UNIVERSITÀ DI PISA

Pisa University
Earth Science Department
MSc in Environmental Science

An Analysis Model for National Park Planning Support and Sustainable Development. The case of 'La Botija' Protected Area, Honduras.

MASTER THESIS RESEARCH

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CHAPTER 1. INTRODUCTION AND THEORICAL FRAMEWORK

1.1. Introduction

Sustainable development is currently acknowledged as being a possible basis for solving complex problems, such as overpopulation, water scarcity, poverty, climate change, or loss of biodiversity. These problems occur in different natural and socioeconomic systems characterized by multiple elements and factors (Folke, C., et al., 2002; Pearce, D.,1988; Zaman, G. & Goshin, Z., 2010). Supporting those systems to improve their sustainability requires the development of specific strategies by policy makers, public officers and project managers. However, each territory area presents multiple factors and elements that policy makers and public officers should take into account for the sustainable development of the area. In fact the assessment of all those territory elements should refer to the evaluation of social, economic, cultural, and environmental interactions as well as to governance processes and the stakeholders and managers interests and opportunities (Olazabal, M. et al., 2007). The simultaneous consideration of these multiple territory elements is required to understand the essence of these complex systems and thus to make suitable decisions and choices. Therefore the implementation of specific actions and strategies should proceed regularly with the support of researches and technical investigations. In this regard the capacity of integrating all the aspects that sustainability has to take into account (economic, environmental, social, public participation, governance processes, etc.) with appropriate tools of spatial planning, improves the chances of developing and implementing efficient action plans from an integrate point of view. For all the above described reasons, GIS based multi-criteria analyses (MCA), integrated with participatory tools, are considered, among the literature, as proper and suitable analyses for the evaluation of the multiple territory elements (Graymore, M. et al., 2007; Greene, R., et al., 2011; Mohamed, A. et al., 2006). Furthermore, there is an often implicit assumption that the use of models integrating GIS systems, MCA and participatory approaches can provide decision support to planners and organizations and can assist them to define innovative strategies and actions. Lastly, in accordance with the literature, this approach can lead to a better and fairer governance, due to the understanding of needs, interests and desires of local stakeholders. (Alshuwaikhat, H. & Aina, Y. 2006; Gerrit J. & Ligtenberg, A. 2007; Jankowski, P., & Richard, L., 1994; Kamal A. & Rashed-Ali H., 2013; Malczewski J., 2006; McCall, M. K. & Minang P. A., 2005).

The research case study is ‘La Botija’ protected area, located in the municipality of San Marcos de Colón, in the south-east part of Honduras, at the border with Nicaragua. In particular the investigated area is characterized by multiple complex social, environmental and economic problems (e.g. water pollution, lack of economic resources, lack of infrastructures, lack of cooperation and motivation of local residents, etc.). This thesis aims to develop an analysis model integrating spatial (GIS-based) multi-criteria analysis (MCA) methods with a specific strategic participatory planning process for analyzing the multiple elements and problems of the investigated area. In particular, the main objective of the proposed analysis model is to identify the priority intervention areas of ‘La Botija’ protected area, simultaneously analyzing both quantitative and qualitative data collected during a fieldwork of three months.

The final goal of the thesis is to support decision making processes and to give advice to policy makers, public administrators and project managers. In fact, the proposed analysis model represents a decision support system (DSS) useful for the development of strategies and actions for sustainable development and improvement of the area. The analytical model could be used by public decision-makers and project managers to understand which areas need priority interventions. The analysis of the suitability maps provides information on the best intervention strategies for the sustainable development of the protected area and its rural communities. The model allows an analysis of the situation both at specific level, looking at rural communities, and at general level, investigating the whole protected area. The creation of suitability maps focusing on eighteen specific themes (e.g. water system, sewer system, school density, water treatments, etc.) permits to analyze both individually and collectively the multiple elements of the area.

The specific participatory approach used in this research is defined as a 'strategic planning process for transformative change' and it was developed by DRIFT (The Dutch Research Institute for Transitions) of the Erasmus University of Rotterdam (The Netherlands) with the collaboration of the Monash Water for Liveability Institute of the Monash University of Melbourne (Australia). The applied methodology is based on Transition Management approach. Transition management is an alternative governance approach for sustainable development which seeks to support the transformative change of socio-political landscapes and socio-technical practices (Frantzeskaki, N. et. al, 2012; Loorbach, D., 2007; Rotmans, J., et al., 2001).

The involvement of local residents through the use of a participatory approach represents a fundamental key of the thesis. The use of this specific participatory methodology aims to promote empowerment by supporting community members' participation in decision making and actions. Local citizens are supported to make transformative change in their practices and to improve their awareness about environmental and social issues. In addition, the demands of local citizens could be analyzed and visualized by policy makers, public administrators and project managers to develop projects closer to needs, desires and interests of local residents.

The methodological approach of this research can be organized in several steps. At a first phase (April-December 2013), the researcher learned about 'Transition theory' and 'Transition management' methods during an internship in the Dutch Research Institute for Transitions (DRIFT) of the Erasmus University of Rotterdam (The Netherlands). At a second stage the research focused on the literature review and the formulation of the research case study and research objectives (December 2013-January 2014). At a later stage the interview guidelines and the workshops framework were formulated (January 2014). From February to May 2014 the researcher conducted the fieldwork in 'La Botija' protected area. During this period qualitative and quantitative data were collected. Specifically the qualitative data collection was realized through the conduction of fifty-seven in-person semi-structured interviews, the participation in fourteen meetings and public events and the participatory observation of the rural life of thirteen rural communities of 'La Botija' protected area. In addition, the researcher organized and realized thirteen workshops with the local citizens of the protected area. These workshops aimed to collect qualitative data and, at the same time, to support the action and the transformative change of the local citizens towards a long-term vision of a sustainable future. Furthermore geographical data referring to the territory elements of the investigated area were elaborated with the use of Geographic Information Systems (GIS). In particular ESRI's ArcGIS project was used to create

suitability maps of specific territory elements (e.g. communities, rivers, streets, bus routes, schools, health centers, etc.). At a later stage both quantitative and qualitative data were analyzed. Regarding the qualitative data analysis, all the recorded and written information were reviewed and transcribed in Spanish. In total twelve Spanish reports of the investigated communities were developed and provided to each community. Subsequently the reports were traduced by the author from Spanish to English and analyzed. Additionally the quantitative date were examined. The integration of qualitative and quantitative data analysis produced the System Analysis including the problems analysis and the actors analysis.

The last stage of the research regarded the construction of an analysis model (May-June 2014). The development of the analysis model can be divided in its turn into three different phases: (a) construction of a multi-criteria analysis (MCA) framework, (b) qualitative and quantitative data analysis through the model, (c) assessment phase with the definition of priorities areas. In the first phase, the hierarchical decision tree of multi-criteria analysis was defined and criteria and attributes were weighted through the Analytical Hierarchy Process (AHP). In the second stage the qualitative and quantitative data previously analyzed were inserted into the analysis model and suitability maps were created by using Geographic Information Systems (GIS). At the third stage the multi-criteria analysis (MCA) was elaborated by GIS with the aim to individualize the intervention priorities areas creating a final map. In particular during this phase suitability maps were transformed into preference maps by weighting them. Then the preference maps were combined, in order to visualize the priority intervention areas in a unique map.

In conclusion, an analysis model has been developed integrating GIS-based multi-criteria analysis (MCA) and participatory methods. In particular, the creation of the conclusive map reveals that the south-east part of 'La Botija' protected area represents the priority intervention area. The maps show which are the major needs and lacks that require to be solved in each point of the investigated area. In this way the analysis model represents an useful and valuable tool that can be used by local policy makers and project managers for developing strategies supporting the sustainable planning and development of the area.

The present thesis revealed that there are a number of research challenges that could be developed in the future. First of all suitability map using Ortho photos could be created to compare with the maps created from a topographic map. Secondly a Digital Terrain Model (DTM) or Digital Elevation Model (DEM) could be developed to analyze the altimetry of 'La Botija' protected area. The creation of a DTM is also fundamental for the calculation of the real distance travelled and time spent on the journey. Additionally the pairwise comparison of weights between criteria and attributes was elaborated directly by the author without the involvement of local stakeholders. For this reason in the future could be useful to organize a meeting to develop a pairwise comparison by the local actors, residents and stakeholders of the area.

1.2. Methodological framework

This research developed an analytical model integrating and combining three different methodologies.

This section describes the methods at the base of this research:

- Multi-Criteria Analysis (MCA) (Paragraph 1.2.1.);

- Geographic Information System (GIS) (Paragraph 1.2.2.);
- Participatory approaches (Paragraph 1.2.3.);

Finally this section describes the integration of these three methods: the participatory GIS based MCA technic (Paragraph 1.2.4.).

1.2.1 Multi-Criteria Analysis (MCA)

Multiple criteria analysis (MCA) has been accepted as an important tool in environmental decision making for formalizing and addressing the problem of conflicting decision objectives (Janssen, 1992; Lahdelma *et al.*, 2000; Linkov *et al.*, 2006; Regan *et al.*, 2007; Yatsalo *et al.*, 2007) and provides well-established decision support tools for a wide range of applications (Mendoza, G.A. & Martins, H, 2006; Belton & Stewart, 2002; Janssen and Herwijnen, 2007). Through the use of MCA many variables or criteria are considered in the prioritization and selection of alternatives or projects.

The MCA process can be divided into different phases (Figure 1.1) (Hajkowicz, 2008):

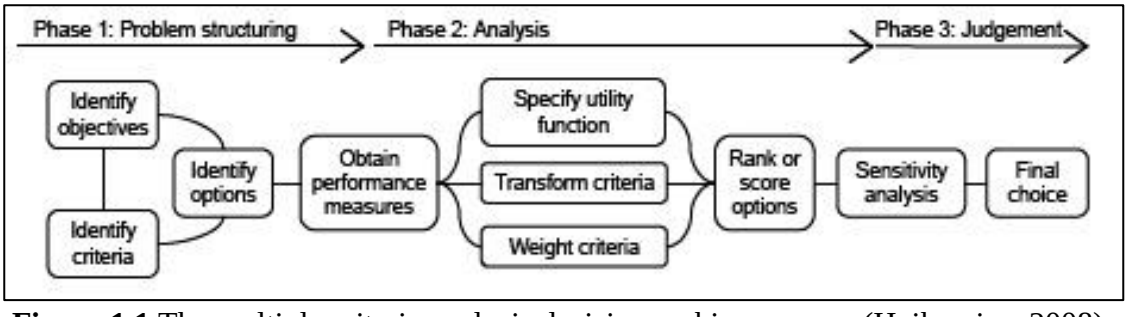

Figure 1.1 The multiple criteria analysis decision making process (Hajkowicz, 2008).

1. ***Problem structuring***
   The MCA method generally starts with the formulation of the decision problem and the goal to be achieved by the analysis.
2. ***Construction of the Hierarchical Decision Tree***
   Another fundamental phase of AMC consists in the decomposition of the problem into a set of criteria and a set of alternatives in order to be more easily analyzed and compared in an independent manner. Following this formulation a hierarchical tree of criteria/alternatives can be developed (Janssen, 2001) (Figure 1.2).

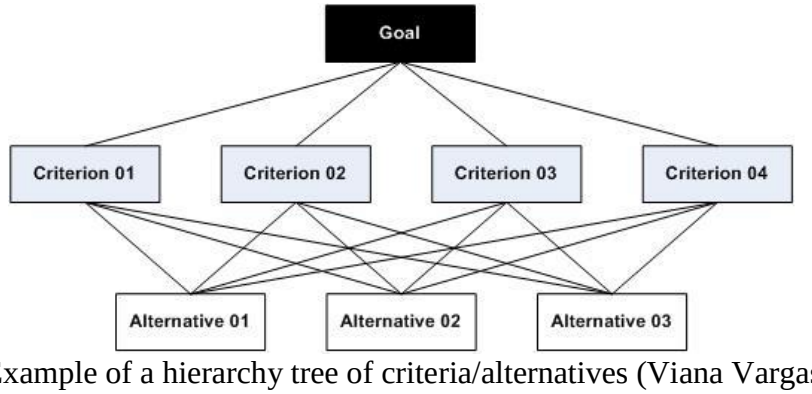

Figure 1.2 Example of a hierarchy tree of criteria/alternatives (Viana Vargas, R., 2010).

3. ***Criteria weighting***
   This phase includes obtaining information from decision makers about the relative importance of criteria. Weights may be expressed at either an ordinal or cardinal measurement level.
4. ***Criteria transforming***
   The criteria are in different units, thus they need to be changed into commensurate units prior to aggregation in the ranking or scoring function.
5. ***Option ranking and/or scoring***
   The weights and transformed performance measures are combined to determine the overall performance of each option, relative to other options.
6. ***Sensitivity analysis and decision making***
   The sensitivity of the result is determined by MCA methods, performance measures, and weights.

The more common MCA algorithms that are used to obtain the final ranking or scoring of the decision options are the following: the Analytic Hierarchy Process (AHP) (Saaty, 1987), weighted summation (Figueira et al. 2005), ELECTRE (Figueira et al. 2005), PROMETHEE (Brans et al. 1986), and Compromise Programming ((Zeleny, 1973).

1.2.2 Geographic Information System (GIS)

Geographical Information Systems (GIS) consist in a computer system that allows to capture, display, store and retrieve spatial data in organized and structured ways (Burrough, P. A., D. J. 1986; Fotheringham S. & Rogerson P., 1994; Maguire, 1991). GIS applications are instruments that permit users to create interactive queries, analyze spatial information, edit data in maps, and present the results of all these operations (Clarke, 1986; Maliene et al.,2011). The possibility to manage and analyze data in various way the data allow the use of GIS in numerous technical and scientific fields.

A fundamental characteristic of GIS is the possibility to spatially manage the data with their geographic coordinates.

Geo-data are composed of two main categories: the graphic data and descriptive data. In the first case, the graphic data are described by geometric elements that can be represented by two main data formats:

- The vector format that is organized in points, lines and polygons;
- Raster format that is characterized by elementary cells

In the second case, the descriptive data qualify and quantify the graphic data through the table of attributes instrument.

GIS manage the interrelation between those graphic data and descriptive data.

The representation and processing of information are influenced by the superposition of different data layers. ; the use of a display order for the different layers that constitute a map representation allows a richer meanings; Furthermore, the overlap of the same logical information layers (overlay) allows to derive new datasets that have, at least in part, the characteristics of the starting data. The production of thematic maps, however, is a time organizational final of all the

information that have been used and therefore represented the end of a process of analysis. This process plays a rather central role in the use of a GIS: the reading of the geographic data, its interpretation, processing and representation are in fact the basic stages through which it develops an analytical approach is the basis of many applications.
GIS allows to show various typologies of data on one map and support the data analysis. Through the GIS technology, researchers can develop integrate knowledge from multiple sources integrating different spatial territory data.

1.2.3. Participatory approaches

This thesis apply a specific participatory approach defined as Transition Management. This method was developed by DRIFT (The Dutch Research Institute for Transitions) of the Erasmus University of Rotterdam (The Netherlands). This specific method will be explain in Paragraph 3.2.4.1. Transitions and Transition Management are concepts that entered in public policy and public administration in the Netherlands with the Fourth Environmental Policy Plan in 2001 (Frantzeskaki, 2011, Kemp & Rotmans, 2009).
Transitions concepts and transition management are described in the following section, in Paragraph 1.2.3.1. and Paragraph 1.2.3.2., respectively.

1.2.3.1. Transitions Concepts

Transitions are defined as shifts from one socio-technical system to another (Grin et al., 2010). Transitions consists in transformation processes in which existing structures, institutions, cultures and practices are broken down and new ones are established (Loorbach, 2007; Loorbach D. and Rotmans J., 2006). This means that the structure (or a subsystem of society) changes fundamentally. Transitions have the following characteristics (Grin et al, 2010; Loorbach, 2007):

- Transitions are co-evolution processes that require multiple changes in socio-technical systems or configurations concerning large scale technological, economical, ecological, socio-cultural and institutional developments that influence and reinforce each other;
- Transitions are multi-actors processes, which entail interactions between different social groups;
- Transitions are long-term processes that covers at least one generation (25 years);
- Transitions include interactions between different scale levels (niche, regime, landscape)

One of the basic premises of transition studies is the presence of ‘persistent problems’ as a specific type of unstructured problems that are hard to ‘manage’ in a traditional sense and are rooted in different societal domains (Loorbach, 2007). The solution at these persistent problems requires transitions and system innovations. A ‘sustainability transition’ refers to a ‘radical transformation towards a sustainable society as a response to a number of persistent problems confronting contemporary modern societies’ (Grin et al., 2010).
The transition research has its origin in innovation studies. Initially the focus was on transitions in socio-technical systems (e.g. mobility, energy, agriculture) while recently developments have

broadened the focus towards societal systems more generally (e.g. regions, sectors) and to 'reflexive' governance for sustainable development (Avelino, 2011).

Transition dynamics

Fundamental frameworks at the base of transition theory are the multi-phase and multi-level concepts (Loorbach, 2007). These concepts analyze the temporal and dynamical dimensions of transitions. The multi-phase concept indicates that transition paths are highly non-linear with different phases, shifting from one dynamic equilibrium to another (Loorbach and Rotmans, 2006). The central assumption is that societal structures are characterized by long periods of relative stability and optimization, followed by relatively short periods of structural change. During this process prevalent and current structures (values, institutions, regulations, markets, etc.) are replaced with new ones. The transition studies suggest the presence of the following four different phases (Grin et al., 2010; Loorbach, 2007; Loorbach and Rotmans, 2006):

1. A *pre-development phase* where there is very little visible change at the systems level but a great deal of experimentation at the individual level;
2. A *take-off phase* where the process of change starts to build up and the state of the system begins to shift because of different reinforcing innovations;
3. An *acceleration phase* in which structural changes occur in a visible way through an accumulation and implementation of socio-cultural, economic, ecological and institutional changes that react each other. Into this phase are present collective and individual learning processes, diffusion and embedding processes.
4. A *stabilization phase* where the speed of societal change decreases and a new dynamic equilibrium is reached.

The phases of the transition process are represented by a S-shaped-curve (Figure 1.3). The S-curve show that the structural change is not gradual and linear and transitions consist in multiple changes at different levels.

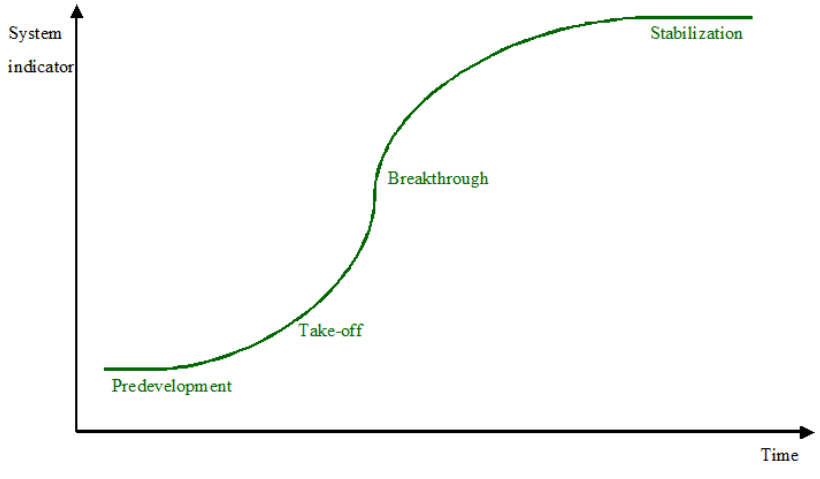

Figure 1.3 Different stages of a transition at different system levels (Source: modified from Loorbach, 2007).

The S-shaped-curve consist in a simplified representation of the transition process. In fact the transition process regard a multiple interconnection between different actors, practices, innovations that develop with different times and at different levels. In fact the transition process regard both the individual and collective change.
A fundamental model of transition studies consist in the multi-level perspective (MLP) that derives from research into technological innovations (see Figure 1.4).
The MLP describes a transition in terms of different layers dynamics, which are interlinked and reinforced each other (see Figure 1.5).. The following are the three different layers of the MLP:

- **Socio-technical 'niches'**
  Socio-technical 'niches' are considered as micro-level innovation protected spaces within which innovations can mature and from there diffuse into the regime (Loorbach, 2007). Inside the niches are created and developed novelties that can consist in new social, economic, technological or policy practices, new rules and legislation, new organizations, new ideas and concepts and new projects. In addition niches consolidate learning and develop network with multiple societal actors. Niches can be part of the dominant structure (the regime), exist outside the regime or even (partly) outside the system.

- **Socio-technical Regime**
  The regime layer constitutes the dominant culture, structure and practices. The regime entails the institutions (sets of rules and procedures), physical infrastructure and culture including certain mental models. The regime refers to all dominant practices, rules and technologies that provide stability and reinforcement to the prevailing socio-technical systems.

- **Landscape**:
  Landscape implies major social changes in the field of politics, culture and world views (such as globalisation and individualisation) or natural characteristics that are difficult to influence and usually change slowly. Landscape developments are the outcome of ideas and acts of a great many players.

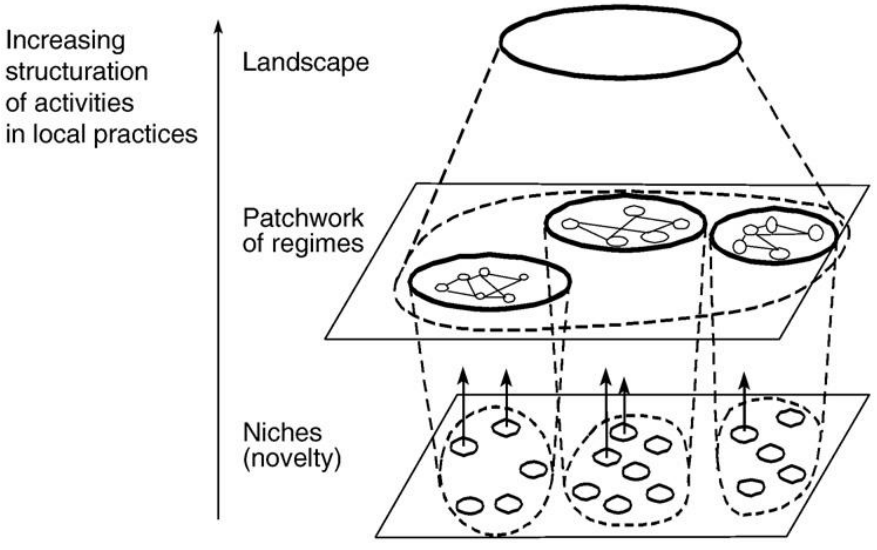

Figure 1.4 Interaction between multiple scale-levels (Source: Geels, 2002).

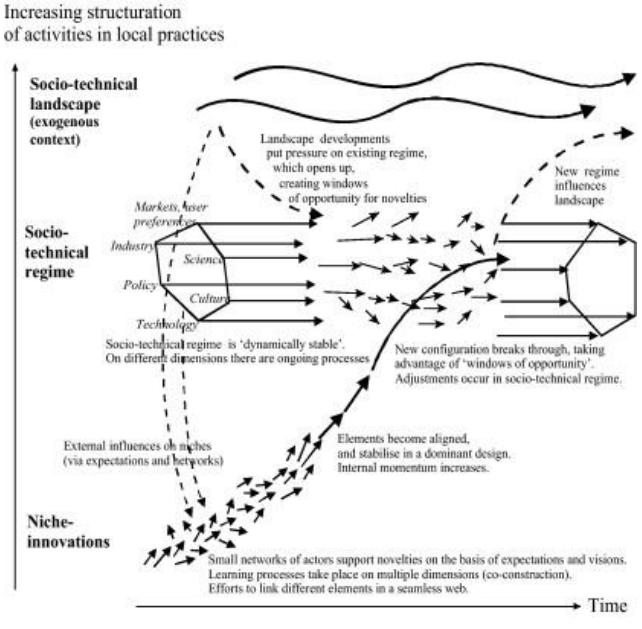

Figure 1.5 Multi-level perspective on transitions (Geels, 2002).

1.2.3.2. Transition Management

Transition management is an alternative governance approach for sustainable development which seeks to support the transformative change of socio-political landscapes and socio-technical practices (Frantzeskaki, N. et. al, 2012; Loorbach, D., 2007; Rotmans, J., et al., 2001). Transition Management approach was used for the first time in the Netherlands for Energy Transition Program (Loorbach, D., 2010).

Transition management is based on the realization that changes towards a sustainable society cannot be achieved by force or in a top-down manner but needs a subtle co-evolutionary approach that integrates empowering, fostering, collaborations and stimulating ongoing experimentation, evaluation and learning (Frantzeskaki, N. et. al, 2012; Rotmans, J. 2005).

Transition management can be organized into different phases as following (Loorbach 2002; Loorbach and Rotmans 2005): (a) structuration of the problem and organization of the transition arena; (b) development of a transition agenda, a vision of sustainability development and the transition paths; (c) establishment of transition experiments and mobilization of the resulting transition networks; (d) monitoring, evaluation and learning from the transition experiments and consequent adjustment in the vision, agenda and coalitions.

Transition arena is the central instrument transition management. Transition arena has been defined as a 'legitimate experimental space in which the actors involved use social learning processes to acquire new knowledge and understanding' (Rotmans, J., 2005). The cycle of transition management is shown in the following figure (Figure 1.6).

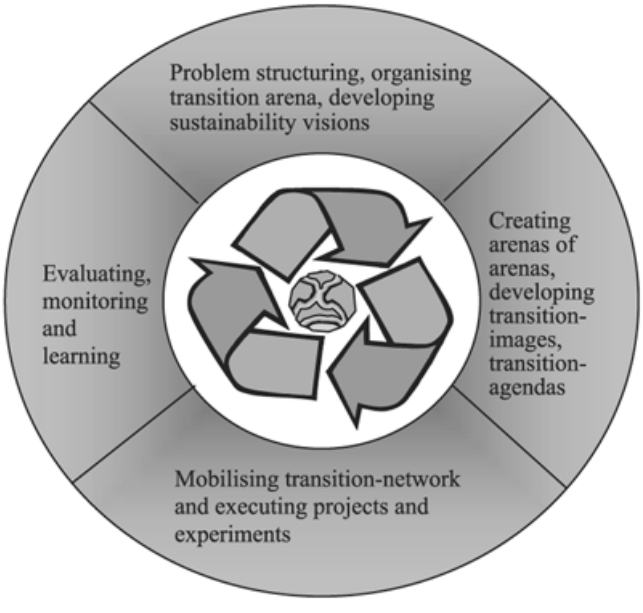

Figure 1.6 The transition management cycle (Loorbach D., 2007).

1.2.4. Participatory GIS-based MCA technics

As previously explained Multi-criteria analysis (MCA) allows many criteria to be considered at one time. It does this by giving a ranking of possible options based on how closely each option meets the criteria. Thus, it is suited to the assessment of the territory elements of an area, considering a number of indicators simultaneously (reference). Coupling MCA with GIS to produce maps, permits to become visual providing a graphic representation of the different criteria/alternatives. To do this each indicator is standardized to a common scale so that it can be compared to other indicators. A weighting is then applied to each indicator to calculate weighted summation for each area in the region.

Participatory GIS (PGIS) is considered, among the literature, as an effective and useful method for spatial planning (McCall, M., 2004; McCall, M. & MINANG, P., 2005; Rambaldi, G. et al., 2006). It was found that Participatory GIS **(**PGIS) contributed to good governance, by improving dialogue, redistributing resource access and control rights, legitimizing and using local knowledge and creating some actor empowerment through training. PGIS promoted

empowerment by supporting community members' participation in decision making and actions (McCall, M. & Minang, P., 2005; McCall, 2004).

