coca. Also, there are major obstacles for coordination and there is a high dependence of public institutions on central control from Bogota.. In general, these obstacles are reflected not just in the limited public sector intervention for sustained protection and integrated management of water resources and biodiversity, but also in the significant obstacles faced by Community Councils in this area.

2.2 Resource systems (RS), Resource Units (RU) and Related Ecosystems (ECO)

The socio-ecological systems analyzed in the Colombian case study are the water resources and biodiversity in the Community Councils of Alto y Medio Dagua and Bajo Calima.

Environmental and soil characteristics of the Alto y Medio Dagua and Bajo Calima, are typical for tropical rainforests, with high levels of precipitation, high levels of biodiversity, high ecosystem fragility and relatively poor soils (Bene et al ., 1979).

According to the Water Resources Group of CVC (2009), Dagua River basin is 1,422 has, with an annual caudal of 28,402 l/s. For its part, the Calima River Basin has 1,374 has, with estimated annual caudal of 186.145 l/s. The two areas have a relative humidity of 88% and an average annual temperature of 26°C.

According to the data recorded in the IDEAM weather station, located in the Buenaventura airport, the annual average precipitation, for the last 10 years, is 6988 mm, the minimum monthly precipitation is 103 mm, maximum 1030 mm, and average monthly precipitation is 582 mm (CC Dagua, 2007: 10). In the case of Bajo Calima, the annual average precipitation is 7500 mm (CC Alto y Medio Dagua, 2008: 42).

Soils for low Calima area mostly deficient in P, Ca, K, Mg, Cu, B, Mn and Zn; the percentage of aluminum saturation is high (between 60 and 90%) indicating toxic levels in the soil; and there is a low cation-exchange capacity at edaphic level (less than 10 meq/100 g). (Martinez, 2007).

The volume II of the characterization made by the CCAMD and FUNDAPAV (2013) mentions that:

"The variety of vegetation and fauna have emerged as one of the most biodiverse regions on the planet [...] it has been identified as" the highest concentration of biodiversity per unit area reported in the world, 400 tree species and 800 vertebrates per has. have been founded, a record data higher than the Amazon ones (Cortes & Restrepo, 2002). Between 7,000 and 8,000 species of plants from the 45,000 that are in Colombia, have been discovered and it is believed that more than 2,000 species of plants and 100 species of birds in the region are not found elsewhere in the world "(Biopacífico, 1994). However biodiversity and endemism have been threatened by deforestation in the region that has reached more than 5,000,000 has.; In this sense, this region has been affected by degradation and loss of forests, which has involved the reduction of biodiversity and the likely extinction of many species.

The intensity of deforestation is increasing alarmingly over time, so only 43% of the estimated forest of the region in 1959 (9.806.050 hectares) remained in the mid nineties (4,248,550 hectares) as a result of annual deforestation estimated at about 154,000 hectares (Sanchez, 1996)" (own translation).

The region has extensive forest areas where high biodiversity is associated. It is important to note that even within the territory there are areas of primary forest, exploitation for years conducted by a private company has replanted a secondary forest with species such as blackberry (*Miconia sp* - melastomataceae), chestnut (*Heliathostylis sprucei* - moraceae) guabo (*Inga sp* - minosaceae), caimito (*Pouteria sp.* - Sapotaceae), azulito (*Mabea chocoensis* - euphorbiaceae), anime (*Protium sp.*, Burseraceae), chaquiro (*Goupia glabra* - Celastraceae), guasco (*Eschweiler sp.* - Lecythidaceae) manglillo (*Icacorea manglillo* -Myrsinaceae) and cargadero (*Guatteria calimensis* - Annonaceae) (Martinez, 2007; CCAMD-FUNDAPAV, 2013). The presence of these species suggests that the basins of the rivers Dagua and Calima in this area are in the process of regeneration: "the emergence of a large number of palms indicates the high development of natural regeneration of forests, which constitute good health" (CCAMD-FUNDAPAV, 2013; own translation). The state of forests is also an indicator of the

state of biodiversity associated to them, with high numbers of birds, reptiles, amphibians and mammals.

As mentioned above, two socio-ecological systems or case studies were selected in each Community Council. Although the four selected social-ecological systems do not have defined physiographic limits, they can be differentiated clearly, responding to the historical trends that have characterized the productive activity in the region. From the people point of view on their territory, the road and the river are both productive and population axes which make differences between socio-ecological systems (Martinez, 2007). These biophysical characteristics allow communities to make permanent use of natural resources and inhabitants are financially dependent on them: the soil resource for agricultural production, water resources for gold mining, sand and fisheries resources, and forest resources associated to biodiversity.

In the case of the Community Council of Bajo Calima, Calima River is its main tributary, although most productive activities occur near streams or small rivers. In the community of El Crucero gold mining and forest resource extraction are identified as the most important activities, because its proximity to the road allows for the transportation of these products.. In the community of La Esperanza, a settlement located along the Calima River, the fishery resource becomes the most important activity, although there are also gold mining and forestry.

In Alto y Medio Dagua, the two case studies (The Delfina and Zaragoza) have access to Dagua river. In La Delfina, agriculture and forestry are related to the resource supply of tropical rainforests (Bene et al., 1979), which are located around the community in the mountainous area. The sloping topography and soil constraints in this type of biomass have generated small-scale agriculture based on ancestral knowledge for food production. The composition of these agro-ecosystems includes a wide variety of medicinal plants, fruits, tubers, palms, etc. For Zaragoza, for its strategic location and access to the river, gold mining is the productive activity that generates more income for this and surrounding communities.

In the Community Councils, there is forest extraction (primary forests in the highlands), gold mining areas, river material extraction (on the banks of rivers) and agricultural production in the lowlands of the rivers where soils are more suitable for these activities. The seasons are determined by rainy and short summers, although they are not perceived by communities as a constraint to livelihoods, the increasing climate variability may generate significant impacts in the future.

The environmental value of resources in the area is high. The four socio-ecological systems are located in a priority area for conservation, especially for the quality and quantity of available water, biodiversity, carbon sequestration and climate regulation. The current community management of natural resources has proposed an initiative for communities to create parks with ecological trails, which have been implemented in Bajo Calima using solid wastes. Also in both Community Councils there are places like "balnearios" and family recreational tourism sites along the Calima River, as well as some recreational places along the Dagua River. In the document on Dagua's characterization (CC Dagua, 2013) there is an

exercise of economic valuation of some environmental services and products of the territory of this Community Council. For the case of Calima, there are not studies related to this.

The greatest threats to the biodiversity maintenance in the study area are the destruction of habitats, commercial extraction (wood, hunting, mining, illicit crops and species traffic), the unplanned growth of human settlements, and environmental contamination derived from limited basic sanitation.

Speaking in terms of agricultural production, CCAMD and Fundapav (2003) says:

"The size of the production unit in the area is not confined to a single space, it is common that the family has several plots for agriculture as well as those which set the houses. There are plots between 1 and 4 has for agriculture and livestock activities. It should be noted that there are large areas of conservation (water sources, streams, flora, fauna), which are also used by community (forestry species, medicinal and magical plants, hunting, etc)" (CCAMD and FUNDAPAV, 2003; own translation).

The boundaries of the territories are clearly established in political terms as well as the access and property rights. Although the territories are collective, every family has at least one plot on which they can cultivate. This, in most cases, is known as "patio" (courtyard), and is the place where there is exclusive private property, whilst in a wider context the ownership of the forest is communal. Although each family has their plot, the conservation area belongs to and should be cared for by the community as a whole. Similarly, rivers, streams, and much of the territory is for collective use and management. Community Councils have their internal rules in a document which establishes the rules and regulations for the management of the territory. However, it is difficult to control access by people outside the community, especially for the extraction of gold mining and forestry resources.

According to the national measurements, the system is highly productive in terms of availability of natural resources. In the four socio-ecological systems, the productivity of the resources system is currently between medium to high. There are large areas of forest reserves and an abundance of water resources. However, there are threats on these resources that can put them at risk in the medium and long term, specifically the water resource is at risk from gold mining activities and processes of pollution and removal effect of the use of backhoes and the presence of illicit crops. Although the Community Councils and environmental organizations carry out education and training activities in order to raise consciousness of these illegal activities, their capacity to intervene is very limited. Local inhabitants believe that the productivity of the soils has declined gradually. Some local experts believe that this decline has been the result of the use of agrochemicals and erosive processes produced by: changes in rainfall regimes and the occurrence of large scale mining affecting ground cover. Also they recognize that productive activity has declined because there is less participation by young people.

With respect to climatic variability, rain and dry seasons determine access to different resources. In general, in dry seasons people carry out activities such as wood extraction, hunting and agriculture, while in rainy seasons they transport wood to commercial centers. After the rainy season, river material and gold are extracted. It is important to clarify that for

local inhabitants, rainy and dry seasons are based on differences in the relative amount of rainfall, not on periods of complete drought. In general, there is a low occurrence of natural disasters, although there are occasional floods, although there is no clear information about cycles or frequencies along Dagua and Calima rivers. In Alto y Medio Dagua, in the community of Triana, there was an avalanche in 2006, which destroyed part of the infrastructure. However, natural disasters arising from the change in the level of the river may increase because of extraction of river material, so the vulnerability to landslides during rainy seasons could increase.

In El Crucero in Bajo Calima, the lack of a sewerage system, has caused soil erosion around the housing for these communities. Also, erosion by rain derived from the wood extractive activity has affected the quality of soils for agriculture and makes them vulnerable to geophysical erosion. In La Esperanza there are floods that frequently affect the community, since there are constant landslides along the river bank, particularly where there have been attempts to carry out mining.. In order to overcome this situation, inhabitants have constructed their houses further away from the banks of the river.

In the four socio-ecological systems, floods have affected seriously the food production and the life conditions of the communities. But extractive dynamics (i.e. wood extraction) are benefited for the river flow increase because this facilitates the transportation. Likewise, according to villagers, floods increase the amount of gold and river material. Therefore, communities easily adapt to environmental changes because sometimes these changes represent opportunities to extract resources. With respect to other extreme conditions, storms, hurricanes, high tides and earthquakes there has been not recent data showing these affecting these communities.

Although they are not series of data that describe accurately the behavior and the relationship between biological, economic and social systems, it is possible to say broadly that socio-ecological systems have high levels of learning and feedback. So far the territory of both councils has been affected by two periods with high extraction of resources. First, from 1959 until 1993, there was wood extraction carried out by concession to a private company. Currently the ecosystem is recovering from this period and there is substantial regeneration of the forest plants. Strong impacts on ecosystems and the difficulty in the recovery of the environmental conditions have generated a process of learning for communities around wood extraction and other extractive processes. Second from 2010 to date, there has been was gold extraction in the area, which is considered critical for its negative impacts in terms of environmental damage and violence.

Another important characteristic of SES is related to the infrastructure or variations that local actors have promoted to improve local living conditions or to boost the connections between the SES and the context. Examples of these are the construction of schools, social centres, houses, community aqueducts, recreation areas, cemeteries, churches, promoting health centres, pedestrian crossings, among others.

Finally, it is important to summarize the socio-environmental conflicts currently affecting the the system resources including : illegal mining; indiscriminate extraction of forest species; pollution of water resources by mining activity; illicit crops (coca); poor management of solid

waste; and poor service of sewer system in the different villages. These conflicts are endangering the general resources system in the area.

2.3 Governance Systems (GS)

In the four SESs it is possible to identify various governance systems of natural resource that overlap each other in the arena of action of the communal territory of each council. For example, in La Delfina it is possible to observe a system of governance related to wood extraction that as it evolves towards conservation and strict regulation of this resource extraction, affects the growth and direction of the governance system of the traditional agriculture. For this reason, the discussion in this section focuses on how the social component of the studied SES generates consensus around the management and water management and biodiversity. It is important to clarify that the governance system of the territory is the common link between the previous systems and it is the general analysis framework that guides COMET-LA. Consequently, it is essential to know the actors and the relationships between them that make up the governance system of water and biodiversity, in the context of Community Council territory. Also, it is necessary to understand the capacity of agency that those actors have, at local, regional and national level.

In both Community Councils, there is a group of organizations whose function is to coordinate and to guide the governance systems in communities and in particular the governance system of biodiversity and water. Although the main authority is in the Council itself, as a central stakeholder in the territory, other entities playing a key role in decision-making and internal processes for achieving consensus on management about biodiversity and water resources are: general assembly, board of directors, legal representative and “veredales” committees or coordinators. Through these entities, the Community Council maintains, establishes and renews its links with other public and private institutions at various levels.

The main link with the public sector at local level is the Mayor of Buenaventura and directly with various secretaries within it, such as the secretary of education, government, health and environmental management, with whom the Community Council interacts in relation to the management of services such as water supply. At regional level, the most important links have been created with CVC, which issues various regulations for the use and access to water and biodiversity. Nationally, there are important links with institutions such as the Colombian Institute for Rural Development (INCODER) in terms of not just regulation of the use and control over the territory, but also in terms of incentives for rural development projects that affect directly and indirectly water and biodiversity. At this level, there are also national institutions such as the National Learning Service (SENA) and the Ministries of Environment, Social Protection, Interior, and Agriculture and Rural Development, which are some of the institutions that the Community Councils are in constant dialogue with. They also channel investment resources through those institutions. In consequence, those entities have material impacts on the governance system.

The private actors carry out important activities that affect the governance system. At local level, eleven NGOs were identified interacting with both councils. Similarly, a set of private companies was identified that has a material impact on the governance system by demanding specific products related to water resources and biodiversity. In this group there are, for

instance, various intermediaries that connect agricultural production and natural resource extraction with regional, national and international markets, local enterprises of gravel production building blocks and small tourism businesses. At regional and national levels, several private institutions were identified that require environmental services related to diversity and water, for instance wood processing companies and the building industry. At this level there is another set of institutions involved in illegal activities which participates in the system without consultation, such as those related to the cocaine market and wildlife traffic, but equally exerts pressure on the governance system since they are interested in maintaining a limited level of governance on natural resources. Finally, at national level it is worth noting the "Proceso de Comunidades Negras-PCN" (Process of Black Communities), since it has a guiding political role, a close relationship with local Community Councils and a key role in the negotiation and establishment of Law 70. In the political dimension, it is necessary to mention the actors formally registered within the National Electoral Council carrying out activities related to the national democratic government system.

In the governance system, other mixed character actors participate such as urban centers that demand environmental services related to biodiversity and water, and the port company demanding large volumes of water from the SES.

All these actors interact directly or indirectly with the SES through their specific form of participation and their role in the governance system of biodiversity and water resources. This dynamic works through the social networking that enables the flow of various forms of natural, economic and social capital. Similarly, social networks enable the sharing of environmental, economic, cultural and political resources and services between the actors involved in the governance system. There are two types of environmental networks: the ecological ones enabling the generation of environmental services, and social networks enabling not just conservation, regulation and reporting of violations, but also the extraction, processing and marketing of natural resources. Finally, market networks not just supply the community with basic needs goods, but also allow the exchanges of products at local and regional level. These networks operate for the transaction of both agricultural products and natural resources.

However, it's worth noting that while the Community Councils have networks with and supports from various organizations and institutions, ownership of the territory corresponding to the community. The ownership of the territory in both Community Councils is collective, with exclusive use for community members. Other actors may enter to the territory via permissions set by the Community Councils. As mentioned before, within the collective ownership, there are individual properties with exclusive use, which are associated with food production and correspond, mostly, to family inheritance. In these communities, the subtractability is high, especially with regard to mining, forest extraction, and extraction of aquatic resources and land.

Within their territories, the Community Councils have internal and external rules and norms that regulate the use of natural resources, specifically for biodiversity and water. As mentioned above, the main external laws influencing Community Councils are transitory article 55 of the Colombian Political Constitution of 1991, Law 70 of 1993 and Decree 1745 of

1995. Also there are some rules stated and implemented by CVC and local institutions. However the Community Councils have a wide range of norms within their internal regulations. For example, in Dagua, industrial mining, water pollution, wood extraction, hunting for commercial purpose, the use of herbicides, dynamite and chemicals are prohibited, while in Calima the rules are oriented to conservation, by prohibiting hunting, wood extraction and pollution of water sources.

Finally, although the boards of directors of the Community Councils have the power to make changes in the internal regulations and management plans, they must be supported by their respective Assemblies. In addition, the CVC is the institution that carries out the monitoring and sanctions processes when the rules are broken. For instance, CVC confiscates timber, other materials or animals. The Boards of Directors also carry out monitoring activities, although their capacity for effective sanction is relatively small.

In summary, the governance system of water and biodiversity in Dagua and Calima is a complex system with a polycentric character, since there is not a single power core but several. That governance system is in a process of consolidation and its central actor (the Community Councils and their internal control and management entities), is one of the newer stakeholders but with more projection in terms of its position and influence. The governance system of water and biodiversity can be understood as the shared link for the legal, social, economic, political and cultural factors that are being used today by a number of public and private institutions for the administration and management of water resources and biodiversity. As described above, this system operates at various scales from local to international level and includes a set of local formal rules, such as those issued by the Buenaventura environmental secretary; regional rules such as the provisions of CVC; national ones such as the national biodiversity policy; and international norms such as those related to wildlife trade. This set of rules also includes traditional social arrangements for water management and biodiversity that are currently being executed by the internal regulations of the Community Councils.

2.4 Users (U)

As mentioned before, communities linked to the SES are occupied mainly with agriculture, artisanal mining, few livestock, small scale timber extraction (especially in Bajo Calima) , and artisanal fishing, and, in some cases, tourism (especially in Dagua). Communities have a subsistence system of agricultural and they buy other products (i.e. toiletries or technology) in Buenaventura.

The poverty conditions are high in general (47.32% of Unsatisfied Basic Needs in rural areas in Buenaventura), but there are differences within the same council. With respect to health services, there are great difficulties with access to emergency care, water supplies. Sewerage and septic tanks are also scarce, leaving the community vulnerable to outbreaks of diseases from untreated sewage. There is a wide coverage of electricity, although La Esperanza does not have this service. There is also good access to basic primary and secondary education, and, for some young people, to technical and technological courses. The provision of education services in the region is based on what is stated by Law 70 of 1993 regarding the right to ethnic education and access to higher education scholarships.

In the four case studies cases, wooden buildings predominate, although some houses comprise cement with brick structures. Although the houses are small they have traditional “patios” or gardens from which are important for supplementing the family food. Houses are located mostly in towns and along the banks of the river and the road.

Activities that generate cultural identity are significantly important for the Community Councils. There are groups for dance, theatre, music, sport, entertainment events and traditional festivals. These events contribute to the connectivity of the council inhabitants. At the same time, there is a decrease of knowledge and cultural practices around traditional uses (crops, hunting, fishing, gathering, timber extraction), traditional medicine, birth and funeral rites, religious and community celebrations, artistic expression (music and dance), traditional forms of solidarity, and traditional games.

Community Councils have a hierarchical government system where the legal representative is the highest authority who makes decisions that affect the entire community. He/she is a leader and the community trusts him/her. One of the main functions of these leaders and in general of the whole community is to contribute to environmental conservation, since it is part of their duties for the collective territories. Although there is awareness of the importance of conservation of natural resources, there are not specific projects as yet.

In general terms, social capital is high, because there are two levels of cooperation, through traditional norms and rules linked to formal institutions, which interact and generate a high level of collaboration among the community.

This social capital is internal and is reinforced by the dynamics of kinship, race and territory. Similarly, it is important that this social capital is related to links created with outside institutions or stakeholders. This social capital also known as bridge-capital, allowing inhabitants to establish relationships with their immediate and regional surroundings through dynamics such as trade, remittances, services and public policies, among others. In the cases studies, there is also a strong potential for human capital not just with Council members but also with technical and professional training for young people.

In relation to gender conditions in the Community Councils, traditional gender roles (productive and reproductive) remain unchanged, although women appear to have the right to participate in the Councils. Nonetheless, it is not clear that the collective land rights generate equitable access for men and women. Some women are organized into associations such as Community Mothers Association and Associative Enterprises of Women.

In relation to local knowledge about socio-ecological systems, both Community Councils have updated and detailed information on animals, plants, soil, water quality and traditional uses. However, it is seemed that this knowledge is being lost through the lack of interest from the younger generation. With respect to knowledge of the effects of social attitudes on natural resources, the consequences of over-exploitation are recognized, but also it is clear that social attitudes could help to protect and empower ecosystems not just for conservation but also for benefit to community.

For people in general it is clear that resources are very important to the community life, since water, fishing and hunting contribute to self-sufficiency of basic foodstuffs; mining and timber are useful for providing income to pay services such as health, education and commercial products. In these practices, the community favors traditional technologies to protect the ecosystem.

2.5 Interactions (I)

The interactions in a social-ecological system are given in many ways: on the one hand, there is an interaction between users and the ecosystem; and on the other hand, there is an interaction between various internal and external stakeholders. All these interactions produce significant impacts associated with the technologies used for the natural resource extraction. For example, illegal mining generates problems of destruction of riverbeds and related ecosystems. With respect to interactions within community, there is a relatively high probability of free-riding, since monitoring capacity is low. However, the boards of directives of Community Councils have established mechanisms for information sharing through “vereda” leaders who report to the rest of the community. There is also a high capacity for deliberation through the right to vote exercised by the entire community for certain procedures or through decisions by the board of directives. However, in the Community Councils there are conflicts about use of natural resources, especially for infringement of the rules related to extraction, the presence of outsiders who do not meet the norms or illegal coca production.

In terms of the relationship with external actors, although Community Councils do not have the financial capacity to invest, they provide workers for various projects carried out by national and local institutions. However, this causes a high impact on the cultural and environmental conditions of the community. In this sense, the Community Councils use lobbying as a way to gaining power in decision-making at regional level. This indicates that the organizational capacity of communities is high, and decisions are taken by consensus.

Within these networks there are interactions, both internal and external, which support the processes. While internal networks are characterized by solving problems associated with basic needs, political participation, capacity building and cooperation, the purpose of external networks is the environmental conservation, management of resources for development, education and communication. Within these external networks, cooperation between different Community Councils is highlighted to strengthen their agency capabilities. Thus, although there are local organizations and institutional arrangements for natural resource management, the influence of external actors limits the potential of local people to manage fully their territory and resources, since there do not own the dissemination mechanisms for their procedures, even though socio-ecological systems satisfy the needs of users and are adaptable to market dynamics.

2.6 Outcomes (O)

It is necessary to sub-divide the way the outcomes are interpreted and explained in order to summarize and integrate the information generated to describe each one of the variables

proposed by the analytical framework. We propose 3 relational dimensions to define and explore the outcomes at the analyzed SES's, namely:

a. Between users, resource users and governance systems

As mentioned when describing the conditions of complexity, management and users strategies and local organization processes. One of the main characteristics of the four socio-ecological systems is that their environmental supply meets their users' needs and the adaptation of market dynamics. In this scenario, community organization aims to contribute to equity in the living conditions through preservation and control mechanisms, such as farmers committees, women's business associations and artisanal mining committees. Community Councils develop plans, programs and projects in order to improve community welfare. Also it is important to mention the violent conflict dynamics in the region, since the presence of armed actors is relevant, which impacts directly on natural resources.

In particular, it has been recognized the efficiency of the traditional norms to manage natural resources, but there is still a long process to follow because the continuous dependency of external market dynamics. One can say that the interaction and sometimes conflict between the local governance system and the national governance system is an effective way to promote institutional change. However, as a general outcome, at the case studies the institutional change and institutional interaction between users and regulators have been an important example at the national level about how to manage locally natural resources but thinking in a national level. It has been also demonstrated that, the extraction levels of natural resources from the local users are not the problem of natural resources over extraction, but they have the responsibility (sometimes in a strong asymmetry structures) to protect the resources from the over use of external actors.

b. Between resource system and governance system

Even though natural habitats are in relatively good conservation condition, the inhabitants of socio-ecological systems recognize the changes in the seasons of rain and their impacts on production. In general, it is recognized the declining soil quality and erosion in the river valleys of Dagua and Calima and, as a result of mining and deforestation. With regard to water, communities have the perception that this is still abundant. However, historical data show a reduction of the size of streams and of the number of water sources in communities.

It is particularly important to mention that water protection and biodiversity maintenance are always on the communitarian council's agenda. But, those resources are not the most negatively impacted from the human activities. Neither they are perceived as scarce or in menace. Therefore, it has been proved by the local authorities that the communities are particularly aware that water and biodiversity are important resources for their existence and always support the design of local norms to protect them.

c. Between settings, related ecosystems and governance systems

As explained previously, the local communities economic situation is similar than the other's communities nearby the case studies. But, on the other hand, their economic situation is particularly lower than the national average and they still suffer of problems of poverty,

limited access to health services and education. That situation has been always a limit when local users try to define long-term management programs for the territory and their resources. Particularly they are exposed to a paradoxical situation, Buenaventura is a place where immense economic transactions take place, but because of corruption practices, people are still in poverty and with deficiencies. Then, bad management practices, corruption, etc. are considered, as the “state of art” for management and rules are considered as not important when obtaining individual outcomes.