1.3. Legislative framework

1.3.1 The National System of Protected Areas of Honduras

The National System of Protected Areas in Honduras (Sistema Nacional de Áreas Protegidas en Honduras", SINAPH), was legally established in 1993 under the General Environment Law, Decree 104-93 (Ley Gen-eral del Ambiente, Decreto 104-93) (Vreugdenhil D., et al., 2002). The SINAPH established eighteen categories of National Parks. Table 1.1 shows the classification of the National Parks categories of Honduras. The existing categories are not always clear in their objectives and limitations.

CATEGORY	NUMBER OF AREAS
Anthropological reserve	1
Biological reserve	24
Botanical garden	1
Cultural monument	3
Ecological reserve zone	1
Forest reserve	2
Forest and Anthropological reserve	1
Man and Biosphere reserve	1
Marine national park	4
Marine reserve	8
Multiple use area	5
Municipal reserve	2
National park	21
Natural monument	6
National monument	1
Nature reserve	1
Species habitat protection area	7
Wildlife refuge	13
TOTAL	102

Table 1.1 Number of declared and proposed areas per category.

Biosphere Reserve Río Platano, National Park Tawahka Asangni Bio-sphere Reserves and the Patuca National Park are the largest legally protected areas in Honduras, covering together an area of approximately 1,000,000 ha. These National Parks are set in the north-east part of the country, at the border with Nicaragua.

The National Parks of Honduras are identified in the following map (See Figure 1.7). Additionally Table 1.2 describes the main characteristics of the various categories of National Parks of Honduras. Table 1.3 presents the IUCN categorization relating to the protected areas management.

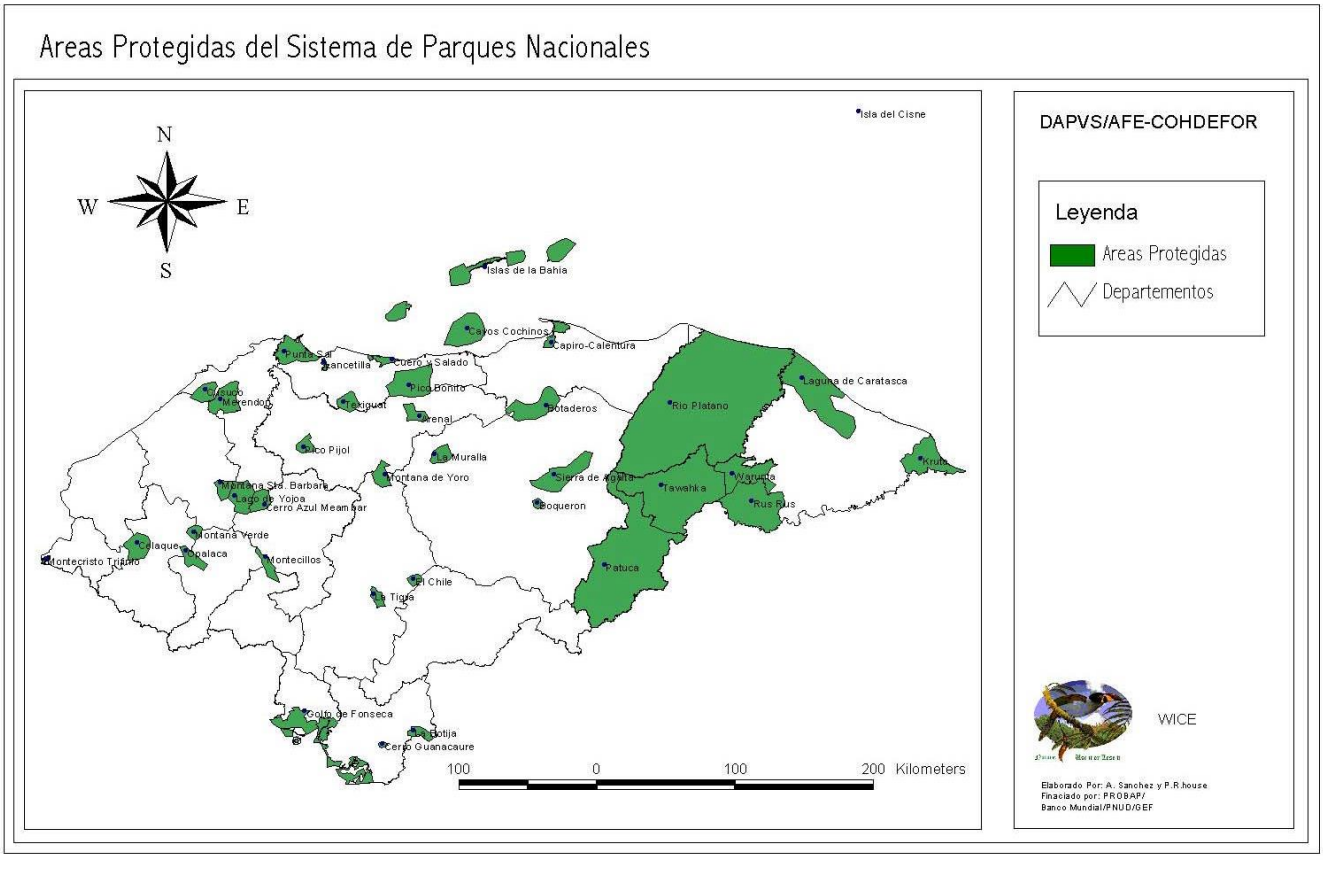

Figure 1.7 Protected Areas of Honduras, an evaluation (Source: Vreugdenhil, *et al.*, 2002).

Characteristics and objectives	National Park	Nature Reserve	National Monument	Multiple Use Area
IUCN Category	**II**	**Ia** and **Ib**	**III**	**V** or **VI**
Size	More than 5000 ha	Any size	Less than 5000	Any size
Importance	National or International	National or International	National	Local
Integrity of a representative example of an eco-system	Yes	Yes	Facultative	Facultative in designated areas
Unique landscapes or geological formations	Yes	Facultative	Yes	Facultative in designated areas
Research	Yes	Yes	Facultative	Facultative
Environmental Education	Yes	Facultative	Yes	Facultative
Visitation and Recreation	Yes	Facultative	Yes	Yes
Production of water	Yes	Yes	Yes	Yes
Production of wood and non-wood products	No	No	No	Yes
Hunting	In designated parts of the buffer zones only	In designated parts of the buffer zones only	In designated parts of the buffer zones only	Yes
Habitation	In designated areas in buffer-zones	In designated areas in buffer-zones	In designated areas in buffer-zones	In designated areas only
Characteristics and objectives	National Park	Nature Reserve	National Monument	Multiple Use Area

Table 1.2 Characteristics and use objectives of categories of management areas.

Management Category (UICN)	Category Name and description	Comments on the ownership and management of the UICN management category and/or on the definition of the management category
II	National Park. Protected Area primarily managed for the conservation of ecosystems that hasrecreation objectives	Normally, ownership and management in this category is in the hands of the national authority with jurisdiction over the area.
VI	Protected Area with Managed Resources. A protected area primarily managed for the sustainable use of natural ecosystems.	Ownership can be in the hands of the national or regional government, the community, individuals or a combination of these. Management must be controlled by public entities with a precise mandate in favor of conservation and this must be carried out in association with the local community; or can be done complying to local customs, with the support and advice of governmental and non-governmental organizations.
IV	Habitat/Species Management Area. A protected area primarily managed for conservation with active intervention.	Ownership and management are in the hands of the national government or, with adequate safeguards and controls, in the hands of other governmental levels, an indigenous population council, a non-profit foundation, a corporation, a private group or individuals
I	Strict Natural Reserve/Wild Natural Area. A protected area primarily managed with scientific goals or with goals of protecting nature.	Ownership and management must be in the hands of the government.
III	Natural Monument. Protected area primarily managed for the conservation of specific natural characteristics.	Ownership and management must be in the hands of the government.
Private	---	This corresponds to the management of specific categories in some countries.
Proposals	---	Although protected areas qualify for some of the management categories that exist on the international level, they have not officially been designated for this purpose by the Competent National Authorities.
Undetermined	---	Protected areas do not qualify for any of the Management Categories that exist on an international level.

Table 1.3 IUCN protected areas management categorization (Source: IUCN, 1994)

The administration of protected areas in Honduras is rather unique because the management of many nationally owned protected areas has been delegated to different NGOs. The risk of this politic decision is to produce a fragmentation of the coherence of the system. Additionally another problem is connected with the low involvement of the people living into the National Parks.

The Multiple-Use Parks of Honduras

A Multiple-Use Area is a terrestrial or aquatic area that integrate productive land use with (1) the conservation of natural and semi-natural ecosystems, (2) the production of high quality water, (3) recreation, (4) forest conservation and sustainable extractive use, (5) scientific research and (6) environmental education. Municipal authorities and departments have the role to approve the management plans of Multiple Use Area. The approval of management plans should be preceded by the development of a participatory approach involving local stakeholders.

Management plans define boundaries for areas for habitation, land uses, recreation activities and regulate the use of natural resources of the area. Additionally the management of multiple-use areas should be close as possible to the local residents.

1.4. Research objectives

The main aim of the current research thesis is to develop the system analysis of the investigated area and to create and to implement an analysis model that integrates the proper tools of territorial analysis as Geographic Information Systems (GIS) and Multiple-criteria analysis (MCA) with a specific strategic participatory planning process.
Regarding the system analysis, the thesis aims to analyse both quantitative and qualitative data collected during a fieldwork with the purpose to understand the problems affecting the area and the actors and organizations operating in the investigated area.
The main purpose of the analysis model developed by this thesis is to identify the priority intervention areas of 'La Botija' protected area ('San Marcos de Colón, Honduras), analysing the multiple territory elements of the area. The analytical model aims to answer to the following research question: 'Which are the priority intervention areas of 'La Botija' protected area?'
Furthermore the creation of the model aims:

- to create suitability maps that characterize the territory elements of the investigated area.
- to promote an action by the local citizens, the public authorities and local stakeholders.
- to support decision making processes and to give advices to policy makers, public administrators and project managers.

1.5. Relevance of the study

The analysis model developed in this thesis represents a decision support system (DSS) useful for both public authorities and local stakeholders for the development of strategies and actions for the sustainable development and management of the area. In fact the analytical model could be used by public decision-makers and project managers to understand which areas need priority interventions. The analysis of the suitability maps provides information on which could be the best intervention strategies for the sustainable development of the protected area and its rural communities. The model permits to analyze the situation both at specific level, looking at the rural communities, and at general level, investigating the whole protected area. However, the created suitability maps focusing on eighteen specific themes (e.g. the water system, the sewer system, the school density, the water treatments, etc.) permits to analyze both individually and collectively the multiple elements of the area.

1.6. Thesis organization

This thesis includes six chapters in total. The organization of the thesis is shown in Figure 1.8.
Chapter one presents an introduction to the research background. The first part of Chapter one introduces the problem statement and outlines the needs of a territory analysis to support 'La

Botija' protected area planning and management and its sustainable development. The second part consists of theory about spatial multi criteria analysis and participatory approach.
The third part of the first chapter presents the elaboration on the research objective, the research questions, the relevance of the study and the research framework.
The second Chapter describes the methods used.
Chapter three provides background information about the case study on 'La Botija' protected area.
Chapter four provides the analysis of both qualitative and quantitative data.
Chapter five presents the developed model. Firstly the analysis of the phases of development of the model are explained. Secondly the suitability maps created with the model are presented. Finally the Multi-criteria analysis results elaborated by the model are explained.
Chapter six draws conclusions of the thesis based on the results and findings of the research. This chapter includes the discussions of the research, the critical reflections of the research and related future research challenges.

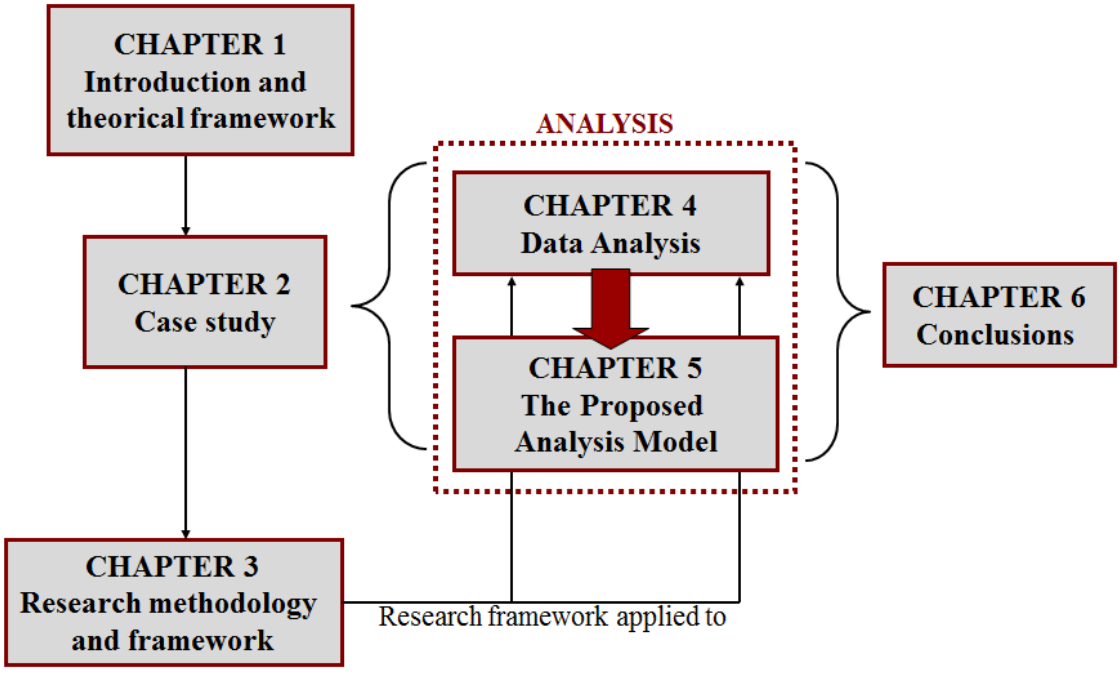

Figure 1.8 Thesis Organization.

CHAPTER 2. CASE STUDY

2.1. Honduras context

The Republic of Honduras is, with approximately 7.7 million inhabitants, the second most populated country in Central America (Andréu, 2012). Additionally Honduras is the second poorest country in Central America. Honduras is a lower middle-income country and is characterized by persistent poverty and inequality challenges. The per-capita income of the country is about US$1,880 (data of 2010). Since 2000 the government has obtained a degree of economic stability but unfortunately the country has never achieved progress, improvement of living conditions of poor people and reduction of poverty (IFAD, 2014).

Even though poverty afflicts the country as a whole, Honduras' poverty is higher in rural areas. Poverty in Honduras affects 60 per cent of the population, while 36 per cent live under extreme poverty conditions. In rural areas, these percentages increase to 63 per cent and 50 per cent, respectively.

Poverty is dominant in central hillside areas in the interior highlands of Honduras, where 75 per cent of the rural population live, including indigenous groups. The problems connected with the poverty conditions are several: lack of infrastructures and basic services, vulnerable and polluted environment and natural resources, lack of access to lands, low agricultural productivity, lack of employment, etc.

The agricultural lands of Honduras cover approximately 28 per cent of the territory. The employment into the agricultural sector is represented by about 39 per cent of the population. The main agricultural products resulting from the agricultural production consists in low-profit crops (e.g. bananas, plantains, rice, maize and beans). In hillside regions farmers may have difficulties to cultivate due to the presence of steep slopes. Additionally soils in Honduras are, in many cases, extremely vulnerable to erosion causing productivity decrease.

Furthermore in Honduras the risk of hurricanes and flooding is high, especially in the North-side of the country, close to the Caribbean coast. In 1998 Hurricane Mitch destroyed the country, ruining infrastructures, houses and food crops and increasing the poverty of the country.

The poorest and most vulnerable group in Honduras consists of rural women, young people and indigenous groups.

2.2. The Province of Choluteca

The Province of Choluteca is located in the southern part of Honduras. Choluteca Province is represented in orange in the map below (see Figure 2.1). The boundaries of this department are Francisco Morazán and El Paraíso in the North, the country of Nicaragua in the East; and the Gulf of Fonseca in the South. The total area of the department is 4,360 km². Choluteca department is divided into 16 municipalities. One of these municipalities is San Marcos de Colón, where is located the study area of this research.

Figure 2.1 Provinces of Honduras (Source: Secretarial office of Natural and Environmental Resources of Honduras (Secretarial de Recursos Naturales y Ambientales de Honduras).

2.3. 'La Botija' multiple-use protected area

2.3.1. Administrative units

The study area is 'La Botija' protected area, located in the municipality of San Marcos de Colón, Choluteca province, Honduras and it set at the border with Nicaragua. Le localization of 'La Botija' protected area is shown in Figures 2.2. and 2.3.

The protect area has a surface area of 19,079.81 hectares (191 km^2) which represents 34% of the surface area of the Municipality of San Marcos de Colon that holds 562,9 Km^2 at an altitude of between 500 and 1,700 meters (Flores Velásquez *et al.*, 2008; Sánchez Villa, 2013).

The protected area is considered important for different reasons: production of water for both Honduras and Nicaragua, presence of forests, wood production, presence of endangered flora and fauna.

Figure 2.2 Localization of 'La Botija' protected area in Honduras (Source: Google Earth).

Figure 2.3. Localization of 'La Botija' protected area (Source: Ford & Lovich, 2006).

'La Botija' Multiple Uses Area (AUMLB), was declared a protected area in 2005 by Decree No. 385-2005 delivered by the National Congress of Honduras. 'La Botija' national Park is a multiple-use protected area (Area de Usos Multiple La Botija'(AUMLB)). As explained in Paragraph 1.3.1. in this protected area are allowed limited productive land use (i.e. agricultural activities) and wood extraction.

Currently 'La Botija' protected area should be officially managed by a group of organizations and institutes following an Area Management Plan called 'Plan de Manejo del Area de Usos Multiples Montaña La Botija'. This plan was approved by the National Institute for Forest Conservation (ICF) in 2009. The organizations involved in the Management of the area are the following: 'Enrich the World' NGO, 'ODESA' NGO, 'APROBOSQUE' organization,

‘INADES’ NGO. In the reality the Area Management Plan was applied from 2010 to 2014 because previously, from 2002 to 2006, the management plan document consisted only in a draft.
Approximately 24 communities live within La Botija.

2.3.2. Hydrology

‘La Botija’ Protected Area is important for water production, since the area represents the water source of 25 communities in Honduras and 2 municipalities in Nicaragua.
La Botija is at the center of three main hydrological systems in the region: the Río Comali, that flows into the Wans Coco Segovia River in Nicaragua (the longest Central American River, that provides 90% of the municipal water supply of San Marcos de Colón); the Torondano River, that flows into the Guasaule and the Negro River in Nicaragua (one of the main watersheds that drain into the Pacific Ocean); and the Iguazala River, that flows into the Ojochal valley within ‘La Botija’ subsequently into Nicaragua (Draft, La Botija Mountain Management Plan, 2002.).The Tepesomoto Reserve also contains sub watersheds of the Wans Coco Segovia (the Coco-Somoto and Estelí Rivers; Atlantic Ocean); and the Estero Real River, sub watershed of the Fonseca Gulf watershed (Pacific Ocean), shared by El Salvador, Honduras, and Nicaragua (Flores Velásquez *et al.*, 2008).

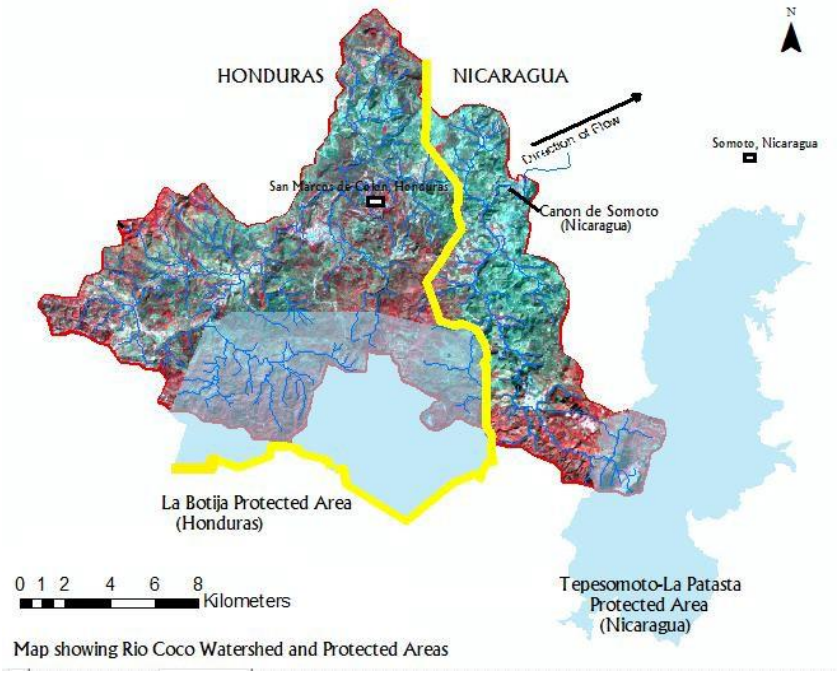

Figure 2.4 Hydrology of ‘La Botija’ protected area
(Source: Macknick *et al.*, 2011).

CHAPTER 3. RESEARCH METHODOLOGY AND FRAMEWORK

3.1. Research approach

This research employed a mixed methods approach. Creswell et al. (2003) defined mixed methods as:

'A collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of data at one or more steps in the process of research.'

The present thesis follows an action research approach. Action research is defined by Greenwood and Levin, 2007 as 'a way of working in the field, of utilizing multiple research techniques aimed at enhancing change and generating data for scientific knowledge production'. Action research rests on processes of collaborative knowledge development and action design involving local stakeholders as full partners in mutual learning processes (Greenwood and Levin, 2007). With action research the researcher directly identifies and observes phenomena that would otherwise be missed and can understand the behavior and power of different actors (Avelino, 2011).

3.2. Research methodology and research strategy

The methodological approach of this research can be divided into different stages, as the following: (1) learning of 'Transition management' method, (2) literature review and formulation of the research case study and research questions, (3) formulation of the interview guidelines and the workshops framework, (4) qualitative and quantitative data collection during the fieldwork, (5) elaboration of geographical data with the use of Geographic Information Systems (GIS), (6) qualitative and quantitative data analysis, (7) construction of an analysis model. The paragraph 2.2. describes the phases followed for the development of this research.
The construction of the analysis model (7) is divided in its turn into three different phases: (a) construction of a multi-criteria analysis (MCA) framework, (b) qualitative and quantitative data analysis through GIS and elaboration of suitability maps, (c) Multi-criteria analysis elaboration by GIS, creation of maps and definition of the priority intervention areas.
The specific research methods used in this thesis are the following:

- Geographic Information Analysis (GIS)
- Multi-criteria analysis (MCA)
- Participatory approach: strategic planning process for transformative change, strictly connected with the 'Transition Management' method.

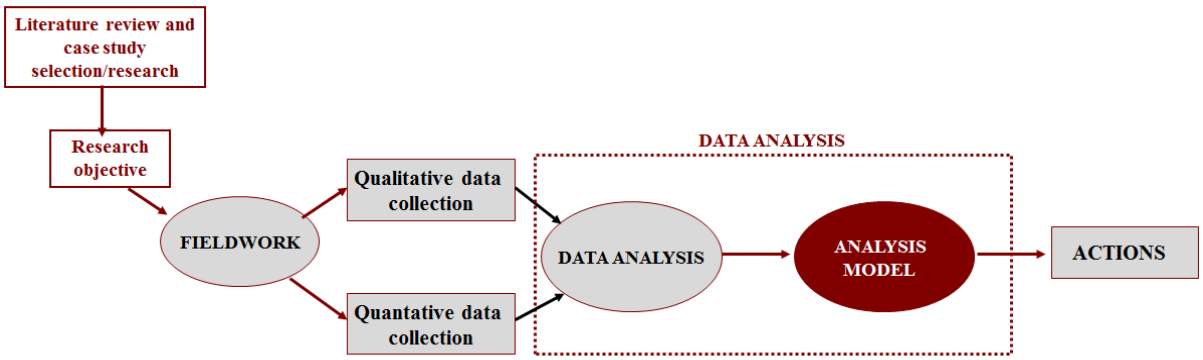

Figure 3.1. The research framework of this thesis.

3.2.1. Step one: Learning of 'Transition management' method

The qualitative data collection and analysis followed a specific methodology called: 'strategic planning process for transformative change', strictly connected with the 'Transition Management' method. Furthermore this specific methodology was used for the organization and realization of community workshops during the fieldwork. The 'Transition Management' technique was developed by 'DRIFT' Institute (Dutch Research Institute for Transition) at the University of Rotterdam (Netherlands). This institute deals with project and consulting on sustainable development as explained in Paragraph 1.2.3. The Transition management method was learned by the author of this research during an internship of nine months, from April until December 2013.

3.2.2. Step two. Literature review and formulation of the research objective

First of all, a literature review exploring current studies related to spatial planning, protected areas legislation in different countries, participatory methods, multi-criteria analysis and GIS analysis was carried out. Based on this first primary literature review the data was collected during the fieldwork. Finally, the research objective were formulated (December 2013-January 2014) (see Paragraph 1.4.).

3.2.3. Step three: Formulation of the interview guidelines and the workshops framework

Based on the study of the case and the literature review, the questions for the interviews to be conducted during the fieldwork were developed (January 2014). At the beginning two interview guidelines were formulated: one for the residents of the rural communities and another for the policy makers and the project managers.

3.2.4. Step four: qualitative and quantitative data collection during the fieldwork

The author collected both qualitative and quantitative data during a fieldwork of three months (February-May 2014) in 'La Botija' protected area, Municipality of San Marcos de Colon, department of Choluteca, Honduras. The author of the research collaborated with a NGO's called 'Enrich The World-Honduras' and she lived with a local family of the rural community of 'El Jocote'. The permanence in the rural community permitted to the researcher to collect

both quantitative and qualitative data. In fact during the fieldwork the author has been in contact with different organizations, institutions and stakeholders of the area. The fieldwork permitted to evaluate the multiple problems and potentialities both at general and specific level, to understand the vision of the local residents and stakeholders and to analyze the possible actions and strategies for the sustainable development of the area.
The data collection during the fieldwork can be divided into two different types: qualitative (Paragraph 3.2.4.1.) and quantitative (Paragraph 3.2.4.2.) data collection.

3.2.4.1. Qualitative data collection and transition management

During the fieldwork the researcher followed a specific method called 'strategic planning process for transformative change'. This methodology is based on Transition Management approach, developed by The Dutch Research Institute For Transitions (DRIFT) of the University of Rotterdam (The Netherlands) Transition Management, as explained in Paragraph 1.2.3.2., is an alternative governance approach developed to initiate and enable transformative change by creating space for innovations, empowering, champions, fostering, collaborations and stimulating ongoing experimentation, evaluation and learning (Frantzeskaki, N. et. al, 2012).. Transition Management is based on Transitions concepts. The aim of transitions researches is to understand patterns and processes of transformative change towards sustainability goals. This means that transition researches seek to develop strategies to enable transformative capacity in the institutions, communities, technology and infrastructure of different systems (Van Eijndhoven, J. et al., 2013).
The 'strategic planning process for transformative change' was developed with the collaboration of the Monash Water for Liveability Institute of the Monash University of Melbourne (Australia) This Institute is based on the 'Resilience Approach' approach. Resilience approach aims to comprehend and account for uncertainties in ecosystem dynamics, to give the possibility to a system to continue to function in the face of disturbances (Chapin III, F. S. et al, 2010). The Resilience method focuses on social-ecological systems (e.g. natural resources, waterways, etc.) trying to develop strategies to improve the resilience of institutions, communities, ecosystems and economies in the different systems. Resilience researches identify that resilient outcomes will only be achieved if there is adaptive capacity and continuous learning in a system (Folke C., et al., 2010). The process adopted in this thesis builds on the Transition Management approach as an overarching framework to consider how Transitional change towards a sustainable future can be enabled. In addition it was expanded to incorporate additional steps focused on building system resilience, with the understanding that the resilience thinking needs to underpin a sustainable future.
The strategic planning process adopted in this research permitted to collect qualitative data and, simultaneously, to support the action and the transformative change of the local citizens towards a long-term vision of a sustainable future.
In particular the 'strategic planning process for transformative change' includes (1) the focus on long-term planning; (2) the development of a visioning process; (3) the use of participatory approaches involving multiple stakeholders; (4) the co-creation of strategies following a

bottom-up process; and (5) the connection between the visions and desires for the future and the possible actions to develop for achieving the dreams.
The overview of the methodology is shown in Figure 3.2.

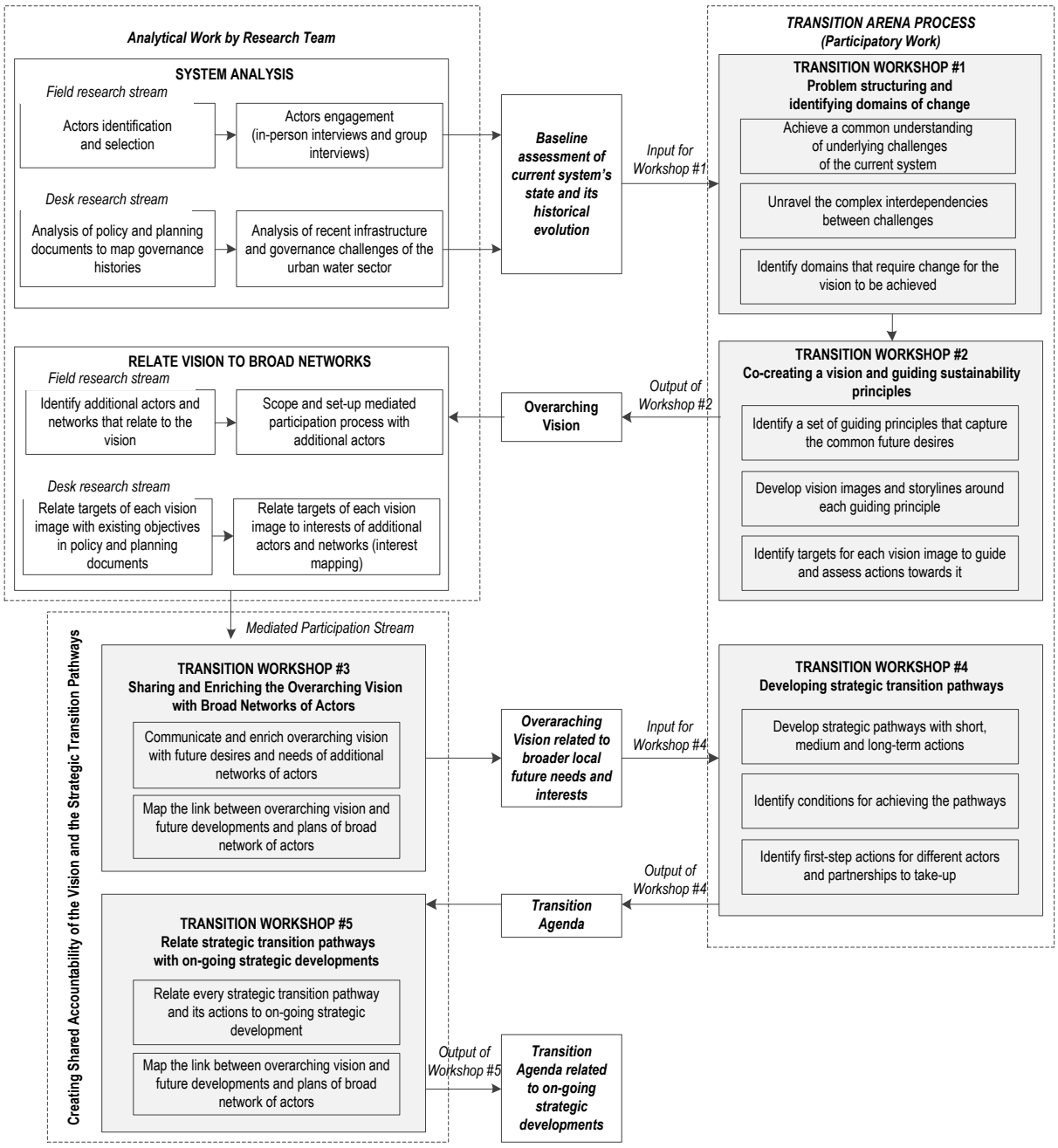

Figure 3.2 Overview of the methodology (Frantzeskaki *et al.*, 2012).

The strategic planning process can be divided into different phases. The first phase consists in the system analysis. In this phase the current context of the investigated area is analyzed. The system analysis can be divided into two different typologies of analysis: problem analysis and actor analysis. In the first case the problems, needs, and domains of citizens and local stakeholders are investigated. In the second case the institutions and actors of the area are identified and selected. These actors were contacted and both in-person and group interviews

were developed. The system analysis represents a baseline assessment of the current situation of the investigated area and its stakeholders.
The second phase is represented by the development of a first workshop aiming to structure the problems, to understand the current challenges and to identify the domains of change.
The third phase concerns the realization of a second workshop, focusing on the visions development for the future.
The fourth phase regards the development of strategic transition pathways. During this phase one or more workshops are organized. The workshop methodology follows backcasting techniques aiming to develop strategies by thinking about the future vision as a starting point. The workshops developed during this phase aim to enable the sustainable development and to build resilience into the system by brainstorm strategies and actions.
The last methodological phase is to create a transition agenda related to on-going strategic development. The workshop organized in this phase focuses on the priority strategic paths considering how the paths may be operationalized in the specific context.
The next section of the thesis describes the qualitative data collection for the System analysis of the area (Paragraph 3.2.4.1.1.) and the structure of the workshops organized and realized in the rural communities of 'La Botija' protected area (Paragraph 3.2.4.1.2.). In particular, in some communities a unique workshop was organized while in other communities more than one workshop were realized.
The system analysis and the organization of the workshops are interdependent. In fact, in our case study, the system analysis aimed at understanding the context to define the best structures and strategies of the workshops to be developed in the further stage. In addition, the actor analysis permitted to identify the stakeholders and residents to be involved in the workshops.

3.2.4.1.1. Data collection for System Analysis

This phase of the research relates the collection, storing and organization of the qualitative data during the three months of fieldwork in 'La Botija' protected area for the development of the system analysis of the investigated area.
The qualitative data, used for the system analysis, were collected using mixed methods that include:

- 57 in-person semi-structured interviews (46 individual interviews and 14 focus group interviews).
- Participatory observation of rural life of 13 communities of 'La Botija' protected area and participation in fourteen meeting and public events organized by different Institutions and organizations.

<u>Semi-structured interviews</u>

The contact with existing organizations, stakeholders and actors of 'La Botija' protected area was established on the basis of the information provided by documents, previous research but especially by the exchange of information with local people. In total fifty-seven in-person semi-structured interviews were conducted: forty-three individual interviews and fourteen collective interviews. During the fieldwork the interview guidelines were modified

and three versions were created: one for the residents and teachers of the schools of the rural communities, one for the officers of NGOs and another for policy makers. The interviewees and the interview designs are included in Appendix A.

Questions for the residents of the rural communities and teachers of 'La Botija' protected area schools were designed to provide explanations on the existing problems, opportunities, visions and possible actions of the community. In particular the interview guidelines followed the following structure: (1) existing problems and opportunities of the community, (2) reasons of the problems persistence, (3) personal visions and dreams for themselves, their family and the community, (4) possible actions to develop in the community. In addition information were asked about the (4) community organizations and their activities (e.g. health committee, water committee, group of organized women, etc.) and their vision of the (5) social and institutional context and (7) the interaction between the community and the local organizations, institutes and the governance level (e.g. the municipality).

The interviews for policy makers, public administrators and projects managers of NGO's aimed at investigating their role, responsibilities and visions. Furthermore they purposed to gather information about the interaction between the several local organizations and institutes. In this case interview guidelines/interview questions can be divided into 4 blocks regarding information about the following fields: (1) Operational (includes implementing and managing policy action plans, explaining roles, capacities and assets); (2) Tactical (includes designing steering activities, programs, funding, establishment of networks and/or partnerships); (3)Vision and expectations for the future; (4) Reflexive (includes monitoring, both assessing and evaluating: a) existing policies and b) assets and c) their interaction); (5) Strategic (includes setting long-term goals, policy development, planning, vision, values, identity, culture and knowledge).

The interview guidelines consisted of a series of open-ended questions. A snowball method was used for the selection of the interviewees. All interviews took between 40 and 120 minutes to be completed. All the interviews were conducted face-to face. All interview responses were recorded on a digital voice recorder by the author.

The contact with the majority of the residents to be interviewed was established through direct communication in the rural communities. In fact a contact by mail or phone was not possible due to the total absence in the area of both internet connection and mobile line. The researcher moved among the various rural communities on foot, by bus or by car and she tried to speak and to interview residents of the multiple communities of the protected area. A fundamental role was played by the teachers of the schools of 'La Botija' area. In fact the teachers, who have been working in the area for a long time, have knowledge about the local inhabitants and the existing problems of the community. The teachers provided useful information about the local economic, social and environmental situation and the stakeholders of the communities that was important to contact and to speak with.

Also the family where the researcher lived contributed to the understanding of the local conditions and its members gave valuable advices for the research development.

During the system analysis research phase, residents, teachers, project coordinators, policy makers, NGO's and institutional officers were identified, contacted and interviewed. Table 3.1 summarizes the interviews conducted in this research. 4

Number of interviews	Typology	Level	Number of interviews	Position interviewees
46	Individual	Communities level	16	Residents
			11	Teachers
			7	Community presidents
		Governance level (NGO's officers, public officers and policy makers)	4	Public officers
			5	NGO's project managers and officers
			1	Policy makers
14	Collective	Communities level	8	Residents
			1	Teachers
		Administration level	5	Public officers
Total interviews			57	

Table 3.1. The interviews conducted in this research.

Figure 3.3 An interview conducted with the teacher of 'Las Flores' school.

Participatory observation and participation in local meeting and events

- **Participatory observation**

  Observation and participatory observation were regularly conducted in the multiple rural communities of the protected area during the fieldwork period. The author had lived for three months (February-April 2014) with a local family of 'El Jocote' community. In addition during the fieldwork the author visited 13 rural communities of 'La Botija' protected area. The involvement in the rural life both of the family and the communities allowed the researcher to take part in and observe the diversity of perspectives, interactions, connections, activities, opinions and views of local people. At the same time the author could understand the local traditions, the history of the

country, the cultural knowledge and the existing local economic, social and environmental problems.

- **Participation in local meeting and events**

  During the fieldwork the author of the research participated in fourteen meetings and public events organized by different Institutions and organizations. Table 3.2 shows the typologies of meetings and events attended by the researcher.
  The involvement and participation in the local meetings and events permitted to understand the multiple interconnections and interactions existing between different initiatives, organizations and local actors. In addition the participatory approach allowed the author to understand the problems and potentialities of the local actors and institutions and to understand which strategies could be developed in the future to improve the area and to support its sustainable development.

Figures 3.4 and 3.5 On the left the meeting between 'APROBOSQUE' members and 'PROPARQUE'; on the right the public event on nutrition (Source: Giorgia Silvestri).

Number	Date	Place	Theme	Organizer
1	10/02/14	San Marcos de Colon – private house	Meeting between the members of 'APROBOSQUE' and USAID-PROPARQUE project	President of 'APROBOSQUE'
2	14/02/14	El Jocote – football field close to the school	Public event on nutrition	Collaboration between different ONG (ODESA, Amigos della Terra (Spanish cooperation))
3	16/02/14	Comali'-COCASAM branch	COCASAM Cooperative annual meeting with members	COCASAM Cooperative
4	20/02/14	San Marcos de Colon – room of catholic Church of San Marcos de Colon	Meeting of ICF on Forest Protection with members of different Institutions, ONGs, private companies of the area of San Marcos de Colon	ICF (Institute for Forest Conservation)
5	22/02/14	Comali'- COCASAM branch	Public event with the participation of the President of Honduras	COCASAM Cooperative
6	23/02/14	El Jocote – ICARO cooperative outdoor gazebo	Meeting of the ICARO cooperative members	ICARO cooperative
7	26/02/14	San Marcos de Colon –ODESA seat	Meeting of the 'La Botija' managers	ODESA ONG and APROBOSQUE organization
8	5/04/14	San Marcos de Colon - ICF seat	Meeting of the 'La Botija' protected area managers	ICF (Institute for Forest Conservation)
9	12/03/14	Las Delicias – Church of the community	Meeting with Municipalities of Nicaragua for the fires prevention of the forest area at the border with Nicaragua	Collaboration between ICF, 'red de mujeres organization' and environmental departments of the municipality of San Pedro del Norte – Chinandega (Nicargua)
10	19/03/14	El Jocote- CEMAS	Meeting of PMA (World Food Programme of United Nations) with the beneficiaries of the project	PMA (World Food Programme) with the collaboration of Enrich the World ONG and the coordinators of some rural communities
11	20/03/14	El Jocote- CEMAS	Meeting of Health Center of San Marcos de Colón municipality and PROSADE project of CARE ONG	Health center, CARE ONG
12	22/03/14	San Marcos de Colon – 'SANMARQUEÑA' cooperative seat	'Cabillo abierto' of the Municipality of San Marcos de Colon. Presence of Mayor, deputy mayor, council members, ICF, Health center	Municipality of San Marcos de Colon with the collaboration of other institutions (e.g. 'red de mujeres' association, 'SANMARQUEÑA' cooperative, Health Center, ICF)
13	26/03/14	San Marcos de Colon - room of catholic Church of San Marcos de Colon	Meeting of 'Red de mujeres' association	
14	7/04/14	El Jocote- CEMAS	Meeting of PROSADE project of CARE ONG	CARE ONG with the collaboration of Enrich The World ONG

Table 3.2 Local meetings and events attended by the researcher.


Figures 3.6 and 3.7 On the left the annual meeting of 'COCASAM' cooperative; on the right the meeting organized by ICF on Forest Protection (Source: Giorgia S
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Figures 3.8 and 3.9 Public event organized by CACASAM with the participation of the President of Honduras (in the Figure on the right side, the third from left to right) (Source: Giorgia Silvestri).


3.10 and 3.11 On the left the meeting of the ICARO cooperative members in 'El Jocote' community; On the right the meeting of the 'La Botija' protected area managers (Source: Giorgia Silvestri).


Figures 3.12 and 3.13 Meeting with Municipalities of Nicaragua for the fires prevention of the forest area at the border with Nicaragua (Source: Giorgia Silvestri).


Figures 3.14 and 3.15 Meeting of PMA (World Food Programme of United Nations) with the beneficiaries of the project (Source: Giorgia Silvestri).

Figures 3.16 and 3.17 On the left the meeting of Health center and PROSADE project of CARE ONG (Source: Fernando Tercero); On the right open meeting (‘Cabillo abierto’) of the Municipality of San Marcos de Colon (Source: Giorgia Silvestri).


Figures 3.18 and 3.19 Meeting of 'Red de mujeres' association (Source: Giorgia Silvestri).

3.2.4.1.2. Workshops organization

This thesis aims to analyze the context of 'La Botija' protected area and, at the same time, to enable the transition to more sustainable practices through the development of strategic actions by the residents by applying the strategic planning process to this case study area.
The 'strategic planning process for transformative change' described above was developed for industrialized and developed countries that present social, cultural and economic factors others from those of developing countries as Honduras. For this reason the methodology was modified in order to adapt it to the context and the local situation of the investigated area. The methodology requires the organization of at least three workshops for each group of participants (in the case study, each rural community). Nevertheless, in the context of 'La Botija' protected area the organization of three workshops in each rural community was not possible due to four different reasons:

- difficulties to reach the rural communities;
- fear and timorousness of participants to express their opinions and ideas;
- lack of a project team of researchers;
- lack of time.

As regards the first reason, the rural communities of 'La Botija' protected area do not have suitable infrastructures and communication system and they are very difficult to reach (see Chapter 3). The researcher had to move by bus but there is a bus service only to some of the communities of the investigated area. In some case the researcher was helped by local residents or teachers of the communities that gave her a lift to the rural communities. In other cases the access to some communities was not possible and the author could not include these specific communities into the investigation.
Regarding the second reason, the execution of the workshops was influenced by the fear and timorousness of the workshop participants. In fact people in rural areas of undeveloped countries present less self-confidence and self-belief and this causes difficulty to speak and to describe their views and opinions. In particular the participants could explain their needs and problems but they had difficulties in expressing their visions, dreams and possible actions.
Although the method was developed for a project team consisting of a project leader, two analysts and an additional facilitator, in this specific case the author had to work alone.

The last reason regards the time, since although the applied method was designed for the development of a research of one year, nevertheless the fieldwork had to be conducted in only three months.

The following map (Figure 3.20) represents the workshops organized during the fieldwork in 'La Botija' protected area. In total thirteen workshops were developed in the rural communities of the investigated area (see Table 3.3).

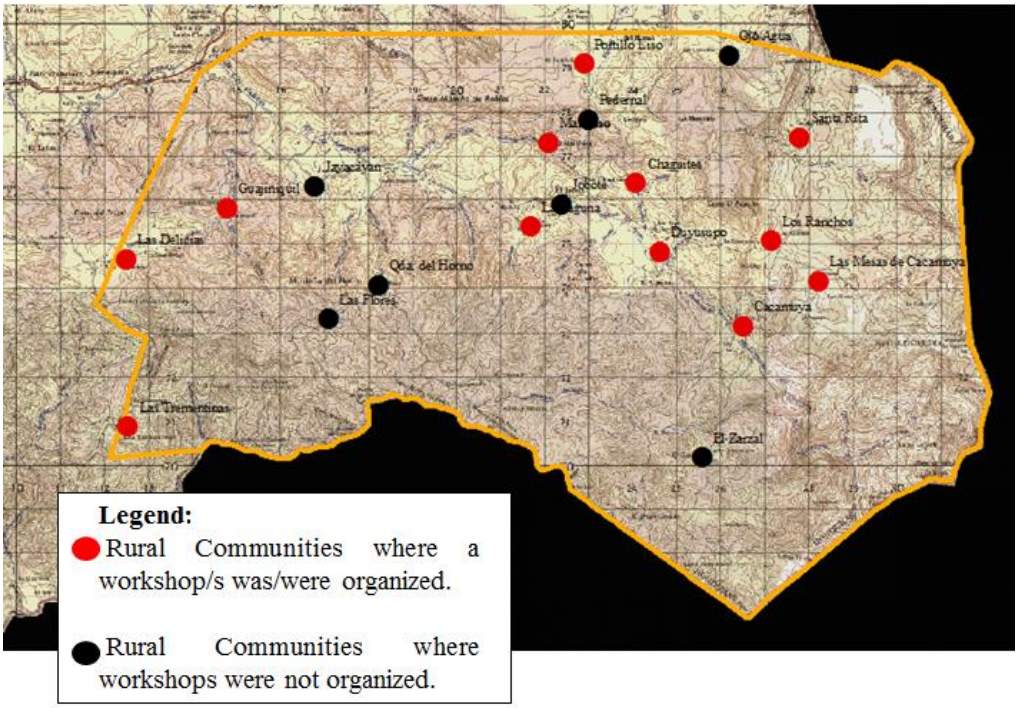


Figure 3.20 The map of the workshops organized in 'La Botija' protected area during the Fieldwork (Source: Giorgia Silvestri, elaborated by GIS).

N.	COMMUNITY	TYPE OF WORKSHOP	DAY	HOURS	PLACE
1	'Los Chaguites'	Analysis challenges, potentialities and visions	Monday 3th of March	From 3 pm to 6 pm (3 hours)	Private house of 'Los Chaguites'
2	'Santa Rita'	Analysis challenges, potentialities, visions and possible actions	Tuesday 4th of March	From 3 pm to 6.30 (3.5 hours)	School building of 'Santa Rita'
3	'Los Ranchos'	Analysis challenges, potentialities, visions and possible actions	Friday 7th of March	From 1 pm to 4.30 pm (3.5 hours)	School building of 'Los Ranchos'
4	'Las Mesas de Cacamuya'	Analysis challenges, potentialities and visions	Friday 14th of March	From 9 am to 2 pm (5 hours)	School building of ' Las Mesas de Cacamuya '
5	'Cacamuya'	Analysis challenges, potentialities, vision and possible actions	Tuesday 18th of March	From 1 pm to 4.30 pm (3.5 hours)	School building of 'Cacamuya'
6	'Mal Paso'	Analysis challenges, potentialities, vision and possible actions	Wednesday 19th of March	From 2 pm to 5.30 pm (3.5 hours)	Community church of 'Mal Paso'
7	'La Laguna', 'Los Chaguites', 'Duyusupo', 'Las Mesas de Cacamuya', 'Portillo Liso' and 'El Rodeo'	Analysis challenges, potentialities and visions with the organized groups of women of the 'Red de mujeres' from 7 different communities of the area	Monday 24th of March	From 9 am to 1.30 pm (4.30 hours)	'Enrich The World' NGO's building
8	'Las Delicias', 'Las Trementinas', 'Guajinijil'	Analysis challenges, potentialities, vision and possible actions	Thursday 27th of March	From 1 pm to 6 pm (5 hours)	School of 'Las Delicias'
9	'Las Mesas de Cacamuya'	Actions (with the drawing of the risk map of the community)	Friday 28th of March	From 8.30 am to 2 pm (5.5 hours)	School building of ' Las Mesas de Cacamuya '
10	'Mal Paso'	Actions (with the real action of cleaning of the community area contaminated by rubbish)	Sunday 30th of March	From 6 am to 12 am (6 hours)	Polluted area of 'Mal Paso'
11	'La Laguna', 'Los Chaguites', 'Duyusupo', 'Las Mesas de Cacamuya', 'Portillo Liso' and 'El Rodeo'	Actions at the individual level, at the community level and at the group of women level (with the practical lesson on compost with the collaboration of a family of the area)	Monday 31th of March	From 9 am to 1 pm (4 hours)	Location of 'Enrich The World' NGO
12	'Las Mesas de Cacamuya'	Strategic plan for project development	Wednesday 2nd of April	From 8.30 am to 2 pm (5.5 hours)	Community building (ex-church)
13	'Las Mesas de Cacamuya'	Strategic plan for project development	Friday 4th of April	From 8.30 am to 2 pm (5.5 hours)	Community building (ex-church)

Table 3.3 The workshops organized by the author in 'La Botija' protected area.

In some communities an unique workshop was organized, while in other communities multiple workshops (from 2 to 6) were developed. Table 3.4 summarizes the number of workshops organized in each rural community. A unique workshop was conducted in five communities, two workshops were organized in four communities, three workshops were

developed in ‘Los Chaguites’ community, six workshops were implemented in ‘Las Mesas de Cacamuya’ community.

Community	Number of workshops
‘Los Chaguites’	3
‘Santa Rita’	1
‘Los Ranchos’	1
‘Las Mesas de Cacamuya’	6
‘Cacamuya’	1
‘Mal Paso’	2
‘La Laguna’	2
‘Duyusupo’	2
‘Portillo Liso’	2
‘Las Delicias’	1
‘Las Trementinas’	1
‘Guajinijil’	1

Table 3.4 Number of workshops conducted in the communities of ‘La Botija’ protected area.

The structure of the workshops followed the specific ‘strategic planning process for transformative change’ framework previously described.
The workshops can be divided into five different parts, as following:

(1) Analysis of needs, domains and challenges of the community.
(2) Investigation of the potentialities of the community and the presence of community organizations and projects working in the community.
(3) Explications of environmental and social problems at general level and in the specific context of ‘La Botija’ protected area.
(4) Analysis of visions and desires for the future.
(5) Identification of possible actions and strategies for the sustainable development and improvement of the community and ‘La Botija’ protected area.

In the case of the organization of a unique workshop all phases were carried out in the same meeting. When there was the possibility to organize more than one workshop the first workshop focused on needs, problems, challenges and vision for the future (phases from 1 to 4) while the second workshop identified the possible actions and strategies to develop in the community (phase 4).
In ‘Las Mesas de Cacamuya’ were developed six workshops. Three workshops followed the strategic planning process, each workshop focusing on a specific theme: the first workshop gave attention on needs, problems, potentialities and environmental and social themes were described (phases from 1 to 3), the second workshop regarded the analysis of visions and desires (phase 4) and the third workshop considered the identifications of strategic actions (phase 5). The others three workshops developed in ‘Las Mesas de Cacamuya’ consisted in the design of a strategic plan for the community. During the fieldwork the participatory analysis focused on this rural community of ‘La Botija’ protect area because the researcher has identified various favorable characteristics for the development of a specific project in the area.

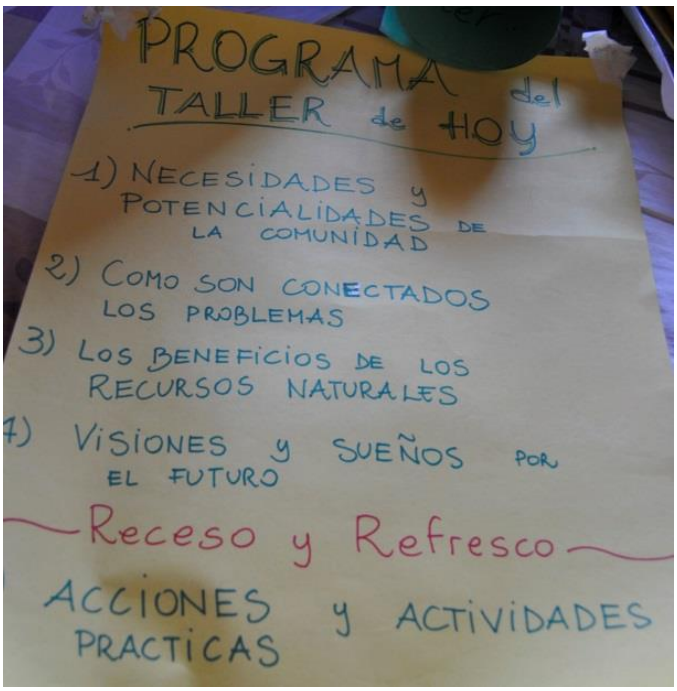


Figure 3.21 The structure of the workshop as shown in a poster during the workshop in 'Cacamuya' community.

(1) Analysis of needs, domains and challenges of the community

During the first phase of the workshops, participants were asked to express their needs and domains as well as to describe the problems, challenges and potentialities of the rural community and of 'La Botija' protected area. During this phase the following questions were formulated: 'Which are the problems of your communities?', 'Which are the needs of you, your family and your community?', 'Which are the potentialities of the area and your community?' In addition the causes of the system and community problems were investigated asking: 'Why do these problems persist?', 'Which are the areas of the community that require a change?'