On the other side, two problematic situations always place the communities in uncertainty areas: eradication of illicit crops and gold extraction. In general, eradication of illicit crops with glyphosate carried out by the government, and burning of forests, are two factors that have contributed to water pollution in the region. In La Delfina, after the flood of 2006, there is a reduction of the flow of streams and rivers. In El Crucero, since the late nineties there has been a reduction of the availability of water in the streams, which is related to the dynamics of timber extraction of private enterprise. In La Esperanza, there has been an important change in the quality of water, due to the pressure of agriculture. Even though gold mining appears now as a controlled activity, local inhabitants are skeptical about the real possibility to control mining because of the extension of the communitarian lands. They recognize that gold mining activities are difficult to manage and their environmental impacts are high and can be perceived at the short-term. Regarding air quality, contamination due to deforestation and the increased traffic flow in the road Buenaventura – Buga - Cali, in Alto and Medio Dagua is evident. This has affected the respiratory health of the community and especially the children. Illegal mining is another major source of pollution that affects air quality and, therefore, the people’s health.

3 Prospective Structural Analysis (PSA) for identification of problems and drivers related to environmental challenges

The application of the PSA methodology was guided by a methodological framework based on the participation of actors directly related to the Studied SES. To this end, three steps were followed:

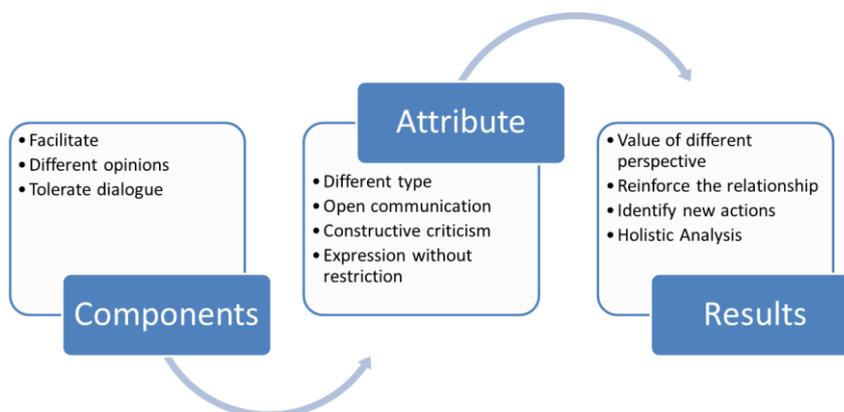
- 1) Three components were stated as fundamental to the exercise in order to facilitate the process, to ensure diversity of the parties, and to respect dissent. They would ensure the viability of joint work between community members, government officials, members of NGOs and other actors related to the specific SES under study.
- 2) Four key attributes were taken into account by the working groups. First, is the need to consider the flow and interaction of various types of knowledge within each SES (La Delfina, Zaragoza, La Esperanza and El Crucero), which could be subsequently used to define clear variables. Second, is the need to ensure open communication between members of the discussion groups and researchers, enabling comprehensive identification and characterization of variables. Third, it was considered essential to provide constructive criticism within discussion groups to ensure accurate and transparent definition of the variables. Fourth, unrestricted expression was guaranteed for each member of the working

groups. These attributes were essential to ensure open and frank discussion on the identified variables.

3) During the phase of results processing and analysis four important aspects were considered. First, is the evaluation of different perspectives in equal conditions, this is perceptions of technicians, officials and community members are treated equally. Second, to ensure objectivity, perceptions of participants were verified through a triangulation process with other sources of information. Third, the exercise sought, through the interaction of various actors in working groups, to strengthen and create new relationships among participants. Working together within the working groups increased communication between stakeholders and facilitated identification of new actions and initiatives for improvements to each SES. Finally, the results obtained were subjected to an integrated analysis, considering the characteristics of the SES analyzed and thereby seeking a direct application of the results obtained.

These three steps are illustrated in Figure 1 which provided a scheme for communities, co-researchers and other local actors on how to implement the MIC MAC exercises.

Figure 1. Step by Step of MIC-MAC exercise with Stakeholders



3.1 Organization of PSA workshops

3.1.1 Workshops design and leading

The activities for the implementation of Prospective Structural Analysis (PSA) occurred over three phases. During the first phase two main activities were carried out: a) Exercise planning, literature review and development of the methodological approach; b) Identification of key stakeholders, selection of participants and formal call. During this first phase, a testing of methodological procedure was performed with students from the Rural Development Master at Pontificia Universidad Javeriana (Bogotá).

The second phase consisted in gathering the necessary information. To this end, five workshops were implemented in the communities: one with co-researchers from Alto y Medio Dagua, another with co-researchers from Bajo Calima, one more with the official workers of the municipality of Buenaventura, and two workshops involving communities living in the

SEs: a workshop with community residents in La Delfina and Zaragoza (Dagua), and a workshop with the inhabitants of the community of El Crucero and La Esperanza (Bajo Calima).

In the final phase, the information obtained in both Community Councils was pooled and systematized and the necessary adjustments were made for processing with MIC-MAC. This software allowed the identification of key variables that were presented and discussed in two additional meetings with local, regional and national stakeholders. These meetings were the second COMET-LA stakeholders forums in Colombia, in Buenaventura and Cali carried out in July, 2013.

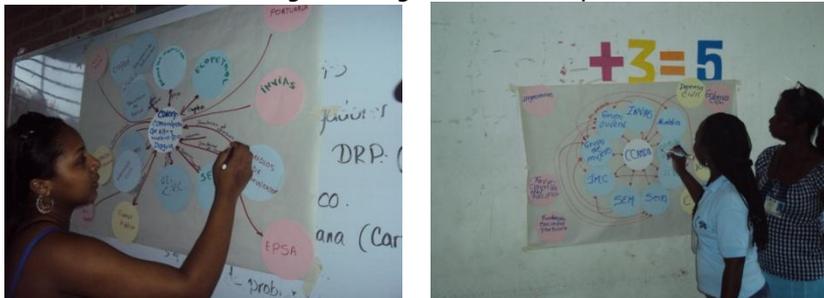
3.1.2 Identification and call of institutional stakeholders

The invitation to participate in the workshops was conducted selectively under the following criteria. For the case of community workshops, the selection criteria were: living in areas of influence of La Delfina, Zaragoza, El Crucero and La Esperanza; have a great knowledge about the territory; or have a direct link to specific social-ecological systems. Annex 3.1 presents a list of community representatives who attended the workshops. In the case of the workshop with the co-researchers, all young people who are part of this team were invited. Annex 3.2 presents a list of co-researchers attending the workshops.

In the case of institutional stakeholders, members from public sector institutions in the municipality of Buenaventura or department of Valle del Cauca with influence in the town and rural area were selected. Also those non-governmental organizations, NGOs, carrying out support activities, and management, research and development activities in the territories of both Community Councils were invited.

For the identification of institutional stakeholders, the information acquired previously during the characterization of SES was used. Specifically Venn diagrams (Geilfus, 1997) were used. The Venn diagram or organizational chart helped to identify institutions, entities and organizations present in the territory of the Community Councils. Also it allowed identification of the level of relationship that these organizations, institutions or entities have with the community and the council. The diagram was worked by both men and women (See Photos 1 & 2 below) from each of the case studies (La Delfina, Zaragoza, El Crucero and La Esperanza). An example of these diagrams is presented in Annex 4.

Photos 1 and 2. Working Venn diagrams in workshops with members of Community Councils



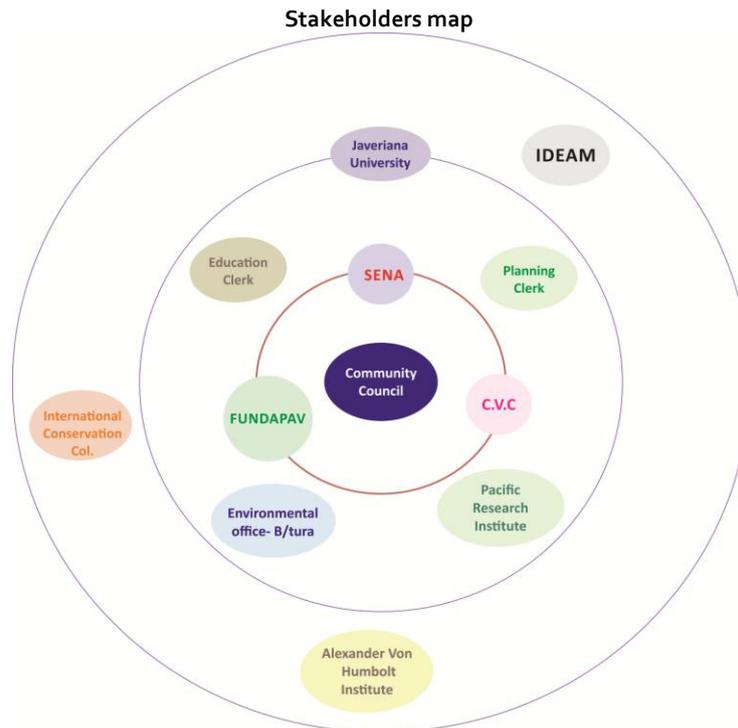
A preliminary list of institutional stakeholders that influence the SES was obtained with this tool. This list was supplemented by a review of secondary sources (institutional web pages, reports, studies) to identify other stakeholders carrying out other political, economic, social and environmental activities in Buenaventura, which affect the Community Councils and, particularly, the rural areas where the SESs are located. From this preliminary identification, the final list was made and the formal call was proceeded by a personal invitation. The final list of institutional stakeholders is presented in Table 1 below.

Table 1. List of Local and regional Stakeholders

Organization	Position
Buenaventura Mayor	Planning secretary
Buenaventura Mayor	Education secretary
Buenaventura Mayor	Environmental secretary
Governmental institution for regional environmental issues (Corporación Autónoma Regional del Valle del Cauca CVC) Buenaventura	Agent for Pacific Region
NGO (Fundación Social Agroambiental Pacífico Vivo-FUNDAPAV)	Member
Pacific Research Institute	Researcher from Buenaventura Office
National Learning Service (Servicio Nacional de Aprendizaje – SENA)	Professor
Institute for biological research Alexander Von Humboldt (Instituto de investigaciones biológicas Alexander Von Humboldt)	Director and researchers
World Wild Foundation WWF	Director and researcher of Governance program – Cali
Governmental institution for regional environmental issues (Corporación Autónoma Regional del Valle del Cauca CVC) –Cali	Member of environmental sector
International Conservation - Colombia	Member of Pacific zone group
Intercultural Studies group - Pontificia Universidad Javeriana- Cali	Researchers

Figure

2.



3.1.3 Workshops development

Testing instruments

Since the methodology for implementing PSA states that this type of exercise should apply to people with extensive knowledge in the field and that it has to be carried out in several sessions in order to discuss each step, it was decided to test the methodology and fit it to a short one day workshop. This test was conducted with a group of 15 students of third semester of the Master in Rural Development at the School of Environmental and Rural Studies at Pontificia Universidad Javeriana, Bogotá. This workshop was conducted by Colombia COMET-LA team.

This preliminary exercise allowed validation of the methodology for use in a rural context. This allowed adjustments to the procedure including: adjustment to the duration for its application; modification to the technical language to a much more uniform and concrete language for communities; specification of the form and type of questions to present and the type of materials to use. Also, the preliminary exercise allowed for calibration of the tasks for the moderator and co-moderator during the workshop.

Workshops with co-researchers

This exercise was carried out in La Delfina on June 4th, 2013 with 25 co-researchers who are part of both Community Councils, and it was conducted by the Javeriana team with the support of some members of an NGO (Fundación Social Agroambiental Pacífico Vivo Fundapav). Initially the characteristics of the PSA methodology and MIC-MAC were reviewed with the participants. This introductory exercise allowed participants to understand the objectives of the exercise. In a second step the participants were divided into two groups: one

for Dagua and one for Calima. In each group, the workshop was coordinated by a moderator and co-moderator from PUJ.

The workshop was divided into two sessions, one in the morning and one in the afternoon during which the dynamics related to biodiversity and water resources in the context of the SES studied were analyzed in detail and the steps for PSA were applied. During the coffee-breaks participants commented on the methodology and how its implementation in rural communities could be improved, according co-researches criteria.

After the group work, there was a plenary for analysing the prioritized variables and results and for give feedback on the characteristics of PSA method and details of the software. In general, the exercise produced the necessary information for the PSA, which in turn increased the confidence of the co-researchers in the methodology. Photos 2 and 3 are from the workshop at La Delfina.

Photo 3 and 4. PSA workshops with co-researchers



Workshop with public institutions and NGOs

A workshop between public institutions and NGOs was carried out in Buenaventura on June 5th, 2013. Representatives of local public entities and NGOs attended this workshop: Office for Pacific Region of the Regional institution for environmental issues (Corporación Autónoma Regional del Valle del Cauca CVC); education, environmental and planning secretaries from Buenaventura Mayor Office; National Training Service (SENA); Pacific Environmental Research Institute; and a NGO (FUNDAPAV). All these entities are responsible for decision-making on a range of of topics related to environmental issues at local level in Buenaventura and influence the rural area, especially because they work with both Community Councils on aspects related to water resources and biodiversity.

Fifteen people participated in the workshop: a member of each institution mentioned above, a representative from Calima and one from Dagua, and four members from Colombia COMET-LA team. Due to time constraints of public officials it was necessary to carry out the exercise in half day. However, it was possible to identify and analyze the relationship between the key variables for both components of analysis: water resources and biodiversity. Photo 5 below is from the Buenaventura workshop.

Photo 5. PSA workshops with local institutions in Buenaventura



Workshop with the community from Alto y Medio Dagua and Bajo Calima

The workshop with representatives of both Community Councils was conducted in La Delfina on June 7th, 2013. Fourteen people (men and women, youth, adults and seniors) from various *veredales* committees from Zaragoza and La Delfina participated in this PSA workshop. Photo 6 below is from the Dagua.

Photo 6. PSA workshop with members of Dagua



The workshop with members from Bajo Calima was carried out in El Crucero on June 6th, 2013. Eleven leaders and representatives (men and women, youth, adults and seniors) from *veredales* committees from La Esperanza and El Crucero participated in the workshop. Photo 7 below is from the La Esperanza/El Crucero workshop.

Photo 7. Participants of PSA workshop in Calima



Feedback Workshops

There were two feedback workshops. The first one was carried out on July 10th, 2013 in Buenaventura as part of the Colombia COMET-LA forum with local stakeholders. The participants of this workshop were members from both Community Councils, leaders and representatives from *veredales* committees from La Delfina, Zaragoza, El Crucero and La Esperanza, some co-researches, as well as representatives of public institutions such as education, environmental and planning secretaries from Buenaventura Mayor Office, and CVC.

In this first workshop, participants gave feedback on the results of PSA analyzes emerging from the MIC-MAC process. Participants reviewed variables which were identified and prioritized in previous workshops with local actors. They suggested some things to keep in mind and concluded that some of these results were new for the community, so they appreciated the work done and led a discussion on the impact of COMET-LA project on community management of natural resources. Photos 9 and 10 below are from the Buenaventura feedback workshop.

Photos 8 and 9. Forum with local stakeholders in Buenaventura. July 10th, 2013



The second feedback workshop was held on July 12th, 2013 in Cali. The participants in this workshop were representatives of public institutions such as SENA, Colombian Institute for Hydrology, Meteorology and Environmental Studies IDEAM, and the Alexander von Humboldt Institution. Also participate members from NGOs such as Conservation International, World Wide Fund for Nature WWF and Fundapav, and representatives of both Community Councils, co-researchers and two members of the intercultural studies group from Universidad Javeriana-Cali. In general, the workshop validated the results and obtained valuable suggestions for improvement. Photo 10 is from the regional and stakeholders feedback forum in Cali.

Photo 10. Regional and National Stakeholders forum in Cali. July 12th, 2013



The feedback from both these workshop vindicates the methodology used for the participatory approach for working with communities involved with the Comet-LA project.

3.2 Variables Identified

3.2.1 Identification of variables and analysis of relationships

The identification of variables in each of the groups was based on a basic question presented at all PSA workshops: Which variables affect directly or indirectly the biodiversity and water resources? Following this question, participants discussed and prioritized the set of variables that emerged in the workshops.

Each variable was classified as internal or external according to how it affects biodiversity and water. The names of variable were written on cards of different colors and according to their priority they were placed in a double-entry matrix which was drawn on a large diagram. Subsequently, the relationship between variables was ranked between 0 and 3, where 0 means "there is not relation" and 3 "strong relationship". Also, a P ("potential relation") was used. This clasification or ranking was given by consensus among participants, following three questions: a) Is there a relationship between the variables?; If the answer was no, they passed to the next couple of relationships. If the answer was yes, the following questions were asked: b) How strong is this relationship? and c) How doesthis relationship work? Detailed notes were taken from the description of the variables and their relations. The subjectivity of this step involved additional triangulation analysis reflected in the final description of each variable. Photo 11 below shows a completed double entry matrix of variables from a PSA workshop at the Dagua community.

Photo 11. Double entry matrix of variables with importance assessment. PSA workshop with members of Dagua

	Agua Interna					Agua Externa					
	Abastecimientos humanos	Transporte terrestre	Minería	Agricultura	Turismo	Tala de Bosque	Fumigación aérea	Normatividad	Macro Proyectos	Extracción de agua	Cambio Climático
Abastecimientos humanos	0	2	0	2	2	2	0	0	0	3	2
Transporte terrestre	3	0	1	2	2	1	0	0	1	0	3
Minería	3	2	0	3	2	2	0	3	P	0	1
Agricultura	0	0	0	0	2	2	0	0	0	0	1
Turismo	2	2	0	2	0	1	0	0	0	2	3
Tala de Bosque	3	2	0	2	P	0	0	0	0	2	3
Fumigación aérea	3	0	0	3	1	0	0	0	0	2	P
Normatividad	1	1	P	0	P	2	P	0	0	2	2
Macro Proyectos	3	3	0	3	2	2	0	0	0	0	P
Extracción de agua	2	0	0	P	P	0	0	0	0	0	0
Cambio Climático	2	2	0	2	2	0	0	1	1	0	0

Before the classification of variables, the form proposed in the methodological meeting held in UCO in February 2013 was filled out which includes the short name of the variables (corresponding to the code for the Ostrom matrix of SES characterization; see Annex 2), the long name that corresponds to the name given by community, and the description of the variable (See Annex 1).

After this, the variables and their relationships for both councils were classified and analyzed with MIC-MAC software.

In this process, first the direct relationships were found, using the MIC-MAC logic (Godet, 1995). The results presented in this deliverable correspond to the first phase of description of results with the Direct Influence Matrix (DIM).

The next step carried out by MIC-MAC is to show hidden variables of the system and other type of classifications for the hierarchy. Thus, the joint analysis of direct and indirect variables on the internal variables in the matrix can show a hierarchy of external variables "in terms of their direct or indirect impact on internal variables and also the hierarchy of the internal variables based on their sensitivity to changes in the system" (Godet, 1995: 95). This operation allows the display of important variables that *a priori* were not considered at the same level of importance. An indirect influences matrix shows the hidden variables in the system. The results of this matrix of indirect influences will be shown and analyzed in the deliverable D2.3 since they are close related to scenarios analysis.

In summary, three steps were carried out. First, the variables affecting biodiversity and water resources were identified and their description was made in individual forms, using triangulation of information. Each variable had a short label according to Ostrom matrix for SES characterization. Second, the relationships between variables were ranked by consensus among those attending the workshops. This score was recorded on a double entry matrix. Finally, variables were classified and processed using the MIC-MAC program.

3.2.2 Variables description

The list of variables identified in the workshops is presented below in Table 2 for Alto y Medio -Dagua, Table 3 from Bajo- Calima , which includes their classification according to Ostrom framework (2009) and a brief description of each variable. Figures 3 and 4 show the Variables classification used from Ostrom (2009) by the communities at Alto y Medio -Dagua and Bajo- Calima, respectively.

Table 2. List of variables. Community Council of Alto y Medio Dagua AMDA

N°	Long Label	Short label
1	Population	S2a
2	Mining	S5b
3	Fishing	U9
4	Deforestation	ECO3(a)
5	Illicit crops	ECO3(b)
6	Institutionality	I8
7	Climate Change	ECO1
8	Oil pipeline	RS4 (b)
9	Land Transport	S5c
10	Hunting	RS1
11	Agriculture	RU3
12	Tourism	S1a
13	Big projects	RS4(a)
14	Public Policy	S4a
15	Water Management	ECO2
16	Higher Education	U2e
17	Research	U7c
18	Aerial spraying	I4
19	Community	GS3a
20	Local Knowledge	U7a

Figure 3. Variables classification, according Ostrom (2009) AMDA

Social, economic and political Settings (S)

S2a Population; S5b Mining; S1a Tourism; S5c Road transport; S4a Public policy

Resource systems (RS)

RS4a Big projects
RS1 Hunting
RS4b Oil pipeline

Governance system (GS)

GS3a Community

Resource units (RU)

RU3 Agriculture

Users (U)

U9 Fishing
U7a Ancestral Knowledge
U7c Research
U2e Higher education

Interactions (I)

I4 Aerial spraying
I8 Institutionalility



Outcomes (O)

Related ecosystems (ECO)

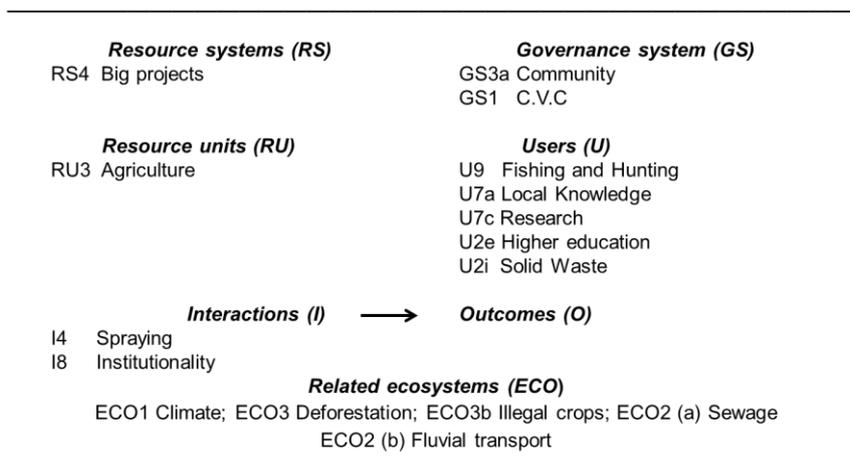
ECO1 Climate change; ECO2 Water management; ECO3a Deforestation; ECO3b Illegal crops.

Table 3. Variables list - Bajo Calima

N°	Long label	Short label
1	Deforestation	ECO ₃
2	Mining	S _{5b}
3	Spraying	I ₄
4	Population	S _{2a}
5	Fishing and Hunting	U ₉ – RS ₁
6	Agriculture	RU ₃
7	Big projects	RS ₄
8	CVC	GS ₁
9	Market	S _{5a}
10	Tourism	S _{1a}
11	Climate	ECO ₁
12	Community	GS _{3a}
13	Solid Waste	U _{2i}
14	Illegal crops	ECO ₃ (b)
15	Armed conflict	S _{3c}
16	Fluvial Transport	ECO ₂ (b)
17	Public Policy	S _{4a}
18	Sewage	ECO ₂ (a)
19	Local Knowledge	U _{7a}
20	Institutionality	I ₈
21	Higher Education	U _{2e}
22	Research	U _{7c}

Figure 4. Variables classification, according to Ostrom (2009). Bajo Calima

Social, economic and political Settings (S)
S_{2a} Population; S_{5b} Mining; S_{1a} Tourism; S_{5a} Market; S_{3c} Armed conflict; S_{4a} Public policy



3.2.3 Description of variables selected in PSA workshops

1. Population (S_{2a}): It refers to the trends of population increase and decrease. This trend is based on the natural growth of the local population, despite the relatively high migration rate of young people, and the influx into the territory of new stakeholders for the exploitation of natural resources. As the population increases there is an intensification in the demand for resources and services provided by the ecological subsystem.

2. Mining (S5b): Mining activity, when it is carried out improperly affects biodiversity and water. Extraction procedures and the use of chemicals destroy and pollute the habitat of different species of flora and fauna that inhabit the SESs. It should be clarified that artisanal mining does not affect the ecosystem at the same level as industrial mining does. The artisanal techniques and local knowledge related to this activity are passed from generation to generation. In general, since the 1990s there is an increase of gold mining, which is linked to gold international price trends.

3. Fishing (U9): The fishing activity conducted by the communities in the SESs studied is artisanal. The most common artisanal tools are cast nets and nets. One of the most valuable species in the Dagua river is freshwater shrimp. For fishing in the Calima river, there has been the use of explosives, although this has been reduced due to institutional and community councils controls. There are no records of catches for fishing activity in the area.