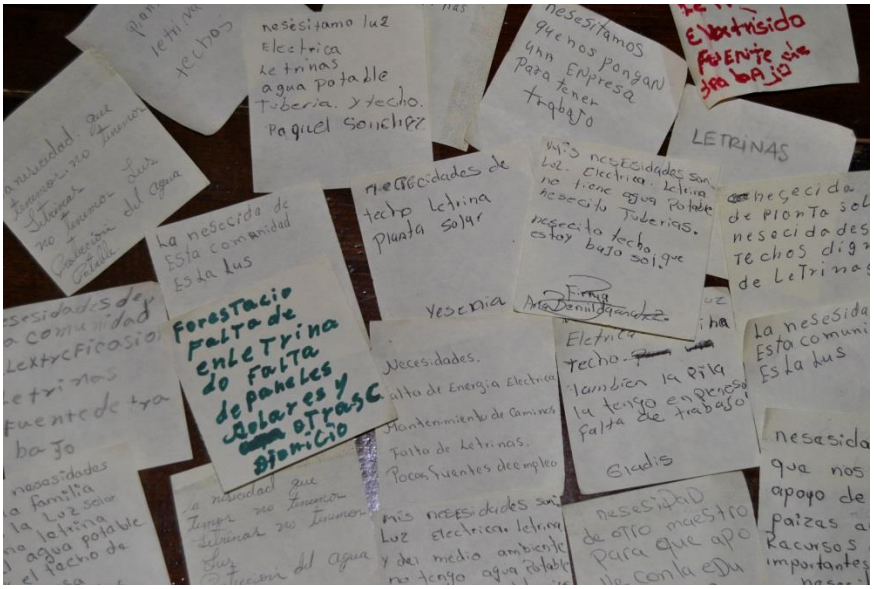


Figure 3.22 The needs expressed by the residents of 'Santa Rita' community during the workshop.

(2) <u>Investigation of the potentialities of the community and the presence of community organizations and projects working in the community</u>

The second part of the workshop regarded the potentialities of the community. In particular the participants were asked to describe their opinions on the potentialities both at the general level of 'La Botija' protected area and at specific level of their community. During this phase the organizations of the community were investigated (e.g. water committee, health committee, group of organized women, etc.). Additionally the activities, problems and challenges of the several community organizations were analyzed asking numerous questions to the participants. Furthermore the researcher formulated questions to obtain information about the projects and NGO's working in the community and the results of their activities.

(3) <u>Explications of environmental and social problems of 'La Botija' protected area.</u>

This part of the workshops aimed to inform and educate the participants about different themes. In particular in this section the different problems of 'La Botija' protected area were described and explained.. The main topics regarded the water and soil pollution, the soil erosion, the nutritional and health problems, the deforestation and the fire risk, etc. All the problems affecting the investigated area were illustrated in a map, as shown in Figure 3.23. The interconnections and interrelations between the problems were explained trying to stimulate thinking about the results of the unsustainable actions developed in the area. During this session the author continuously asked the opinions and ideas of the people to understand also their vision and knowledge about the problems affecting the area. Moreover this part of the workshop aimed to investigate the knowledge of the citizens about different issues (e.g. fire prevention, sustainable practices, treatments used for water and waste, etc.).

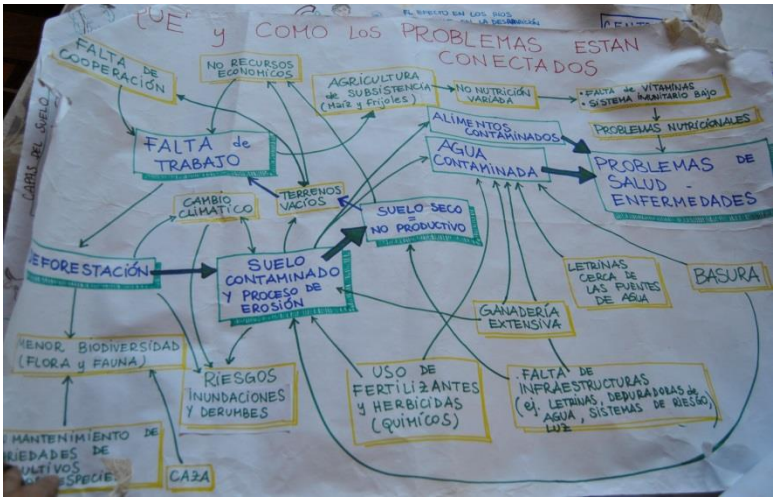
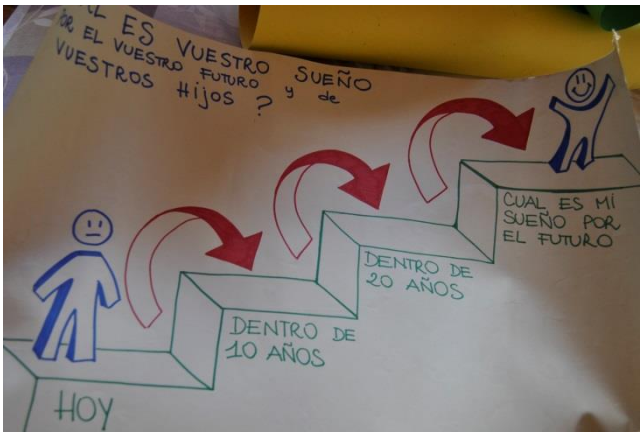


Figure 3.23 The poster on the interconnection between problems in 'La Botija' protected area, as shown during a workshop.

(4) <u>Analysis of visions and desires for the future.</u>

This part of the workshop focused on the visions, dreams and desires of the participants for the future of the area. This phase aimed to stimulate thinking about long-term aspirations

rather than quick fixes to system's problems. In this stage were asked questions as the following: 'What are your dreams for you and your children for the future?', 'What do you dream for your community and 'La Botija' area?'. During this part of the workshop the discussion between the participants was strongly supported.
At the end of the investigation of the dreams of the participants a presentation of guiding principles of similar aspirations and visions was developed (see Figures 3.24 and 3.25). During this phase of the workshop it was explained that the guiding principles work in synergy with each other. This means that, for example, the prevention of water pollution provides a better environmental quality, and, at the same time, supports the health of the citizens. In addition different future context scenarios were presented, showing a range of possible combinations of trends that could affect the area.



Figures 3.24 and 3.25 On the left the poster presented during the investigation of the visions of the participants. On the right a poster on guiding principles.

(5) <u>Identification of the possible actions and strategies for the sustainable development of the community and 'La Botija' protected area.</u>

This phase of the workshop is strictly connected with the development of visions. In fact in this stage the participants were asked to identify a set of strategies to achieve the dreams and visions that they had previously defined (See Figure 3.27). This part of the workshop purposed to develop strategic thinking to solve current problems and to reach the future visions. This part of the workshop purposed to identify a broad range of actions at individual, community and governance level.
When the participants explained the possible actions to develop in their territory the discussion and the sharing of ideas and opinion was supported.
In addition the participants were asked which strategies could enable specific changes. Furthermore, short, medium and long-term horizons were defined for the strategies. In this regards were asked questions such as 'what needs to be done now?', 'what needs to be done in the near future?', 'What needs to be done in the far future?' or more specifically: 'When should each strategy be implemented?'.
A poster summarizing the visions expressed by the participants was shown to support the expression of the actions. In addition another poster identified the imagines of different transition pathways. In particular a pathway represented what would be the future in the case of not changing any current practices while the other scenario pictured the possibility to

improve the quality of life adopting different practices (See Figure 3.26). The pictures of the different pathways wanted to underline the possible outcomes of the actions and strategies that the participants could develop in the near future.
Finally the workshops focused on the priorities paths that should be developed in community. In this stage was asked: 'Which do you think is the most important change for the community?'. In addition the researcher tried to organize a first practical action with the workshop participants. For example in 'Mal Paso', 'Las Mesas de Cacamuya' and 'Las Delicias' a community cleanliness was organized. This activity consisted in the waste collection in all streets of the community. The cleanliness had the aim to improve the quality of the community, and, at the same time, to educate the citizens about the importance of not throwing wastes into lands and rivers.
During all the phases of the workshop/s, but especially during this last stage, the researcher motivated the participants to cooperate, to build collaborations and to self-organize.

Figures 3.26 and 3.27 On the left a poster on different pathways representing the future, as shown during a workshop; on the right the actions as expressed by the residents of 'Santa Rita' community.

3.2.4.2. Quantitative data collection

During the fieldwork were collected topographic maps of Honduras. The maps were provided by the National Institute for Forest Conservation (ICF), by the department of Biology of the University of Tegucigalpa, by engineers working at TERRA company and by the ONG Enrich The World.
Other quantitative data were collected by the collaboration with the Health Center of San Marcos de Colón. The Health Center provided the demographic, social and infrastructural data collected during 2012. In addition the Health Center supplied the water-analysis of the communities of 'La Botija' protected area realized during 2011 and 2012. In particular these water-analyses gave us information about the amount of fecal coliforms detected into the water of the rivers and waterways of the rural communities.
Unfortunately quantitative data of the area are limited. In fact the topographic maps provided by the Institutes do not have a good quality. In addition the water analyses were not realized

in each community and they did not include the analysis of chemical pollution but investigated only the presence of fecal coliforms.

3.2.5. Step five: elaboration of geographical data with the use of Geographic Information Systems (GIS)

Geographic data of 'La Botija' protected area were elaborated using Geographic Information Systems (GIS). The data elaboration refers to a topographic map of the protected area provided by the Institute for Forest Conservation (ICF). This data analysis permitted to investigate the territorial elements of 'La Botija' protected area creating suitable maps (see Paragraph 5.2.).

3.2.6. Step six: qualitative and quantitative data analysis

3.2.6.1. Qualitative data analysis

The collected qualitative data were in-depth analyzed following a qualitative and interpretative approach. The collection of qualitative data allowed to develop the system analysis and the workshops analysis of 'La Botija' protected areas and its rural communities. Additionally the qualitative data analyses were used for the creation of suitability maps by GIS, as explained in the Chapter 5 while describing the analysis model development.
The following section describes firstly the system analysis (Paragraph 3.2.6.1.1.) and secondly the workshops analysis (Paragraph 3.2.6.1.2.).

3.2.6.1.1. System analysis

The system analysis aims to understand the context and its current institutional setting (e.g. politics, organizations, capacities, connections between organizations, policies and strategic plans).
The system analysis is based on information obtained from different, complementary data collection methods: the semi-structured interviews, the literature review, the participant (e.g. informal conversations, participation to meetings and events) and non-participant observation. The recorded interviews were reviewed, transcribed and translated by the author from Spanish to English. Additionally, information obtained from the participant observation were considered. The following step consisted in the analysis of the content of the interviews. The most important quotes identifying specific problems, potentialities, visions and actions were chosen and underlined. Following this method it was possible to describe the main problems, potentialities, actors and institutes and, thus, to develop the system analysis of the investigated area.
The system analysis includes the problems analysis and the actors analysis.
In the first case the problems analysis identifies the principal needs of the investigated area and the interconnections and interrelations between these different problems. To better

understand these interconnections a map (‘problem tree’) was created, as shown in Paragraph 4.1.1.1.
In the second case, in the actors analysis, the principal institutions, organizations and projects that operate in the area and their problems, potentialities and the level of their collaboration were investigated. Additionally, the different roles and responsibilities of the local stakeholders were analyzed. Furthermore the connections existing between these varoius institutes, organizations and actors were identified. The actor analysis focused on the most important local institutions (e.g. Municipality, Health Center, Institute for the Forests Conservation (ICF), etc.), on the NGO’s operating in the area and on the local residents of the rural communities.
The system analysis is presented in Paragraph 4.1.1..

3.2.6.1.2. Workshops analysis

All the workshops were recorded. During all the workshop/s the author kept notes of phrases, words, and descriptions of needs, visions and possible actions. In addition the most important information provided during the discussions were written on posters and post-its.
In addition, the author transcribed the recorded workshops. All the recorded and written information were reviewed and transcribed in Spanish. A Spanish report for each investigated community was developed and provided to each rural community. In total twelve reports were elaborated and analyzed. Subsequently, the reports were traduced by the author from Spanish to English and in-depth analyzed. At a later stage the data collected through the workshops were connected with the information coming from the system analysis. Finally a report of the qualitative data analysis of each investigated area was developed.

3.2.6.2. Quantitative data analysis

3.2.6.2.2. Demographic, social, infrastructural and environmental quantitative data

The Health Center of ‘San Marcos de Colón’ municipality provided multiple quantitative data: demographic, social and infrastructural data. Specifically the data provided by the Health Center refer to the population density, the infrastructures existing in each community (e.g. sewer system, water system, etc.), the water and waste treatments utilized in each community and the fecal coliforms water analyses. The demographic, social and the infrastructures data were collected in 2012 by the officers of the Health Center and the Municipality of ‘San Marcos de Colón’.
The chemical analyses refer to the water pollution by fecal coliforms. Also the water analyses were conducted and provided by the Health Center of ‘San Marcos de Colón’ municipality in 2012 and 2013. The laboratory that made the chemical analysis of fecal coliforms is set in the city of Choluteca, in the province of ‘San Marcos de Colón’.
The unit of measure of the fecal coliform quantity in the water is colony-forming unit (CFU) on 100 ml (CFU/100 ml). Colony-forming units, usually abbreviated as CFU, refer to individual colonies of bacteria, yeast or mold. A colony of bacteria or yeast refers to a mass of individual cells of the same organism, growing together. For moulds, a colony is a group of

hyphae (filaments) of the same mould growing together. Colony-forming units are used as a measure of the number of microorganisms present in or on surface of a sample. Colony-forming units may be reported as CFU per unit weight, CFU per unit area, or CFU per unit volume depending on the type of sample tested. In the case of the chemical analyses of the investigated area, the CFU are reported as CFU per unit volume (100 ml). To determine the number of colony-forming units, a sample is prepared and spread or poured uniformly on a surface of an agar plate and then incubated at some suitable temperature for a stated number of days. The colonies that form are counted. CFU is not a measure for individual cells or spores as a colony may be formed from a single or a mass of cells or spores.

The analysis of the quantitative data was fundamental to better understand the current economic-social situation of each community and the whole protected area. In addition, this type of data was fundamental for the development of the analysis model, for the creation of suitability maps and for the identification of the priority intervention areas.

The following table shows the typologies of the collected quantitative data (see Table 3.5).

Type of Data		**Meaning**
Population density		Total population density.
		Female Population density.
		Male population density.
		Number of illiterates.
Number of houses		Number of houses in the Community.
Sewer system		Number of houses without latrines (outside the house).
		Number of Houses with septic tanks (outside the house).
		Number of Houses with washable latrines (outside the house).
		Number of Houses with toilets (inside the house).
Water system	Number of houses without water.	
	With a well	Number of houses with a well without pump.
		Number of houses with a well with pump.
	With connection with a suitable aqueduct	Number of houses with connection with a suitable private aqueduct .
		Number of houses with connection with a suitable public aqueduct.
	With connection with an unsuitable aqueduct	Number of houses with connection with an unsuitable private aqueduct.
		Number of houses with connection with unsuitable public aqueduct.
Water treatments		Number of families who use chlorine.
		Number of families who boil water.
		Number of families who use other water treatments.
		Number of families who do not use any water treatments.
Water chemical analysis		Chemical analysis of total fecal coliforms. Unit of measure: colony-forming unit (CFU)/100 ml.
Waste treatments/disposal		Number of families who burn waste.
		Number of families who burrow waste.
		Number of families who throw waste (in lands and rivers).
		Number of families who use other methods for the waste treatment/disposal.

Table 3.5 Typologies of the collected quantitative data analyzed in this research.

3.2.7. Step seven: construction of an analysis model (May 2014)

At this stage of the research an analysis model was developed. The model is based on a mixed method and it connects GIS and multiple-criteria analysis (MCA).
The general goal of MCA is to assist the decision maker in selecting the best alternative from a number of feasible alternatives under the presence of multiple choice criteria and priorities (Jankowksi, 1994). GIS has the role of aiding in the search for feasible alternatives. In fact the creation of maps permits to cartographically represent each alternative as a map layer (Jankowksi, 1994). Thus, through the use of this mixed method approach, e.g. interacting GIS and AMC, was possible to analyze simultaneously multiple territory data and to individuate the priority intervention areas of 'La Botija' protected area. The specific description of the realization phases of the model is given in Chapter 5.
This section describes the methods used for the creation of the GIS-based multi-criteria analysis model.
In particular the following are explained:

1. Multi-criteria analysis (MCA) framework;
2. Geo-processing tools used in ArcGIS;
3. Elaboration of multi-criteria analysis (MCA) by GIS;

3.2.7.1. Multi-criteria analysis (MCA) framework

The multi-criteria programming performed through the use of the Analytic Hierarchy Process is a technique for decision making in complex environments where many variables or criteria are considered in the prioritization and selection of alternatives or projects. AHP was developed in the 70's by Thomas L. Saaty and has been since then extensively studied, being currently used in decision making for complex scenarios, where people work together to make decisions when human perceptions, judgments and consequences have a long term repercussion (Bhushan, N. & Rai, K., 2004).

The multi-criteria analysis (MCA) technic can be divided into the following phases:

1. Definition of the decision problem
2. Construction of the Hierarchical Decision Tree
3. Pairwise comparison

a) <u>Definition of the decision problem</u>

The MCA method generally starts with the formulation of the decision problem and the goal to be achieved by the analysis.

b) <u>Construction of the hierarchical structure</u>

Another fundamental phase of AMC consists in the decomposition of the problem into a set of criteria and a set of alternatives in order to be more easily analyzed and compared in an independent manner. Following this formulation a hierarchical tree of criteria/alternatives can be developed (see Figure 3.28).

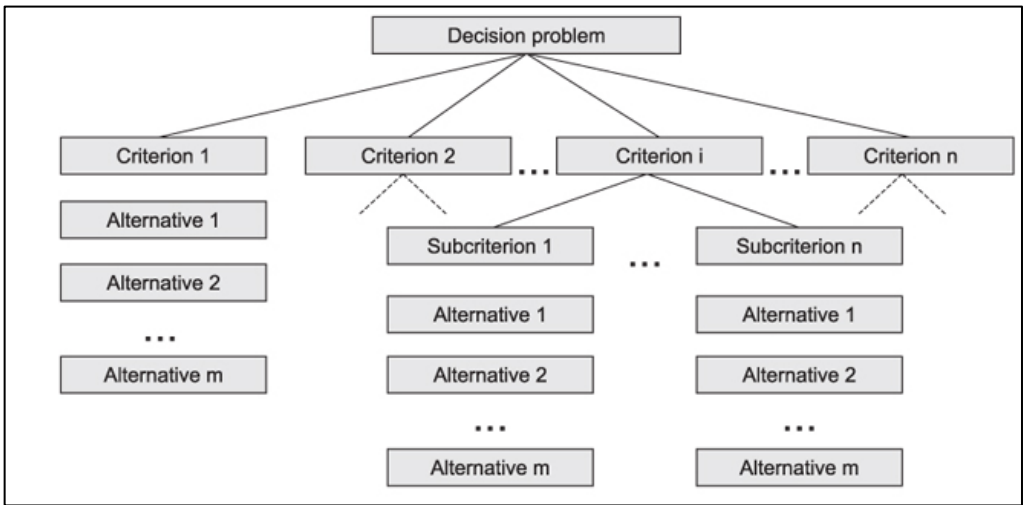


Figure 3.28 Example of a hierarchy tree of criteria/alternatives (Ribeiro *et al.*, 2012).

c) <u>Pairwise comparison</u>

After this logical hierarchy is constructed, the following step consists in the assessment of the alternatives by making pairwise comparisons for each of the chosen criteria. The pairwise comparison method can be divided into three phases:

- **Generation of the pairwise comparison matrix**

  A matrix of the criteria of the hierarchical structure is developed to permit the comparison between each element of a row with each element of the column. This research adopted a scale with values ranging from 0 to 1 to rate the relative preferences for two criteria. The criterion of greater importance is given a value of 1, the criterion of lower importance assumes the value of 0 and when two criteria have equal importance to both of them is given a value of 0.5. The scale adopted in this thesis for the pairwise comparison is shown in Table 5.2.

- **Computation of the criterion weights**

  This phase involves the following operations: (a) sum of the values in each column of the pairwise comparison matrix; (b) divide each element of the matrix by the sum of all the elements of the total column; and (3) compute the average of the elements in each row of the normalized matrix, that is, divide the sum of normalized scores for each row by the number of criteria. These averages provide an estimate of the relative weights of the criteria being compared. Using this method, the weights are interpreted as the average of all possible ways of comparing the criteria.

- **Estimation of the consistency ratio**

  This stage evaluates if the developed comparisons are consistent. This phase involves the following operations: (a) determine the weighted sum of the attributes of each criteria (b) determine the consistency vector by dividing the weighted sum vector by the criterion weights determined previously.

3.2.7.2. Geo-processing tools used in ArcGIS

The maps created by ArcGIS were elaborated through the use of different geo-processing tools, in particular the elaboration of the maps was made through the use of the euclidean distance tool and the kriging tool.

- **Polygon to raster tool**

The ‘Poligon to raster’ tool converts polygon features to a raster dataset. The conversion to raster dataset is the first step that has to be done for the creation of the maps.

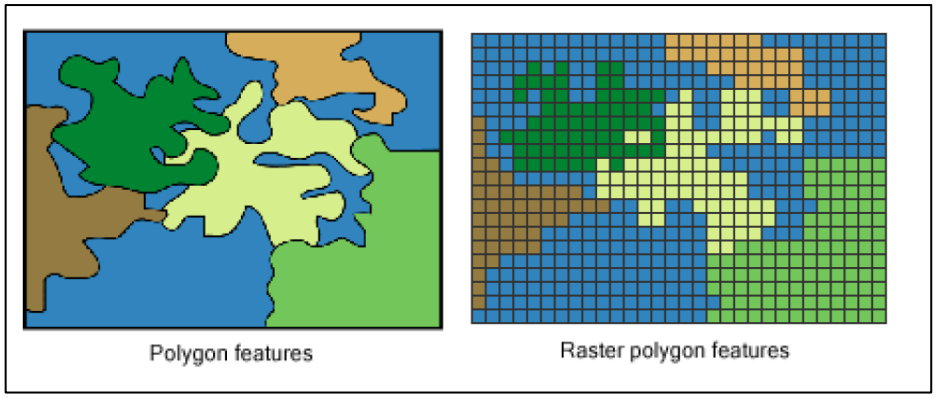


Figure 3.29 The ‘Polygon to raster’ tool (Source: ESRI ArcGIS help).

- **Euclidian distance tool**

The ‘Euclidean distance’ tool calculates, for each cell, the Euclidean distance to the closest source. This geo-processing tool permitted to calculate the Euclidean distances from multiple points that represent specific territory elements (e.g. schools, health centers, bus route, etc.).

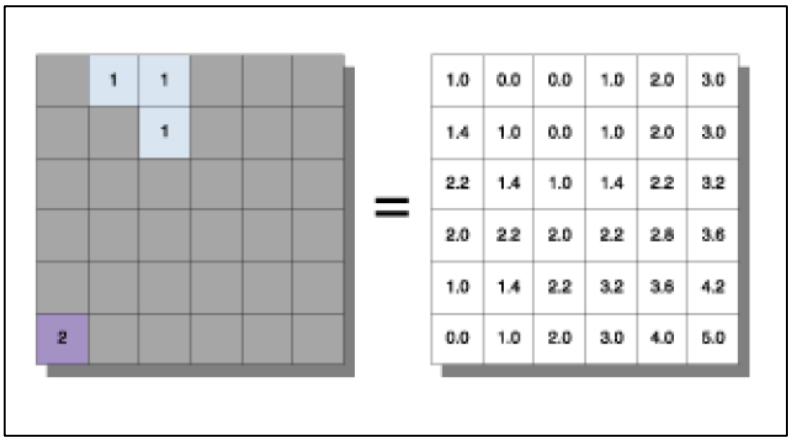


Figure 3.30 The Euclidean distance tool (Source: ESRI ArcGIS help).

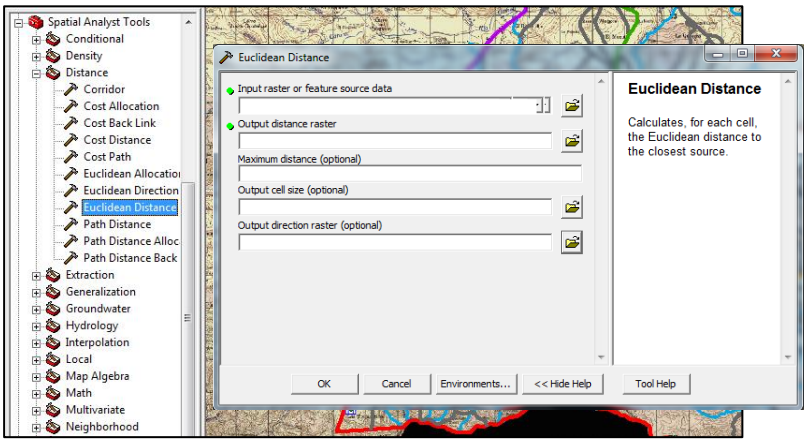


Figure 3.31 The Euclidean distance tool (ArcGIS project).

- **Reclassify tool**

By reclassifying, it is possible to modify the values in an input raster and save the changes to a new output raster.

Old values	new values
0-29	1
30-58	2
59-87	3
88-115	4
116-142	5
143-170	6
171-197	7
198-226	8

Figure 3.32 The reclassify tool (Source: ESRI ArcGIS help).

- **‘Kriging’ tool**

The ‘Kriging’ tool allows to graphically represent the qualitative and quantitative data inserted in the Table of attributes.

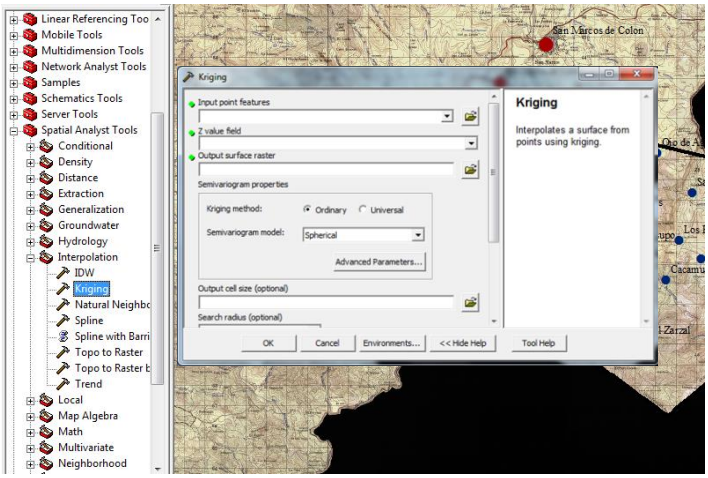


Figure 3.33 Kriging tool

The description of the elaborated maps will be presented in Chapter 5.

2.2.7.3. Elaboration of multi-criteria analysis (MCA) by GIS

In this phase of the analysis model the multi-criteria analysis (MCA) was elaborated by GIS using the Raster calculator tool as geo-processing tool (Figure n.). This instrument permitted to calculate the weighted sum of the elements (criteria, attributes, sub-attributes) of the hierarchical decision tree and to create preference maps that graphically representing the different weight of the MCA elements.

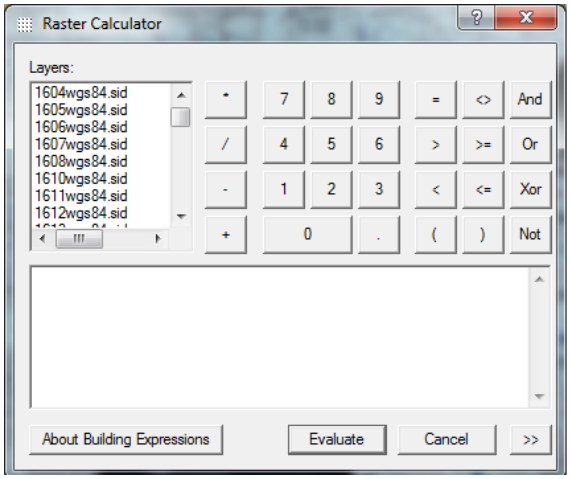


Figure 3.34 Raster calculator tool.