4. Deforestation [ECO3 (a)]: Timber extraction affects biodiversity because, among other things, the ecological niches are destroyed, some species become endangered and erosion processes are generated. Similarly, deforestation is considered one of the main causes of global warming. This is a human activity that has affected local ecosystems and members of Community Councils report that deforestation generates significant negative impacts on agriculture and soil. The timber extraction in the nineties increased with activities carried out by a private enterprise (Carton de Colombia), which destroyed significant forest areas in Bajo Calima. In both councils, timber extraction continues nowadays, since it represents an important income source for these communities.

5. Illicit Crops [ECO3 (b)]: In both Community Councils there are coca crops and various environmental and social problems associated with this activity. Coca cultivation is carried out with intensive technology based on the use of agrochemicals. The use of agrochemicals and deforestation are two factors that directly affect biodiversity and water. This is considered a foreign activity and is concentrated mainly in the area of Bajo Calima. This crop competes with agriculture for food and generates various social tensions. The dynamics of violence linked to the coca trade and control of the activity have affected local people and in some cases displacing them from their homes.

6. Institutionalility (GS8): This variable refers to the set of formal institutions that carry out direct actions on the territory of both Community Councils. It is considered that the existence of Community Councils has allowed the persistence of ethnic groups, which in turn has helped to preserve traditional knowledge. This means that resources are maintained and retained. The analysis of this variable generated a debate within workshops in relation to the entity of Community Councils and its role in the governance system in community territories. There is a concern about its limited regulation and the meaning of self-government in the territories. It is important to note that there is a generational difference between how older and younger people understand the institutions and structure of the governance system of their specific SES .

The Community Councils interact with various local and international NGOs and public and private institutions in order to manage and put in practise different actions for development. In general, participants in workshops recognize the role of some institutions (mainly CVC,

SENA, departamental government and ministries) that offer training, support programs and regulate natural resource extraction. However, they criticize the role of institutions such as the Mayor's office and the State Colombian oil company (Ecopetrol) due to their limited support and presence in the territories of Community Councils.

7. Climate Change (ECO₁): Climate change is a relevant variable for agricultural systems that are developed with traditional techniques based on crop rotation, low use of agrochemicals and with high dependence on seasonal rainfall. Crops are planted in both river valleys and highlands, which allows the management of various crop species. Due to the limited infrastructure for drinking water supply, inhabitants use rain water for consumption. Thus, any change in the rainfall and in the rain and dry seasons affects directly agro-biodiversity and the social subsystem, impacting directly on local livelihoods.

Moreover, there is a gradual consolidation of local knowledge on climate variability and communities have a clear perception of how this has evolved. In general, three aspects were mentioned in the workshops: increased rainfall, shorter dry periods, and increased extreme events, including floods and avalanches. This dynamic of change is starting to cause problems in relation to the planning of crops throughout the year, their advancement in plain areas of the rivers and streams, increased pests and diseases and problems associated with flowering fruit trees. Although researches in this field were not identified, the IDEAM projections presented in its third technical report support these findings (IDEAM, 2010).

8. Ground Transportation (S_{5c}): The councils, especially Dagua, are facing the expansion of the main road that connects Buenaventura with Cali. This road has a strategic importance for economic development of the country, as it is the only connection between the port and other colombian regions. Some communities of Dagua are connected by a railway, used by locals as a means of transport adapted to their needs. There are also roads connecting the communities which use local buses ("buses escalera" or "chivas"). The transport variable affects biodiversity and water resources during and after the process of building the road. These impacts are related to the emission of gases from vehicles, washing vehicles on the road, the death of animals in accidents and noise pollution.

9. Hunting (RS₁): Hunting, in particular that related to the illegal wildlife trade and for regional markets, is considered as a variable that directly affects the populations of native species. Similarly, the role of various spices is highlighted as transport of seeds, so a reduction of these species is reflected in the forest resilience. Hunting affects biodiversity by causing a decrease in the resources and services provided by different components of the system. It is clear for the participants at workshops that this activity should be allowed just as a subsistence activity linked to livelihoods. The CVC qualifies it as an activity that has a strong impact, but that impact is mediated by the controls nowadays. The councils also has regulatory mechanisms.

10. Agriculture (RU₃): Agriculture carried out in the SES analyzed is for subsistence, applying ancestral cultural practise with low level of technology. This type of agriculture is carried out in small plots (no more than 5 has.), in which poly-crops are established, looking for associations between different species of plants and animals and a better crop development. Crops are planted associated with various species of timber trees, fruit trees and palms. A

guiding principle to create the crop mix is to ensure diversity and permanence of a balanced diet throughout the year. Similarly, this combination of species respond to other aspects such as pest and disease control, source of income throughout the year, and efficient use of the available labor force.

The participants recognize that although agriculture is guided by traditional ecological knowledge, agrochemicals are used, in particular for the control of pests and diseases, which affect biodiversity, soil, water and ecosystems near crops. The use of agrochemicals is growing as new generations do not adopt and appropriate cultural and traditional customs linked to agriculture, which allows increased use of chemical pesticides and fertilizers.

11. Tourism (S1a): Tourism has become one of the various sources of income for livelihoods in the SES studied. However, this activity generates a number of direct impacts on biodiversity and water resources. A major cause is the very limited regulation of the activity and the construction and operation of balnearios in the rivers. As a result, various problems are observed such as washing cars and motorcycles, clothes washing, solid waste disposal and sewage directly into water sources and use of river beaches without any control.

12. Megaprojects [RS4 (a)]: These are large infrastructure projects that are currently under development and have direct impact on the territories of the councils. The Port of Aguadulce and the double-way road that connects Buenaventura to Buga and Cali are two of the most important megaprojects. During the process of implementation of these projects, significant impacts are generated on biodiversity and water resources, since there is destruction of forests, wildlife, flora and even some places of cultural significance to the community.

13. Public Policy (S4a): This variable refers to the impacts, positive and negative, that generate public policies on biodiversity and water resources. This variable emphasizes explicit contradictions, for example, between the National Biodiversity Policy and promotion of megaprojects and mining from the National Development Plan, which currently drives various large-scale projects in the municipality of Buenaventura. Another important example in this area is the national policy for the control of illicit crops which control tool is the aerial spraying with glyphosate.

14. Water management (ECO2): In Bajo Calima, water management has been focused on construction of aqueducts, which allow rain water storage and subsequent distribution by pipe to each of the houses. In Alto y Medio Dagua, inhabitants have also tried to build this type of infrastructure. Currently, the communities of both councils are facing a crisis that has a political dimension of water. Water is a common resource that is involved in most of the economic activities and livelihoods of the Community Councils (agriculture, mining, river material extraction and tourism). In this sense, water management is currently done in a controlled manner by the council, but there is not an entity that regulates the quantity of water for human use.

15. Formal Education (U2E): This variable refers to formal education, basic primary and secondary, conducted at schools existing in both Community Councils. Similarly the role of SENA is highlighted as an important institution for the promotion of environmental education, preservation of natural resources and promoting sustainable tourism. Also, the

education institution José María Córdoba promotes education for children and youth, environmental awareness and sustainability programs. Participants in workshops agree that formal education is a mechanism that stimulates the migration of young people, since rural education is decontextualized and there are not own curricula that recognize traditional knowledge and cultural dynamics.

16. Research (U7C): The research is part of the councils initiatives and is reflected in activities such as environmental impact studies for construction of double-way road and other mega-projects in the area. There is some progress such as the characterization of biotic, abiotic, socio-cultural, political and economic components of councils. Some of the aspects in the research agenda for Community Councils are: protection of biodiversity, conservation of natural resources, delimitation of protected areas and areas for the protection of water sources, good practices in the landscape use, creating of recreation areas, ecological corridors (connectivity) and ecotourism trails (research and education).

In this sense, some NGOs have accompanied the participation of Community Councils in researches, which have been linked to development and innovation processes in rural areas to improve the living quality of the inhabitants of the SES studied. People mention the need for progress in this field since research has potential for conservation of biodiversity and water resources. But they also suggested that the research conducted by external actors could be have a negative impact when ancestral knowledge is looted.

17. Aerial Spraying for illicit crops control (I4): Aerial spraying of glyphosate is an instrument established through the national drug policy. Glyphosate is a systemic herbicide that destroys coca crops. However, the way it is used affects also the forest, food crops and other commercial agriculture and even the health of people and animals. Today the most intensive spraying is in Bajo Calima.

18. Community (GS3a): The meaning of this variable is the inhabitants of a Community Council as a social group and its characteristics. This variable highlights the responsibility of the community in using and conserving biodiversity and water resources. This variable does not refer to demographics. "Community" refers to issues directly related to the social group and its affect on biodiversity and water resources. For example, when the community is not aware about resources and their importance and the need of care them, they may sell those resources, e.g. gold and wood, with a market value, to outside actors- thinking just on individual benefits, especially money, and not in collective ones. Although the bargaining power of the community compared to large infrastructure projects has improved, it is difficult to reach similar levels for facing dynamics such as illicit coca crops and gold mining. Moreover, the bad management conducted by communities of water and biodiversity affect them negatively. People emphasize that there is no culture of waste management and sewage flow directly into rivers and streams without any treatment.

19. Ancestral Knowledge (U7a): This variable involves the body of knowledge, practices and beliefs of the community about the relationships among living beings (including humans) and their immediate environment. In other words, there is an ancestral knowledge regarding the SSE in which they live, which evolves through a process of historical adaptation and is transmitted from one generation to another. Participants in PSA workshops relate directly to

ancestral knowledge, but forget about to the increasing alterations to natural cycles. In the past, people had very clear hierachies of authority, but now there is not credibility in them. Ancestral knowledge is usually transmitted by the elderly, which in turn affects the creation, maintenance and administration of rules regarding the use of biodiversity and water resources. The migration of the young and the increasing links of the councils with urban centers, among other external factors, impact negatively on this variable, by eroding important cultural aspects such as identity and sense of belonging.

20. Regional institution for environmental issues (Corporación Autónoma Regional del Valle del Cauca CVC) (GS1): CVC is a public institution responsible for decisions regarding environmental issues in the department of Valle del Cauca. The territories of Dagua and Calima are under the jurisdiction of this institution, and they must follow the rules and regulations established for CVC for the management of natural resources. CVC issues permissions and licenses for certain timber extraction activites and for hunting and fishing. CVC also regulates the activities of biodiversity use carried out by communities and supports sustainable agricultural activities taking place in the territory.

21. Market (S5a): Natural resources extracted from ecological subsystem, such as agricultural products, are not usually processed and they are sold in local and regional markets. Some of these products (gold, timber and chontaduro) go to other markets such as Cali and Bogota. Some resources such as gold, timber, tagua or Pecari (*Catagonus wagneri*) and tatabro (*Tayassu albirostris*) have a high demand which encourages their continued extraction and increasingly affects their availability. The participants of workshpos recognized an important and growing influence of regional markets on natural resource extraction which directly affects biodiversity and water resources.

22. Solid Waste (U2i): There is no solid waste treatment system in any of SES studied. Burning garbage in the community is a common practice, which generates direct impacts on biodiversity and water resources. It is considered that this affects directly tourism as a result of pollution of waters and beaches. Participants of workshops agree that improper handling of solid waste currently represents a major problem for public health.

23. Armed Conflict (S3c): This variable refers to the interference of illegal armed groups in the control of territory. The actions of these groups have been associated with the control and benefit of coca crops, illegal mining and control of strategic corridors for drug trafficking. These activities, as described above, have a direct impact on biodiversity and water resources. Sometimes, these groups have led to the displacement of people, which directly impacts the social structure of the SESs.

24. Transport (ECO2): This variable refers to the transport through the Calima River. The boats with big engines generate waves that impact the river valleys, which contributes to the erosion of its banks and damage ecosystems. Similar to ground transportation, boat maintenance represents a major source of pollution, waste disposal and oil in the water, polluting and affecting biodiversity.

25. Wastewater (ECO2): None of the SESs studied, community have sewerage infrastructure, although some families have septic tanks. In some cases, especially in houses located in a

dispersed manner along the railway and road, sewage drains into nearby water sources, especially the river or open field. These practices directly affect biodiversity and water resources by polluting rivers and streams that are in turn used in agriculture, human consumption and recreation. Sewage is a problem identified as a priority for the health of the communities, as they are source of infection, disease and epidemics that become a public health issue.

4 Identification of the role played by different variables

As described above, PSA was directed to the analysis of biodiversity and water in the context of selected SES in Bajo Calima and Alto y Medio Dagua. Although the overall analysis focuses on the study of selected SES (La Delfina and Zaragoza in Alto y Medio Dagua, and La Esperanza and El Crucero in Bajo Calima), biodiversity and water are structural elements of the ecological dimension of these systems and reflect the general characteristics of biogeographic Chocó ecoregion. Similarly, the livelihoods identified in the selected SES reflect a relatively high dependence on biodiversity and water, since core activities such as agriculture, hunting, fishing and timber extraction depend on these two aspects.

Therefore, PSA allows the identification of a set of variables that are analyzed with respect to their role in the development and trends of biodiversity and water, as central components of the SES studied. This structure of analysis, that we will call in this document as *the system*, differs substantially from the context of the traditional enterprises from which PSA was developed, and as a consequence various methodological variations were introduced in order to adapt PSA to a rural context such as Dagua and Calima.

This section of the deliverable provides a description of the role played by the variables identified in this context. To this end, influence/dependence maps are presented and described. Similarly, the relationships between the variables are identified and an additional analysis for identification of loops is carried out. Loops represent the feedback process and relationship between the variables of the analyzed SES.

4.1 Influence / Dependence Maps

4.1.1 Identification of variables: Alto y Medio Dagua

In the case of Alto y Medio Dagua 20 final variables were identified and are presented in Table 4.

Table 4. Variables identified in PSA workshops in Community Council of Alto y Medio Dagua

Variable	LABEL	TYPE (internal-external)
Deforestation	ECO ₃ (a)	Internal – external
Institutional	I ₈	External
Mining	S ₅ b	Internal – external
Formal education	U ₂ e	External
Oil pipeline	RS ₄ (b)	External
Ancestral knowledge	U ₇ a	Internal
Public policy	S ₄ a	External
Community	G ₅ 3a	Internal
Population	S ₂ a	Internal
Illicit crops	ECO ₂ (b)	External
Agriculture	RU ₃	Internal
Tourism	S ₁ a	External
Aerial spraying	I ₄	External
Research	U ₇ c	External
Armed conflict	S ₅ a	External
Climate change	ECO ₁	External
Fishing	U ₉	Internal
Megaprojects	RS ₄	External
Water management	ECO ₂	Internal

These variables can be classified into three groups: internal, external and transition (internal-external).

Six variables (ancestral knowledge, community, population, agriculture, fishing and water management) were considered by participants as internal since they are originated and are a structural part of the ecological and social dimensions of the studied SES. Similarly, their behavior and evolution, although occasionally influenced by market dynamics, depend heavily on the decisions and internal institutional structure of SES.

Meanwhile, nine variables (institutionality, formal education, public policy, illegal crops, tourism, research, armed conflict, climate change and megaprojects) were considered as external variables, since, although they affect directly biodiversity and water, their origins, motivations, interests or contents come from external dynamics to studied SES. For example, coca crops affect the ecological dimension by polluting water as a result of the chemicals used in the process and affect biodiversity as a result of aerial spraying with glyphosate carried out by the government to control the growth of these crops. Similarly, they affect social dimension by generating impacts related to the deterioration of security in the territory, the loss of livelihoods and migration patterns. However, the behavior and persistence of this variable is essentially based on external dynamics such as illegal activities, drug trafficking and the market.

Deforestation and mining variables were considered as transition variables. Although they are strongly affected by the demand of regional, national and international markets, stakeholders involved in these dynamics are internal and external. For instance, in mining there are two types of miners: artisanal ones who use local techniques and knowledge; and the industrial miners who use industrial machinery and modern extractive techniques. The same happens with deforestation, as this has been promoted by private timber companies as Cartón de

Colombia, under government concessions. But also deforestation has been occurred as result of coca crops, agriculture and other economic activities linked to local actors.

For their part, water management variables and macro-projects (duel carraigeway road and oil pipeline) are particular variables because there are present just in La Delfina and Zaragoza in Community Council of Alto y Medio Dagua. The other variables are common to the four case studies.

After analysis of the variables the identification and ranking of their relationships was carried out. The results for Alto y Medio- Dagua are presented in Table 5 below.

Table 5. Identification and ranking of the relationships between variables. Community Council of Alto y Medio Dagua

	1 : S2a	2 : S5b	3 : U9	4 : Eco3(a)	5 : ECO3(b)	6 : I8	7 : ECO1	8 : RS4 (b)	9 : S5c	10 : RS1	11 : RU3	12 : S1a	13 : RS4(a)	14 : S4a	15 : ECO2	16 : U2e	17 : U7c	18 : I4	19 : GS3a	20 : U7a
1 : S2a	0	2	2	2	2	0	3	0	2	2	3	2	1	0	3	1	1	0	2	1
2 : S5b	3	0	3	2	2	3	2	0	2	1	3	2	1	3	3	1	1	2	0	3
3 : U9	2	0	0	0	0	1	2	0	0	0	0	0	1	0	0	0	0	0	3	2
4 : Eco3(a)	3	0	2	0	2	2	3	0	1	3	2	0	3	2	3	3	2	0	3	3
5 : ECO3(b)	2	1	3	3	0	0	2	0	0	2	2	3	0	1	0	1	1	3	1	1
6 : I8	3	2	2	2	1	0	0	0	1	1	3	3	3	3	1	3	3	3	2	1
7 : ECO1	2	0	P	0	1	0	0	0	2	P	2	2	1	1	1	0	1	0	P	P
8 : RS4 (b)	1	0	3	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
9 : S5c	2	1	0	1	0	0	3	0	0	0	1	2	1	0	0	1	1	0	2	0
10 : RS1	0	0	0	0	0	3	0	0	0	2	2	0	1	0	1	1	0	2	2	2
11 : RU3	2	0	1	2	2	1	0	1	2	0	2	0	1	0	2	2	0	3	3	3
12 : S1a	2	0	1	1	2	2	2	0	2	1	2	0	1	P	2	2	P	0	3	2
13 : RS4(a)	3	3	2	3	0	0	3	1	2	2	2	2	0	0	2	1	1	0	3	2
14 : S4a	1	2	2	2	3	3	0	0	1	1	3	P	0	2	3	3	P	3	1	1
15 : ECO2	2	0	1	0	0	P	0	0	0	P	P	0	0	0	0	0	0	0	1	0
16 : U2e	0	3	3	3	3	P	0	0	1	3	3	1	3	1	0	3	0	3	1	1
17 : U7c	0	P	3	3	P	1	P	0	0	P	3	P	0	1	P	3	0	0	1	1
18 : I4	3	0	1	0	2	0	2	0	0	1	3	P	2	0	2	0	0	0	3	1
19 : GS3a	0	2	2	2	2	1	0	0	1	3	3	2	1	P	3	3	0	0	3	3
20 : U7a	1	3	3	2	2	P	0	0	3	3	3	0	1	1	1	3	0	3	0	0

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4.1.2 Identification of variables: Bajo Calima

In La Esperanza and El Crucero in Bajo Calima, 22 variables were identified and presented in Table 6 below.

Table 6. Variables identified in PSA workshops in Community Council of Bajo Calima

Variable	Label	Type (internal-external)
Illicit crops	ECO ₃ (b)	External
Institutional	I8	External-internal
Formal education	U _{2e}	External
Mining	S _{5b}	Internal – external
Aerial spraying	I _{4a}	External
Megaprojects	RS ₄	External
Deforestation	ECO ₃	Internal – external
Population	S _{2a}	Internal
Market	S _{5a}	External
Armed conflict	S _{3c}	External
Ancestral knowledge	U _{7a}	Internal
Agriculture	RU ₃	Internal
Public policy	S _{4a}	External
Autonomous corporation of valle del cauca	GS ₁	External
Tourism	S _{1a}	External
Climate change	ECO ₁	Internal
Community	GS _{3a}	Internal
Fishing	U ₉ – RS ₁	Internal
Research	U _{7c}	External
Solid residues	U _{2i}	Internal
Fluvial transportation	ECO ₂ (a)	Internal
Water management	ECO ₂ (b)	Internal

Similar to Dagua, these variables were classified in three groups: internal, external and transition (internal-external).

The internal variables that affect biodiversity and water in the context of studied SES in Bajo Calima, are: population, ancestral knowledge, agriculture, climate change, community, fishing, solid waste, fluvial transportation and water management. The subgroup associated with basic sanitation (solid waste and wastewater) is important in the sense that these variables impact directly biodiversity and water and currently have very limited treatment by the municipality of Buenaventura and government ministries.

The external variables are illegal crops, aerial spraying, formal education, mega-projects, market, armed conflict, public policy, CVC, tourism and research. In this group, it is interesting to note that although formal education, research, and activities and projects carried out by CVC represent direct benefits to the inhabitants, their contents, design and orientation are due to external dynamics that do not necessarily consider the point of view, knowledge or interests of local communities.

The transition variables are: deforestation, mining and public institutionality. It is important to note how public institutionality is seen as an external variable, reflecting the limitations persisting regarding the participation of citizens in the decision-making process on public issues and limited public intervention and support of the municipality of Buenaventura for the SES.

Megaprojects (new roads and freshwater port), armed conflict and river transportation are particular variables because they influence directly in the case of La Esperanza and El Crucero. The other variables are common to the four cases.

After analysis of the variables the identification and ranking of their relationships was carried out. The results for Bajo-Calima are presented in Table 7 below.

Table 7. Identification and ranking of relationships between variables. Community Council of Bajo Calima

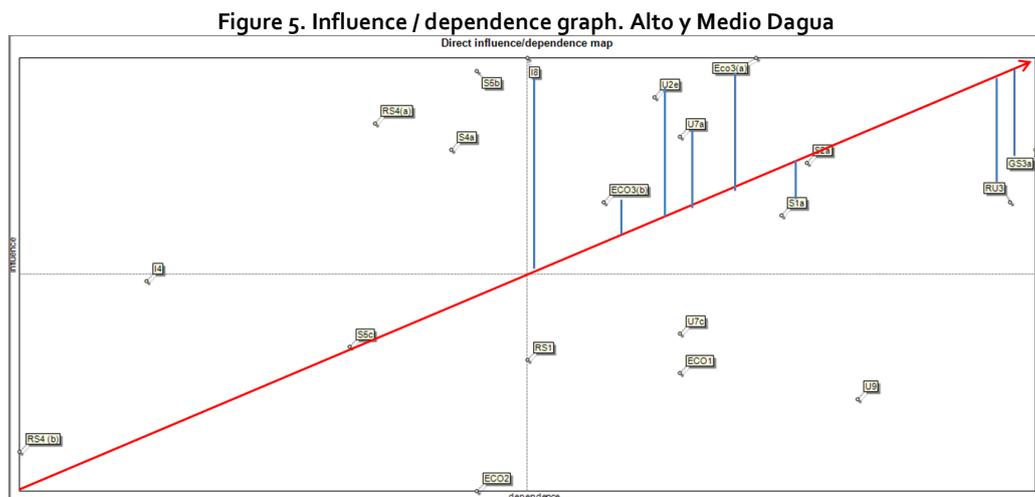
	1: ECO3	2: S5b	3: I4a	4: S2a	5: U9	6: RU3	7: RS2	8: GS1	9: S5a	10: S1a	11: ECO1	12: GS3a	13: U2i	14: ECO3(b)	15: S3c	16: ECO2b	17: S4a	18: ECO2	19: U7a	20: I8	21: U2e	22: U7c
1: ECO3	0	0	0	2	3	2	0	0	0	2	3	3	0	1	1	P	1	0	3	2	3	2
2: S5b	2	0	2	2	2	2	0	0	0	2	P	3	0	2	2	1	2	0	3	3	1	2
3: I4a	3	0	0	3	3	3	0	0	3	3	3	2	0	2	1	0	0	0	1	0	2	0
4: S2a	2	2	0	0	3	2	2	0	0	P	3	2	2	0	0	1	1	3	1	1	1	1
5: U9	0	0	0	2	0	2	0	0	0	1	1	2	0	0	1	0	0	0	2	1	1	1
6: RU3	1	0	0	0	2	0	0	0	3	2	1	2	0	2	0	0	1	0	3	2	2	2
7: RS2	3	2	0	3	2	2	0	0	2	1	2	3	2	1	2	1	0	1	1	0	1	0
8: GS1	2	3	0	2	2	0	3	0	2	P	P	1	0	0	0	0	2	1	0	1	0	2
9: S5a	3	3	0	2	2	3	0	0	0	P	3	2	1	3	1	0	1	0	2	0	0	0
10: S1a	2	0	0	3	P	P	0	0	P	0	1	P	3	2	0	2	P	0	2	2	2	P
11: ECO1	0	1	1	3	3	2	1	0	2	P	0	1	0	2	0	P	1	0	1	P	0	1
12: GS3a	3	3	0	0	1	0	2	0	0	0	0	0	P	2	1	2	0	1	2	0	0	0
13: U2i	0	0	0	0	1	2	0	0	0	3	2	2	0	0	0	1	0	0	0	0	0	0
14: ECO3(b)	2	3	3	1	2	2	0	0	0	2	1	3	0	0	3	1	3	2	3	3	3	1
15: S3c	1	2	0	1	1	2	2	1	1	2	0	3	0	2	0	1	3	0	1	1	0	0
16: ECO2b	0	0	0	0	1	1	0	0	1	1	1	2	1	1	1	0	0	0	0	0	0	0
17: S4a	2	2	1	2	1	0	2	0	1	1	P	3	0	0	2	0	0	0	1	2	1	1
18: ECO2	0	0	0	2	0	2	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0
19: U7a	2	3	0	0	3	3	0	0	0	3	P	2	0	2	0	0	0	0	2	1	3	3
20: I8	3	3	0	1	1	3	3	0	0	3	0	2	1	2	1	1	3	1	1	0	3	3
21: U2e	3	3	0	2	2	3	0	0	0	3	P	3	1	3	0	0	3	1	1	3	0	3
22: U7c	3	P	0	0	P	3	0	0	0	P	P	1	P	P	0	0	1	P	1	1	3	0

4.2 Influence/dependence graphics

4.2.1 Alto y Medio Dagua

Influence/dependence graphic

The influence / dependence graph is shown in figure 5 below, which is the result of prioritization of variables for Alto y Medio Dagua, carried out by Mic-Mac software.