CHAPTER 4. DATA ANALYSIS

In this chapter, the data analysis is presented. This chapter is organized in two different parts: the first section regards the data analysis at general level while the second part concerns the in depth-analysis of the rural communities investigated in this research.
The first section, i.e. the data analysis at general level (Paragraph 4.1.) presents the system analysis and the geographical analysis of 'La Botija' protected area. The system analysis addresses the problems and potentialities of the protected area and the actor analysis. A 'problems tree' was designed to better understand the connection and relation between the multiple territory problems. In addition, referring to the actor analysis a 'stakeholders map' was developed to visualize the links and interconnections between the local stakeholders.
On the basis of the geographical data analysis Paragraph 4.1.2. shows the geographical data analysis of 'La Botija' protected area through the geographic information system (GIS).
The second section (Paragraph 4.2.), as previously explained, focuses on the data analysis of the rural communities of 'La Botija' protected area investigated in this research. The data analysis of the local communities is divided respectively in qualitative and quantitative data analysis. The data were used for the construction of a SWOT matrix for each analyzed community.

4.1. Data analysis at general level

4.1.1. The system analysis

The system analysis provides information about 'La Botija' protected area context. The system analysis is divided in three different sections: the problems analysis (Paragraph 4.1.1.1.), the potentialities analysis (Paragraph 4.1.1.2.), and the actors analysis (Paragraph 4.1.1.3). In the first case the system analysis aims to understand the social, economic and environmental problems affecting 'La Botija' protected area.
In the second case the research tries to understand which are the local and multiple potentialities for the sustainable development of the area.
In the third case the analysis purposes to map the relevant stakeholders of the investigated area. This means that this analysis intends to clarify the relationships between the different stakeholders, institutions and organizations that operate in the local area.
The in-depth system analysis aims to understand which are the problems, challenges and potentialities of the territory and of different actors and institutions and which governance decisions could improve the whole system.
In accordance to Wittmayer, a system analysis is a method to attain an overview and an integrated perspective of the system under study (Wittmayer J. et al, 2011).
System analysis stimulates a systemic understanding of the current situation and the interaction between multiple domains. Through the systems analysis is possible to distinguish between symptoms and deep-rooted problems, and to shift the focus from superficial solutions to systemic challenges and opportunities (Roorda C. et al, 2012).
System analysis encourages holistic thinking about the local context under examination. In addition the system analysis is important for preparing the transition workshops. In fact the

first context analysis is fundamental to develop the participatory framing of the transition challenge and the collective envisioning process.
The actor analysis is also decisive to understand the social and cultural setting of the investigated area. Furthermore the actor analysis provides a structured overview of the stakeholders that are related to the selected area.
The system analysis of this research consists of the following steps:

- Delineation of the system analysis boundaries in space, time and themes. Regarding the space the system analysis focuses on 'La Botija' protected area. In reference to the time we chose to analyze the system at the current time. Finally the system analysis themes are multiple since they are regarding social, economic, environmental, and cultural issues. This multidisciplinary selection of themes follows the sustainable development research definition. In fact, according to the literature, the science of sustainability connects many different disciplines and implies the pursue of multi-, inter- and trans-disciplinary researches (Zaman & Goschin, 2010).
- Data collection through direct interviews and the participation to different meetings and events organized by multiple institutions and organizations of the area. In particular we developed semi-structured interviews with inhabitants, teachers of the local communities, community presidents, administrators of NGO's and public institutions, etc. The description of the data collection methodology is given in Chapter 3.
- Analysis of the data collected during the previous phase. The data analysis permitted to develop a 'problems tree', an 'actors map' and a list of local potentialities. Firstly the relevant problems affecting the investigated area, and covering social, environmental and economic domains, were identified (e.g. water pollution, lack of infrastructures, lack of economic resources, lack of education, etc.) and 'a problem tree' was designed and described. This 'problems tree' was fundamental to understand the problems connections and interrelations. The characteristics of the problems were defined and explained. Secondly the potentialities of the area were characterized and described. Thirdly, regarding the actors analysis, the local stakeholders and institutions of the area were identified. To better understand the connection between them a 'actors map' was developed and illustrated.

4.1.1.1. Problems analysis

The evaluation of the problems affecting 'La Botija' protected area is shown in the 'problems tree' represented in the following figure (Figure 4.1). The lack of infrastructures, the environmental contamination, the destruction of forests, the lack of employment and economic resources, the lack of motivation and self-confidence and the lack of cooperation represents the main problems of 'La Botija' protected area.
In the case of the lack of infrastructures, in every community the residents expressed their need to improve and, in same case totally create, water and sewer systems. The environmental contamination is due to several factors such as the lack of suitable waste treatments, produced both by inhabitants and livestock, the excessive use of chemical fertilizers, the lack of

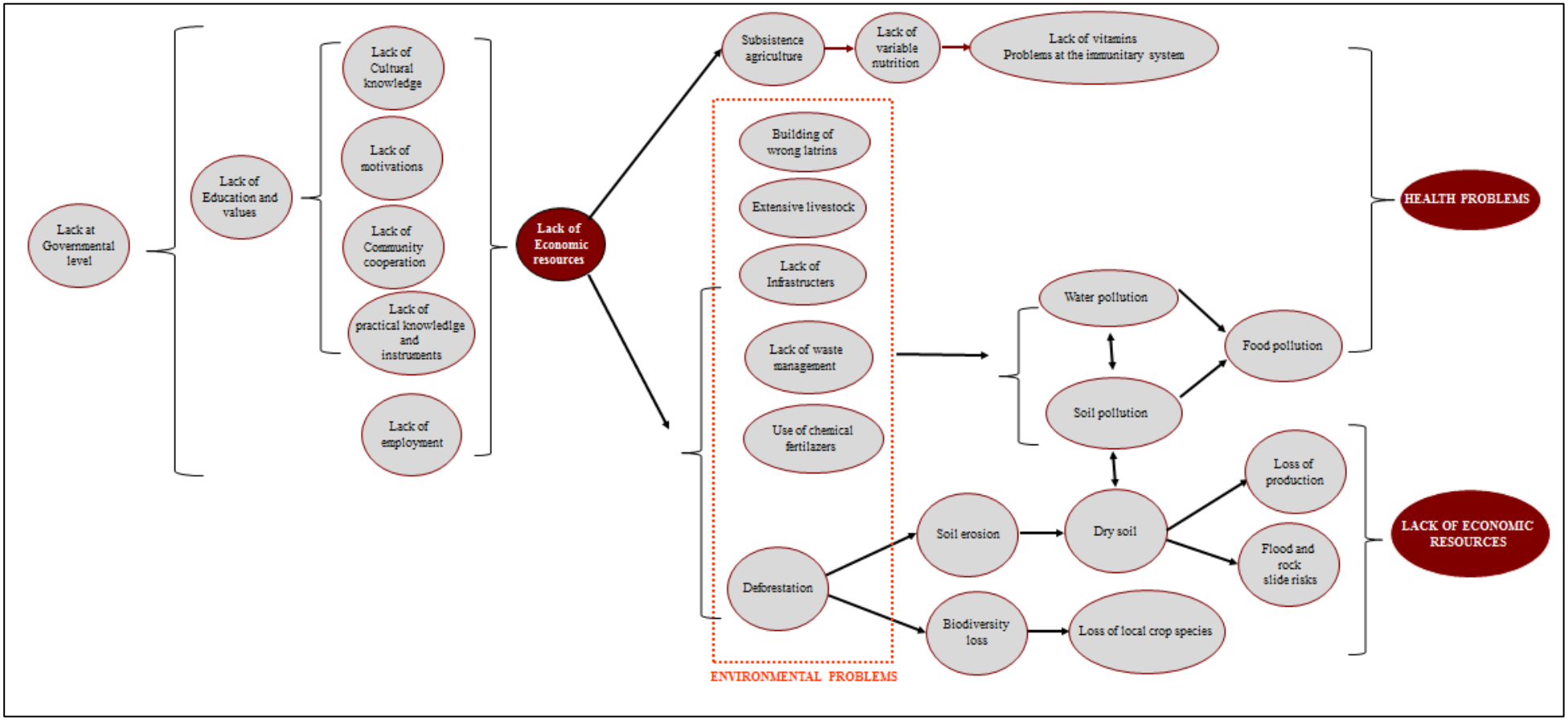


Figure 4.1 'Problems tree' of 'La Botija' protect area (Source: Giorgia Silvestri).

infrastructures, the low cultural level of citizens, the deforestation and fires. The consequence of these factors are the pollution of water, soil and aliments and consequently health diseases.

The deforestation and the fire are critical problems for the area because they have been getting worse over the years and they provoke the destruction of food crops and the soil erosion. The quality of soil is another grave problem in the area and it is caused not only by the forest destruction (through fires and deforestation) but also by the excessive use of chemical fertilizers by local farmers.

The water pollution by fecal coliforms was confirmed by the chemical analyses data provided by the Health Center of San Marcos de Colón. The water pollution by fecal coliforms is caused both by livestock waste and by the lack of suitable latrines in several houses of the investigated area. However, analysis and detection of chemical contaminants in the water were not made in the area and they would be fundamental to understand the level of water pollution by waste and chemical fertilizers.

Regarding the lack of employment and economic resources, these problems affect each community of the investigated area. The majority of families live on subsistence farming products or on the wages of temporary works during the coffee and corn harvest.

Additionally during the fieldwork it was possible to understand the low level of motivation, self-confidence and collaboration among the residents of the majority of the communities. In fact, in most of the cases, people needed to be motivated to action and change of practices as well as cooperation into the community.

Furthermore the level of knowledge about ecological practices (e.g. composting, organic agriculture, practices to prevent fires, etc.) is often low.

Anyway some communities are more organized than others and they present a higher collaboration and cooperation (e.g. Las Mesas de Cacamuya, Mal Paso, Las Trementinas and Guajiniquil and Las Flores).

4.1.1.2. Potentialities analysis

The potentialities identified in 'La Botija' protected area are the following:

- High value of the landscape: 'La Botija' protected area is characterized by beautiful views and beautiful places (e.g. various ecosystems, different waterfalls and a cloud forest) that could represent an opportunity for the tourism development.
- High ecological value: the investigated area has a high biodiversity represented by threatened species of both flora and fauna.
- Presence of a favorable climate.
- Strategic location: 'La Botija' protected area is located at the border with Nicaragua. Additionally it is close to San Salvador country. This position could be an opportunity for the improvement of tourism in the area.
- High security: compared to Honduras the investigated area is a safe area and it is not affected by delinquency.
- Lack of malaria illness: 'La Botija' is one of the few areas of Honduras where there is not malaria.

- Provision of water: the studied area supplies water to several communities of Birth of two great river both Honduras and Nicaragua.
- Presence of different organizations operating in the area.
- Presence of organic coffee production as historic tradition of the rural communities of the investigated area.
- Presence of COCASAM cooperative that sells organic coffee to foreigner countries (especially USA and Germany) and represents an opportunity for the improvement of organic coffee production in the area.
- Local production of different products (e.g. beans, bananas, corn, sugar, coffee,etc.) following traditional and historical processes.
- Presence of more active and motived communities such as Las Mesas de Cacamuya, Mal Paso, Las Trementinas, Guajiniquil and Las Flores.

4.1.1.3. Actors analysis

The main institutions and organizations operating in the area are ICF (Institute for the Conservation of Forests), the Municipality of San Marcos de Colón, ODESA NGO, COCASAM cooperative, the 'Red de Mujeres' association, Enrich the World NGO, APROBOSQUE association, etc., as shown in Figure 4.2.
The main existing problems among these different organizations and stakeholders are the lack of communication, cooperation and sharing of information. These problems are particularly significant between the managers of the protected area (ODESA, Enrich the World, INADES, APROBOSQUE, Municipality of San Marcos de Colon, ICF). The governmental institutions are characterized by several problems such as the inability/unwillingness to support communities and residents (e.g. providing them with infrastructures), the corruption, the lack of organization, the lack of communication with other governmental institutions and organizations.

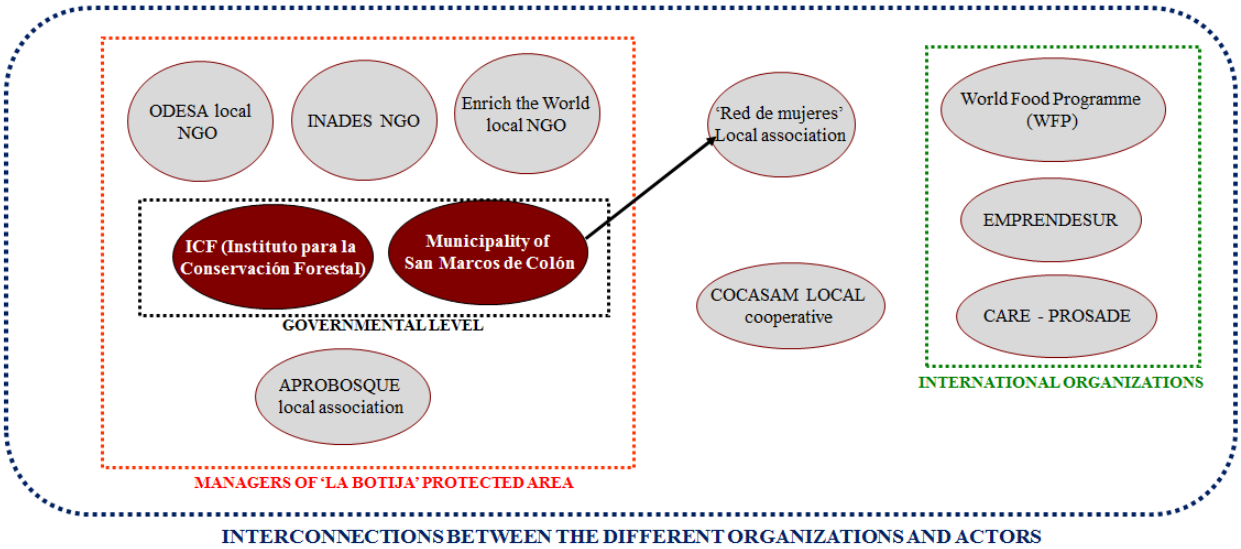


Figure 4.2 The actors map of 'La Botija' protected area.

4.1.2. Geographical data analysis with Geographic Information Systems (GIS) elaborations

This section presents the elaboration of geographic data using Geographic Information Systems (GIS). This data elaboration permitted the creation of suitable maps of 'La Botija' protected area.
The topographic map of the protected area was provided by the Institute of Forest Conservation (ICF).
The following table (Table 4.4) shows the geographic elements analyzed through the GIS system, while the description of each geographic element analyzed with the use of GIS is given in the following paragraphs.

Geographic element	Shapefile name	Shapefile type	Shapefile information
'La Botija' protected area limits	Protected area limits	Polygon	Area
Water	Rivers	Lines	Number of rivers, Length
Communities	Communities	Points	
Infrastructures	Streets	Lines	Number of roads, length
	Schools	Points	Number of schools, Number of students by school
	Health Centers	Points	Number of Health Centers
Communication	Bus service	Lines	

Table 4.1 Geographic elements analyzed through the GIS system

4.1.2.1. 'La Botija' protected area limits

The limits of 'La Botija' protected area were designed following the coordinates points provided by the National Institute for Forest Conservation (ICF). 'La Botija' protected area covers a surface of 190977093,07 square meters. The protected area limits are shown in the following map (Figure 4.4).

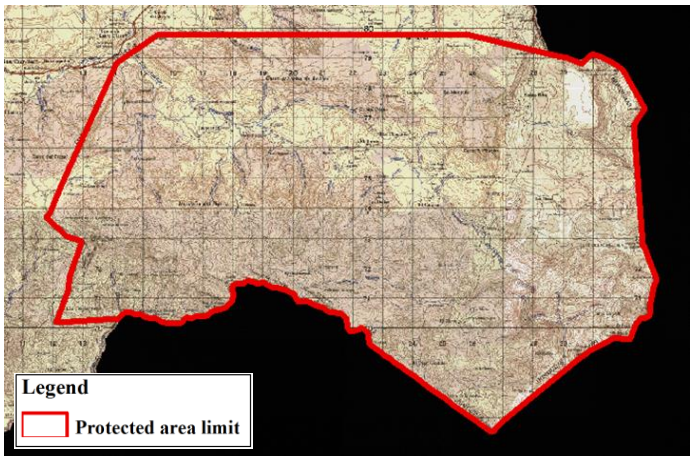


Figure 4.4 The limits of 'La Botija' protected area (Elaborated by GIS).

4.1.2.2. Rivers and water sources

The following map (see Figure 4.5) represents the rivers, streams and water sources of 'La Botija' protected area elaborated by the Geographic Information Systems (GIS).

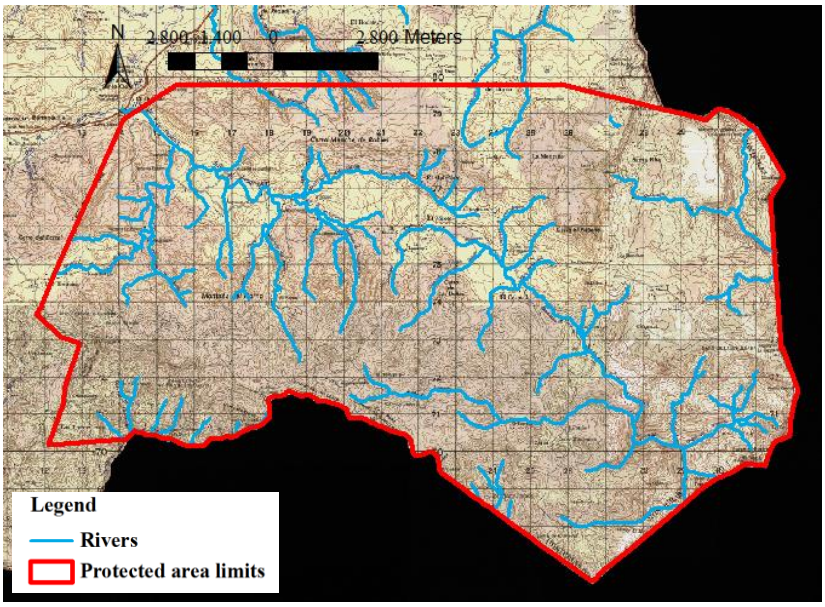


Figure 4.5 The rivers, streams and water sources of 'La Botija' protected area (Elaborated by GIS).

4.1.2.3. Communities

In 'La Botija' protected area are located 19 rural communities, as shown in the following map (Figure 4.6) and in the attributes table (see Figure 4.7) elaborated by GIS.

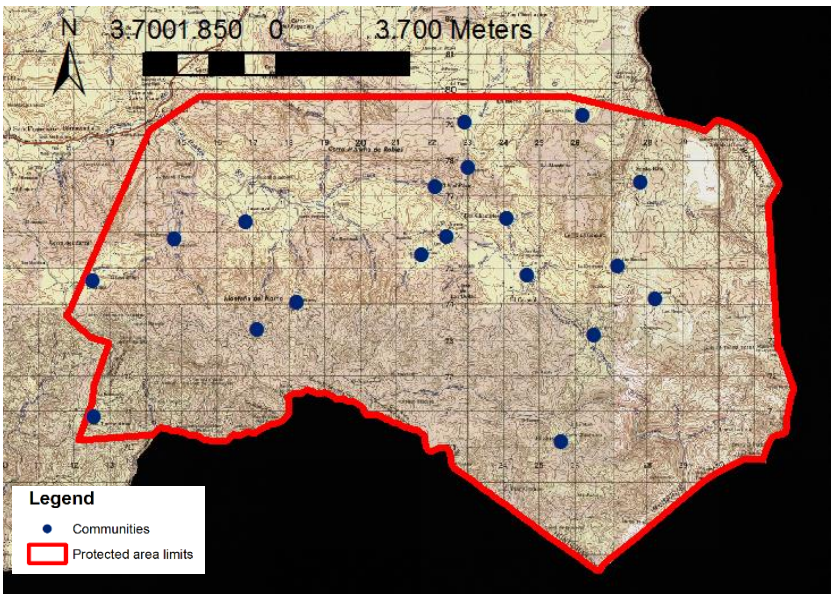


Figure 4.6 The rural communities of 'La Botija' protected area (Elaborated by GIS).

Attributes of Communities

FID	Shape *	Id	Name
1	Point	1	Cacamuya
6	Point	2	Chaguites
2	Point	3	Duyusupo
9	Point	4	El Zarzal
12	Point	5	Guajiniquil
13	Point	6	Jayacayan
3	Point	7	Jocote
4	Point	8	La Laguna
11	Point	9	Las Delicias
18	Point	10	Las Flores
0	Point	11	Las Mesas de Cacamuya
10	Point	12	Las Trementinas
8	Point	13	Los Ranchos
5	Point	14	Mal Paso
16	Point	15	Ojo Agua
17	Point	16	Pedernal
14	Point	17	Portillo Liso
15	Point	18	Qda. del Horno
7	Point	19	Santa Rita

Figure 4.7 The attributes table of the rural communities of 'La Botija' protected area.

4.1.2.4. Infrastructures

4.1.2.4.1. Roads

All the roads of 'La Botija' protected area are unpaved. The following map was elaborated indicating both roads and paths of the protected area. In fact the distinction between roads and paths on the topographic map was not possible. Additionally GIS was used to calculate the roads length.

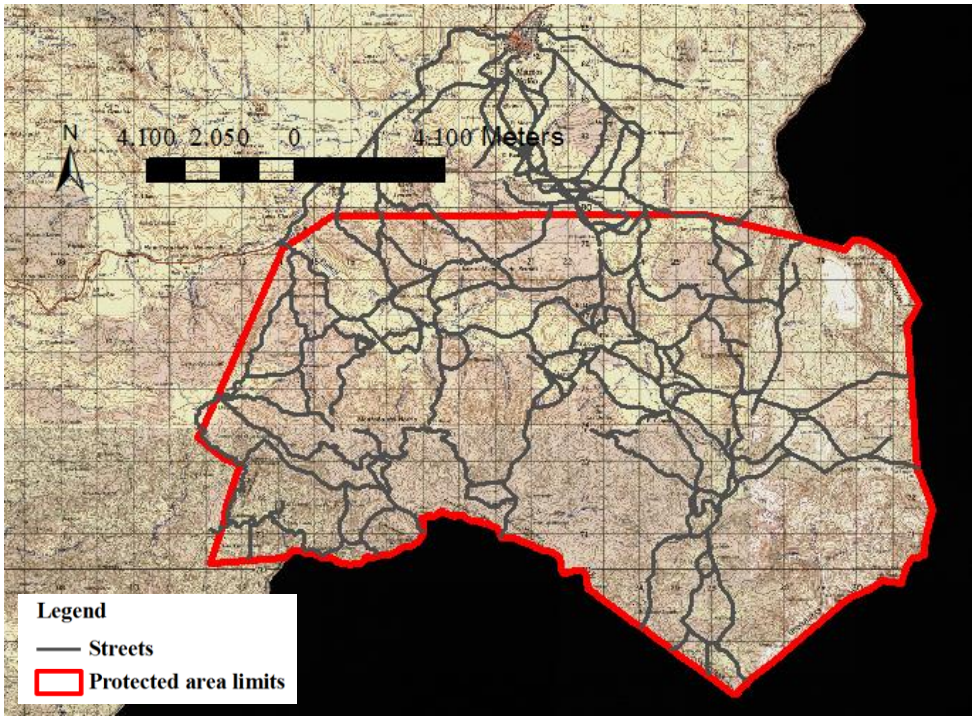


Figure 4.8 The streets of 'La Botija' protected area (Elaborated by GIS).

4.1.2.4.2. Schools

'La Botija' protected area presents 16 schools. In the map elaborated by GIS the author chose to insert only the schools of the rural community investigated in this study (see Figure 4.9).

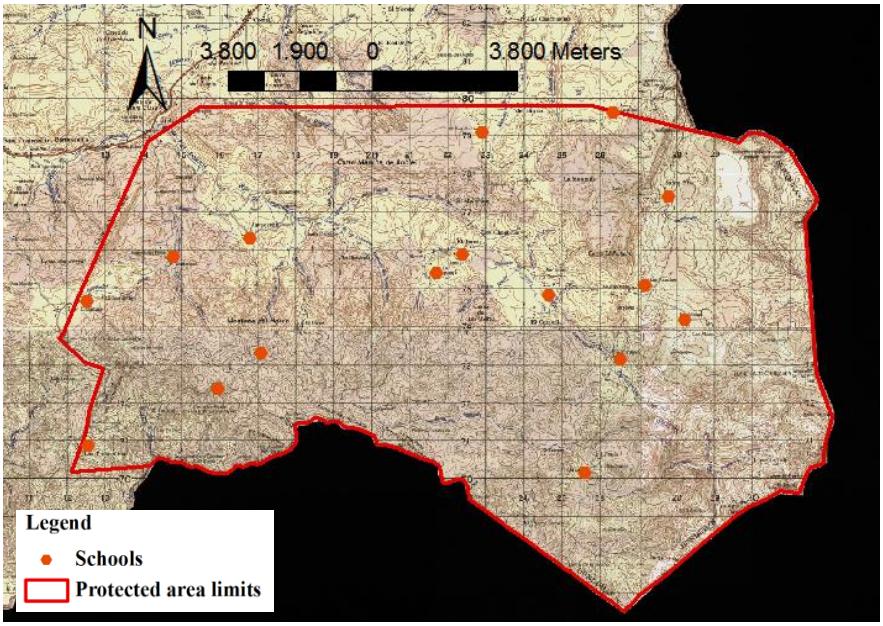


Figure 4.9 The schools of the investigated community of 'La Botija' protected area (Elaborated by GIS).

4.1.2.4.3. Health Centers

'La Botija' protected area presents only two Health Centers that are set in 'Duyusupo' and 'Las Trementinas' rural communities, respectively. The following map shows the localization of the Health Centers of the protected area (see Figure 4.10).

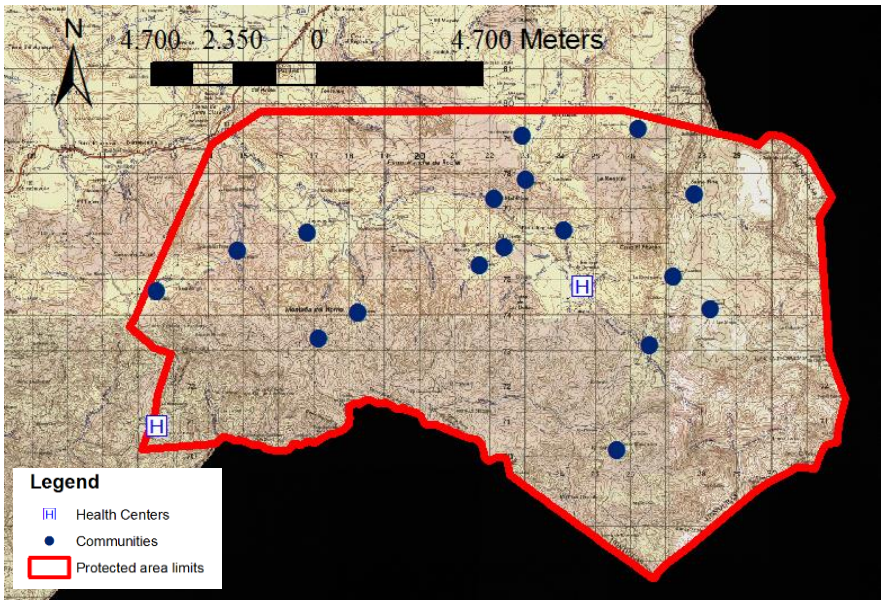


Figure 4.10 The health centers of 'La Botija' protected area (Elaborated by GIS).