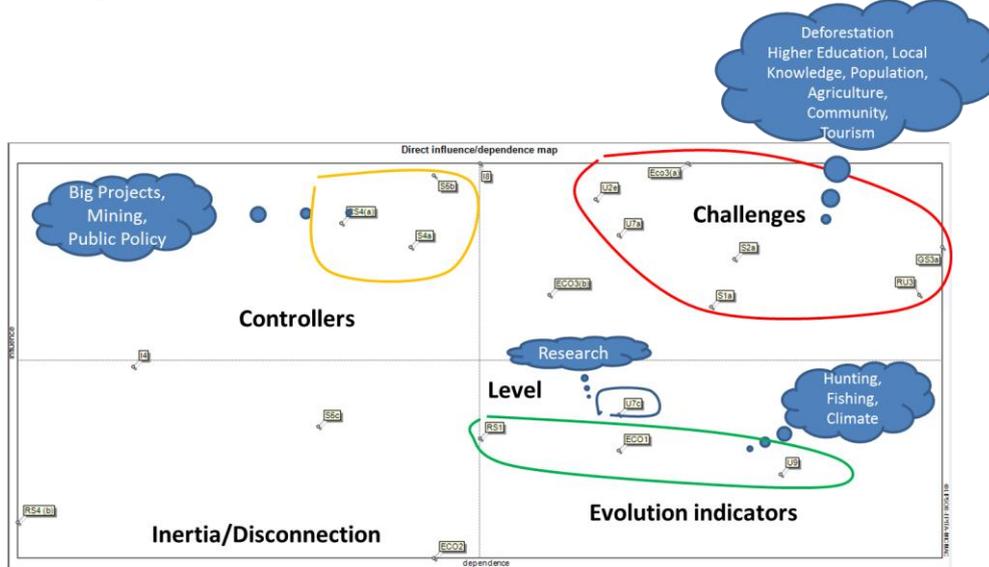
Above, the MicMac methodology positioned nine (9) key variables in the Upper-right quadrant: Institutionalility (I8), deforestation (ECO₃(a)), formal education (U₂E), ancestral knowledge (U₇a), coca (ECO₃b), population (S₂a), tourism (S₁a), community (GS₃a) and agriculture (RU₃).

From this set, the variables deforestation, ancestral knowledge, formal education, coca crops and institutionalility are the closest to the point (0,0), however, those variables are the ones with the higher influence on the system. Indeed, in La Delfina and Zaragoza, variables such as deforestation coca crops have generated a substantial impact on biodiversity and water. Although currently these two variables are subject to greater control by communtiy council and their level of incidence is lower than in Calima, their influence continues. The variable ancestral knowledge has a high recognition in its influence for the process of recovery and protection of biodiversity and water. There is, however, a major challenge associated with generational change, youth migration to urban centers and the limited recognition of this variable by public policy. Formal education and public institutions, as in Calima, are recognized as key variables that generate a significant impact on the sustainability of biodiversity and water resources. However, these effects on the system, in the current context, are related to the limitations of these variables to influence in a more forceful and determined way in terms of the problems that affect the system.

The other variables (community, agriculture, population and tourism) are the farthest from the axis (0,0) but have a higher degree of dependence of the system. This result is related to the role of the community in the recovery and conservation of the ecological subsystem and environmental services, essential for maintaining livelihoods in the area, that although focusing on a pluractivity strategy, largely dependen on agriculture and tourism. Population growth is a challenge facing the community in the future since they must simultaneously balance the pursuit of a higher level of welfare for a growing population with the preservation of ecological subsystem. In other words, these four variables represent a challenge for CC since its proper routing may depend more on behavioral guidance SES and Zaragoza and??? La Delfina. For example, an appropriate combination of sustainable agriculture and alternative tourism can be a combination of sources of income which is formed at the center of future livelihoods and biodiversity conservation and water.

Variables located in the remaining three quadrants were subjected to a further interpretation, based on the location of the variables in the matrix, the degree of influence / dependence and relationships between variables. The results are presented in Figure 6 below.

Figure 6. Interpretation of the influence / dependence graphic. Alto y Medio Dagua



As shown in this graph, the variables located in the upper left quadrant are interpreted as “regulators” due to their high impact on the system. These variables are mining (S5b) megaprojects (RS4(a)), public policy (S4a) and aerial spraying (I4), which actually are variables that currently generate significant impacts on the studied SES. The large-scale mining and megaprojects (construction of double-via road), for example, generate a combined effect that stimulates continued deforestation in the area, contamination of water sources, the deterioration of the water ecosystem water of the Dagua River and declining of important species to the community as freshwater shrimp. Moreover, although there is a set of public policies for the protection of biodiversity and water resources, these do not fit sufficiently in this context and some (i.e., aerial spraying) generate contradictory effects. Thus, promoting a decline in the level of influence of these variables will generate significant positive effects on biodiversity and water resources.

Moreover, the variables located in the lower left quadrant (Figure 6) should not be considered as secondary despite its low level of influence and dependence. On the contrary, they are variables which reflect dynamics that need specific actions and initiatives that are difficult to treat. These variables are ground transportation (S5c), oil pipeline (RS4 (b)) and water management (ECO2). For example, road transportation along the double-via road that connects Buenaventura with Buga and Cali, generates significant impacts on biodiversity and water resources through permanent pollution generated by the freight transport and the destruction of ecosystems for expansion of this important road. Moreover, water management is a very sensitive variable for Zaragoza and La Delfina since it reflects the growing current problems related to the management of water resources, the need to improve the supply and treatment of drinking water, wastewater treatment and the decline of aquatic resources as a result of mining and large infrastructure projects. Similarly, this variable reflects that community has a strong sense of belonging and relationship with the ecological dimension and has a significant potential for income generation through alternative tourism.

It is notorious the limited intervention of public institutions in this field and the difficulties of Community Councils to meet the demands of the community related to this variable.

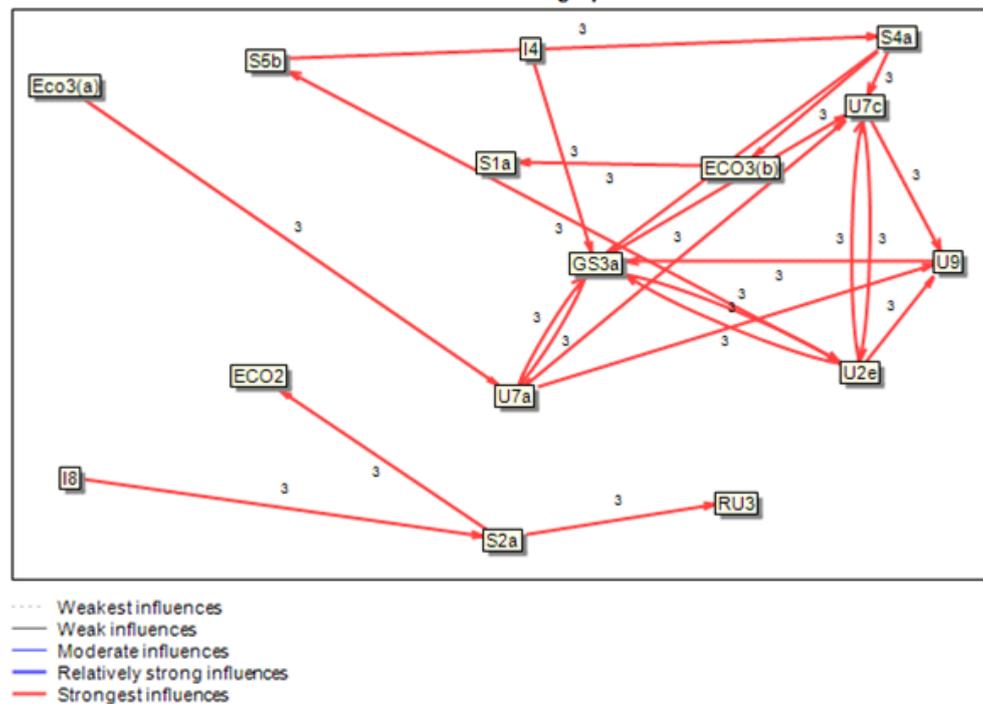
Finally, the variables located in the lower right quadrant, which reflect a greater degree of dependence and a low level of influence on the system, were organized into two groups. In the first group is a single variable, research (U7C), located on the axis that separates the upper and lower right quadrants (Figure 6). This location allows to consider this variable as a *lever*, since it is relatively less dependent and more influential in the system, so the management in this field can help to guide the key variables.

The second group of variables reflects a higher degree of dependence of the system, which provide a means to observe the evolution of the system, then they could be used as indicators of evolution. These variables are: hunting (RS1), climate (ECO1) and fishing (U9). Indeed, although currently welfare levels in Zaragoza and La Delfina are limited, the community has better access to public services, infrastructure and development projects than in the case of Calima, which has allowed them to depend less on fishing and hunting, so these do not have a decisive influence on the structure of their livelihoods.

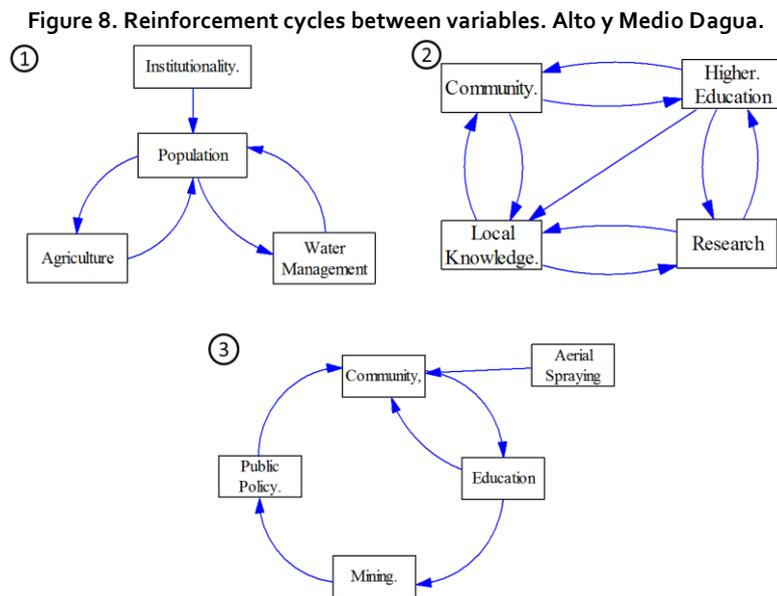
Direct influence graph

The Direct influence graph (Figure 7) shows the direct connections between the various variables that make up the Alto and Medio Dagua and thereby can determine the relationship with the greatest influence.

Figure 7. Direct influence graphic. Alto y Medio Dagua
Direct influence graph



Vensim software (Vennix, 2002) was used to identify the more important relationships from the Direct Influence graph for Alto and Medio Dagua. The three most important reinforcement cycles are shown in Figure 8 below.



The first diagram shows the relationship between public institutions, population, agriculture, and water management. While agriculture is very important for livelihoods in Zaragoza and La Delfina, the difficulties in relation to water management, population growth and limited support from public institutions in this field are a major challenge that must be addressed in an integrated manner. The population growth, combined with the limited sources of employment and income, generates a higher demand for food and consequently put pressure for increasing the area available for agriculture. Similarly, population and economic dynamics increase pressure on water resources which, as demand increases, deteriorates from agricultural activities, mining, tourism and limited integrated management actions for this resource. The intervention of public institutions in this field is limited, which contributes to the continuation of this trend. Consequently there is a very strong reinforcing cycle that must be broken through collaborative planned interventions between public institutions, the community and the Community Council.

The second diagram shows the relationship between community, formal education, ancestral knowledge and research. It shows the urgent need to increase the level and quality of research and formal education to take advantage of the ancient knowledge combined with scientific knowledge for the benefit of the community of the studied SES.

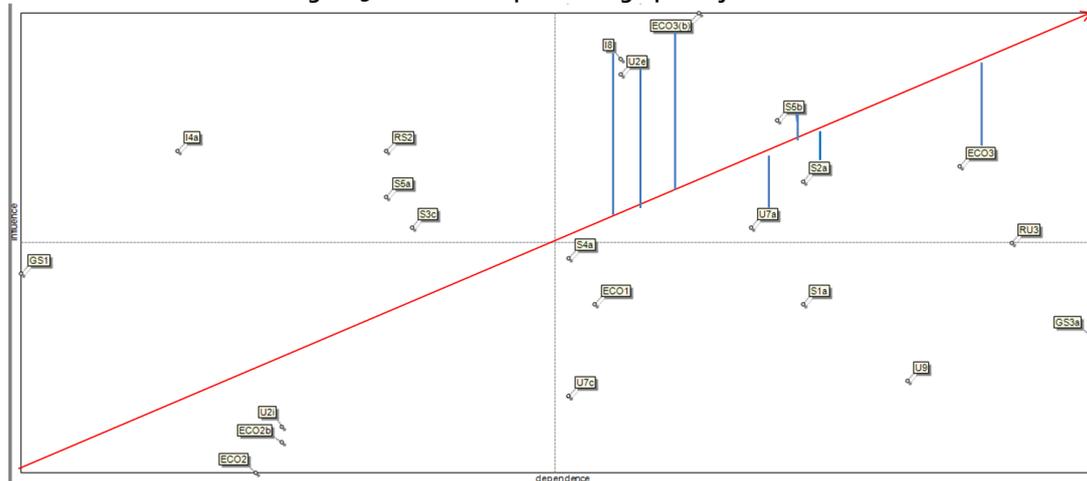
The third diagram shows the limitations of public policy to control illegal activities such as coca crops and large-scale mining, which in turn impacts on the community and environment. As can be seen, these are reinforcing cycles arising from the direct relationship between variables and potentiate their effects on biodiversity and water.

4.2.2 Bajo Calima

Influence/dependence graph

The influence / dependence graph is shown in Figure 9 below which is the result of prioritization of variables for Bajo-Calima, carried out by Mic-Mac software.

Figure 9. Influence/dependence graph. Bajo Calima



As can be seen, and according to the methodology, the key variables identified in the upper-right quadrant (Figure 9) are eight: coca crops (ECO3 (b)), public institutions (I8), formal education (U2E), mining (S5b), population (S2a), ancestral knowledge (U7a), deforestation (ECO3), and agriculture (RU3). Coca crops, formal education and public institutions are the closest to the axis (0,0), however they have the greatest degree of influence on the system. Mining presents a high degree of influence on the system. Indeed, these four variables are those with a higher degree of impact on biodiversity and water. Formal education and public institutions generate a significant impact on the sustainability of biodiversity and water resources; however, these effects on the system are related to the limitations of these variables to influence on the problems that affect the system.

The other variables (population, ancestral knowledge, agriculture and deforestation) are the furthest from the axis (0,0) but they have a higher degree of dependence on the system. This result is related to the role of livelihoods in the system as well as the increasing population in the context of studied SES. In other words, these four variables represent a challenge for Community Councils since their proper routing could affect the behavior of La Esperanza and El Crucero. For example, recovery of ancestral knowledge and the consolidation of an agricultural model based on this knowledge and other sustainable practices can lead to solve the impacts caused by deforestation in the past, and to increase the welfare of the population. Variables located in the remaining three quadrants had a complementary interpretation which is presented in Figure 10 below.

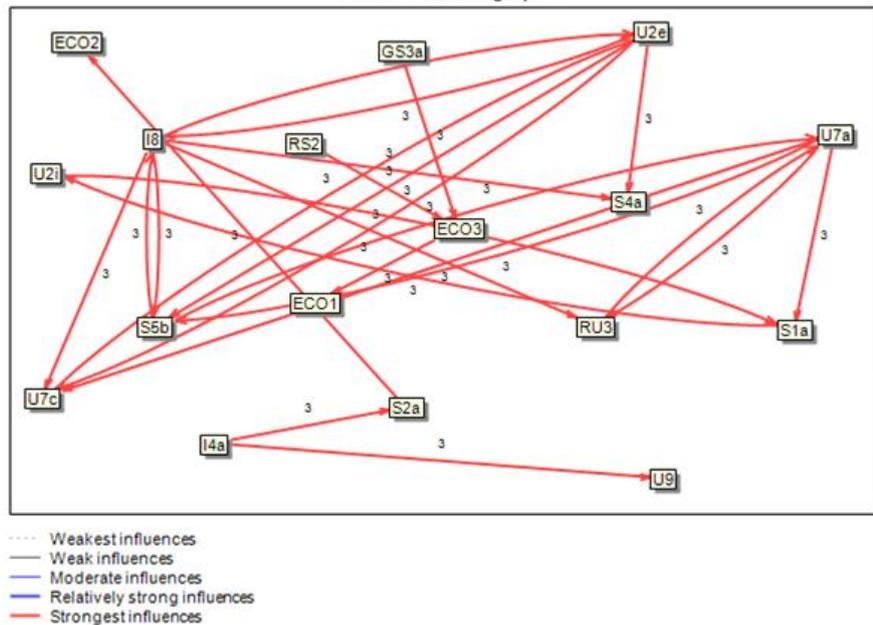
system, while influencing trends of climate variability and implementing a tourism management system linked to traditional knowledge, can generate significant positive effects on biodiversity and water and improve the governance of the analyzed SES.

The second group is a set of variables that have a higher degree of dependence and, therefore, they are a means to observe the evolution of the system, this is, they can be used as indicators of system evolution. These variables are research, fishing, hunting and community. Indeed, currently levels of welfare of inhabitants in La Esperanza and El Crucero are very limited, while fishing and hunting are in decline and are no longer a decisive influence on the structure of their livelihoods, which reflects a major crisis in the SES analyzed.

Direct influence graph

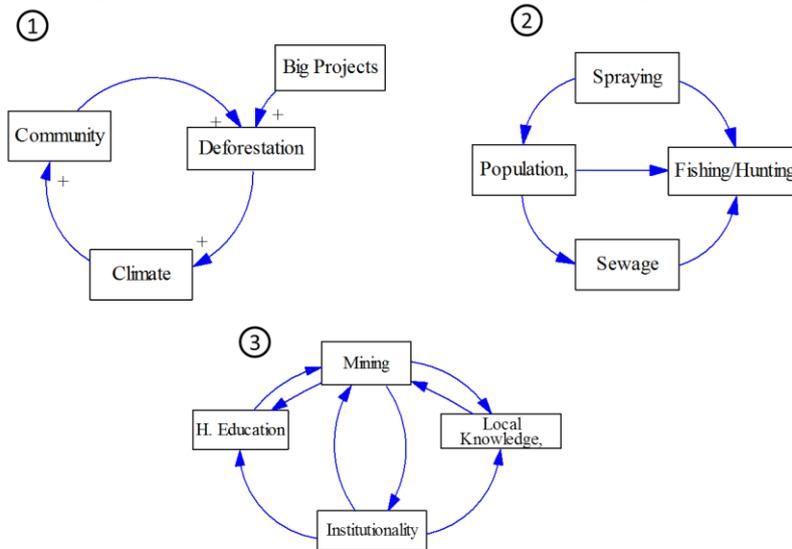
The Direct influence graph in Figure 11 below shows the direct connections between the various variables that make up the Bajo-Calima system and thereby can determine the relationship with the greatest influence.

Figure 11. Direct influence graph. Bajo Calima
Direct influence graph



Vensim software (Vennix, 2002) was used to identify the more important relationships from the Direct Influence graph for Bajo Calima. The three most important reinforcement cycles are shown in Figure 12 below.

Figure 12. Reinforcement cycles between variables. Bajo Calima



The graph in shows how the continued deforestation, partly fueled by mega-projects, encourages climate variability which affects directly biodiversity and water resources, which in turn encourages the negative changes in the community and continued deforestation.

The second cycle shows a complex relationship between mining, ancestral knowledge, public institutions and formal education. This relationship suggests that a combination of institutional control over mining, in particular illegal, improving formal education and positioning ancestral knowledge, can generate a higher level of regulation of this activity, transparency in its implementation, and better distribution at local level of benefits generated by a sustainable activity.

The last cycle illustrates a link between coca crops, population, sewage and fishing / hunting. This relationship illustrates how coca crops affect local people and increase the volume of wastewater resulting from the high level of agricultural chemicals on crops and combined with glyphosate used in the aerial spraying conducted by the national police. This combination produces a substantial impact on biodiversity and water resources which is reflected in lower numbers of organisms available to fishermen and hunters. This decline affects living standards and encourages the continuation of the link with illicit crops.

5 Results of the Prospective Structure Analysis (PSA): interpretation and validation by stakeholders

The results and interpretation described in the previous sections were presented to local stakeholders, regional and national stakeholders. In general, the information and interpretation presented was validated by them.

At local level, the discussion focused on public policy. This variable is very dynamic and currently there are changes at least in at least three areas which it is worth consideration since they will impact directly on the structure of the SES . Also, aspects related to regulation

development of Law 70 were taken into account, in particular chapters 4, 5 and 6¹ that will impact directly on the management and use of land in the territory of the Community Councils.

Similarly, the importance of Act 1617 of 2013 was highlighted, which changes the nature of the municipality of Buenaventura and gives it the character of "special district". In this sense, there will be changes in the internal structure of the municipality that can potentially lead to changes in land use and impacts on the structure of the studied SES.

Finally, it was agreed with the stakeholders to group the variables double-via road, oil pipeline and mega-projects, since they have the same nature and origins, and their effects on biodiversity and water are at the same level. Similarly, it was agreed to group "illicit crops" and "aerial spraying" as part of the same dynamics related to coca cultivation in the territory.

Co-researchers were trained in PSA and they gave some constructive criticism to the methodology. The main comment is that the method is a rigorous method, since the exercise had always a moderator who explained very well its objectives and, although it has an element of subjectivity in the ranking of variables. In the ranking exercise, co-researchers gave to the main problems a high score, so the exercise was useful to find the key variables. For co-researchers, the MIC-MAC tool was easy to use and the method adapted by the PUJ team provides a methodological guide that is friendly to the oral cultural dynamics in the Colombian Pacific region. This facilitated that communities accepted the methodology and co-researchers applied it in a good way. This also allowed that visual communication and oral discussion were carried out freely in the implementation of the workshops.

6 [Discussion of results](#)

Based on the results, it is important to consider several aspects:

1. a. The set of key variables can be interpreted not only as part of the system of variables which have a certain degree of influence / dependence on it, but also, as subsets of variables which act according to their location in the matrix of direct influences MDI, as *regulators* of the system, *levers*, *intervention tools* for re-addressing the system, *challenges* that need to be dealt with urgently, and *indicators of the system's evolution*.
2. b. In addition to analyzing the position of the variables in the influence/dependence matrix, and the influence of each on the SES studied, it is very important to analyze the forms of relationship between these variables since there is a possibility of identifying the effects on an SES arising from the combination or reinforcing cycles between these variables, that are not evident or visible to the community and researchers.
3. c. It is important to consider that the analysis of all variables in a socio-ecological context differs substantially from a similar analysis in a business

¹ These chapters are related to: iv) land use and protection of natural resources and environment; v) mining resources; and vi) mechanisms for protection and development of cultural rights and identity.

context. While in the business context the key variables are the subject of primary care, in the context of the SES analyzed, the attention should focus on the set of variables identified, the role they play in the system and their interactions within it.