4.1.2.5. Bus service

The following map shows the bus service of 'La Botija' protected area. In particular there are three bus routes reaching some of the community of the investigated area: the first route goes from 'San Marcos de Colón' to 'Duyusupo' (green line in the map), the second route departs from 'Duyusupo' and arrives to 'Las Mesas de Cacamuya' (orange line in the map) and the third route leaves from 'San Marcos de Colón' and reaches 'Las Delicias' community (purple line in the map) (see Figures 4.11 and 4.12).

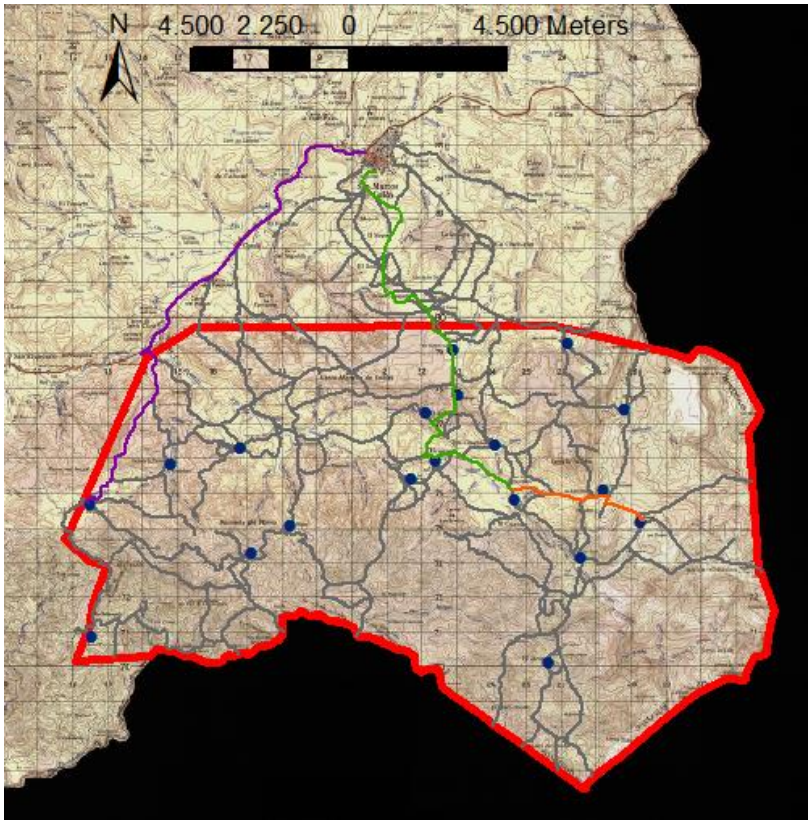


Figure 4.11 The bus service of 'La Botija' protected area (Elaborated by GIS).

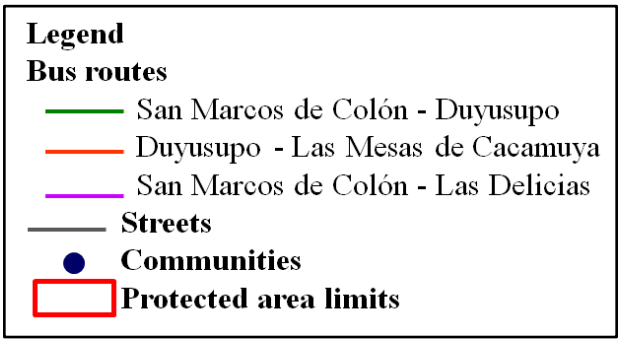


Figure 4.12 The legend of the bus routes of 'La Botija' protected area (Elaborated by GIS).

4.2. In depth data analysis of the rural communities of 'La Botija' protected area

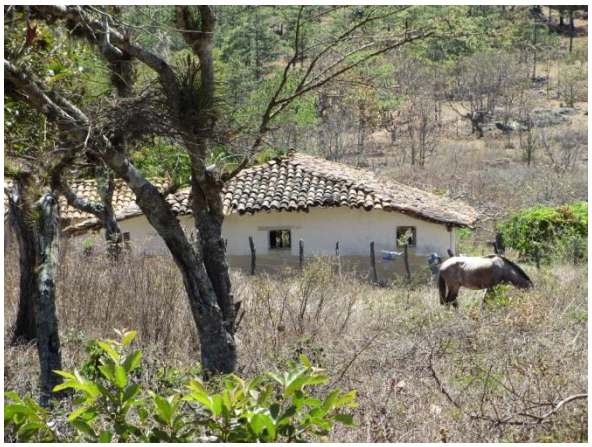
This section provides a both qualitative and quantitative in-depth data analysis of the rural communities of 'La Botija' protected area investigated in this research.

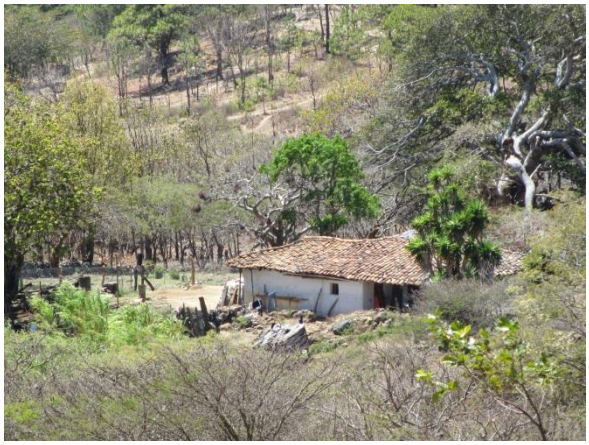
4.2.1.‘Los Chaguites’

Quantitative data

Los Chaguites is a small rural community close to ‘Las Moras’ mountain. The following map shows the setting of ‘Los Chaguites’ inside the protected area.

Figure 4.13 The setting of ‘Los Chaguites’ rural community (Source: Google Earth).





Figures 4.14 and 4.15 Houses of ‘Los Chaguites’ community(Source: Giorgia Silvestri).

Figures 4.16 and 4.17 Houses of ‘Los Chaguites’ community (Source: Giorgia Silvestri).


Figures 4.18 and 4.19 An inhabitant of 'Los Chaguites' community and his house.

The following table (Table 4.2) shows the population density and the number and percentage of illiterates of the community.

Number of houses	Total population	Female population	Male population	Number of illiterates	% of illiterates
17	78	41	37	8	10,26

Table 4.2 Demographic and social data of 'Los Chaguites' community.

In addition the following data indicate the infrastructures of the community. Table 4.3 refers to the sewer system of the community. As shown in Table 4.3, 16 houses on a total of 17 do not have latrines and only one house presents a septic tank that is considered an unsuitable sewer system. Looking at the percentage of the houses with an unsuitable sewer system 'Los Chaguites' community presents a 100% of houses with an unsuitable sewer system. This data express the lack of sewer infrastructures of the investigated community.

Number of houses	Number of houses without latrines	Number of houses with septic tank	Number of houses with washable latrines	Number of houses with toilet	Number of houses with unsuitable sewer system	% houses with unsuitable sewer system	Number of houses with suitable sewer system	% houses with suitable sewer system
17	16	1	0	0	17	100%	0	0%

Table 4.3 Sewer system of 'Los Chaguites' community.

Table 4.4 regards the water system of the community. As shown in the table the hydric system of 'Los Chaguites' is totally unsuitable with a percentage of 100%. In fact 29,41% of the houses do not have water and the remaining 70,59% of the houses do not have a connection to any aqueduct. The majority of the families use water directly from rivers and streams using captation methods. Fortunately 'Los Chaguites' community is close to 'Las Moras' mountain where there are water sources. However the lack of a suitable water system do not permit to maintain the water quality. In fact the water is polluted by different factors, first of all due to an unsuitable sewer system, as explained in the previous paragraph (paragraph 4.1.1.1.).

Number of houses	Number of houses without water	Number of houses with well without pump	Number of houses with well with pump	Number of houses with connection with a suitable private aqueduct	Number of houses with connection with suitable public aqueduct	Number of houses with connection with unsuitable private aqueduct	Number of houses with connection with unsuitable public aqueduct	Number of houses without aqueduct system
17	5	0	0	0	0	0	0	12
% houses without water	**% houses with well without pump**	**% houses with well with pump**	**% houses with connection with a suitable private aqueduct**	**% houses with connection with suitable aqueduct**	**% houses with connection with unsuitable aqueduct**	**% houses without aqueduct**	**% houses with unsuitable water system**	**% houses with suitable water system**
29,41%	0%	0%	0%	0%	0%	70,59	100%	0%

Table 4.4 'Los Chaguites' community water system.

Table 4.5 indicates the water pollution by fecal coliforms in 'Los Chaguites' community. Analyses results show that the pollution by fecal coliforms is high with a media of 158 CFU/100ml.

Community	Number of samples	Fecal coliforms (CFU/100 ml)	Notes	Average
'Los Chaguites'	1	20	River close to the school	158 CFU/100ml
	2	4	'Los Corrales' water source	
	3	450		

Table 4.5 The fecal coliforms pollution in the rivers and streams close to 'Los Chaguites' community.

Table 4.6 presents data on water treatments that families use in 'Los Chaguites' community. The water treatments analysis regarded all the families of the community (17 houses). The results show that 2 families use chlorine, 8 families boil the water and other 2 families use other water treatments. In total 12 families on a total of 17 use water treatments while 5 families do not use any water treatment. The percentage of families that use water treatment is 70,59%. The percentage families who do not use water treatments is 29,41%.

Number of analyzed families	Number of families who use chlorine	Number of families who boil the water	Number of families who use other treatments	Number of families who do not use any treatments for the water	Total families who use water treatments	% families who use water treatments	% families who do not use water treatments
17	2	8	2	5	12	70,59%	29,41%

Table 4.6 Water treatments used by the families of 'Los Chaguites' community.

Table 4.7 refers to the data on the waste treatments/disposal. Also in the case of the waste treatments all the families of the community were analyzed. The results of the investigation are the following: 7 families burn the waste, 1 family burrow the waste in the soil and 9 families throw waste away without using any treatment. The percentage of families who burn waste is 41,18% while the percentage of families who do not burn waste is 58,82%. These results express that more than half of the population of 'Los Chaguites' community do not use appropriate waste treatments.

Number of analyzed families	Number of families who burn waste	Number of families who burrow waste	Number of families who throw waste (in lands and rivers)	Number of families who use other waste treatments	% of families who burn waste	Total families who do not burn waste	% of families who do not burn waste
17	7	1	9	0	41,18%	10	58,82%

Table 4.7 Waste treatments/disposal methods used by the families of 'Los Chaguites' community.

Qualitative data analysis

In 'Los Cahaguites' community in total were conducted five individual interviews and one collective interview (focus group). The following tables (see Table 4.8 and 4.9) show information about the interview.

Date	Place	Position Interviewee
05/02/14	Community of El Zarai (close to Las Moras) one of the two houses (Los Chaguites)	Farmer
05/02/14	Community of El Zarai (close to Las Moras) one of the two houses (Los Chaguites)	Farmer
06/02/14	Community of 'Las Moras' (Los Chaguites)	Farmer
06/02/14	Community of 'Las Moras' (Los Chaguites)	Farmer
06/02/14	Community of 'Las Moras' (Los Chaguites)	Farmer

Table 4.8 The individual interviews conducted in 'Los Chaguites' community.

Date	Area	Position Interviewee	Number of Interviewees
19/02/14	Los Chaguites	Focus group with the women of the community	13 women

Table 4.9 The collective interview conducted in 'Los Chaguites' community.

In total were organized three workshops with the inhabitants of 'Los Chaguites' rural community. The first workshop was conducted on Monday 3th of March in a private house of a woman of the community. At this workshop participated 10 women. The following picture shows the participants in the first workshop (Figure 4.20).

Figure 4.20 The participants in the first workshop in 'Los Chaguites' community.

The second and third workshops were conducted in 'Enrich The World' NGO's building with participants from other six communities of 'La Botija' protected area. The second and third workshops were conducted respectively on Monday 24th of March and on Monday 31th of March 2014.

Table 4.10 summarizes the priorities problems expressed by the community inhabitants during the interviews and the workshops.

During the interviews and the workshops the people confirmed the quantitative data on the sewer and water systems. In fact the majority of the interviewees and participants at the workshops expressed as the priority needs of the community the building of latrines and the creation of a suitable water system. The women that participated to the workshops explained that they developed, in collaboration with a NGO's, a project for the construction of latrines in the community. They sent the project to the municipality of 'San Marcos de Colón' but they did not receive any answer.

Referring to the water system, the workshops participants explained their fundamental need of a better water system. In fact, as explained also in the quantitative data analysis, the water system of the community is completely unsuitable. People affirmed that the majority of the families take the water directly from the rivers and streams, using tubes and pipes. Moreover the families use to share the water. In fact some water owners give the possibility to other residents to use their water.

Other needs expressed by the interviewees and workshops participants relates the lack of employment and the lack of economic resources. These needs represent a general problem for the whole protected area.

In addition, other priority problems that the author understood during the interviews and the workshops are the lack of knowledge and the lack of motivation. In the first case the residents of the investigated community do not know the majority of the organic cultivation practices and they present a low awareness about different issues (e.g. waste and water treatments, use

of chemical fertilizers, etc.). And the second case the community inhabitants are not motivated to action and

Finally, another priority problem expressed by the community citizens regards the dry soil. The soil erosion and the growing difficulties could be due to multiple factors. One of the factors could be the excessive use of chemical fertilizers that may have had a negative impact on the soil. In fact the workshop participants reported that, at the current time, chemical fertilizers do not produce concrete results as before. This means that the chemical fertilizers use may have exceeded the soil tolerance capacity of chemical fertilizers. In addition the territory of 'Los Chaguites' is characterized by the presence of pine forests. The pine trees provoke the increase of the soil acidity and the consequent loss of soil fertility.

Priority problems	**Explanation**
Lack of Latrines	None of the 17 families have latrines.
Lack of a suitable water system	Most of the houses do not have water. People explained that in most of the cases the families take water directly from rivers and streams. Furthermore the residents use to share the water between families. They also said that are aware about the contamination of the water they use. In fact the Health Center reported the chemical analysis made on the community water.
Lack of knowledge	Lack of knowledge about different issues and practical activities. For example the workshops participants explained their lack of knowledge about composting and other organic agriculture practices.
Lack of employment	There are not sources of job in the community. There are only temporary works (e.g. during the coffee and corn harvests).
Lack of economic resources	There is a lack of initial resources to start a new business. For example people explained their lack of economic resources for the livestock.
Lack of motivation	The participants of the workshops are not motivated to take the initiative to practical actions.
Dry soil	The soil is dry but people explained that the use of fertilizers help the soil to increase its fertility. Participants explained that the chemical fertilizers do not produce concrete results as before.

Table 4.10 Priorities needs expressed by 'Los Chaguites' inhabitants.

Table 4.11 shows other problems and needs of the community. All the other needs explained by the community citizens regard the lack of suitable infrastructures. In fact people spoke about the lack of electricity in all their community, the lack of solar panels for the houses recently built, the presence of many damaged houses, the lack of a proper street and the lack of suitable fireplaces in the kitchens.

Other needs and problems
Lack of solar panels for new houses
Lack of electricity
Damaged houses (especially the roofs)
Damaged streets
Lack of suitable fireplaces in the houses

Table 4.11 Other needs and problems of 'Los Chaguites' inhabitants.

The following table (Table 4.12) regards the health common problems of 'Los Chaguites' community, as reported by the community citizens. The presence of vomit and diarrhea as common health problems could be connected to the presence of polluted water, as shown by the chemical analysis previously described in the quantitative data analysis part.

Health common problems	Explanation
• Diarrhea • Vomit • Flu	Diarrhea and vomit may be due to the water pollution in 'Los Chaguites' community.

Table 4.12 Health common problems.

Table 4.13 refers to the potentialities of the community in accordance with the community residents. The potentialities of the community are the low level of deforestation, the use of the community lands and the cooperation between the residents.

Potentialities
Deforestation is not high.
Land use: almost all lands are used.
The community is quite united (especially the poor people).

Table 4.13 The potentialities of 'Los Chaguites' community.

During the first workshop was asked to the participants to list the organizations of 'Los Chaguites' community. The community organizations reported by the participants are the group of women and the water committee (Table 4.14).

Community organizations	Explanation
Group of women	Problems of the women groups: • Lack of knowledge and awareness about different topics. • Lack of practical activities. • Lack of motivation. • Lack of cooperation and union between women.
Water committee	

Table 4.14 'Los Chaguites' community organizations.

Another information requested during the workshop refers to the external organization operating in the community. As shown in Table 4.15 the only project working operating in the community is the World Food Programme (WFP). This international project try to encourage

citizens to learn organic practices and to prevent fire risks. The presence of the WFP working in the community is seen by 'Los Chaguites' citizens as an opportunity to learn and develop. However people expressed also their negative opinions about the WFP. In fact they explained that the project did not organize educational meeting and did not directly explain how to coordinate the practical activities.

External organizations (e.g. NGOs, cooperation projects, etc.)	Explanation
WFP (World Food Programme)	The WFP aims to the development of family allotment gardens by the beneficiaries of the project. The allotment gardens have to be totally organic and people have to use organic soil fertilization methods. In addition the project beneficiaries should develop actions for the fire prevention. The WFP is considered by the citizens an opportunity to learn organic practices: (e.g. how to make organic fertilizer).

Table 4.15 External organizations of 'Los Chaguites' community.

During the second workshop, conducted on Monday 24th of March, the participants expressed their visions and dreams for the future. As shown in Table 4.16 people explained their dreams to achieve some of their ideas for the improvement of the community. In addition many dreams refer to the infrastructures development. In fact many participants spoke about their idea of new community with the presence of latrines and a better water system. Other infrastructures required by the citizens are an health center, school besides the repair of the damaged houses. Furthermore the workshop participants expressed their dream to have job opportunities and to develop practical knowledge (e.g. handmade knowledge). Another expressed dream refers to the increase of security in the community.

Visions and dreams	Explanation
Achievement of objectives	('We want to achieve and accomplish something of all the ideas and dreams that we have thought'. 'I hope that some projects or institutions could help us to achieve our dreams').
Increase of the water system	
Construction of latrines	
Business and sources of job creation	('We would like to work for a company or have an institute providing job that gives us opportunities') The workshop participants explain also their dream to develop a company to produce flowers.
Practical activities and knowledge development	People expressed their dream to learn handmade knowledge.
Creation of a health center	
Creation of a school	
Increase of security	('We dream to have more security in the community').
Restoration of the houses	('We would like to have decent houses').

Table 4.16 Visions and dreams of 'Los Chaguites' community.

The third workshop, conducted on Monday 31th of March, concerned the possible actions that could be develop in the community. The participants explained as possible actions for the community development the creation of vegetable gardens, the organization of trainings on different issues and the improvement of the infrastructures such as the water system and the sewer system. Referring to the group of women organization, the workshop participants expressed as objective the increase of the women practical knowledge through the development of trainings and special meetings.

Possible actions	**Explanation**
Creation of vegetable gardens	Development of organic vegetable gardens for the families of the community.
Development of multiple trainings	Development of educational sessions about different themes. People expressed their interest to learn organic growing techniques (e.g. organic fertilizers, organic pest control methods, etc.).
Improvement of the water system	Provision of water to every houses of the community.
Improvement of the sewer system	Construction of latrines.
Improvement of the group of women organization	Workshops and trainings on different topics through the 'red de mujeres' organization with the aim to learn practical knowledge (e.g. Flowers growing, pastry-making and other practical activities).

Table 4.17 Possible actions that could be developed in 'Los Chaguites' community.

4.2.2. 'Santa Rita'

'Santa Rita' is a rural community set in the east area of 'La Botija' protected area.

Figure 4.21 The setting of 'Santa Rita' rural community (Source: Google Earth).

As shown in Table 4.18, the demographic data indicates that 'Santa Rita' community presents 62 houses and a total population of 250 people. The percentage of illiterates in the community is 10,40%.

Number of houses	Total population	Female population	Male population	Number of illiterates	% of illiterates
62	250	132	118	26	10,40%

Table 4.18 Demographic and social data of 'Santa Rita' community.

The sewer system of the community is not suitable. In fact, as shown in Table 4.19, 44 houses on 62 do not have latrines. Only 16 houses present washable latrines while 2 houses have a septic tank. Considering as suitable sewer systems both washable latrines and toilets the percentage of houses with a suitable sewer system is 25,80%. In fact the majority of the houses are characterized by an unsuitable sewer system (percentage of 74,19%).

Number of houses	Number of houses without latrines	Number of houses with septic tank	Number of houses with washable latrines	Number of houses with toilet	Number of houses with unsustainable sewer system	% houses with unsuitable sewer system	Number of houses with suitable sewer system	% houses with suitable sewer system
62	44	2	16	0	46	74,19%	16	25,80%

Table 4.19 Sewer system of 'Santa Rita' community.

Table 4.20 indicates that also the water system of 'Santa Rita' community is totally unsuitable. Indeed, 24 houses are connected with a damaged water system and 15 houses do not have any connection with a water system; in this latter case the families use the direct capitation of water from rivers and streams. In addition 21 houses do not have water in the house. Looking at the percentages, the percentage of the houses that have a suitable water system is 3,23%, the percentage of houses with an unsuitable water system is 96,77%.

Number of houses	Number of houses without water	Number of houses with well without pump	Number of houses with well with pump	Number of houses with connection with a suitable private aqueduct	Number of houses with connection with suitable public aqueduct	Number of houses with connection with unsuitable private aqueduct	Number of houses with connection with unsuitable public aqueduct	Number of houses without aqueduct system
62	21	2	0	0	0	24	0	15
% houses without water	% houses with well without pump	% houses with well with pump	% houses with connection with a suitable private aqueduct	% houses with connection with suitable aqueduct	% houses with connection with unsuitable aqueduct	% houses without aqueduct	% houses with unsuitable water system	% houses with suitable water system
33,87%	3,23%	0%	0%	0%	38,71%	24,19%	96,77%	3,23%

Table 4.20 'Santa Rita' community water system.

The water chemical analyses of the rivers and water sources of 'Santa Rita' community do not show a high water pollution. In fact the concentration of fecal coliforms has an average of 2,33 CFU/100 ml, as presented in the following table (see Table 4.21). However the chemical analyses refer only to three water samples; this means that to have reliable information about the water quality the analyses should be repeated.

Community	Number of samples	Fecal coliforms (CFU/100 ml)	Media (CFU/100 ml)
'Santa Rita'	1	1	2,33
	2	3	
	3	3	

Table 4.21 Data about fecal coliforms pollution in the rivers and streams close to 'Santa Rita' community.

Table 4.22 presents the social analysis conducted by the Health Center of 'San Marcos de Colon' to investigate the water treatments used by the families of 'Santa Rita' community. The analyses were conducted on 50 families on the total of 62 families of the community. The analyses on water treatments show that 7 families use chlorine, 4 families boil the water, other 4 use other treatments and the majority of the families (35) do not use any water treatment. These results show that the inhabitants of 'Santa Rita' have a low awareness about the importance of applying treatments to guarantee the water quality. In fact, looking at the percentages, only 30% of the families implement water treatments while 70% of the families do not use water treatments.

Number of analyzed families	Number of families who use chlorine	Number of families who boil the water	Number of families who use other treatments	Number of families who do not use any treatments for the water	Total families who use water treatments	% families who use water treatments	% families who do not use water treatments
50	7	4	4	35	15	30%	70%

Table 4.22 Water treatments used by the families of 'Santa Rita' community.

The data on the waste treatments/disposal used in 'Santa Rita' community show that the majority (with the percentage of 58%) of the citizens do not burn waste (see Table 4.23). In fact only 21 families on the 50 analyzed families use to burn the waste with a percentage of 42%.

Number of analyzed families	Number of families who burn waste	Number of families who burrow waste	Number of families who throw waste (in lands and rivers)	Number of families who use other waste treatments	% of families who burn waste	Total families who do not burn waste	% of families who do not burn waste
50	21	4	22	3	42%	29	58%

Table 4.23 Waste treatments/disposal used by the families of 'Santa Rita' community.

Qualitative data analysis

In 'Santa Rita' community were conducted two individual interviews with the school teacher and the president of the community, respectively. In addition a collective interview with three

women of the community was made during a nutrition event on Friday the 14th of February 2014. The information about the interviews are presented in Tables 4.24 and 4.25.

Date	Area	Position interviewees	Gender
11/02/14	Santa Rita	Teacher	Female
11/02/14	Santa Rita	'Patronato' President	Male

Table 4.24 The individual interviews conducted in 'Santa Rita' community.

Number	Date	Area	Position interviewees	Number of Interviewees	Code
1	14/02/14	Event on Nutrition	Community of Santa Rita (group interview)	3 women	

Table 4.25 The collective interviews conducted in 'Santa Rita' community.

In addition on Tuesday the 4th of March a workshop was organized in the school of 'Santa Rita' community with the participation of 15 people. The following figures illustrate the setting and the participants to the workshop (see Figures 4.22 and 4.23).


Figures 4.22 and 4.23 The workshop conducted in 'Santa Rita' community.

Table 4.26 resumes the priorities needs of the citizens of 'Santa Rita' following the information provided by both interviews and workshops data. The priority needs of 'Santa Rita' are similar to the needs of 'Los Chaguites' community, as described in the previous paragraph. In fact the priority needs of Santa Rita consist in the lack of a suitable water and sewer systems. In addition other primary problems to solve are the lack of employment and the lack of economic resources. In addition the workshop participants and the interviewees pointed out as problem the lack of advantage coming from the use of community resources such as the natural resources and human capacities.

Another problem regards the difficulty to reach 'San Marcos de Colón' municipality. In fact the bus service do not reach 'Santa Rita' community and people have to walk one hour to arrive at the bus route of the protected area.

The author during the workshop and speaking with the community interviewees understood, as another problem of the community, the lack of motivation and self-awareness of the people. In fact, especially during the workshop, people expressed with difficulties their ideas and opinions. When asked about their visions and dreams at a first moment the participants

could not answer. The teacher of the school spoke to them, explaining her idea on the importance of education and encouraging them to express their opinion. Only at this moment some women started talking but still without self-confidence and with fear.

Priorities Needs	Explanation
Restoration of the water system	The water is scarce and a lot of families do not have water in their houses. During the workshop many people explained the need of restoration and improvement of the water system.
Water quality protection and prevention	The water is not drinkable.
Lack of latrines	The lack of latrines is considered by the workshop participants the second priority need of the community.
Lack of Employment	Lack of industries (sources of jobs).
Lack of economic resources	
Lack of advantage of resources (humans, natural, etc.)	
Lack of bus connection	
Lack of motivation and self-awareness	Especially during the workshop, and speaking about dreams and possible practical activities people had problems to express their ideas and opinions.

Table 4.26 Priorities problems present in 'Santa Rita' community.

Figures 4.24 and 4.25 The workshop organized in 'Santa Rita' community.

Other problems explained by the participants relate to the improvement of the community infrastructures such as the electricity, the installation of solar panels on the new houses, the restructuration of some houses and the improvement of the quality of roads (see Table 4.27).

Other needs
Solar panels for new houses
Lack of electricity
Restructuration of houses roofs
Maintenance of roads and paths

Table 4.27 Other needs and problems expressed by 'Santa Rita' inhabitants.

Regarding the potentialities, many people considered as an opportunity for the community the presence of various natural resources representing an opportunity for the economic and touristic development of the community (see Table 4.28).

Potentialities
Presence of multiple natural resources

Table 4.28 The potentialities of 'Santa Rita' community.

The organizations of 'Santa Rita' community are shown in the Table 4.29, as described by the workshop participants. The organizations of the community are the water committee, the health committee, the group of organized women of the 'red de mujeres', the parents committee, and the school snacks committee.