4. d. In the analyzed SES it is important to improve the actions and the program guidance developed by public institutions, and to encourage decentralization and citizen participation in public decision making, so that the consolidation of Community Councils may continue. This process of deepening democratization in the field of public administration can generate significant positive effects on the structure of the governance system of natural resources, including biodiversity and water. Collaborative planning and coordinated development of new initiatives and programs in this context is a key action that will result in the improvement of governance systems of natural resources in the territories of the Community Councils.
5. e. It is necessary to consider that there is a set of variables with a high degree of influence on the system that are not in the hands of Community Councils. Such variables, such as coca crops and mega-projects are already generating significant impacts on biodiversity and water, which in the long term can be reflected in a big crisis in the four SES.
6. f. The variables identified in this activity coincide with the main variables identified by Ostrom in 2009 to characterize SES. Particularly, it is recognized the importance of strengthening traditional governance systems, and to build a number of previous institutional arrangements that allow assuming the changes in environmental supply.

7 Conclusions

1. The implementation of the matrix of variables proposed by Ostrom in 2009 allowed testing of the validity of theoretical models developed for the study of SESs. It is recognized that locally, especially given the scale, many variables overlap and it is difficult to collect data for their characterization because of the novelty of some terms for communities.
2. It is recognized that the methodological combination proposed in this research was effective for recognizing the variations and mental models at local level that local inhabitants have about the interaction of the social, ecological and economic systems.
3. The process at local level allowed to observe the importance of analyzing the local governance systems and to identify that not all activities are regulated locally, because inhabitants do not recognize this as necessary, but at the same time they recognize that extraction and new stakeholders have to be taken into account in the regulations design.
4. The combination of the characterization of the SES and PSA allow identification of variables such as resilience, strength and vulnerability that are needed to develop and enhance the community participatory process.

5. The use of Mic-Mac methodology, as an analytical tool, in the context of socio-ecological systems proved useful, not only to identify variables that determine the evolution of the system, but also to enable a deeper understanding of the structure of socio-ecological system. It is important to make an educational effort in order to adapt the entire prospective methodology to local situations and stakeholders.
6. Since the SES analyzed are located in the Colombian Pacific context and in a special political and administrative division, 90% of the identified variables were common to SES selected in the territories of Dagua and Calima. However, the variables that are not common play an important role in the behavior of the SES, so it is possible to say that the spatial proximity and similar socio-economic structure do not necessarily determine similar behaviors or structures, and their evolution can take different paths depending on the role played by key variables and their interactions within the system.
7. Within the overall set of variables, external variables play a key role in guiding the evolution of the SES. These variables, such as large infrastructure projects and illicit crops have a low level of influence, but generate, in turn, a high impact on the system structure such as pollution and deforestation.
8. The governance system of water resources and biodiversity in the SES studied is part of its social subsystem and is based on a process of social structuring that gradually has been including various stakeholders who have social, environmental, economic and political roles and have various forms of technical and institutional support. However, this external support is not sufficient and different dynamics hinder its orientation towards an ideal way in which consensus and local institutions are in the first level. It is therefore possible to consider that the governance system in this case is in the process of consolidation and has a polycentric character since the power is shared by multiple actors.
9. These difficulties prevent the possibility of Community Councils taking autonomous responsibility for the management of biodiversity and water. They need more support from public institutions. In this sense, it is important to consider both the effects of existing environmental conflicts, and the relationships between the stakeholders in the system and in particular between the public institutions and the Community Councils, the role played by these in the territory, and the difficulties present in this.

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Annex 1. Detailed description of all variables identified during the workshops and used in the PSA

Population (S2a)

The current population tendency is to increase. Therefore the increase of the natural resources has increased, exerting the increasing of good and services; the principal explanation for this trend is the natural growth of the local population and the migratory process from external actors seeking for gold at the territory. Even though there is an increasing of the migration of youth to nearby cities, the population maintain a tendency to increase from the early 80's. Between the years 2000 and 2006 the population showed a slight tendency to decrease because of armed conflict. From 2007 the population tendency was again as before 2000.

Zooming into the four case studies, the principal population features are:

Community	Population features and tendencies
La Delfina	99 families, the 85% are afro-Colombians and indigenous communities and external settlers compose the remaining 15%. The settlers started to occupy land after the year 2000. There is not a complete estimation about their number, because their migration patterns are too high and based on Gold availability.
Zaragoza	106 families, high migration tendencies for afro-Colombians and "white" settlers motivated by the "gold boom" between 2000 and 2005. The population is distributed in several small "villages" or groups of houses, determined principally for the places to extract gold.
El Crucero	82 families with approximately 304 people. The majority of the population is afro-Colombian with a small group of indigenous and "white" settlers. The community was founded in the earliest 80's. In the 90's a big influx of indigenous and "white" settlers came to the area for wood logging. This community has suffered forced displacement because of the presence of guerrillas at the territory. By the year 2000 a massive forced displacement took place at the area, and the local inhabitants moved to other's communities looking for refuge. In the last decade the traditional-local inhabitants returned to El Crucero and nowadays the population is increasing.
Nueva Esperanza	23 families with approximately 98 people. The migration tendencies at the area show a high migration patterns either inflow or outflow, particularly at the year 2000 they suffer a forced displacement, this community chose a new area to settle nearby the Calima River looking for a better place to have access to better lands for agriculture and mining.

Mining (S5b)

Artisanal mining is particularly less harmful than the big-scale mining. Artisanal mining is recognized at the local level as a traditional/cultural activity used not only to generate economic profits but also as a way to teach the young generations the way natural resources can be extracted preserving the ecosystem equilibrium. On the other hand, when mining is done in a big scale or in an unsustainable fashion affects biodiversity and human health. Prompted by international gold price increasing, a competition between artisanal mining and big-scale mining took place between the 90's and 2005. The results of that competition were armed conflict, external settlers coming to the area and environmental damage. Especially at "la Delfina" and "Zaragoza" communities the impact of the big-scale mining changed the welfare of the local inhabitants in many situations: change at the rivers caudal and water

quality, pollution. But the mining boom not only modified the local environmental conditions, it has also changed local consumption habits and local agriculture was replaced for food purchase in regional markets. At the “El Crucero” community the situation is slightly different, they depend mainly on logging (50%), followed by Mining (30%), and agriculture (10%). Women mainly make the artisanal mining activity and they report some conflictive situations because of water pollution. In the “la Nueva Esperanza’s” case, the mining activity is not reported as the most important in economic terms due the limited access to markets. Therefore, the level of production is not enough to assume transportation fees.

When thinking about the effects of the mining activity around the country, the results and the information are still biased and it’s difficult to have a clear idea about the mining impact. Environmental studies carried out by some state agencies declare that even though the impact of gold mining is high, it can be controllable. On the other hand, local communities and environmental NGO’s declare that the presence of oil and heavy metals used in the gold extraction processes are highly polluting.

Fishing (U9)

The fishing activities carried out by the local communities at the SES’s are principally handmade. The principal fishing gears used are cast nets and nets. There are not records and detailed information about the species, levels and periods of fishing. But, the local communities share high knowledge about the activity itself, the fishing periods and the best fishing areas. In all the four communities a decrease in the fishing activity has been reported. Local communities suggest that the declining of fishing activities is because different situations:

1. The introduction of the “tilapia” (*Oreochromis niloticus*) a non-native specie and some environmental affectations.
2. Pollution from mining activities
3. Transformation of the rivers channels and sedimentation.
4. Infrastructure construction activities
5. Flooding’s
6. Glyphosate spraying

The fishing activity has been regulated by local agreements defined by the communitarian councils. Nowadays some fishing practices are forbidden and the compliance level is high. Some of the restricted practices are:

1. Use of dynamite
2. Use of acids, poison or chemical products
3. Fishing of “Munchillá srimp” (*Macrobrachium rosenbergii*)

Deforestation [ECO₃ (a)]

Deforestation, as an integrative term needs to be analyzed in four different levels at the studied SESs:

1. First level. Industrial extraction. Nowadays there is not industrial extraction of wood at the local level. The expulsion of a big national company called

“Cartón de Colombia” at the 90’s is considered as one of the principal outcomes of the local organization at the Calima River. The extraction practices of that enterprise were considered unsustainable and the local communities decided to fight against their activities and presence at the common land.

2. Second level. Logging for external market. Logging for external market affects biodiversity, generate erosion and put more pressure on key ecosystems. The activity is jointly regulated by the local environmental authority (CVC) and the communitarian councils. Because of the control, local inhabitants are not key players in this level, because they are principally loggers but not middlemen’s.
3. Third level. Logging for internal market. The internal market is particularly dynamic and is mainly attached to middleman’s demands. At the communities of “La Nueva Esperanza” and “El Crucero” logging is considered the main economic activity and active part in their livelihoods.
4. Fourth level. Logging for basic private needs. The logging for private needs is probably the less harmful activity, but it should be problematic if the population increases and the demand surpasses the regeneration dynamics.

In the four case studies, logging activities have been reduced. The reduction is explained for 4 main conditions:

1. The scarcity of high-valued species to offer at the regional market.
2. The difficulty of the extraction process and the limits for transporting the extracted material
3. The gold boom, changing some of the traditional production and extraction activities
4. The increasing logging control made by the local environmental authority

ECO₃ Illicit Crops (b)

Coca crops have been reported in both Communitarian councils. The illicit crops carry some environmental and social problems. At the local level those problems are:

1. High use of novice agrochemical products (affecting soil, biodiversity and water quality)
2. Deforestation
3. Armed conflict
4. Weakening of the local organization and vulnerability
5. The use of glyphosate to control the coca production affects the water quality, crops production, animal production and human health.
6. Forced displacement
7. Influx migration without possibility to control it

The drugs production is a multi-dimensional problem. And at the local level it can be perceived in different levels and with different affectation for the local inhabitants. For

instance, the communities of “La nueva esperanza” and “el crucero” suffered directly the effect of the presence of armed actors, forced displacement and pollution originated by the glyphosate spreads. In “Zaragoza” the situation was more complex, because of the alliances between some gold extractors, armed actors and coca producers. The strategy there was more violent, killing local people and generating a non-trust environment.

Monitoring and sanctioning processes (GS 8)

This variable refers to the group of formal institutions designed at the local level to manage and preserve the natural good and services available at the communities. It is considered that the existence of the communitarian councils has allowed the permanence of ethnic groups. The analysis of the monitoring and sanctioning processes at the local level always generates a debate about the utility and importance of the governance structures at the local level. The question is not the existence of communitarian structures to govern natural resources; the question is whether they are strong enough to face all the external threats in a particularly big areas. Whatever the answers is, it is important to recognize that the new rules systems generated by the communitarian councils have taken into account the local needs. One can say that the governance structure exists, and has been proven over the last years, but it is still early to define their efficacy. Thinking about ties, relationships and networks, the communitarian council’s work together with institutions like the CVC, SENA, and some Ministers. The joint activities with those bodies are: conservation strategies, development projects, capacity building and education. On the other hand, they also recognize the low presence of other state institutions as, ECOPETROL (Oil Colombian company).

When thinking about natural resources management, each community has particular ties with specific agencies:

1. In la Delfina, the institutions or agencies are: Education regional office, CVC, SENA, Ministry of Health, ICBF and Ecopetrol.
2. In Zaragoza the Civil defense and the Fire management and CLOPAD are additional to the listed above.
3. In “la Nueva Esperanza” and “El Crucero” communities, the institutions are: CVC, PCN, ONCAPROTECA, Youth organizations and the department of social Prosperity.

Climate Change (ECO1f)

The change in some of the climatic conditions at the local level has prompted some adaptation process for agriculture. The principal variations perceived for the communities are:

1. Increase of rainfall
2. Shorter periods of summer
3. Increasing of extreme events as floods or avalanches

Therefore, the principal adaptation mechanisms defined by the local communities are:

1. Change in the patterns of production

2. Rotation of crops

There is still uncertainty about the water supply, especially in the summer periods because the principal way to gather water is from rainfall. Some local inhabitants have defined the need to design and implement irrigation systems for agriculture.

Ground transportation (S5c)

The communitarian councils, specially the Alto y Medio Dagua are facing the impacts of the expansion of the road connecting Buenaventura's port with other regions. The project is considered as necessary for economic development of the country. Then, it show two side effects. On one side, the communities (Zaragoza and La Delfina) are well connected and their economic relations have been improved, particularly in providing services for tourism, the capacity to move to Buenaventura and market connectivity. On the other side, the road expansion has generated negative impacts to the water availability and to the biodiversity. The communities recognize the increase of noise and air pollution generated by the cars.

For the communities at the Bajo Calima (El crucero and La Nueva Esperanza) there is also a project to build a road connecting a new maritime port with the rest of the country. Once again the effects are doubled side. On one side the communities will be better connected and it might be an advantage to have access to new markets. But on the other side, a road construction has a strong environmental impact, particularly on deforestation, change in the use of soils, and landscape transformation.

Hunting (RS7e)

Hunting for commercial purposes is illegal at the local level. The decline of native species is considered as a threat for natural resources renovation and reduces the resilience of the forest. Even though the activity is considered as illegal, there is not a strong control either by the CVC or the communitarian Councils. The explanation of this low control levels is because many families based their animal protein consumption in hunting and, because there is no other economic alternatives, the situation might generate social conflicts. In general local habitants report a declining of hunting activities because the reduction of available animals or the need to cover bigger areas in order to find them. Three principal reasons are considered for the reduction of hunting:

1. Sprays of Glyphosate and the arrival of foreigners.
2. Changes at the landscape for infrastructure construction (fragmentation)
3. Displacement of animal species to higher lands

Even the transformations and the reduction of hunting activities, it is still considered as a traditional activity, principally for family consumption or to share with the neighbors'. The most appreciated animals are:

1. Buses (Dinomys sp.)

2. Guatines (*Myoprocta pratti*)
3. Sainos (*Peccary tajacu*)
4. Munchillá Shrimp (*Macrobrachium rosenbergii*)
5. Tatabros (*Tayassu albirostris*),
6. Armadillo (nine-banded armadillo)
7. Bald monkeys (*Cebus capucinus*)
8. Deer (*Odocoileus virginianus*)
9. Sloth Bear (*Melursus ursinus*)

Agriculture (RU3)

Agriculture is still considered as an important subsistence activity in the analyzed SES's. But it has been a notable decrease on agricultural production. The agricultural production at the local level is particularly basic, but rich in adaptation strategies. The adaptation strategies are principally the use of small plots for production, taking advantage of the nutrition's flows, the interaction among species (plagues control, soil improvement, seeds dispersion, shadow generation, etc.). Also traditional peasants use to have mixed crops (fruit trees, timber trees and palms) to respond to soil erosion, and pest control.

Local farmers recognize that although agriculture is guided by traditional ecological knowledge, the use of agrochemicals (pest control, diseases, fertilizers) is increasing. In La Delfina, the farmer's tradition has been declining because external products are more attractive for local consumers and in general they consider agriculture as a heavy job. In all the case studies the agriculture was the main economic activity between the 60's and 70's, then at the late 80's the activity decline because the effects of the use of high levels of agrochemicals, reduction of supply nutrients, soil erosion and high soil acidity. Then the production became more difficult, demanding of more time and more agrochemicals.

In all the four case studies the local farmers report a deterioration of the traditional knowledge about food production and activities like mining, hunting or wage jobs are more attractive for the new generations.

Tourism (S1a)

Tourism is one of those "promising economic activities" for the livelihoods in the studied SES's. But some doubts are behind this activity either because the lack of knowledge of the business and low social capacity or because the non-evaluated environmental impacts of large scale tourism. It is a particular condition at the area that the type of tourism that has increased over the last years is that tourism that does not appreciate the environmental values and generate high levels of rubbish and pollution. Also, because parallel to the tourism activities, other secondary activities as washing cars and motorcycles, providing houses and services generate more environmental impact that economic growth.

Local inhabitants recognize the high valuable touristic attractions at the area, for instance waterfalls and natural pools in La Delfina and Zaragoza. The waterfalls and the river at the San Cipriano's protected area appreciated by tourist coming from Buenaventura or Cali. But

providing a natural preserved area for tourism has a price, and it is the careful design of mechanisms to maintain the natural landscape and to manage the services for tourist. The situation in el Crucero and La Nueva Esperanza is particularly different, because the geographical conditions and the “natural” isolation limit the probability for people to come to do tourism. But in general local communities still do not perceive tourism as a worth economic activity comparing to mining or logging. The Community Councils are currently evaluating the potential of each area to provide space for entertainment and enjoyment to tourists.

Megaprojects (RS2).

Some large infrastructure projects or “megaprojects” are taken place now at the case studies territories. The current projects are:

1. Two Ports.
2. Roads to connect the ports with the main road Buenaventura – Cali.
3. A New oil pipeline
4. High voltages transfer cable from the Anchicaya to Malaga road.

Some of the effects of those projects are:

1. Transformation of the landscape with erosive process.
2. Destruction of forests, wildlife and places of cultural significance to the community.
3. Displacement of native communities
4. Pollution

Public Policy (GS3b)

This variable refers to the impacts and contradictions between some policies designed to protect the natural resources and the local communities and some development policies. Some examples are:

- a. The large-scale infrastructure projects and the Water and National Biodiversity Policy
- b. Large-scale mining projects prompted by the National Development plan and the autonomy of natural resoruces management for Black communities established at the Law 70 of 1993.
- c. The protection and conservation for natural resources legal framework and the effects of the National Policy to combat illegal crops using glyphosate to eliminate coca crops.

It is particularly important to mention the rights that the Law 70 of 1993 gives to the local afro-Colombian communities:

- a. Autonomy to manage, control their territory and it’s natural resources.
- b. A previous consultancy mechanisms to have opinion and blocking capacity to projects proposed from the central administration that might risk their cultural identity

- c. The option to define their own development goals and mechanisms to reach them
- d. The recognition of local institutions (based on trust and reciprocity) to govern natural resources
- e. The autonomy to assembly and to define their leaders

Formal Education (U2D)

Formal education at the local context is understood as the primary, secondary, specialization and university education. In the area of the case studies primary and secondary education is available for the community.

When thinking about environmental education and environmental awareness education, specific programs have been developed to provide environmental knowledge for kids, youth and adults. It is also important to mention that the local communities have the capacity and are looking for the design of local adapted teaching tools.

Local inhabitants frequently ask for capacity strengthening to search and apply for advanced studies in universities and technological education institutions. At the country, the participation of afro-Colombians in universities is very low because the costs to move to different cities to get the education are very high and the capacity to obtain a place in public universities is very low. Some education strategies have been implemented in the communitarian councils, programs designed for training of rural women in productive activities. The relevant strategy then is to eliminate the disparities in access to graduate level education for local inhabitants and assure the possibility to have access to education for the new generations.

Research (O3a)

Research activities have been defined as a priority for the communitarian councils. Nowadays they are co-researchers in different projects and also, have a clear protocol to be asked and consulted when universities or research groups want to do research in their territory. Some of the research activities that they have been involved are:

1. Characterization of biotic, abiotic, socio-cultural, political and economic conditions at the communitarian councils
2. Analysis of the impact (environmental, social, economical) of the megaprojects carried and projected at the area
3. Delimitation of protected areas
4. Design of locally adapted strategies to protect water sources and defining good practices in the use of landscape
5. Defining strategies to make tourism ecological friendly

Aerial Spraying (I4A).

Aerial spraying of glyphosate was defined as one of the strategies to eliminate coca crops by the national drugs policy. Glyphosate is a herbicide that helps to destroy coca crops but the aerial spraying damage not only the coca crops, it has also affected the quality of lands, traditional production plots, animals and human health.

The aerial spraying of glyphosate conducted at the La Colonia, El Crucero y La Nueva Esperanza between 2011 and 2012 had disastrous effects for the local communities and the biodiversity. There is not data about the particular affectations, but local inhabitants report loss of fertility, deterioration of forests, deterioration of water quality, poisoning of animal species and respiratory and skin diseases. The communitarian councils are working on a proposal to obtain economic compensation because the negative impacts.

Community (GS3a)

This variable refers to the community dynamics around natural resources management and conservation. It shows the permanent dilemma for individuals between getting private incomes but from a common pool resource. Also it refers to the possibility from the local organization to bargain with the national government the externalities of infrastructure projects. There are currently few situations that are challenging the local organization capacity, those are:

1. The presence of armed actors, and the influx of settlers that use violence as strategy to control territory for gold extraction
2. The multiplicity of interests among the community and the difficulty of reaching agreements about the territory development strategies

Ancestral Knowledge (U7a)

Ancestral knowledge preservation and diffusion has been used as the spearhead for the afro-Colombian political movement. Ancestral knowledge is the body of knowledge, practices and beliefs of the community about their surrounding environment. The ancestral knowledge is considered as one of the principal tools for human adaptation to environmental changes.

At the four case studies the situation about ancestral knowledge diffusion is problematic because:

1. Social patters, as trust, respect and reciprocity are necessary for knowledge transmission, and elderly people consider that young generations are not interested into learning about the environment.
2. High migration levels of the youth
3. Social competition with new external consumption patterns
4. Short-term perspective

Regional Autonomous Corporation of the Valle del Cauca CVC (GS1)

The CVC is the public institution for environmental management. As part of environmental policy structure in Colombia, they have the follow responsibilities:

1. Determine the rules, regulations and restrictions for natural resource's extraction.
2. To give the permits, and licenses for mining and logging
3. Control the accomplishment of the national normative about water protection and biodiversity management
4. Support the communities in their definition of development goals and protection of natural resources.

The relations with the local communities and the CVC vary from the type of regulations they have to compel, the personal relations between the technicians and the local leaders and the policies they need to establish.

Community	Relationship
LA Delfina	Good and close relationship. They have been supported the community in training for agricultural production.
Zaragoza	Close relationship. The CVC has accompanied the local communities in defining some of the conservation areas and reducing hunting. On the other side, because the CVC was in charge of the gold mining permissions and titles, the relationships around mining issues were mostly problematic.
La Nueva Esperanza	Close but conflictive relationships, because the permanent control to logging activities.
El Crucero	Close but conflictive relationships, because the permanent control to logging activities. The communities also have asked for more control to mining activities made by external users and say that the CVC has not control foreigners.

Market (S5a)

Markets influences and demands are different in each of the four communities. But it can be say that the level of influence of external markets is high and that the pressures for local resources are determined by the external market demands. In order of influence the important markets places are Buenaventura, Cali and Bogotá. The participation at the markets differs in each community, some of the principal features are:

1. In La Delfina agricultural production is the principal connection with markets, especially local markets and weekend markets in seasons of tourism. The principal produced products are: palm (*Bactris gasipaes*) lulo (*Solanum quitoense*) and cassava (*Manihot esculenta*), the principal way of access to that market is the road Buenaventura – Buga. The market demands are not high enough to threat the environmental conditions.
2. In Zaragoza the principal product is Gold, the dynamics with the gold extraction and commercialization vary from individuals or groups extracting and the participation of middlemen or the transport to the product to the market in Buenaventura. The networks around gold extraction and distribution are well established. The information about the functioning of those networks is difficult to gather, basically because the combination between violence and gold extraction.

3. In El Crucero and La Nueva Esperanza the principal economic activity and the most demanded from external markets is logging. Once again, the configurations and arrangements around the activity vary from individual extraction to groups' production. About the market, most of the time there is a local group of middlemen in charge of collect wood and send it to Buenaventura or Cali. In La Nueva Esperanza they also produce some agriculture, Banana (*Musa acuminata*), papachina (*Colocasia esculenta*), maize (*Zea mays*) and peach. Most of the time the buyers come directly to the community to collect the products.

Solid Waste (U2F)

There is not a treatment system for waste in any of the settlements of the analyzed SES's. Basically in all of them, the solid waste is either burned or buried. Local inhabitants report that mismanagement of solid waste has been a major problem of public health.

Armed Conflict (S3c)

Armed conflict has two principal sides at the SES's. The first one is the presence of guerrilla associated with coca crops and coca production and trafficking. On the other side, the armed actors came to the area to protect the foreigner gold miners. In both cases, there is the perception that those actors will be longer at the area and it destabilize the social structures and limit the capacity for local leaders to comply the management strategies defined by the communities.

Transportation in waterways (ECO2b)

Waterways transportation is one of the most used transportation ways at the Calima River. It has not been documented but some inhabitants report that big boats generate waves that contribute to the erosion of the banks and increase the ecosystem fragility. A pattern of contamination from boats transportation has been reported at the La Nueva Esperanza Community. The pollution patterns are: waste and oil disposal on water, air pollution and noise.

Sewage water (ECO2)

Sewage, are identified as a priority issue in the health of communities, they are source of infections, disease and epidemics that becomes a public issue locally and territorial. This has occurred in communities of Bajo Calima as "El Crucero", where the level of pollution by mining activities in the area, has resulted in children some skin fungus. It has also shown poor management of water, since the sewer system is absent in communities like La Esperanza, where the discharges are made directly to the river and septic runoff that also reach the tributary of the river. At the communities of "la Delfina" and "Zaragoza" some plans exists to compensate the infrastructure development providing sewage water systems for the inhabitants, but the situation, more than a solution has been a problem because not all the



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houses should have connection to the systems and then there is no sense to provide it for few and not all of them.

Annex 2. Matrix for characterization of the socio-ecological system in Colombian CSs.

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	Description of the economic sectors in the study area	Main economic activities: 1. Timber extraction 2. agriculture 3. artisanal mining 4. Artisanal fishing. 5. Tourism
				S1b	Income per capita	In AMDA, monthly income per capita is aprox. col\$ 60,000 (USD 30). The income from timber cutting is approximately \$ 60,000 to \$ 600,000 (USD 30-300), in hunting \$ 30,000 to \$ 40,000 per month (USD15-20), in mining \$ 50,000 to \$ 110,000 (USD 25-55), in fishing \$ 120,000 (USD 60), agriculture or those working as laborers \$ 20,000 (USD 10). People also sell small quantities of products, such as food products and crafts \$ 50,000 to \$ 100,000 (USD 25-50), tourism \$ 70,000 (USD35). The monthly income of 51.10% of households in Bajo Calima is between 100,000 and 300,000 pesos (us\$50-150). 23.64% has a monthly income of about 100,000 (Us\$50) and 25.6% did not report income.
				S1c	Employment per sector (% and trends)	Usually communities engaged in more than one productive activity which allows them to have multiple sources of income to meet their needs. Dagua: timber extraction: 11 out of 507 families. Agriculture: approximately 167 families are dedicated to it. Tourism: only 23 families are engaged in this. Armed conflict diminished activity.
				S1d	Subsistence activities	The main livelihood activities are timber extraction, agriculture, mining and artisanal fishing.

First tier		Second tier		Third tier		
				S1e	Non-paid activities (related to land management)	In the Community Councils there are no-paid activities related to management and decision-making on the territory, carried out by members of the boards of directives and the legal representative, who do receive any payment for it, and therefore they share their time between these community work for leadership and economic activities that generate income to support themselves and their families.
				S1f	Income dispersion	Although there is no quantitative information available on the dispersion or distribution of income, we can say that in the Chocó biogeographic region the poverty index is high, and there is inequality within region in terms of income distribution.
				S1g	Time allocation among the different economic activities carried out in the area	Nowadays, inhabitants dedicate between 3 and 7 days a week to agricultural activities. In past times, they engaged more time to agriculture (between 6 and 8 days per week). The second activity in which they currently spend more time is mining; 26% of producers devoted 3 days or more in the week to this activity. Today people do not dedicate much time to fishing; eventually it is carried out by some natives. In past times, 9% of the population worked 3 or more days per week in fishing. Tourism activities, crafts, timber extraction and trade are complementary, since they support livelihoods. People spent time during the week eventually to this activity.

First tier		Second tier		Third tier		
				S1h	Specialization of stakeholders (in one of different economic activities)	Pluriactivity is important. High dependence on natural resources makes that some members of each family are engaged and learn various productive / extractive activities.
		S2	Demographic trends - Development, changes and status of the human population	S2a	Number of inhabitants	Bajo Calima: Families: 1045. Inhabitants: 3550. Alto y Medio Dagua: 550 Families. 2150 inhabitants
				S2b	Population density	Calima: 0. 05 personas per has. Dagua: 0.23 people/has.
				S2c	Gender ratio	Bajo Calima: 52% of the population is male and 48% are women. Dagua: 51% women and 49% men.
				S2d	Demographic structure	Annex 2.1.
				S2e	Population growth rate	There is not quantitative data. There is a tendency to the increase of the population. This trend is based on the natural growth of the local population, despite relatively high migration of young people, and the influx into the territory of new actors in search of natural resources and in particular gold.
				S2f	Migration trends	Young people (men and women) migrate to Buenaventura and Cali. There is no quantitative data. Permanent migration would be 1-5%. Go to the city and comeback is around 20% (especially more educated people)
				S2g	Ethnical diversity (in % per group)	In the collective territory of the two Community Councils 90% of population is Afrodescendant (black people). There are small groups of "colonos" from different regions of the country. About 5% of inhabitants are indigenous. They have their own

First tier		Second tier		Third tier		
						collective territory.
				S2h	Settlement patterns	Calima: total population located in the road: 2810 in 5 villages: La Colonia, Villa Stella, El Crucero, Brisas and La Estrella. Total population located in the river: 609 in 5 villages: San Isidro, La Esperanza, Trojita, Ceibito and Guadua. Dagua: total population located in the road in 6 towns: Zaragoza, La Delfina, Triana, Bendiciones, Km 40 and El Salto
		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)	* Political Constitution of Colombia of 1991: it recognizes and seeks to promote the rights of indigenous peoples and Afro-Colombians to their territory and the preservation of their customs. * Law 70 of 1993 which recognizes the right to collective ownership to black communities who have been occupying uncultivated land in coastal rural areas of the rivers of the Pacific basin, in accordance with their traditional production practices. * Decree 1745 1995: a black community may become Community Council, which is the highest authority of internal administration within the lands of the black communities as a legal entity. * The black communities are demanding regulation of law 70.

First tier		Second tier		Third tier		
				S3b	Level of norm compliance (norm stability, capacity of reinforcement, knowledge of norms)	The norms compliance level is between medium and low in general
				S3c	Type of conflicts	The country is in a situation of armed conflict between 3 main actors (guerrilla, paramilitary and security forces), which are distributed in the country and also have a presence in the study area. At the local level the conflict occurs primarily for access to resources such as gold and land property, but it is not related directly to water and biodiversity, although armed conflict affects the uses and conservation.
				S3d	Security indexes (e.g. the UN Security Risk Rating Index)	The security index for Colombia is 2.09. Colombia is listed as a country at high risk according to the political risk index
				S3e	Respect for democratic values (e.g. human rights, corruption)	There are democratic values although the conflict has been motivated in the majority of cases by the constant problem of income distribution and high levels of poverty.

First tier		Second tier		Third tier		
		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	In 1991, the Colombian Political Constitution gave to the State the responsibility to "protect the diversity and integrity of the environment" and "conserve areas of special ecological importance" (article 79, inc. 2). In addition, the Constitution recognizes that research and information are central elements for the practice of rights and environmental obligations (Chaves and Santamaria 2006, p.78). The national environmental system, which contains guidelines, regulations, activities, resources, programs and institutions that allow the implementation of the General environmental principles established by the law was established in 1993. Law 70 of 1993 recognized the black community as an ethnic group and defined the rights of collective ownership.
				S4b	Environmental policies at national, regional and local levels and the implementation level (including climate change mitigation strategies)	In 1997, the national biodiversity policy, which had three main themes: to know, to conserve and to use biodiversity in a sustainable way. In 2011, the quadrennial institutional environmental research plan (2011-2014) was established as the main institutional strategy to guide and support the management of biodiversity in the country, in the context of productive activities. The strategic products of this plan are: 1) biodiversity and structural nature in the territory; (2) biodiversity as an essential factor for the Colombians well-being; (3) public awareness, biodiversity for all a place within our culture; (4) strengthening of capacities and institutions.

First tier		Second tier		Third tier		
				S4c	Environmental regulatory and policy frameworks compliance	The external rules for both councils are applied by the environmental authorities, specifically the CVC (State regional institution for environmental issues).
		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 timber consumption is mainly motivated by the domestic market. Products such as sand, fishing or agriculture respond only to local markets. 1. Local operations: These operations are directed mainly to trade agricultural products and wood in the markets of Buenaventura and Cali. The provision of services to tourism is an important activity although is not regulated. 2. Global operations: These operations are related to the extraction of gold and coca crops, which end-markets are international.
				S5b	Type of products (e.g. commodities, certified products, other kind of labeling)	Timber extraction: it is not significant Dagua. Only 11 507 families. In Calima is large: 15,000 has. Artisanal Fishing: Dagua and Calima. It is only used for own consumption and not for commercial purposes. Artisanal mining: Dagua and Calima. The extraction of gold is part of their livelihoods. Agriculture: In Calima is less significant than timber extraction. Inhabitants use it mainly for consumption. In Dagua, approximately 167 families are dedicated to this activity. Livestock and fish farming: Calima and Dagua: hens, chickens and pigs for consumption. In smaller scale: fish farming and breeding of some species of wildlife such as Guati (<i>Dasyprocta fuliginosa</i>). Tourism: For the case of Dagua, only 23 families are engaged in this. Armed conflict diminishes this activity.

First tier		Second tier		Third tier		
				S5c	Access to markets (distance, commercialization channels and networks, marketing)	<p>Both Councils are located near the city of Buenaventura (approximately 40-minute by car). Also they are located a few hours from Cali (between 3 and 5 hours by car), the capital of Valle del Cauca Department. Currently, the road between Buenaventura and Cali has 122 kilometers and the double-way is in construction. So, it takes between 2 - 5 hours to arrive to the city.</p> <p>In Calima, the communities are connected by the river and by a secondary road that is derived from the main road. However, most of the territory of Calima is not connected by roads, which only leaves the river as the main option of transportation between communities. It is important to note that the access to some regions of Bajo Calima is very difficult, due to the density of the forest or the presence of illegal armed groups, whose control over the territory threatens various factors of the development of the communities.</p> <p>In addition, the city of Buenaventura is connected with Bogotá through a flight which takes place three times a week.</p>
				S5d	Demand for natural resources from local, regional, national and international markets	<p>Approximately 90% of the extracted resources (timber, gold) are distributed in the local market. Buenaventura is the main commercial axe. 95% of products from hunting, fishing, and agricultural production are for local consumption and the remaining 5% is for local markets, tourists or to offer on the road. Colombian Pacific region has one of the most significant sources of biodiversity in the world, and provides 79% of the wood used in the country</p>

First tier		Second tier		Third tier		
				S5e	Market incentives for natural resource conservation (e.g. existence of taxes, fees and charges, tradable permits, eco-labeling, financial mechanisms, liability and compensation schemes)	Today in the region there are not processes of incentives market for conservation. At national level, there is a system of incentives for conservation promoted by Ministry of the environment and some NGOs. In the Valle del Cauca, the Cipav (private research and rural extension entity) has implemented several projects of this type. However, in the Community Councils of Buenaventura there is not development of these economic incentives for conservation
		S6	Media organization - Number, diversity, freedom... of private and public media	S6a	Existence of communication networks	Radios: one private, one State (Mayor's office) and one of the armed forces. Community Councils are mainly related to stations located in the city of Buenaventura. There are no community radios but communication or sending messages by radio system has been widely used by communities in rural areas. Loudspeakers are commonly used for aspects related to natural resource management. TV channel: Telepacífico that does not have a strong relationship with Community Councils but generates contents related to socio-ecological systems.
				S6b	Media deterrence capability	The ability of deterrence of Community Councils to the media is low, although some options have been opened recently. The subject of the complaint in the media is something relative. Although the intention of denouncing is minimal, it has increased in recent years, and the constant fear for the consequences of denunciation is still. The level of impact of external media is low in local decision making processes

First tier		Second tier		Third tier		
				S6c	Interest of media in socio-environmental issues	The interest from the media about the state of the SES is low, although there is an increase in the interest from local media of covering the progresses that Community Councils have had in the protection of natural resources. In general in Colombia the issues related to mining have had media attention in the last 5 years.
Resource Systems (RS)	Comprises the environment where the resource is produced/found	RS1	Sector(s) (e.g. water, forest, pasture, fish) - Different biological production systems	RS1	Sectors	In La Delfina agriculture and forestry are related to the abundance of tropical rainforest around the community in the high lands. The development of agriculture in the mountains and ancestral techniques of planting on sloping lands, has allowed the success in the improvement of this productive activity. Mining activity in La Delfina is part of its productive activities. The presence of coastal areas in the Dagua River in Zaragoza community has been an opportunity for this community for minerals extraction. This activity is recognized by the community as the activity that generates more income. Environmental and soil characteristics of Community Councils of Alto y Medio Dagua and Bajo Calima, are typical for tropical rainforests, this is high levels of precipitation, high levels of biodiversity, high ecosystem fragility and relatively poor soils (Bene et al ., 1979). According to the Water Resources Group of CVC (2009), Dagua River basin is 1,422 has, with an annual caudal of 28,402 l/s. For its part, the Calima River Basin has 1,374 has, with estimated annual caudal of 186.145 l/s. In average, the annual precipitation for Dagua River Basin is 2,583 mm, and for the lower part of the Calima River Basin it is 9,246 mm. The two areas have a relative humidity of 88% and an average annual temperature of 26oC. Soils for low Calima area mostly deficient in P, Ca, K, Mg, Cu, B, Mn and

First tier		Second tier		Third tier		
						Zn; the percentage of aluminum saturation is high (between 60 and 90%) indicating toxic levels in the soil; and there is a low cation-exchange capacity at edaphic level (less than 10 meq/100 g). (Martinez, 2007).
		RS2	Clarity of system boundaries - Clarity of the system's geographical, social and legal boundaries, describing if the boundaries of the studied resource system are clear, fuzzy or undefined	RS2a	Natural boundaries (e.g. rivers, mountains, specific vegetation)	Although the four selected social-ecological systems do not have defined physiographic limits, they can be differentiated clearly, responding to the historical trends that have characterized the productive activity in the region. From the people point of view on their territory, the road and the river are both productive and population axes which make differences between socio-ecological systems (Martinez, 2007). These biophysical characteristics allow communities to make permanent use of natural resources and inhabitants are financially dependent on them: the soil resource for agricultural production, water resources for gold mining, sand and fisheries resources, and forest resources associated to biodiversity. La Esperanza community limits with San Isidro and the slope of the Calima River; it is located at a 21 meters above sea level. El Crucero is 9 km from the road to the Calima River and borders the community of Las Brisas and the community of Villa Stella. The community of La Delfina is located at 29 km of the via Loboguerrero-Buenaventura, in Pacific railway Pacific which passes through this community, Dagua river surrounds the community. The community of Zaragoza is divided into Alto and Bajo Zaragoza. This territory bordered by the communities of Bendiciones and Kilómetro 40. The community is also between the Pacific railway the Dagua River.

First tier		Second tier		Third tier		
				RS2b	Anthropogenic boundaries (e.g. land use distribution, conservation areas)	The Community Council of Dagua has an area of 4.71% for agricultural and livestock production and 42% dedicated to the conservation and sustainable use. In Calima 10.3% of the territory is dedicated to conservation. There are 83.7 has for enrichment, 60.9 for forest management, 1.041 for forest, 5% agriculture.
				RS2c	Extraction access and property boundaries	The boundaries of the territories are clearly established in political terms as well as the access and property rights. Although the territories are collective, every family has at least one plot in which they can cultivate. This, in most cases, is known as "patio" (courtyard), and is the place where there is exclusive private property in a wider context where the ownership of the forest is communal. Although each family has their plot, the conservation area belongs to and should be cared for by the community as a whole. Similarly, rivers, streams, and much of the territory is of collective use and management. Community Councils have their internal rules in a document which establishes the rules and regulations for the management of the territory. However, it is difficult to control access for external people especially for the extraction of gold mining and forestry resources.
		RS3	Size of resource system - Size of each type of resource (private, club, open access or common pool resources)	RS3	Size	10% of plots have less than 1 has., 20% 1-2 has., 10% 3-5 has. Although each family has their plot, the conservation area belongs to and should be cared for by the community as a whole. Similarly, rivers, streams, and much of the territory is of collective use and management. Community Councils have their internal rules in a document which establishes the rules and regulations for the management of the territory. However, it is difficult

First tier		Second tier		Third tier		
						to control access for external people especially for the extraction of gold mining and forestry resources.
		RS4	Human constructed facilities - Antropogenic structures facilitating resource management (e.g. boundaries, accessways, storage or transformation facilities)	RS4	Constructed facilities (e.g. roads, enclosures, field systems, boundary banks and ditches, ponds, parks and woods, wind and water mills, manor houses, moats and churches)	La Delfina: 1 Community Council social venue. 1 school for primary and secondary levels. 1 health services house located in the social venue, 1 community aqueduct. 1 pedestrian bridge that crosses the river. 2 soccer fields, one belonging to the indigenous reserve and the other one to the Community Council. There are also communication towers of mobile phone. 1 church and 1 cemetery. Zaragoza: 1 Community Council, which is located in the same primary school. There is promotion of health care, but this activity is carried out at health promoter home because there is not health venue. 1 community aqueduct. Also there are towers of communication for mobile telephony, 1 cemetery and 1 church. El Crucero: 1 Community Council social venue, 1 school for primary and secondary education. There is not health post. The aqueduct built in 2001 does not work currently. There is no pavement of the road but there are places with asphalt for pedestrian passage. 1 soccer field. 2 communication towers of mobile telephony. 1 church and 2 cemeteries. La Esperanza: 1 school which is at the same time the Community Council social venue. 1 room for kindergarten serving 17 children under five years old. There are not care health house, aqueduct or electricity. There is system of pump that works for a period of four hours per day, which is regulated by the authority of the Community Council. There is no pavement of the road but there are places with asphalt such as the basketball court. There is mobile phone

First tier		Second tier		Third tier		
						communication tower.
		RS5	Productivity of system - General estimation of the resource system productivity	RS5a	Productivity of the resource system (high, medium, low, exhausted)	According to the national measurements, the system is highly productive in terms of availability of natural resources. In the four socio-ecological systems, the productivity of the resources system is currently between medium to high. There are large areas of forest reserves and an abundance of water resources. However, there are threats on these resources that can put them at risk in the medium and long term, specifically the water resource is at risk for gold mining activities and processes of pollution and removal effect of the use of backhoes and the presence of illicit crops. Although the Community Councils and environmental organizations carry out education and training activities in order to be conscious in relation to these illegal dynamics, their intervention capacity is very limited. Local inhabitants believe that the productivity of the soils has declined gradually. Some local experts believe that this decline has been the result of the use of agrochemicals and erosive processes produced by: changes in rainfall regimes and the entry of large scale mining affecting ground cover. Also they recognize that productive activity has declined because young people participate less in this.
				RS5b	Resource regeneration period	"The emergence of a large number of palms indicates the high development of natural regeneration of forests, which constitute good health" (CCAMD-FUNDAPAV, 2013; own translation). The state of forests is also an indicator of the state of biodiversity associated to them, with high rates of birds, reptiles, amphibians and

First tier		Second tier		Third tier		
						mammals.
				RS5c	Resource extraction period	It is not specifically regulated by extraction seasons. But rain and dry seasons determine people access to different resources. In general, in dry seasons people carry out activities such as wood extraction, hunting and agriculture, while in rainy seasons inhabitants transport wood to commercial centers. After rainy season, river material and gold are extracted. It is important to clarify that for local inhabitants, rain and dry seasons are actually days with much rain and days with less rain.
		RS6	Equilibrium properties - Influences (positive and negative) on the equilibrium of the resource system (interaction between species, in social systems, or between biological and antropological systems)	RS6a	Equilibrium properties	Although they are not series of data that describe accurately the behavior and the relationship between biological, economic and social systems, it is possible to say broadly that socio-ecological systems have high levels of learning and feedback. So far the territory of both councils has lived two times of high extraction of resources. First, from 1959 until 1993, there was wood extraction carried out by concession to a private company. Currently the ecosystem is in the process of absorption of the impact and there is plant regeneration. Strong impacts on ecosystems and the difficulty in the recovery of the environmental conditions have generated a process of learning for communities around wood extraction and other extractive processes. Second, there has been gold extraction in the area, which is considered critical for its negative impacts in terms of environmental damage and violence from 2010 to date.

First tier		Second tier		Third tier		
				RS6b	Natural hazards occurrence (frequency and magnitude): e.g. flooding, fires, drought	<p>In general, there is a low occurrence of crisis by natural phenomena. And although there is no clear information about cycles or frequencies, in different areas of Dagua and Calima rivers there have been floods. In Alto y Medio Dagua, in the community of Triana, there was an avalanche in 2006 which destroyed part of the infrastructure. Natural disasters arising from the change in the level of the river may increase because of extraction of river material, so the vulnerability to landslides in rainy seasons can increase.</p> <p>In El Crucero in Bajo Calima, the floods due to lack of sewer sanitary system, have been a determining factor of the soil erosion and the deterioration of the land where the houses are located. Also, erosion by rain derived from the wood extractive activity has affected the quality of soils for agriculture and makes them vulnerable to geophysical erosion. In La Esperanza there are floods that frequently affect the community, since there are constant landslides of soil profiles that border the river, because there have been attempts to carry out mining in these areas. In order to overcome this situation, inhabitants have constructed their houses further away on the banks of the river.</p> <p>In the four socio-ecological systems, floods have affected seriously the food production and the life conditions of the communities. But extractive dynamics (i.e. wood extraction) are benefited for the river flow increase because this facilitates the transportation. Likewise, according to villagers, floods increase the amount of gold and river material. Therefore, communities easily adapt to environmental changes because sometimes these</p>

First tier		Second tier		Third tier		
						changes represent opportunities in the form of access and extract resources. With respect to storms and hurricanes, there has not been, in recent years, data from strong phenomena associated with tectonic movements or high tides affecting these communities.
				RS6c	History, evidence of impacts in sub-systems and its effects	The region has extensive forest areas where high biodiversity is associated. It is important to note that even within the territory there are areas of primary forest, exploitation for years conducted by a private company has installed a secondary forest with species such as blackberry (<i>Miconia</i> sp - melastomataceae), chestnut (<i>Heliathostylis sprucei</i> - moraceae) guabo (<i>Inga</i> sp - minosaceae), caimito (<i>Pouteria</i> sp. - Sapotaceae), azulito (<i>Mabea chocoensis</i> - euphorbiaceae), anime (<i>Protium</i> sp., Burseraceae), chaquiro (<i>Goupia glabra</i> - Celastraceae), guasco (<i>Eschweiler</i> sp. - Lecythidaceae) manglillo (<i>Icacorea manglillo</i> - Myrsinaceae) and cargadero (<i>Guatteria calimensis</i> - Annonaceae) (Martinez, 2007; CCAMD-FUNDAPAV, 2013). The presence of these species suggests that the basins of the rivers Dagua and Calima in this area are in the process of regeneration: "the emergence of a large number of palms indicates the high development of natural regeneration of forests, which constitute good health" (CCAMD-FUNDAPAV, 2013; own translation). The state of forests is also an indicator of the state of biodiversity associated to them, with high rates of birds, reptiles, amphibians and mammals. A private company (Cartón Colombia) left installed a secondary forest where the species can be found as: mora (<i>Miconia</i> sp - MELASTOMATACEAE), chestnut (<i>Heliathostylis</i>

First tier		Second tier		Third tier		
						<p>sprucei - MORACEAE), guabo (Inga sp - MIMOSACEAE), caimito (Pouteria SP. - SAPOTACEAE), azulito (Mabea chocoensis - EUPHORBIACEAE), anime (Protium SP. - BURSERACEAE), chaquiro (Goupia glabra - CELASTRACEAE), guasco (Eschweilera SP. - LECYTHIDACEAE), manglillo (Icacorea manglillo - MYRSINACEAE) and landing (Guatteria calimensis - ANNONACEAE). In general when there's food production processes such as flooding looks seriously affected, but in turn to other extractive dynamics can be wood, floods or increase in bodies of water makes it more efficient transport of produced, likewise after increase in water levels is said there are more available and material Gold River to extract.</p>
		RS7	<p>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</p>	RS7	<p>Predictability of system dynamics</p>	<p>Social-ecological systems are generally stable. Units flows by traditional knowledge have been constant. Given the historically stable regimes of rainy and dry times, residents have been able to plan their forms of use of the territory. Although in recent years the uncertainty about the system has increased, agricultural productivity is low, but enough for consumption. Local knowledge about the socio-ecological systems is high. There is a high level of knowledge of the impact of extraction of natural resources. The main indicator is the productivity of the land</p>

First tier		Second tier		Third tier		
		RS8	Storage characteristics - Retention of information about the system dynamics	RS8	Storage (memory) of the effects of disturbances on a system or sub-systems	<p>It is high. It is determined by the specialization in productive activities, which varies from person to person. In biological terms, it is not possible to say with accuracy which the characteristics of storage are in collective territories.</p> <p>High level of storage of knowledge about the functions of social-ecological systems, but this knowledge is starting to decrease since young people do not have interest in continuing with the traditional productive activities.</p>
		RS9	Location - Geographic location	RS9	Geographical location, distribution and distribution patterns	Annex 2.2
Governance Systems (GS)	Describes the governance system affecting and affected by the SES	GS1	Government organizations - Permanent or semi-permanent organizations (or systems of rules) controlled by national, regional and local regulation institutions	GS1	Government Organizations	<p>Local level: Buenaventura Mayor office and its secretaries (Environment, education, government, health, planning). Police Offices. Regional level: Government of Valle del Cauca, Corporation for environmental regulation (CVC). National Level: Ministry of Environment, Ministry of mining and energy. Ministry of Social Protection. Ministry of Agriculture and Rural Development, Ministry of Education, Department for Social Prosperity, Ministry of State , Colombian Institute for Rural Development (INCODER). SENA (technical capacity building and education).</p>

First tier		Second tier		Third tier		
		GS2	NGOs - Different types of NGOs (e.g. social, environmental, technical organizations) interacting with the analyzed SES	GS2	NGOs	FUNDAPAV (NGO that have been supporting the Community Councils for approximately 7 years). Save the Children. ECOBIOS. Foundation AGROESOP. International Red Cross. Fundación Puerto Aguadulce. ONCAPROTECA (Black peasant organization for the protection of the territory of Bajo Calima). Fundación Simbiosis. Fundelpa. Fundación San Cipriano. Sociedad Portuaria Foundation. JUBCA: United youth working for the strengthening of Calima
		GS3	Network structure - Networks related to the management and use of resources inside the socio-ecological system	GS3a	Social networks	1) Social networks that enable or mediate the exchange of resources (physical, financial, human and information). (2) Related to environmental services and activities (Social networks related to the extraction, processing and marketing of natural resources. Social networks related to processes of preservation, remediation of environmental impacts and public policies for the protection and regulation of natural resource extraction. (3) Social networks related to the economic dimension: trade and provision of services. (4) Social networks related to the cultural domain of each Community Council: for example those formed by actors. (5) Social networks related to public services e.g. health, education, electricity, and Government subsidies. (6) Social networks related to the political dimension.
				GS3b	Environmental networks	Ecological networks related to the generation of environmental services (construction of specific agreements for the conservation

First tier		Second tier		Third tier		
				GS3c	Market networks	There are two general types of markets: (1) for the transaction of agriculture products (2) for the transaction and use of natural resources. Agriculture producers first supply the family, then they offer products to neighbors (trade) and the rest is offered to local intermediaries. In the case of gold, there are two tendencies: one is to offer gold to local merchants from the same community or to other people in Buenaventura where the payment is better. The fishing products are is commercialized locally. For timber there are clear market networks.
		GS4	Property-rights systems - Presence or absence of formal property right systems for the resources (e.g. land property, exclusive fishing rights)	GS4a	System of property right	The ownership of the territory in both Community Councils is collective, with exclusive use for community members. Other actors may enter to the territory via permissions set by the Community Councils. As mentioned before, within the collective ownership, there are individual properties with exclusive use, which are associated with food production and correspond, mostly, to family inheritance.
				GS4b	Excludability (i.e., possibility to exclude potential users from using the resource)	Excludability is low due to the expansion of the territories, but in the case studies each community can easily exclude external actors (which is supported by the functions of the Board of directives of the Community Councils)
				GS4c	Subtractability (i.e. whether resource appropriation by one user reduce availability to others)	Water: The subtractability at this time is low, given that there is a high supply of water resources. Forest: The subtractability is high. Biodiversity: the subtractability is currently low given the diversity of species available and usable. Mining: Mining is the resource where the subtractability is high. Land: the subtractability is high.