Community organizations
Water committee
Health committee
Parents committee
School snacks committee
Group of organized women ('red the mujeres')

Table 4.29 'Santa Rita' community organizations.

The only project operating in the community is the World Food Programme (WFP).
Table 4.30 shows the visions and dreams of 'Santa Rita' inhabitants, as explained by the participants during the workshop conducted on Tuesday the 4th of March. As previously described, at the beginning people had difficulties in expressing ideas and opinions, especially about dreams and possible actions.
When the author asked about their visions and dreams the participants didn't answer at first. In fact, they started to talk only after the teacher of the school explained the importance to improve education and the need of the creation of an educative center. She explained that an educative center could be fundamental to follow and help children to study and develop recreation and youth activities also during the afternoon (e.g. sports, handmade courses, etc.). The teacher explained the importance of an educative center to teach children life values in order to prevent alcoholism and juvenile delinquency.
Many people, after her speech, agreed on the importance of education and they both spoke and wrote about the improvement of education as a priority. A woman said that a second teacher could be useful to improve the school education.
In addition many people expressed as a dream the creation of employment in the community.
Other participants explained their vision of a better community, with the presence of water and latrines in every house.
Some women explained their desire to live in a more cooperative and unite community. Finally other three participants spoke about the improvement of tourism. They said that they would like to have tourists in the community because it could be an opportunity for the valorization of the community and the increase of economic revenue.

Visions and dreams	Explanation
Improvement of education	• Another teacher to implement and improve the education and the school • Creation of an education center
Improvement of infrastructures	Referring especially to the water and the sewer system.
Creation of employment	Creation of a micro-business or a firm that could create jobs.
Improvement of cooperation, organization and union inside the community	
Improvement of tourism	

Table 4.30 Visions and dreams of 'Santa Rita' community.

The final part of the workshop focused on the possible actions to develop in the community (see Table 4.31). The participants pointed out as priorities the improvement of the water system and of the water quality. In addition another action, that refers to the implementation of infrastructures, regards the construction of latrines.

Other people expressed some ideas about the increase of job opportunities and the improvement of economic resources. In this regards some people expressed the wish to develop a micro-business but they also described the hindrances that they could find in the achievement of this objective. In fact they explained the lack of a place to organize the activity of the business and the lack of initial economic resources. Another idea connected to the improvement of the economic resources regards the collaboration between big and small land owners. The big owners could rent to small farmers the fifth part of their land to cultivate. If this would happen the small farmers could eat some of the products and the land owners could take some advantage from lands that are currently abandoned.

As regards to the environmental problems existing in the community, the participants expressed the possibility to try to contrast and prevent the soil and water pollution, using less chemical fertilizers and increasing the use of organic compost. Another action to increase the environmental quality could be the reforestation.

At the end of the workshop the participants spoke also about the importance to develop training at community level on different themes. They said that they would like to learn organic farming practices (e.g. how to make organic compost) and other activities to prevent the fire risk.

Possible actions	Explanation
Development of a water project to improve the water system and the water quality	This action is considered by the workshop participants the most important priority.
Construction of latrines	
Creation of a micro-business (e.g. bakery)	The problem for the creation of a micro-business is the lack of a place to start the activity and the need of initial economic resources.
Prevention and contrast to the soil pollution	Use of organic technics to fertilize the soil (fertilizer, organic agricultural techniques, risk systems).
Constitution of a micro-enterprise cooperation between owners of land and poor people (rural cooperatives)	An action to contrast the lack of jobs and economic resources.
Maintenance of water quality and prevention of water pollution	Less use of chemical fertilizers to prevent the water pollution.
Reforestation and Forest Care	
Training on different topics	For example to learn organic growing practices and other activities to prevent the fire risk.

Table 4.31 Possible actions that could be developed in 'Santa Rita' community.

4.2.3. 'Los Ranchos'

'Los Ranchos' is a rural community set in the east part of 'La Botija' protected area. The following map (Figure 4.26) indicates the setting of 'Los Ranchos' community.

Figure 4.26 The setting of 'Los Ranchos' community (Source: Google Earth).

'Los Ranchos' is a small community as shown by the demographic data reported in Table 4.32. The percentage of illiterates of the community is quite high with 16,67%.

Number of houses	Total population	Female population	Male population	Number of illiterates	% of illiterates
17	66	28	38	11	16,67%

Table 4.32 Demographic and social data of 'Los Ranchos' community.

The data presented in Table 4.33 give information about the sewer system of the community. As shown in Table 4.33, n. 4 houses on 17 do not have latrines, 11 have washable latrines and 4 have the toilet. Looking at the percentage of the houses with unsuitable sewer systems 'Los Ranchos' community presents a percentage of 23,53%. The percentage of houses with sustainable sewer systems corresponds to 76,47%. The sewer system has an almost acceptable quality level.

Number of houses	Number of houses without latrines	Number of houses with septic tank	Number of houses with washable latrines	Number of houses with toilet	Number of houses with unsustainable sewer system	% houses with unsuitable sewer system	Number of houses with suitable sewer system	% houses with suitable sewer system
17	4	0	11	2	4	23,53%	13	76,47%

Table 4.33 Sewer system of 'Los Ranchos' community.

CHAPTER 5. THE PROPOSED ANALYSIS MODEL

In this chapter the analytical model developed by this research will be presented.
As explained in the Paragraph 1.4 our analysis model developed has the following aims:

1. To understand which are the priority intervention areas of 'La Botija' protected area.
2. To combine and to integrate the territory data of 'La Botija' protected area analysing simultaneously multiple data. In particular the model purposes to connect the specific participatory approach called 'Transition Management' with the proper tools of territory analysis such as Geographic Information Systems (GIS).
3. To promote actions by the local citizens, the public authorities and local stakeholders.

The ultimate goal of the analytical model is to answer to the following decision question: 'Which are the priority intervention areas of 'La Botija' protected area?'
This means that the model aims to represent a governance tool that can identify the priorities and the strategies of intervention for each territory area, in relation to both the specific characteristics of the area and the needs and visions of the local people.
The individualization of priority intervention areas is possible only analyzing in a holistic way the elements of the case study area. For this reason the model integrates different typologies of data that refer to multiple themes and territory aspects.
The connection between multiple data types is possible using a specific spatial (GIS-based) multi-criteria analysis method. Using this methodology the analytical proposed model permits to integrate the following three different typologies of data analyses:

- Geographic data analysis;
- Quantitative data analysis;
- Qualitative data analysis.

In the first case, the geographical data analysis refers to the territory elements elaborated by Geographic Information Systems (GIS) as described in the paragraph 4.1.2. The rivers, the roads, the bus routes and other elements of the investigated area were elaborated in a GIS file.
Regarding the quantitative data, the model considers the demographic, social and infrastructural information of each rural community.
In reference to the qualitative data, the model focuses on needs, dreams and interests of local inhabitants and stakeholders. This information, collected as a result of interviews, participatory observation and workshops following a specific methodology called 'Transition Management', has permitted to understand the level of organization, cooperation and knowledge of each rural community of the area. In addition this qualitative analysis permitted to collect information also about environmental and economic issues. In this regards local people were asked to explain some of the environmental problems of the area. Local citizens explained the local environmental problems such as the deforestation, the water and soil pollution, the fire risk. This data are used both to collect new information and to confirm the quantitative data on the same topics. The participatory approach has been considered a key element of the research because it permits to understand the perceptions and willingness of local people. The possibility to understand the needs and desires of citizens is considered a fundamental tool for a better governance and projects development. This specific method, defined in the literature (Albrechts L. et al., 2003; McCall et al., 2003; McCall M. K., 2003; Rambaldi G. et al, 2006; Van den Brink A., 2007) as participatory spatial planning, permits

to consider the indigenous knowledge and to understand the needs and wishes of local people. All these elements represent fundamental tools for an equitable and fair governance.
Regarding the third aim, the proposed model purposes to represent a tool for the action on the territory. As explained in the paragraph 1.2.3.2 one of the aim of 'Transition Management' is to encourage learning process development at local level. The workshop participants were motivated to take practical actions and to change behaviors. In addition the construction of the model represents a decision support system (DSS) useful for public administrators and policy makers. In fact the analytical model could be used by public decision-makers and project managers to understand which areas need priority interventions. In this regard the model provides information on which could be the best intervention strategies for the sustainable development of the protected area and its rural communities. Moreover the model represents a tool for the effective use of the financial resources and permits to analyze the situation both at specific level, looking at the rural communities, and at general level, investigating the whole protected area.

The proposed model framework

Figure 5.1 shows the framework of the analytical proposed model. As explained in the previous paragraph the model connects different types of data analyses. The right part of the figure shows the quantitative data analysis, represented by the geographic, social, demographic and infrastructural data. The left part of the figure describes the qualitative data collected by the Transition Management participatory method. These two types of data are interconnected with the development of the model. The model uses a spatial (GIS-based) multi-criteria analysis method with the aim to determine the priority intervention areas of 'La Botija' protected area. The 'actions' square is connected both with the qualitative data analysis method and the model. In fact, as we have previously explained, both Transition Management workshops and the model comport the development of actions. In the first case the workshops represent learning instruments for the change of behaviors and the increase of motivation by the participants. In the second case the model permits to advice policy makers and project managers on the best strategies to develop in the investigated area.
The following section of the thesis describes the phases of the proposed model development:

1. Construction of a multi-criteria analysis (MCA) framework. This phase is divided into different stages that will be describe in Paragraph 5.1.
2. Creation of suitability maps by Geographic Information Systems (GIS) (Paragraph 5.2.). This stage is divided into two parts. The first section regards the calculation with the 'Euclidean distance tool' of distances from different territory elements (e.g. schools, health centers, bus route, etc.). In the second section the qualitative and quantitative data analyses are connected with the geographic data analysis through the use of the 'Kriging tool'.
3. The multi-criteria analysis (MCA) is elaborated by GIS with the aim to identify the intervention priorities areas (Paragraph 5.3.).

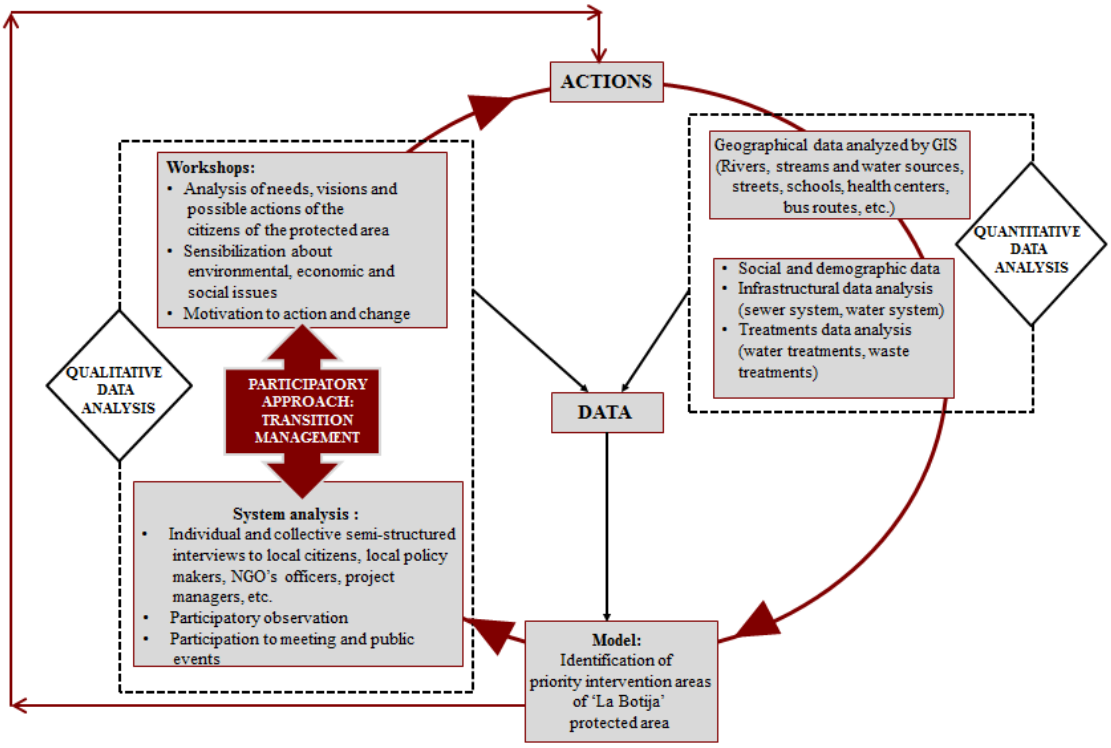


Figure 5.1 The framework of the analytical proposed model.

5.1. Construction of the Multiple-criteria analysis (MCA) framework

In accordance with the literature, multi-criteria analysis (MCA) provides a well-established decision support tool for policy analysis with conflicting objectives (Arciniegas, G.A. et al., 2011; Belton and Stewart, 2002; Janssen and Herwijnen, 2007). The theoretical description of the MCA is reported in Paragraph 1.2.1.
The multi-criteria analysis (MCA) permits to evaluate, in a holistic way, the characteristics of the investigated area.
The development of the MCA is divided into the following phases:

1. Definition of the decision problem.
2. Construction of the hierarchical structure;
3. Pairwise comparison method.

5.1.1. Definition of the objective of MCA

The first stage of the MCA is the identification of the final object of the analysis. The complex decision problem considered by this research is the identification of the priority intervention areas of 'La Botija' protected area.

5.1.2. Construction of the hierarchical structure

The objective of MCA represents a complex 'problem' that it is not easy to solve. For this reason the MCA evaluation process follows several distinct phases where the complex objective is divided into a series of sub-problems with an easier solution. Also in the case of this research the final object of the analysis (the identification of the priority intervention

areas of ‘La Botija’ protected area) represents a decision problem with a high degree of complexity.

For this reason the construction of a hierarchical framework or ‘tree structure’ permits to divide the ultimate analysis objective in different criteria and attributes that have a lower level of complexity.

The hierarchical decision structure of the MCA developed in this research is shown in Figure 5.2.

The hierarchical tree is divided into a set of criteria and attributes that characterize the territory elements and represent the qualitative and quantitative data analyzed in the previous part of this research (Chapter 4).

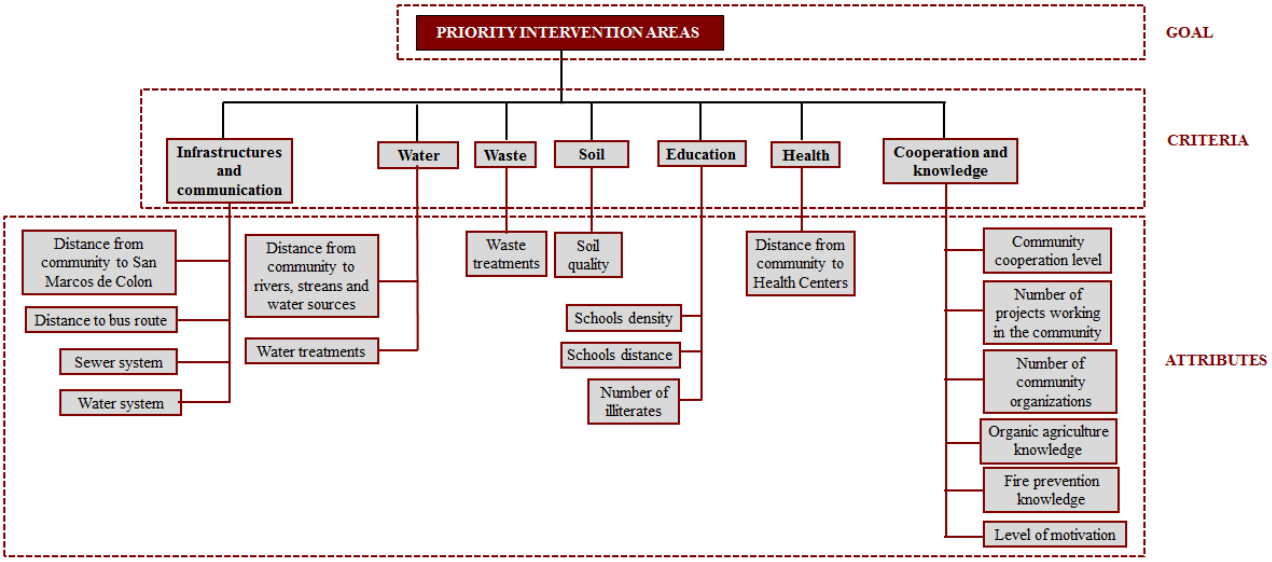


Figure 5.2 Hierarchical structure of the multi-criteria analysis (MCA).

A total of 7 criteria and 18 attributes have been identified, as shown in the hierarchical structure (Figure 5.2) and in Table 5.1.

The following are the criteria of the proposed model of this research:

1. Infrastructures and Communication: describes the infrastructures of ‘La Botija’ protected area. This criterion is described by four attributes: distance from community to San Marcos de Colón, distance from bus route, sewer system, water system.
2. Water: is divided into two attributes: distance from community to rivers, streams and water sources, and water treatments.
3. Waste: investigates the quality of the waste treatments used in each area of ‘La Botija’ protected area
4. Soil quality: represents the quality and the level of fertility of the soil.
5. Education: this criterion is described by three attributes: schools density, schools distance and number of illiterates.
6. Health: represents the health quality and is represented by, only an attribute, i.e. the distance from community to health centers.
7. Cooperation and Knowledge: this criterion describes both the level of cooperation and the level of knowledge of the inhabitants of the rural communities. This criterion is

divided into six attributes: community cooperation level, number of projects working in the community, number of community organizations, organic agriculture knowledge, fire prevention knowledge and level of motivation.

CRITERIA	ATTRIBUTES
Infrastructures and communication	Distance from community to San Marcos de Colon
	Distance from bus route
	Sewer system
	Water system
Water	Distance from community to rivers, streams and water sources
	Water treatments
Waste	Waste treatments
Soil quality	Soil quality
Education	Schools density
	Schools distance
	Number of illiterates
Health	Distance from community to Health Centers
Cooperation and knowledge	Community cooperation level
	Number of projects working in the community
	Number of community organizations
	Organic agriculture knowledge
	Fire prevention knowledge
	Level of motivation

Table 5.1 Criteria and attributes of the MCA developed in this research.

5.1.3. Pairwise comparison method

In order to determine which of the elements of the hierarchical decision tree is more significant in determining the priority intervention areas values, the model performs a pairwise comparison between the multiple elements that constitute it. The pairwise comparison was developed first between criteria (Paragraph 5.1.3.1.) and at a later stage between attributes (Paragraph 5.1.3.2.). The pairwise comparisons are based on the personal valuation of the author following the data analysis and the fieldwork experience. In the future could be useful to involve local stakeholders for the realization of the pairwise comparison.
The procedure of pairwise comparison consists of three major steps: generation of the pairwise comparison matrix, criterion weights computation, and consistency ratio estimation. The phases of the pairwise comparison of MCA methods are described in Paragraphs 1.2.1. and 3.2.7.1.
The creation of a ratio matrix permits to compare each element of a level with the elements of its same level. The pairwise comparison employs a scale with values ranging from 0 to 1 to rate the relative preferences between the elements of the hierarchical structure. In the scale in case of comparison of the criteria with different importance, the criterion of greater importance is given a value of 1 and the criterion of lower importance assumes the value 0; in

case of the criteria of equal importance to both of them is given a value of 0.5. The scale adopted in the pairwise comparison is shown in the following table (Table 5.2).

Intensity of importance	Definition	Meaning
0	Lower importance	The element on the column is less important than the element on the row.
0,5	Equal importance	The elements on the column and row have the same importance
1	Greater importance	The element on the column is more important than the element on the row.

Table 5.2 The scale used in the pairwise comparison.

5.1.3.1. Pairwise comparison between criteria

The pairwise comparison between criteria is shown in Table 5.3 and in Figure 5.3 Infrastructures and communication represents the most important criterion and its weight results in a value of 0,23. This criterion is followed by the education with the value of 0,21, while the criterion about Cooperation and knowledge with a weight of 0,20.

CRITERIA	Infrastructures and communication	Water	Waste	Education	Health	Cooperation and knowledge	Soil quality	FV	W	nW
Infrastructures and communication		1	1	0,5	1	1	1	1	6,50	0,23
Water	0		0	0	0	0	1	1	2,00	0,07
Waste	0	1		0	0	0	0,5	1	2,50	0,09
Education	0,5	1	1		1	0,5	1	1	6,00	0,21
Health	0	1	1	0		0	1	1	4,00	0,14
Cooperation and knowledge	0	1	1	0,5	1		1	1	5,50	0,20
Soil quality	0	0	0,5	0	0	0		1	1,50	0,05
TOTAL									**28,00**	**1,00**

Table 5.3 The pairwise comparison between criteria.

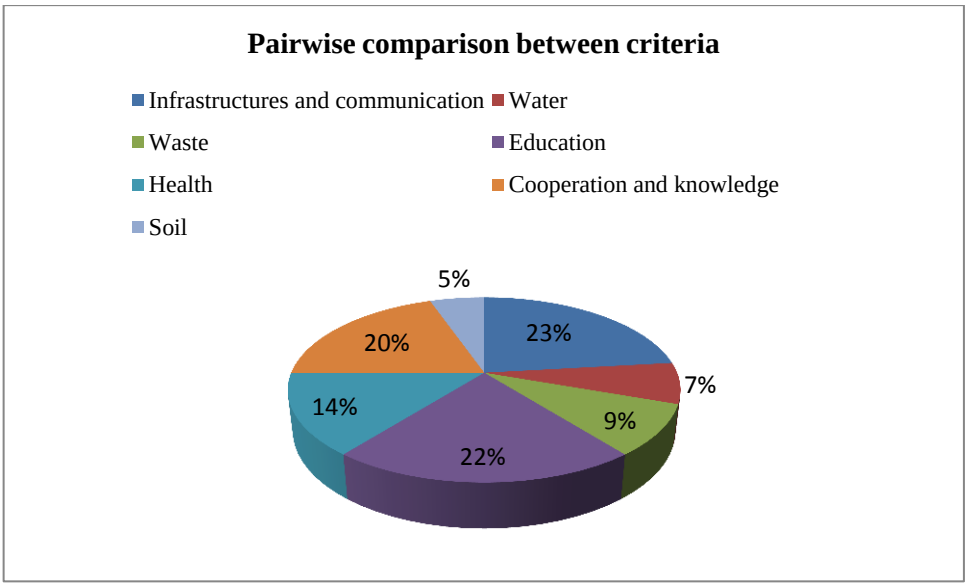


Figure 5.3 Pairwise comparison between criteria.

5.1.3.2. Pairwise comparison between attributes

5.1.3.2.1. Pairwise comparison between the attributes of infrastructures and communication criterion

The result of the pairwise comparison between attributes of infrastructures and communication criterion is presented in Table 5.4 and in Figure 5.4.
The Table shows that the water system attribute is the most important with a score of 0,4. The distance from bus route attribute presents a weight of 0,3 and it is followed by the sewer system with a weight of 0,2. The attribute considered less important is the distance from community to San Marcos de Colon with a weight of 0,2.

Infrastructures and communication	Distance from community to San Marcos de Colon	Distance from bus route	Sewer system	Water system	**FV**	**W**	**nW**
Distance from community to San Marcos de Colon		0	0	0	1	1	0,1
Distance from bus route	1		1	0	1	3	0,3
Sewer system	1	0		0	1	2	0,2
Water system	1	1	1		1	4	0,4
TOTAL						**10**	**1**

Table 5.4 The pairwise comparison between the attributes of infrastructures and communication criteria.

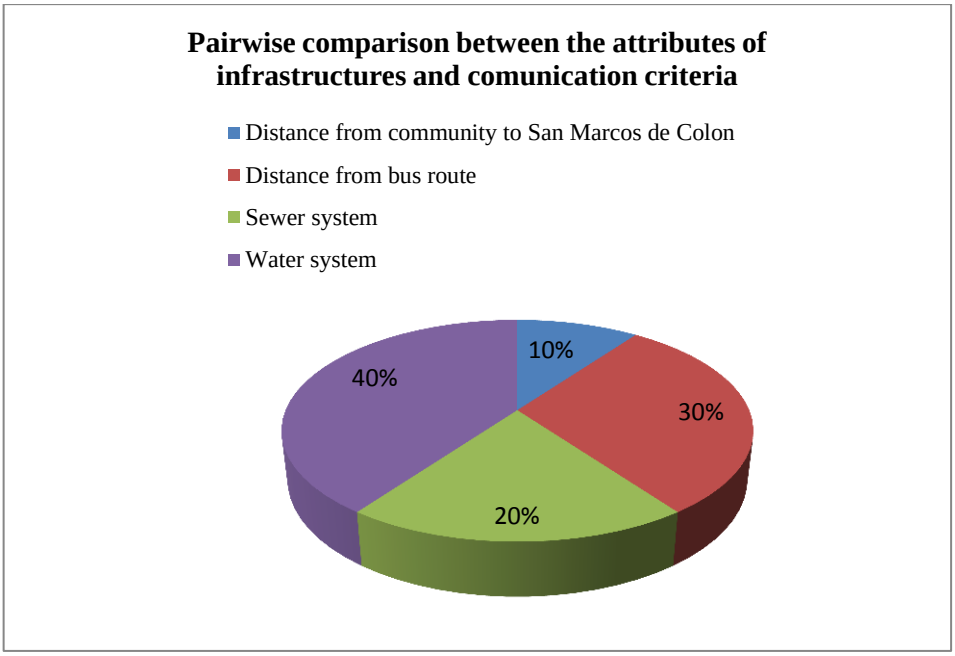


Figure 5.4 Pairwise comparison between criteria attributes of infrastructures and communication criteria.

5.1.3.2.2. Pairwise comparison between the attributes of water criterion

The following table (see Table 5.5) shows the pairwise comparison between the attributes of the water criteria. The attributes received the same score and they have a weight of 0,50. The weights resulting from the pairwise comparison between the attributes of the water criteria are shown both in Table 5.5 and in the Figure 5.5.

Water	Distance from community to river/water source	Water Treatments	VF	W	Wn
Distance from community to river/water source		0,5	1	1,50	0,50
Water Treatments	0,5		1	1,50	0,50
TOTAL				3,00	1,00

Table 5.5 The pairwise comparison between the attributes of water criteria.

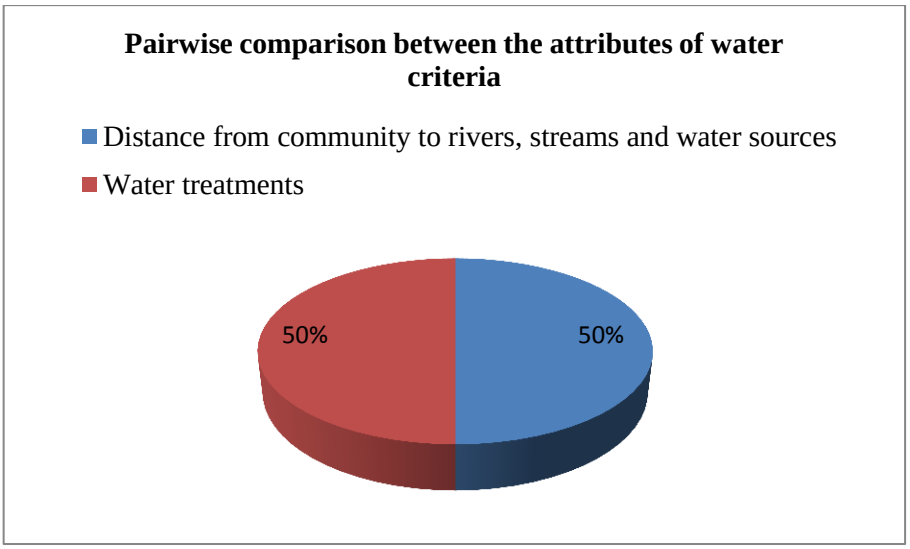


Figure 5.5 The pairwise comparison between the attributes of water criteria.