First tier		Second tier		Third tier		
		GS5	Operational rules - Community rules established for the extraction, management, access and use of natural resources	GS5	Operational rules (local rules for defining Who, How, Where, When, and Why have access to local natural resources)	There is a set of internal and external rules governing the use of natural resources, specifically the biodiversity and water in both Community Councils. For example, in Dagua, industrial mining, water pollution, wood extraction, hunting for commercial purpose, the use of herbicides, dynamite and chemicals are prohibited, while in Calima the rules are oriented to conservation, by prohibiting hunting, wood extraction and pollution of water sources.
		GS6	Collective-choice rules - Collective-choice rules used to change the day-to-day operational rules related to the resource management	GS6	Collective-choice Rules	The boards of Directors of Community Councils are those who have the power to make changes in the internal regulations and management plans supported and approved in assemblies of Community Councils
		GS7	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	Political Constitution of Colombia, 1991 - transitional article 55. Law 70 of 1993. 1745 Decree of 1995. National policy on biodiversity and national water resources policy.
		GS8	Monitoring and sanctioning processes - Set of methods to monitor and enforce the operational rules	GS8a	Monitoring processes	Monitoring of the compliance of rules and regulations: by State (CVC) and the boards of Directors of the Community Councils
				GS8b	Sanctioning processes	Sanctions (fines and forfeitures) for timber extraction are carried out by the State (CVC)
Resource Units (RU)	Describes the natural resource	RU1	Resource unit mobility - Resource mobility (e.g. fish are mobile, while molluscs are static)	RU1	Resource unit mobility	Mainly static for wood. Relatively mobile for biodiversity, highly mobile for water.

First tier		Second tier		Third tier		
		RU2	Growth or replacement rate - Growth/replacement rate based upon the resource unit's life cycle (e.g. reproductive age, harvesting age, growth rate)	RU2	Growth or replacement rate	There is no available statistical information. But we can say that growth and regeneration rates are higher than use rates although for some people resources are beginning to be threatened, and the main indicator is the decline in the supply of wood species.
		RU3	Interaction among resource units - Resource units interaction (e.g. competition, collaboration)	RU3	Interaction among resource units	1. Ecological interactions: these interactions are multiple and of the type predator - prey, soil - water - plants, etc. 2 Interactions related to the agriculture units: a. soil conditions, availability of water resources and climatic conditions allow more diversified agricultural activities in AMDA than in Bajo Calima. b. reduction of the number of units of agricultural production in the areas of alluvial plain, domestic spaces and the number of agriculture plots, due to the pressure exerted by the extraction of mineral and forest resources units.
		RU4	Economic value - Economic value of the resources	RU4a	Market value	Timber: A piece of rectangular cutted timber: \$ 8,000-15,000 (US\$ 4-8) depending on the specie. Fishing: \$10,000 - 20,000 per kg (us\$ 5 - 10) depending on the specie. Gold: between \$30,000 and 35,000 per gram (US\$15-18) in Buenaventura. Water: no data available. The community water users pay \$3,000-\$4,000 monthly (US\$1.5 - 2) for the system maintenance. River material: \$20,000-\$45,000 (US10-23) depending on the material extracted.

First tier		Second tier		Third tier		
				RU4b	Environmental value	The environmental value of resources in the area is high. The four socio-ecological systems are located in a priority area for conservation, especially for the quality and quantity of available water, biodiversity, carbon sequestration and climate regulation. The current community management of natural resources has proposed an initiative for communities to create parks with ecological trails, which have tried to be implemented in Bajo Calima using solid wastes. Also in both Community Councils there are places like "balnearios" and family recreational tourism sites in the Calima River, as well as some recreational places in Dagua River. However, there are not studies about economic valuation of these environmental services.
				RU4c	Strategic value (e.g. economic, social, geopolitical, cultural, symbolic)	The strategic value of natural resources is high. Particularly water and biodiversity. There are no studies on this, but it is widely known that rain schemes, carbon capture and climate regulation have high strategic value. In particular the area is considered strategic for national regulators in the production of environmental services, even higher than the direct environmental goods.

First tier		Second tier		Third tier		
		RU5	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	Although there is a general perception that currently there are enough resources to all the inhabitants, it is clear for people that there is a decrease in environmental supply or possibly a displacement of animals for further forest areas. In the case of Dagua, studies have been carried out on flora and fauna associated with five geographical points in the territory corresponding to streams such as Pericos, Oso, Limones, Zaragoza and Triana. In these studies it was possible to quantify the richness and the abundance of species of the most representative taxa. There is a high biodiversity in forests which present a richness of species even higher comparatively with regard to other tropical rainforest of the country. There is a decline in resources, mainly forests (timber), water resources in streams, birds, mammals, rodents, amphibians and reptiles. This perception of history of the state of natural resources has been from 1970. Community observes a significant decrease from 1970 until now.
		RU6	Distinctive markings - Natural or artificial markings to distinguish categories in the resource	RU6	Distinctive markings	There are not distinctive markings

First tier		Second tier		Third tier		
		RU7	Spatial and temporal distribution - Availability of the resource in space and time	RU7	Spatial and temporal distribution	The presence of large amount of sediment in the Calima River allows the nutrition of fishes and ecological dynamics linked to aquatic organisms, which enhance the productivity of this resource in Bajo Calima. So, fieldwork showed that the opportunity of accessing to fishing resources is greater with respect to other activities, such as the forestry and mining, where there are limited access even if these activities are recognized as important part of livelihoods in La Esperanza. In El Crucero, where the road allows easy access to streams of the mountains, the mining activity and the extraction of forest resources are common. All resources extracted in collective territories are considered available permanently and throughout the territory. There are only variations in agricultural production, and this is determined by the type of species and crops. Community Councils have established areas of forest extraction (mature forests, in the Highlands forests), areas of gold extraction and river material (on the banks of the rivers). Agricultural production is carried out in the lower parts. Seasonality is determined by rain and water availability, but it is not identified as a constraint.
Users (U)	Describes users of the resource system under consideration	U1	Number of users - Number of the direct users of the SES	U1	Number of users	In both Community Councils it is considered that each person can access to the resource and productive activity that each wants. This is determined mainly by physical skills and/or knowledge. Bajo Calima: Agriculture 64, mining 52, livestock 41, timber cutting 39, shop 17, Production and sale of drinks and sweets 13, fishing 10, sales of products by catalogues 10, others 8, crafts 7, river material extraction 3, tourism 3, Total 267. Alto y Medio Dagua: agriculture 122, mining 167, animal breeding 97, timber extraction 11, fishing 10, others

First tier		Second tier		Third tier		
						70, none 96, Total 624.
		U2	Socio-economic attributes of users - Socio-economic characteristic of the resource system users	U2a	Sources of income (linked or not with the resource)	1. Timber extraction. 2. Agriculture 3. Artisanal mining. 4. Tourism (Dagua).
		U2b		Consumption patterns (e.g. local resources, local/imported food, shopping)	The community has an agriculture system that allows consumption of certain products. Also people consume products which are not produced in the region (rice, beans, oil, milk), and also toiletries.	
		U2c		Women rights (e.g. land tenure, empowerment, gender equity, private-public roles, health, education)	There are no quantitative data available. However, although cultural gender roles (productive and reproductive) have not changed, women seem to have a greater right to participate in the Community Councils. It is not clear that the collective rights on land create equal access for men and women. There are associations of community mothers and associative enterprises of women.	
		U2d		Access to health	In the Community Councils there are health posts, but they do not have basic services of water and sanitation. There is not rural doctor or nurse for emergencies. There are no ambulances and it is difficult to access to urgent care for the river communities. There are special programs for the attention for tropical diseases such as Malaria. There are plans for prevention and information on them. Improving access to health at the local level is one of the more frequent requests in communities.	

First tier		Second tier		Third tier		
				Uze	Access to education	There are approximately 17 branches of 2 schools in Community Councils, which cover basic and secondary education. The high scholars have access to the national service of learning SENA. Law 70 includes the ethno-education in childhood and adolescence in schools and educational centers; and there are programs of scholarships for young people who aspire to education in State universities.
				Uzf	Poverty (e.g. income, life cost, access to food)	Houses in the Community Councils are built in cement and zinc, some with wood. The spatial distribution of the houses has reduced spaces between them. They have patio or homegarden where they grow some food products for family consumption or raise some minor species such as chickens, pigs and guati, contributing to the family food.
				Uzg	Vulnerability (e.g. social, economic, institutional, environmental)	Poverty level is high and the vulnerability of people is high
				Uzh	Cultural identities (e.g. language, food, celebrations, traditions)	Culture is significantly important. In the four case studies there are a variety of cultural groups: dance, theatre, music and sports. There are different games and traditional festivals. There is a decrease of popular knowledge and cultural practices in relation to ancestral uses (crops, hunting, fishing, gathering, wood extraction), traditional medicine, birth and funeral rites, religious and community celebrations, music and dance, traditional forms of solidarity, traditional games.

First tier		Second tier		Third tier		
				Uzi	Sanitation	In none of the Studied SES, community has sewerage infrastructure, although some families have septic tanks. In some cases, especially in houses located in a dispersed manner along the railway and road, sewage are arranged nearby water sources, especially the river or open field.
				Uzj	Access to drinking water	The supply of water is deficient which is reflected in health and sanitary conditions. AMDA: the main source of water for human consumption is obtained from the small rivers, there is not potable water supply. Bajo Calima: just 20% of 2 communities studied has aqueduct, and there are deficiencies in the maintenance of the infrastructure. 80% remaining has a system of collection of rainwater, and one of the communities built a dam for its collection and delivery.
				Uzk	Access to electricity	In Calima 80% of people have access to electricity. In 100% of people have access to electricity.
				Uzl	Home gadgets (e.g. TV, washing machine, computer, telephone)	Most of the families have: • Television • DVD player • Player sound and Radio equipment • mobile phone • Blender • Iron. Non-common: • Washing machine • Computer • Refrigerator • Motor boat. Inhabitants in the majority of households in remote rural areas cook with firewood (approximately 70% of households). Also the gas is used (20% approx) and the rest combines the use of gas with electricity.

First tier		Second tier		Third tier		
		U ₃	History of use - Chronological description of resource extracting methods	U ₃	History of use	1940s: first settlers arrive from the Chocó department to extract gold. 1950s: the private company Carton de Colombia was established in the region. 1990s: Both Community Councils were created. In 1993 (13 February), Carton de Colombia ended its activities in the region. Between 1998 and 2000: paramilitaries arrived in the region and with them coca crops also came. In 2010, coca crops increased, which led to a new aumigation in 2011-2012.
		U ₄	Location - Geographical location of users of the resource system (e.g. settlements, villages, dispersion)	U ₄	Location/dispersion patterns	Bajo Calima: located at north of the municipality of Buenaventura, Department of Valle del Cauca. The community of El Crucero is located on the road towards the colony via Rio Calima bordering the Community Councils La Brea and Las Brisas. The territory has increased its area towards the forests area and the road. The community of La Esperanza is located in the lower basin of Calima river; it is one of the last communities in rural area of the municipality of Buenaventura, bordering with the basin of the San Juan river in the North of the Department of Chocó. The territory has been extended from the banks of the Calima river and the coast of the north side, to the forests of bordering the coast of the San Juan river in Choco. Alto y Medio Dagua: it is located in the Department of Valle del Cauca, in the rural area of the municipality of Buenaventura. La Delfina community is located in the south coast of the upper and middle basin of Dagua river, it extends from the beginning of the road, and occupies the mountainous area and in the side of the Pacific railway. The territory also borders the Dagua river. The process of expansion of the territory has been characterized by taking part of the mountainous

First tier		Second tier		Third tier		
						region, some Nasa Indians have settled in houses outside the shelter in the middle part of the mountain and they share the territory with Community Councils. The community of Zaragoza occupies both slopes of the basin of the upper and middle basin of Dagua river. Some houses are located in one side of the road and others in the side of the railway and the river. With regard to expansion, its location is taking territory from the mountainous with settlements in colonies located in streams where mining activity is carried out.
		U5	Leadership/entrepreneurship - Existence of, and attitude towards leadership and entrepreneurship among users	U5a	Leadership patterns (e.g. level of acceptance, prominence, leadership models)	Community Councils have a hierarchical government system where the legal representative is the highest authority who makes decisions that affect the entire community. He/she is a leader and the community trusts him/her.
				U5b	Attitudes toward conservation (e.g. entrepreneurship, maintenance, sustainable use)	One of the main functions of these leaders and in general of the whole community is to contribute to the environmental conservation, since it is part of their duties as collective territories. There is awareness of the importance of conservation of natural resources, but there are not yet specific projects in this sense.
		U6	Norms/social capital - Levels of social interaction, reciprocity and trust among users	U6a	Social capital	The social capital is internal and is reinforced by the dynamics of kinship, race and territory. Similarly, it is important the social capital related to links created with outside institutions or stakeholders. This social capital, also known as bridge-capital, allows to inhabitants establish relationships with their immediate and regional surroundings through dynamics such as trade, remittances, services and public policies, among others. In the SES studied,

First tier		Second tier		Third tier		
						there is also a strong potential for human capital not just of Councils directives but also of technical and professional training for young people.
				U6b	Traditional forms of collaboration among users (e.g. norms, habits, traditions, customs)	In general terms, social capital is high, because there are two levels of cooperation, through traditional norms and rules linked to formal institutions, which interact and generate a high level of collaboration among the community.
		U7	Knowledge of SES/mental models - Level of knowledge among the users of the SES conditions, perturbation patterns and possible effects	U7a	Local knowledge on SES (based on traditional or scientific knowledge)	In relation to local knowledge of socio-ecological systems, both Community Councils have updated and detailed information on animals, plants, soil, water quality and traditional uses. However, it is seemed that this knowledge is being lost by the lack of interest from the younger generation. For people in general it is clear that resources are very important to the community life, since water, fishing and hunting contribute to self-sufficiency of basic foodstuffs; mining and timber are useful for gain income in order to pay services such as health, education and commercial products. In these practices, community uses traditional technologies in favor of protecting the ecosystem.
				U7b	Knowledge of the effect of over-harvesting	With respect to knowledge of the effects of social attitudes on natural resources, the consequences of over-exploitation are recognized, but also it is clear that social attitudes could help to protect and empower ecosystems not just for conservation but also for benefit to community.

First tier		Second tier		Third tier		
				U7c	Knowledge of the effect of social attitudes toward resource management on the SES	There is a high level of knowledge of the effects of social attitudes on resources. People know that these social attitudes can degrade the ecosystem, but also they know that they can protect it and enhance it for conservation and benefit of the community.
				U7d	Knowledge of the effect of biological shocks on the SES	The level of knowledge of the environmental effects is medium, since although people know the implications that certain activities have on human ecosystems, sometimes this impact is not measured. For instance, this happened with the forest cutting or with fishing with explosives.
				U7e	Mental models related to SES management (e.g. conservation, exploitation, human-nature relationships)	Locals share knowledge about natural resource conditions. They recognize which human interventions affect the state of natural resources. Given their level of knowledge on natural resources they can easily identify changes in biological structure.
		U8	Importance of resources - Users dependence on resources for livelihood	U8	Importance of resources for livelihood	The importance of resources for livelihoods is high. Water for agriculture, wood for sale, fishing for consumption, mining (gold and material river) for sale, hunting for consumption and sale.
		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 different technologies	U9	Type of technologies used on the SES	1. Taking water by floating gallery, rain water systems in houses and water driving systems through hoses to supply housing. 2 Tools for mining as: "batea", "pica" and "pala". 3 Tools for cutting wood: Machete, axe, power saws. 4 Tools for agriculture in patios and gardens: hoe, machete.

First tier		Second tier		Third tier		
Interactions (I)	Describes interactions among all before mentioned variables	I1	Harvesting levels of diverse users - Quantity of the resource(s) harvested by different users	I1a	Harvesting level and effects on SES	<p>There is no concrete information that allow to quantify the biological effect of extraction of resources in each of the components of the ecosystems of tropical rainforest and the river. However, there are some effects of the gold and river material extraction on the health of ecosystems. Some of the consequences of the material river extraction are the divert of the river channel and there is a trend to <i>colmatar</i> the banks that have been emptied of rocky material, which increases the level of water in the bank of the river and promotes the loosening of the soil that sustains this band of the river. Similarly, in mining, there is removal of material that changes the dynamics of stability of the rivers, essential elements in the SES. For example, in La Delfina the main consequences of landslides and avalanches in the tributary of the river occur in places where removals in mass of material (stone, concrete or sand) have taken place. However the community performs these activities for community use. The demand of the material river has increased since the construction activity has also increased. The effect of this type of extraction on ecosystems of river board has grown. Regarding forest harvesting carried out by community, for example in El Crucero, people know that deforestation for community purpose and for trade, has generated that some animals move outside the forest. Also the dynamics of plant succession are not stimulated. This causes that in the long term there is no recuperation of forest and then the effect on the socio-ecological systems is high. There is not quantitative data on how much wood should be removed to generate a devastating effect on the ecosystem, but the community, based on their local knowledge, is able to influence these</p>

First tier		Second tier		Third tier		
						decisions by preventing cut all trees in a place intended for the extraction. In agriculture in La Esperanza, there has been the contribution of leachate and organic wastes from the productive activity of the community to Calima river. Also in La Delfina there has been organic waste to the Dagua river. This has not been quantified. Then, the effect of this on the dynamics of the pollution of the river is not known. However, the effect of the accumulation of heavy metals in the water that leads to the reduction of populations of fishes and other aquatic organisms associated with the river is known.
				l1b	Free-riding	There is a relatively high probability of free-riding, since monitoring capacity is low. However, the boards of directives of Community Councils have established mechanisms of information sharing through "vereda" leaders who report to the rest of the community.
		l2	Information sharing among users - Methods of information sharing among users	l2a	Knowledge dissemination on the SES	Knowledge creation on socio-ecological systems is relatively low, but it exists.
				l2b	Information/knowhow sharing about the SES variations	The Board of directives of the Community Councils has established mechanisms for distribution of information through the community leaders who report to their communities.
		l3	Deliberation processes - Deliberation process used among users	l3a	Deliberation processes among users	There are two ways. The first is the call to the community and stakeholders to discuss specific situations that affect the entire community, and the decisions are taken based on consensus and voting. Second way: Some decisions are taken by Board members and then they are reported to the community. Anyone can communicate directly with

First tier		Second tier		Third tier		
						the legal representative and inform about a situation.
				l3b	Knowledge about participation mechanisms and rights	People know the mechanisms of participation. The structure of Community Councils makes that the main way is that directives call councils members for participation.
		l4	Conflicts among users - Existing conflicts among users	l4	Type of conflict (e.g. conflict based on greed, grievance, scarcity, technology, access, power, information)	Alto y Medio Dagua: illegal mining, timber extraction, pollution of water sources, pollution deriving from the construction of infrastructure, which is also related to changes in the landscape and the gradual presence of foreigners. The most serious is the illegal mining for gold extraction. Bajo Calima: illegal coca crops, deforestation and pollution of water, illegal mining and hunting. Illicit crops is the most important. Intermediation is a role in part exercised by the illegal armed groups (guerrillas and paramilitaries). The second conflict in order of importance is the deforestation and the pollution of the water. Illegal mining is carried out on two levels: traditional and industrial. Finally, hunting and the illegal trade of biodiversity.
		l5	Investment activities - Investments for improving and managing the resources (investor, amount invested and destination of investment)	l5	Investments activities (investor, amount invested and destination of investment)	Although Community Councils do not have the financial capacity to invest, they provide workers for various projects carried out by national and local institutions. However, this causes a high impact on the cultural and environmental conditions of the community.
		l6	Lobbying activities - Lobbying activities (internal, external, influence capacity)	l6	Lobbying activities (actors involved, expected outcomes)	The Community Councils use lobbying as a way to gaining power in decision-making at regional level. This indicates that the organizational capacity of communities is high, and decisions are taken by

First tier		Second tier		Third tier		
						consensus.
		17	Self-organizing activities - Self-organization activities among users for extracting resources	17	Self-organizing activities (include description of any solidarity activities)	The Community Council in plenary is the highest authority in the territory, who makes decisions in general meetings. It has a general coordinator, advisors, legal representative, general secretary, president, coordinator of health, fiscal and specific committees for sports and culture, communication, infrastructure, gender, adult and youth, environment and a conciliator.
		18	Networking activities - Networking activities of the users within and outside the community	18a	Internal networks	Internal networks are characterized by solving problems associated with basic needs, political participation, capacity building and cooperation, the purpose of external networks is the environmental conservation, management of resources for development, education and communication.
				18b	External networks	External networks for purposes such as environmental conservation (conservation ONG's as FUNDAPAV), trade (participation in informal market networks), management of resources for development (participation in decisions related to the Mayor of Buenaventura), information (work associated with Ministries), education (teachers networks), communication and resources transfer (with ministries and ECOPETROL, to discussions about transfers and payments due to environment damage), support between families (main support to families by remittances from Buenaventura and Cali).

First tier		Second tier		Third tier		
				I8c	Partnership and cooperation	Participation of Community Councils in regional consultative processes. Councils are working in group with other neighboring Community Councils and are strengthening other weak councils. Similarly the Community Councils interact with various local and international NGOs and public and private institutions to manage and implement initiatives for development.
				I8d	External communication channels	External communication channels are limited. In general, inhabitants recognize great diversity of institutions (mainly Mayor, Government and ministries) through which they have mechanisms for communication but still they do not have mechanisms of dissemination of their processes.
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	O1a	Efficiency	Analyzed socio-ecological systems are efficient. Environmental supply allows to satisfy the needs of users and the adaptation to not just the market dynamics but also to the dynamics of natural resources.
				O1b	Equity (distribution of benefits between SES users)	Community organization aims to contribute to equity in the living conditions through preservation and control mechanisms, such as farmers committees, women's business associations and artisanal mining committees. Community Councils develop plans, programs and projects in order to improve community welfare.
				O1c	Socio-economical sustainability	Some of the basic services needed to ensure good living conditions of the inhabitants of the area, are threatened due to the fact that some of them are not offered.

First tier		Second tier		Third tier		
				O1d	Accountability	During the last ten years, the Community Councils have worked for integral well-being of the communities, and they have goals in quantitative and qualitative terms in the development of plans, programs and projects
				O1e	Effects of deliberation processes on the SES	Creation of mechanisms for the defense of the environment and the preservation of traditional activities such as artisanal mining and agriculture. Committees are created for this purpose.
				O1f	Empowerment (including gender analysis)	There are no available quantitative data. The conformation of Community Councils has enabled an increase in the capacity of management, level of training of leaders, and participation in processes of decision-making on the territory. Within these leaderships there are some women who are leaders of youth groups.
				O1g	Adaptation strategies to climate change	Community Councils adapt to new social, economic and environmental dynamics, through the creation of mechanisms of control and preservation, such as committees of agriculture producers, women associative enterprises and committees of artisanal miners.
		O2	Ecological performance measures (e.g. overharvesting, resilience, biodiversity, sustainability) - Impact of different activities on	O2a	Environmental sustainability	Environmental sustainability is relatively high. The locals recognize that in environmental terms any of the productive activities in the four case studies threatens the future of species or ecosystems.

First tier		Second tier		Third tier		
			ecological performance	O2b	Pressure on resources (e.g. increasing demand, new actors, overharvesting)	The pressure on resources has increased, by external actors, which may cause scarcity of resources in the future.
				O2c	Natural habitat (e.g. biodiversity indexes, species richness, connectivity, habitat conservation/degradation/fragmentation)	Recent biological studies show that natural habitats are still highly conserved. Richness, abundance and biodiversity indexes are high and consistent. Also there are consistent with the typical richness of these areas. Richness and abundance indexes are especially high for plant species.
				O2d	Effect of SES management on natural hazards (e.g. changes in type, frequency, pattern)	The locals recognize changes in the rainy seasons. Recently a dry season was longer than normal and altered some productive situations in case studies, but the national records of occurrence of droughts, floods, flow alterations are constant.
				O2e	Structure and function of resources (e.g. changes, interactions among resource units, trophic chains)	Some entities such as CVC, Red Juntos and RESA project, are supporting 77 families with fish projects, 66 families with agroforestry projects and two livestock projects. Agrarian Bank carries out a house improvement project with 50 families in the community.

First tier		Second tier		Third tier		
				O2f	Soil (e.g. erosion, degradation, improvement)	Local inhabitants believe that the productivity of the soils has declined gradually. Some local experts believe that this decline has been the result of the use of agrochemicals and erosive processes produced by: changes in rainfall regimes and the entry of large scale mining affecting ground cover. With respect to the natural erosion of soils due to the rain, there is a clear influence of deforestation on increasing this natural phenomenon especially in El Crucero. The degradation of soils due to the gold extractive activity in Zaragoza has increased since more holes have been opened for searching gold and they remained uncovered, causing flooding resulting in landslides of soil and its consequent erosion. In the case of La Delfina, use of chemicals in agriculture has generated change in the soil PH, causing reduction in fertility, and pollution of surface water and the reduction of nutrients available to plants, the decrease in the rate of degradation of organic matter, among others.
				O2g	Water (e.g. quality, availability)	In general, eradication of illicit crops with glyphosate carried out by the government, and burning of forests, are two factors that have contributed to water pollution in the region. In La Delfina, after the flood of 2006, there is a reduction of the flow of streams and rivers. In El Crucero, since the late nineties there has been a reduction of the availability of water in the streams which is related to the dynamics of timber extraction of private enterprise. In La Esperanza, there has been an important change in the quality of water, due to the pressure of agriculture.

First tier		Second tier		Third tier		
				O2h	Air (e.g. quality)	Regarding air quality, it is evident its contamination due to deforestation and the increased traffic flow in the road Buenaventura - Cali, in Alto and Medio Dagua. This has affected the respiratory health of the community and especially the children. Illegal mining is another major source of pollution that affects air quality and therefore inhabitants' health.
				O2i	Pollution (e.g. waste generation, frequency of occurrence)	There are no available data on frequency and effects on the degradation of ecosystems. The main source of pollution is the road connecting Buenaventura-Cali as a result of the transit and washing trucks and heavy machinery. Illegal mining is another major source of pollution.
				O2j	Resilience	With regard to the capacity of ecosystems to absorb disturbances on the system, those ecosystems with high biodiversity levels, are less vulnerable to changes in ecosystems by external effects. So most preserved forests as La Delfina, show greater resilience than the mountainous area of Zaragoza. In La Delfina rainforest preserves several species of trees that mitigate the high direct solar radiation on the ground, which allows to reduce the chances of erosion and maintenance of the seed bank that will be the livelihood of forest in the medium and long term. Areas with highest rates of deforestation as the community of El Crucero, would tend to a less resilience capacity given the conditions of transformation of the landscape by forestry activity. There are not experiments that allow to measure the resilience of the ecosystems in the Community Councils. In order to issue specific claims about system resilience it is necessary to have a good set of data for long periods of time, but currently this is not

First tier		Second tier		Third tier		
						available for the region.
				O2k	Vulnerability	
		O3	Externalities to other SES - Positive or negative impacts on other SESs without previous agreement or request	O3a	Positive externalities (e.g. CO ₂ capture, water protection, biodiversity conservation)	<ul style="list-style-type: none"> - CO2 capture -Protection of biodiversity -Conservation of natural resources -Protected areas -Protection of water sources -Maintenance of water sources -Landscape -Recreation areas -Ecological corridors (connectivity) -Paths of Ecotourism (research and education)
				O3b	Negative externalities (e.g. CO ₂ emissions, pollution)	<ul style="list-style-type: none"> - Generation of waste that is burned -Generation of waste that goes to water bodies -Removal of plant material -Soil removal -Erosion - Water contamination as a result of mining, agricultural activities and transport in the road Buenaventura - Cali is led to the marine ecosystem without any treatment or mitigation actions.
Related Ecosystems (ECO)	Describes the connection of the considered ecosystem	ECO1	Climate patterns - Climate patterns affecting the considered SES	ECO1	Climate patterns (e.g. precipitation, temperature, sea level, extreme events, seasonal changes)	In average, the annual precipitation for Dagua River Basin is 2,583 mm, and for the lower part of the Calima River Basin it is 9,246 mm. The two areas have a relative humidity of 88% and an average annual temperature of 26°C.

First tier		Second tier		Third tier		
		ECO ₂	Pollution patterns (water, waste, soil, air, other) - Pollution patterns affecting the considered SES (e.g. water, waste, soil, air)	ECO ₂	Pollution patterns (water, waste, soil, air, other)	The productive activities such as mining and the extraction of material from river, have caused pollution of Calima and Dagua rivers. Also the shedding of engine and ACPM oils used for mobilization in the river. Another vector of contamination has been the chemicals used in agriculture. Mining generates impact on groundwater.
		ECO ₃	Flows into and out of focal SES - Flows from other SESs affecting the considered SES and viceversa	ECO ₃	Flows from other SESs affecting the considered SES and viceversa (economic pressures, environmental effects and social effects)	Finally, it is important to highlight that the system resources currently present the following socio-environmental conflicts: illegal mining; indiscriminate extraction of forest species; pollution of water resources by mining activity, illicit crops (coca), poor management of solid waste and poor service of sewer system in the different villages. These conflicts are endangering the general resources system in the area.

Annex 2.1. Demographic structure

Estructura demográfica

Para el caso de **Calima**: No se presenta en este documento el número de habitantes por edad, debido a que los datos disponibles no son consistentes

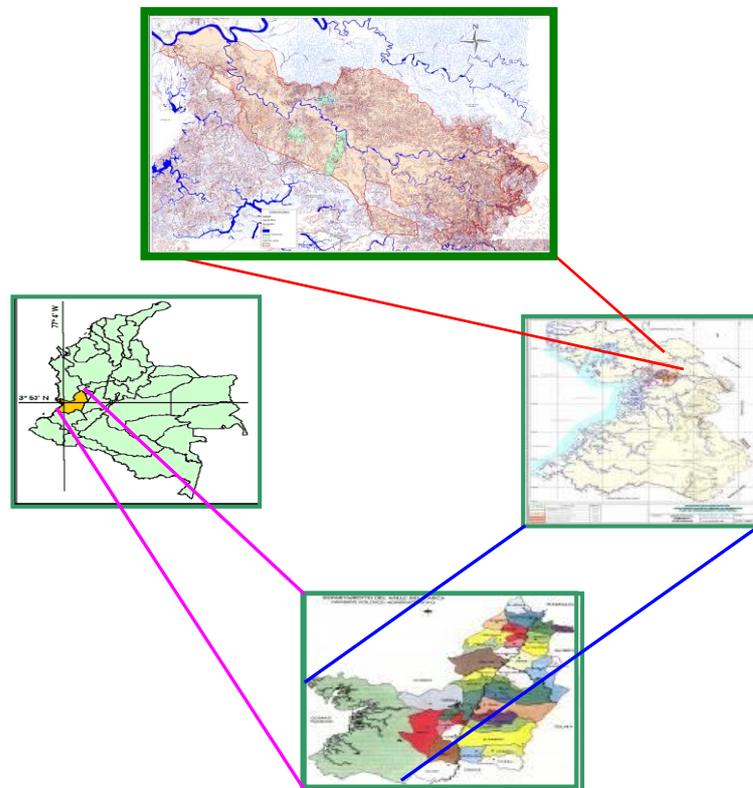
Dagua:

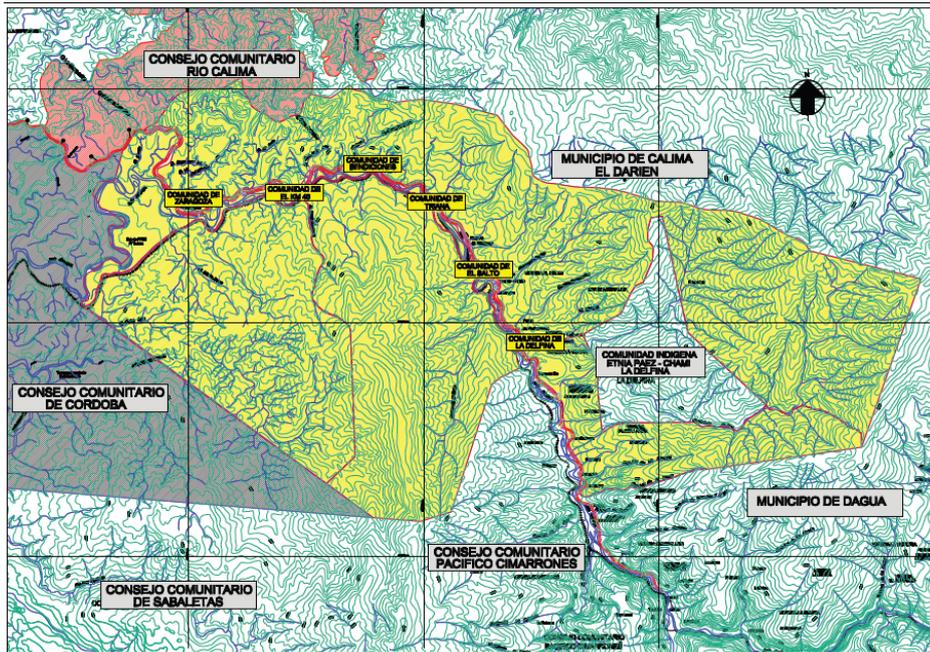
Rango de edad	Hombres	Mujeres	Total
0-4 años	123	124	247
5-10 años	163	140	303
11-17 años	188	174	362
18-39 años	332	376	708
40-60 años	161	181	342
Más de 60 años	61	57	118
Total	1028	1052	2080

Fuente: Consejo Comunitario de la Comunidad Negra de la parte Alta y Media de la Cuenca del Río Dagua, Corporación Autónoma Regional del Valle del Cauca - CVC and Fundapav, 2007

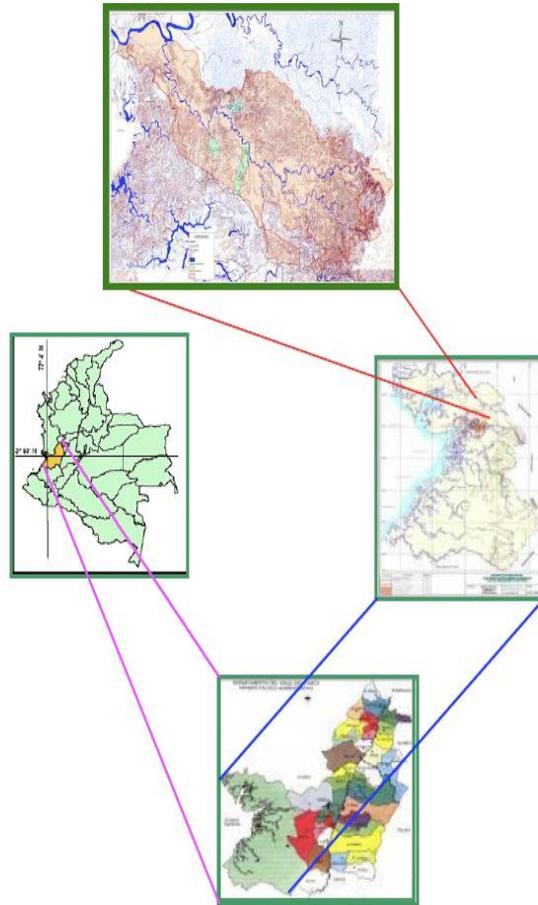
Annex 2.2. Geographical location of Community Council of Alto y Medio Dagua and Bajo Calima

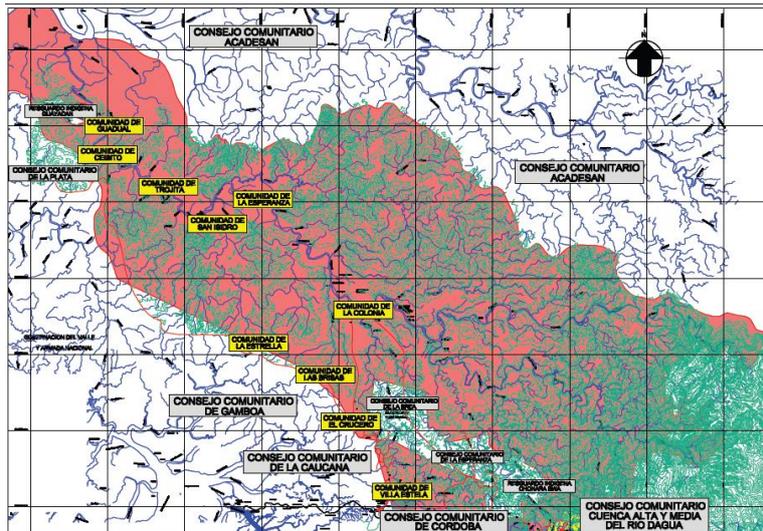
Alto y Medio Dagua





Bajo Calima





Annex 3. List of workshops participants

Annex 3.1. List of workshop participants. Alto y Medio Dagua. Date: June 7th, 2013.

NAMES	Gender (H: Men M: Women)	Institution
BRYANN ESTEBAN AVENDAÑO URIBE	H	UNIVERSIDAD JAVERIANA
MANUELA VELASCO	H	AMDA
MARIA JUDITH ANGULO	M	AMDA
MARINA MOSQUERA	M	AMDA
YAMILETH CASTRO C.	M	AMDA
NETTY BANGUERA	M	LIDER COMUNITARIA AMDA
AURA MARIA V	M	LA VÍBORA AMDA
ALBA MILENA ROMERO	M	COMITÉ DE APOYO AMDA
ROSINA PEREA	M	COMITÉ DE APOYO AMDA
FALCIO RIASCOS	H	AMDA
JUAN O. RIASCOS	H	AMDA
CARMEN TULIA RIVERA	M	AMDA
MARÍA ESPERANZA R	M	AMDA
CÉSAR ORTIZ	H	UNIVERSIDAD JAVERIANA

Annex 3.2. List of PSA workshop participants. Bajo Calima. Date: June 6th, 2013.

NAMES	Gender (H: Men. M: Women)	Institution
BRYANN ESTEBAN AVENDAÑO URIBE	H	UNIVERSIDAD JAVERIANA
ANGIE TAMAYO	M	BACA
JOHANNA MOSQUERA	M	LIDER COMUNITARIO BACA
CAMILO DELGADO	H	BACA
JEFERSON BALANTRA	H	BACA
JHONATHAN MOSQUERA	H	BACA
CLAUDIA TAMAYO	M	BACA
ALFREDO PERLAZA	H	BACA
MANUEL CARDENAS	M	BACA
JOSE ISAAC GUITOTO	M	BACA
CESAR ORTIZ	M	UNIVERSIDAD JAVERIANA

Annex 3.3. List of co-researchers from AMDA and Bajo Calima participating in PSA workshop.
Date: June 4th, 2013.

NAMES	Gender (H: men. M: women)	Institution
MARIA CRISTINA ASPRILLA	M	CC AMDA DELFINA
EVELIA MORENO	M	CC AMDA
NAYIBE MINA	M	CC AMDA
GUSTAVO ADOLFO B	H	CC AMDA
LUCILA MARTÍNEZ	M	CC AMDA
SAMIR ESTUPIÑÁN	M	FUNDAPAV
MARIA EUGENIA MORENO	M	CC AMDA
MARTÍN H. RUIZ	H	FUNDACIÓN ECOBIOS
CORNELIA MORENO	M	CC AMDA
LUIS NELSON ANGULO CEBALLOS	H	FUNDAPAV
JOSE E. MURILLO	H	CC AMDA
RAFAEL ARROYO PONCE	H	FUNDAPAV
EMIRA MONDRAGÓN	M	BAJO CALIMA
JAIR TORRES B.	H	BAJO CALIMA
MARCOS VENDE P.	H	BAJO CALIMA
YENCY BALLESTEROS P.	M	BAJO CALIMA
FRANCIA PIEDAD URBANO	M	BAJO CALIMA
NALJI ANGULO C.	M	C.C. CITRONELA
JEFFERSON BALANTA RIASCOS	H	BAJO CALIMA
AGUSTINA URBANO	M	BAJO CALIMA
MARÍA ORLINDA RAMOS	M	BAJO CALIMA
NANCY LORENA CHALA B.	M	BAJO CALIMA
NARLINTON MORENO	H	BAJO CALIMA

ANA MARIA SIERRA	M	UNIVERSIDAD JAVERIANA
NATALIA OCAMPO D.	M	UNIVERSIDAD JAVERIANA
CÉSAR ORTÍZ	H	UNIVERSIDAD JAVERIANA
ALADINO MOSQUERA	H	BAJO CALIMA
LINA PINZÓN M.	M	UNIVERSIDAD JAVERIANA
BRYANN ESTEBAN AVENDAÑO URIBE	H	UNIVERSIDAD JAVERIANA

Annex 3.4. List of PSA workshop participants. Official workers. Date: June 5th, 2013.

NAMES	Gender (H: men. M: women)	Institution
BRYANN ESTEBAN AVENDAÑO URIBE	H	UNIVERSIDAD JAVERIANA
NATALIA OCAMPO	M	UNIVERSIDAD JAVERIANA
ANA MARÍA SIERRA	M	UNIVERSIDAD JAVERIANA
OSCAR VALLEJO	H	DIRECCIÓN TÉCNICA AMBIENTAL
JUAN CARLOS LÓPEZ	H	PLANEACIÓN
EFREN ANDRÉS VIVEROS	H	INSTITUTO DE INVESTIGACIONES DEL PACÍFICO
MARIA MELBA CHALÁ M.	M	C.V.C. BUENAVENTURA
LUCILA MARTÍNEZ	M	CC AMDA
YANCY BALLESTEROS	H	CC BAJO CALIMA
LORENZO GONZÁLEZ	H	CC BAJO CALIMA
ORCAR O. HERNÁNDEZ	H	SENA C.N.P.
JOSE LUIS URBANO	H	CC BAJO CALIMA
CAMILO DELGADO	H	CC BAJO CALIMA
SIRLEY VÁSQUEZ	M	FUNDAPAV
CÉSAR ORTÍZ	H	UNIVERSIDAD JAVERIANA

Annex 3.5. Number of participants by gender and their institutional or community affiliation – Stakeholders forum in Buenaventura – July 10th, 2013

Institution or community		Men	Women
Local Stakeholders	Consejo Comunitario Bajo Calima	4	
	Consejo Comunitario Alto y Medio Dagua	2	2
	Consejo Comunitario Bahía Málaga	2	
	Planning Office – Buenaventura Mayor Office	1	
	Environmental Technical Office - Buenaventura Mayor Office	1	
	Corporación Autónoma del Valle del Cauca (Government Office for Environmental Management of Department of Valle del Cauca)	1	
	Fundación Socioambiental Rionaya (NGO)	1	
	Pastoral Social Buenaventura (Social office of Buenaventura Catholic Church)	1	
	SENA (Government institution for learning)	1	
	Fundapav (NGO)	1	2
COMET-LA	Universidad Javeriana (Colombia)	2	3
	Universidad Nacional del Sur (Argentina)	1	1
	NILU (Norway)		2
	Sagremarisco-Viveiros de Marisco Lda (Portugal)	1	
	JHI (United Kingdom)		2
	UIC Spanish Committee		2
	ERA (Mexico)	1	
	Universidad de Córdoba (Spain)		1

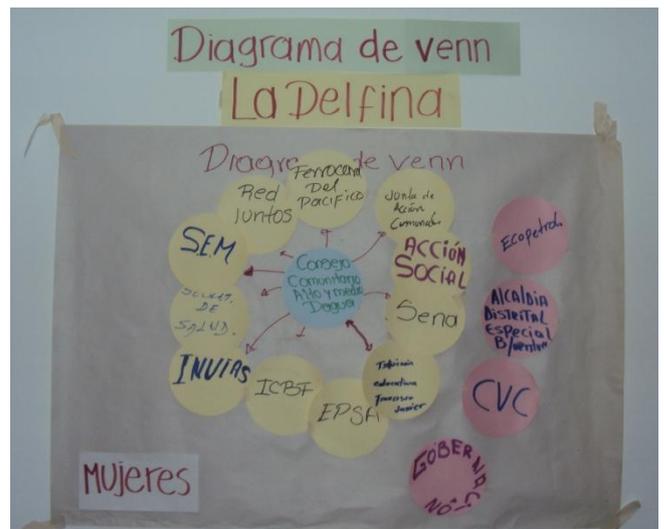
	UNAM (Mexico)	1	
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Annex 3.6. Number of participants by gender and their institutional or community affiliation– Stakeholders forum in Cali – July 12th, 2013

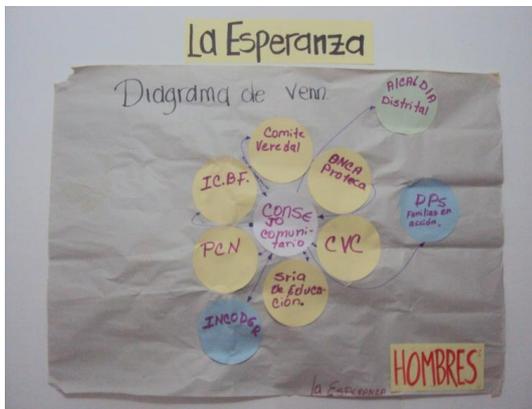
Institution		Men	Women
Department, regional and national stakeholders	International Conservation		1
	WWF	1	1
	IDEAM (National Institution for Hydrology, Meteorology and Environmental Studies)		1
	Centro de Estudios Interculturales – Universidad Javeriana Cali	2	
	SENA (Government institution for learning)	1	
	Instituto Von-Humboldt	1	1
COMET-LA	Universidad de Córdoba (Spain)		1
	Consejo Comunitario Alto y Medio Dagua (Colombia)	2	1
	Universidad Javeriana (Colombia)	2	3
	Universidad Nacional del Sur (Argentina)	1	1
	NILU (Norway)		1
	Sagre Marisco-Viveiros de Marisco Lda (Portugal)	1	
	UIC Spanish Committee		2
	ERA (Mexico)	1	

Annex 4. Characterization of local stakeholders with PRA tools: Venn Diagrams, differentiated by men and women. La Delfina, Zaragoza, El Crucero and La Esperanza

Annex 4.1. Venn diagram built by inhabitants from Alto y Medio Dagua (men and women)



Annex 4.2. Venn diagram built by inhabitants from Bajo Calima (men and women)



Annex 5. Form used with communities for description of variables

Ostrom framework category	S, RS, GS, RU, U, I, O, ECO	Subcategory	
Short label			
Full name of the variable			
Description of the variable	<p>From PSA workshop:</p> <p><u>Triangulation:</u></p>		