5.1.3.2.3. Pairwise comparison between the attributes of education criterion

Regarding the education criteria, the school distance and the number of illiterates present the same weight with a score of 0,42. These attributes are followed by the school density with a weight of 0,12 (see Table 5.6 and Figure 5.6).

Education	Schools density	Schools distance	Number of illiterates	**VF**	**VC**	**VCn**
Schools density		0	0	1	1	0,12
Schools distance	1		0,5	1	2,5	0,42
Number of illiterates	1	0,5		1	2,5	0,42
TOTAL					**6**	**1,00**

Table 5.6 The pairwise comparison between the attributes of education criteria.

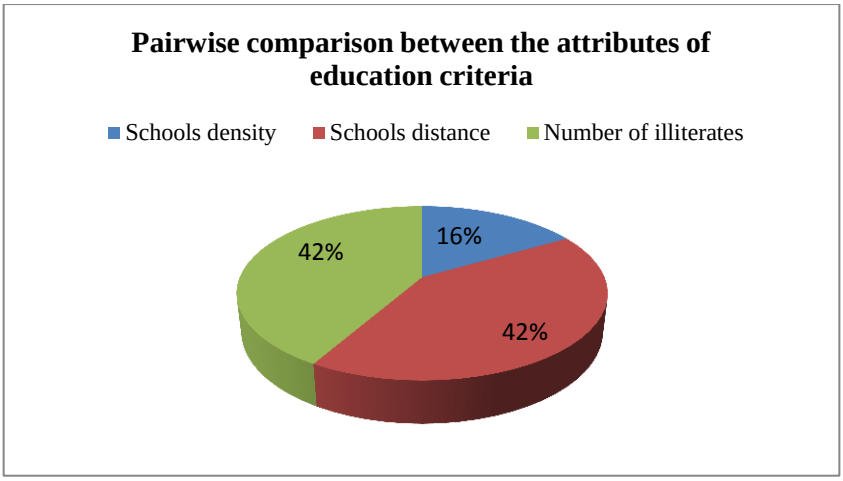


Figure 5.6 The pairwise comparison between the attributes of education criteria.

5.1.3.2.4. Pairwise comparison between the attributes of cooperation and knowledge criterion

The Table 5.7 shows the results of the pairwise comparison between the attributes of cooperation and knowledge criteria.
The community cooperation level represents the attribute that receives the higher score (0,24). This attribute is followed by the level of motivation (0,21) that is considered also important and by the number of community organizations, with a score of 0,19. Number of projects working in the community, organic agriculture knowledge and fire prevention knowledge has a weight of 0,14, 0,12, 0,10, respectively. From this information was created a pie chart to show the different preferences between the attributes (see Figure 5.7).

Cooperation and knowledge	Community cooperation level	Number of Projects working in the community	Organic agriculture knowledge	Level of motivation	Fire prevention knowledge	Number of Community organizations	**VF**	**W**	**Wn**
Community cooperation level		1	1	0	1	1	1	5	**0,24**
Number of Projects working in the community	0		1	0	1	0	1	3	**0,14**
Organic agriculture knowledge	0	0		1	0,5	0	1	2,5	**0,12**
Level of motivation	1	1	0		0,5	1	1	4,5	**0,21**
Fire prevention knowledge	0	0	0,5	0,5		0	1	2	**0,10**
Number of Community organizations	0	1	1	0	1		1	4	**0,19**
TOTAL								**21**	**1,00**

Table 5.7 The pairwise comparison between the attributes of cooperation and knowledge criteria.

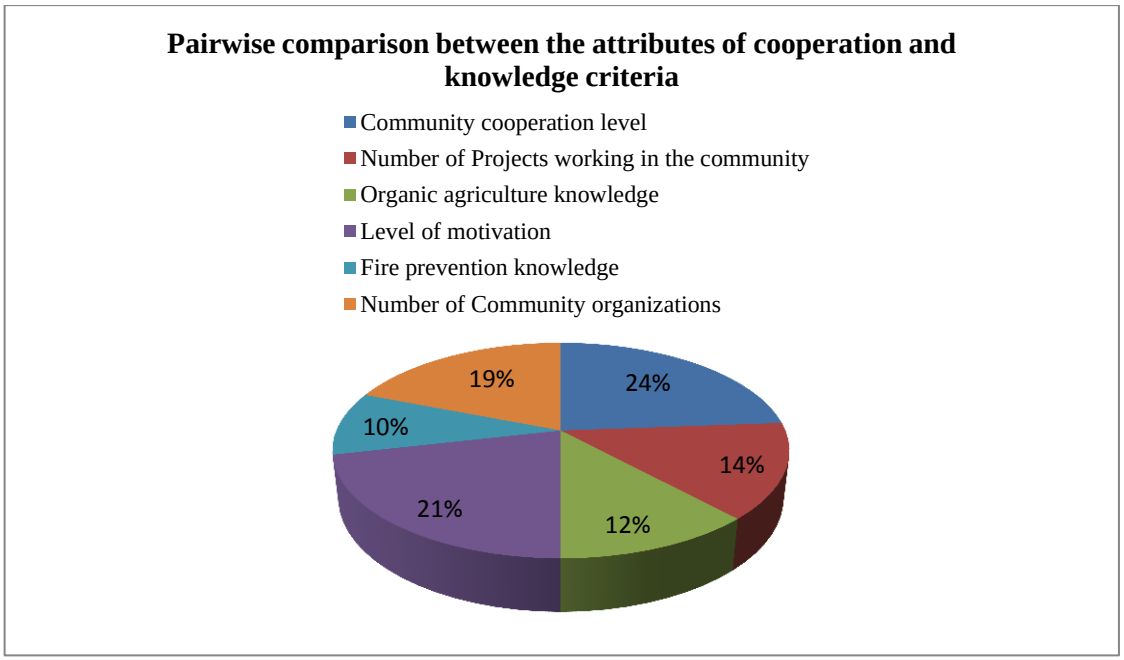


Figure 5.7 The pairwise comparison between the attributes of cooperation and knowledge criteria.

5.2. Creation of suitability maps by GIS

In this paragraph the elaboration by GIS of the hierarchical elements of the MCA is described. Depending on the aim of the GIS analysis, distinct geo-processing tools are used to analyze the attributes of the hierarchical structure. In this research two different geo-processing tools are adopted for the construction of the maps: the Euclidean distance tool and the Kriging tool. The Euclidean distance tool is utilized for the calculation of distances (e.g. distance from schools, distance from health centers, distance from bus route, distance from community to rivers, streams and water sources, etc.). The kriging tool is used for the calculation of qualitative or quantitative data already analyzed (see Paragraph 3.2.7.2.).
The following table (Table 5.8) shows the typologies of geo-processing tools applied for each attribute.
The elaboration of suitability maps developed by the Euclidean distance tool is described in the Paragraph 5.2.1., the creation of suitability maps using the kriging tool is explained in the Paragraph 5.2.2.

CRITERIA	ATTRIBUTES	Euclidean distance	Kriging
Infrastructures and communication	Distance from San Marcos de Colon	X	
	Distance from bus route	X	
	Sewer system		X
	Water system		X
Water	Distance from community to rivers, streams and water sources	X	
	Water treatments		X
Waste	Waste treatments		X
Soil quality	Soil quality		X
Education	Schools density		X
	Schools distance	X	
	Number of illiterates		X
Health	Distance from community to Health Centers	X	
Cooperation and knowledge	Community cooperation level		X
	Number of projects working in the community		X
	Number of community organizations		X
	Organic agriculture knowledge		X
	Fire prevention knowledge		X
	Level of motivation		X

Table 5.8 Typologies of geo-processing tools used for each attribute of the hierarchical tree.

5.2.1. Suitability maps developed by Euclidian distance tool

When the specific attributes involved distances, the Euclidean distance tool is used for the creation of suitability maps. The Euclidean distance tool represents an instrument of the Spatial Analyst Tools of ARCGIS program, as explained in the Chapter 2.

The quantitative and qualitative analyzed data and the map developed by GIS were reclassified using a valuation scale with values ranging from 1 to 5. The value 1 corresponds to an excellent situation while the value of 5 represents the worst situation, as explained in the Chapter 2. Table 5.9 shows the valuation scale used in this research. In the case of the quantitative data the scores were assigned based on mathematical calculations and percentages. In the case of the qualitative data , the values were assigned by the author following the in-depth analysis of the workshops and interviews collected during the fieldwork (See Chapter 4). The classification of the maps in accordance with valuation scale into the ArcGIS project was performed by the 'Reclassify' tool.

Score	Definition	Meaning
1	Excellent (+ +)	Most positive situation
2	Good (+)	Positive situation
3	Average (0)	Neutral situation
4	Below average (-)	Negative situation
5	Worst (- -)	Most negative situation

Table 5.9 Valuation scale use for the reclassification of both analyzed data and maps.

5.2.1.1. Distance from San Marcos de Colón

The map representing the Euclidean distance from the Municipality of San Marcos de Colón is shown in Figure 5.8. The elaboration of this map permits to characterize investigated area referring to the distance from the municipality. In particular a valuation scale of five values was used to classified the area. The lightest color represents the shortest distance (range 0 – 8000 meters) with the value 1 while the darkest color identifies the longest distances (> 14000 meters) with the value 5. The other colors represent distances of the classes 8000 - 10000 meters, 10000-12000 meters, 12000-14000 meters, respectively. Table 5.10 shows the classification of the rural communities according to the distance from San Marcos de Colón. The closest communities to San Marcos de Colón are Portillo Liso, El Pedernal, Mal Paso and Ojo de Agua (0-8000 meters). Jayacayan, El Jocote, La Laguna and Los Chaguites are situated between 8000 and 10000 meters from San Marcos de Colón. Guajiniquil, Quebrada del Horno, Las Flores, Duyusupo, Santa Rita, Las Mesas de Cacamuya are at a distance of 10000-12000 meters. Portillo Grande, Los Ranchos, Las Delicias, Cacamuya are located at 12000 - 14000 meters from the Municipality centre of San Marcos de Colón. Finally the communities that are located in the farthest position from San Marcos de Colón are El Sarzal and Las Trementinas (> 14000 m).

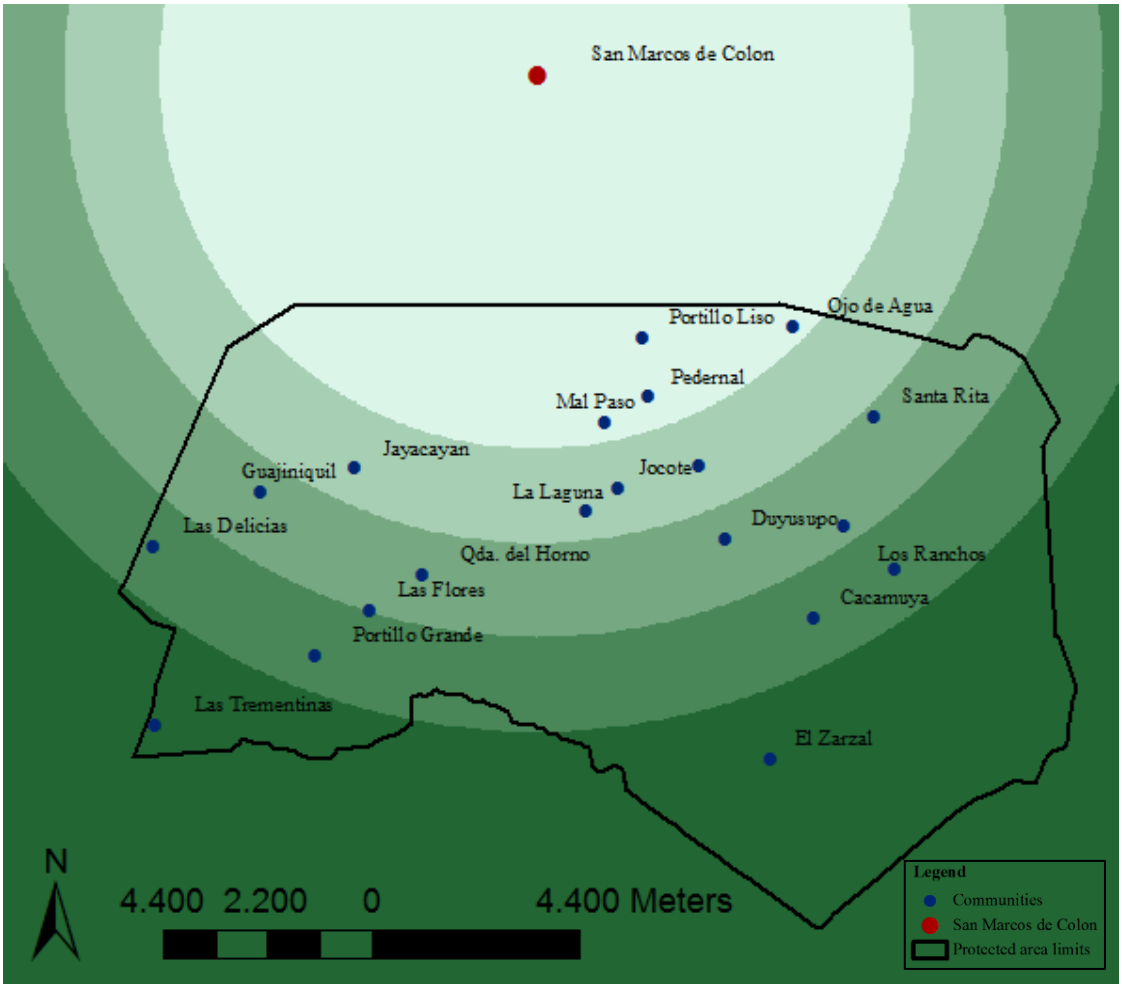
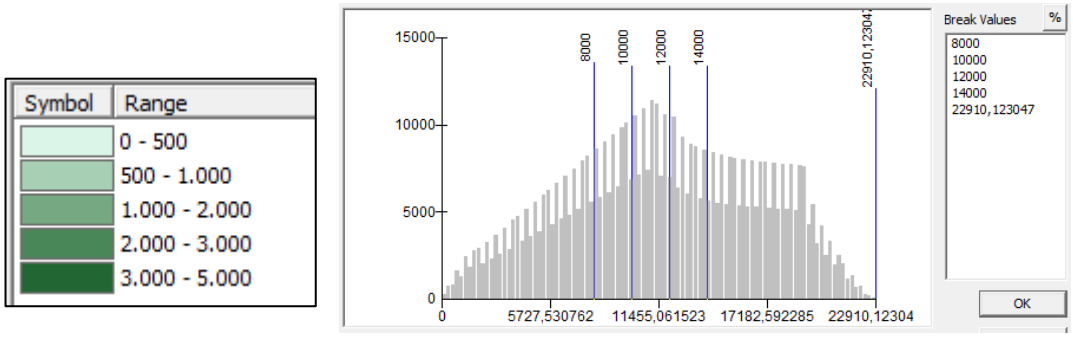


Figure 5.8 Distance from the Municipality of San Marcos de Colón.



Figures 5.9 and 5.10 Legend of the values of distances given to the different colors.

Score	Range of distance from San Marcos de Colón (meters)	Communities
1	0 - 8000 m	Portillo Liso, El Pedernal, Mal Paso, Ojo de Agua
2	8000 - 10000 m	Jayacayan, El Jocote, La Laguna, Los Chaguites
3	10000 - 12000 m	Guajiniquil, Quebrada del Horno, Las Flores, Duyusupo, Santa Rita, Las Mesas de Cacamuya
4	12000 - 14000 m	Portillo Grande, Los Ranchos, Las Delicias, Cacamuya
5	> 14000 m	El Sarzal, Las Trementinas

Table 5.10 Classification of the communities based on the range of distance from bus San Marcos de Colón.

5.2.1.2. Distance from bus route

The map that analyzes the distances from bus route is shown in Figure 5.11. This map represents the distance from bus route to and from the Municipality of San Marcos de Colón.

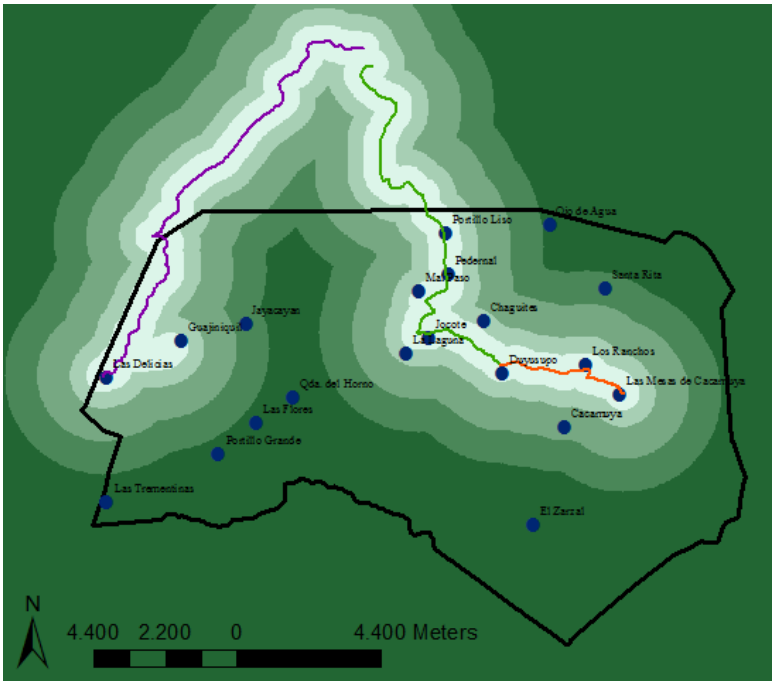
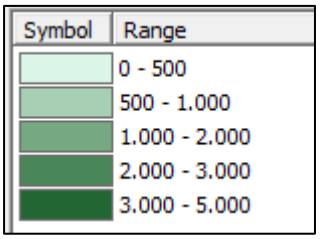
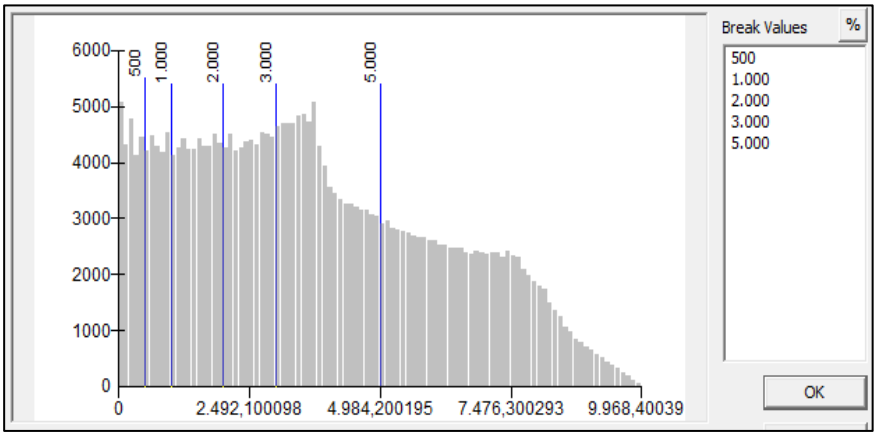


Figure 5.11 Distance from bus route.

A different shade of green represents a specific range of distances from the bus route. In total the distances are classified into five different classes, as shown in Figures 5.12 and 5.13. The lightest color represents the shortest distance (range 0-500 meters) while the darkest color identifies the longest distances (3000-5000 meters). The other shades of color represent distances in a range of 500-1000 meters, 1000-2000 meters, and 2000-3000 meters, respectively. The graphic representation permits to characterize the rural communities depending on the distance from bus route. Table 5.11 shows the classification of the rural communities according to the distance from the bus route. The closest communities to the bus route (range 0 - 500 meters) are Las Delicias, Guajiniquil, Portillo Liso, El Pedernal, Mal Paso, El Jocote, Duyusupo, Los Ranchos, Las Mesas de Cacamuya, respectively. La Laguna and Los Chaguites are situated between 500 and 1000 meters from the bus route. Santa Rita and Jayacayan are at a distance of 2000 - 3000 meters from the bus route. Finally the community that are located in the farthest position from the bus route are El Sarzal, Las Trementinas, Las Flores, Quebrada del Horno, Ojo de Agua and Portillo Grande.





Figures 5.12 and 5.13 Legend of the values of distances from bus route given to the different shades of colors.

Score	Range of distance from bus route (meters)	Communities
1	0 - 500 m	Las Delicias, Guajiniquil, Portillo Liso, El Pedernal, Mal Paso, El Jocote, Duyusupo, Los Ranchos, Las Mesas de Cacamuya
2	500 - 1000 m	La Laguna, Los Chaguites
3	1000 - 2000 m	Cacamuya
4	2000 - 3000 m	Santa Rita, Jayacayan
5	3000 - 5000 m	El Sarzal, Las Trementinas, Las Flores, Quebrada del Horno, Ojo de Agua, Portillo Grande

Table 5.11 Classification of the communities based on the range of distance from bus route.

5.2.1.3. Distance from community to rivers, streams and water sources

The use of the Euclidean distance tool permitted to calculate the distance from rivers, streams and water sources. In this case the five different classes of distance are represented by different shades of blue, as shown in Figure 5.14. The graphic representation allows to classify the rural communities into five different groups accordingly to the distance from

water (Table 5.12). The communities that are the closest to the rivers are Las Delicias, Quebrada del Horno, Guajiniquil, Jayacayan, La Laguna, El Jocote, Duyusupo, Mal Paso, Santa Rita, Cacamuya (range 0 - 200 meters). La Laguna and Los Chaguites are located between 200 and 400 m. Portillo Liso is set at a distance of 600 - 1000 meters. Los Ranchos, Las Mesas de Cacamuya, Las Trementinas,

Las Flores and Portillo Grande are positioned at a distance of 600 - 1000 meters. The communities that are located in the farthest position from rivers, streams and water sources are El Sarzal and Ojo de Agua, with a range of distance of 1000 - 2000 meters.

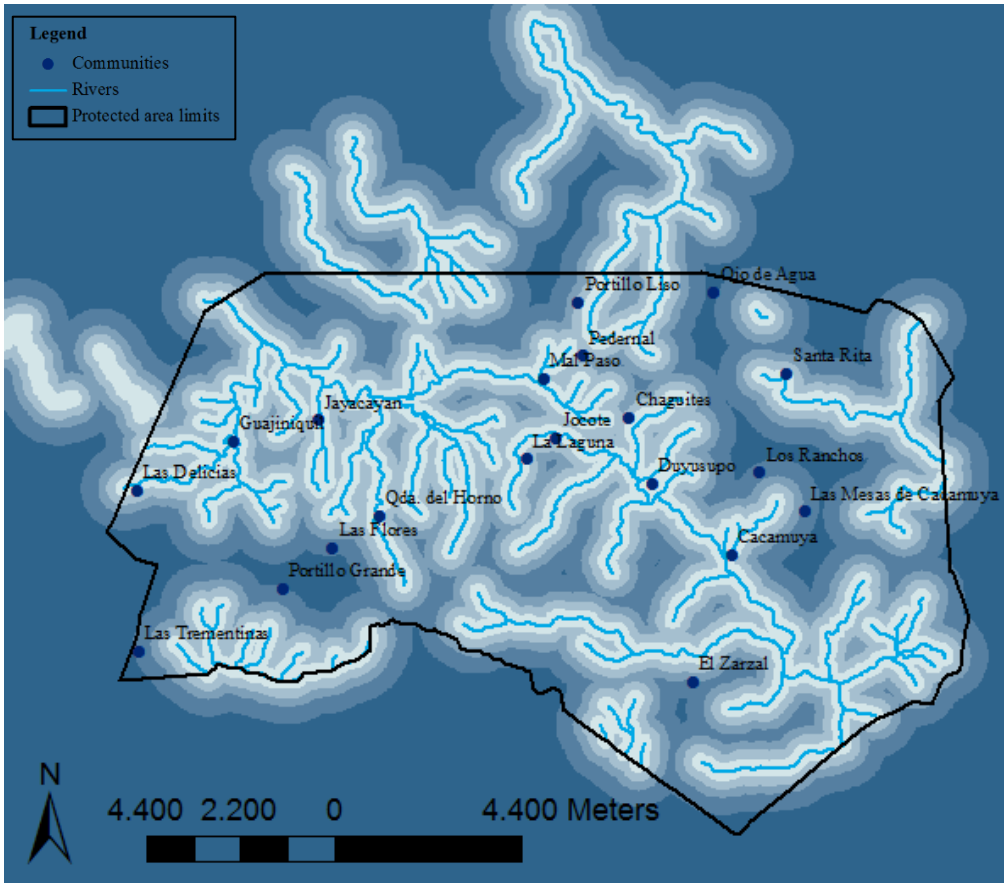
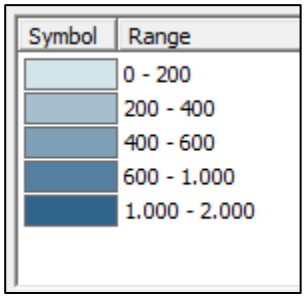
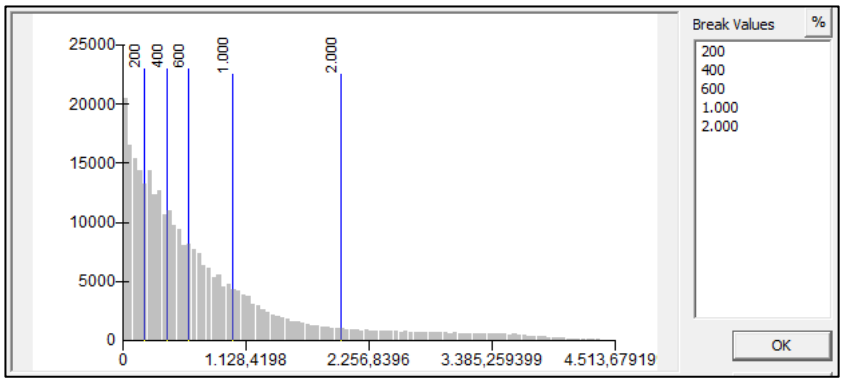


Figure 5.14 Distance of Communities belonging to 'La Botija' protected area from rivers, streams and water sources.





Figures 5.15 and 5.16
Legend of the values of distances from rivers, streams and water sources given to the shade of colors.

Score	Range of distance from water (meters)	Communities
1	0 - 200 m	Las Delicias, Quebrada del Horno, Guajiniquil, Jayacayan, La Laguna, El Jocote, Duyusupo, Mal Paso, Santa Rita, Cacamuya
2	200 - 400 m	La Laguna, Los Chaguites
3	400 - 600 m	Portillo Liso
4	600 - 1000 m	Los Ranchos, Las Mesas de Cacamuya, Las Trementina, Las Flores, Portillo Grande.
5	1000 - 2000 m	El Sarzal, Ojo de Agua

Table 5.12 Classification of the communities based on the range of distance from rivers, streams and water sources.

5.2.1.4. Schools distance

As described in the Chapter 4 the schools of 'La Botija' protected area are fifteen. The Euclidean distance tool permitted to calculate the distance from these fifteen schools of the investigated area. The result of the analysis of the distance from schools is shown in the Figure 5.17. The distance ranges chosen for the calculation of the distances from schools are shown in the first column of Table 5.13. Fortunately the majority of the rural communities are close to the schools, since they are mostly located in a range of 0-500 meters. The communities that are situated at a shortest range to the schools are shown in the first row of Table 5.13. Farther communities are Quebrada del Horno, Pedernal and Mal Paso with a distance of 1000-1500 meters. The community that is set in the farthest location is Los Chaguites (range of distance between 1500 and 2000 meters).

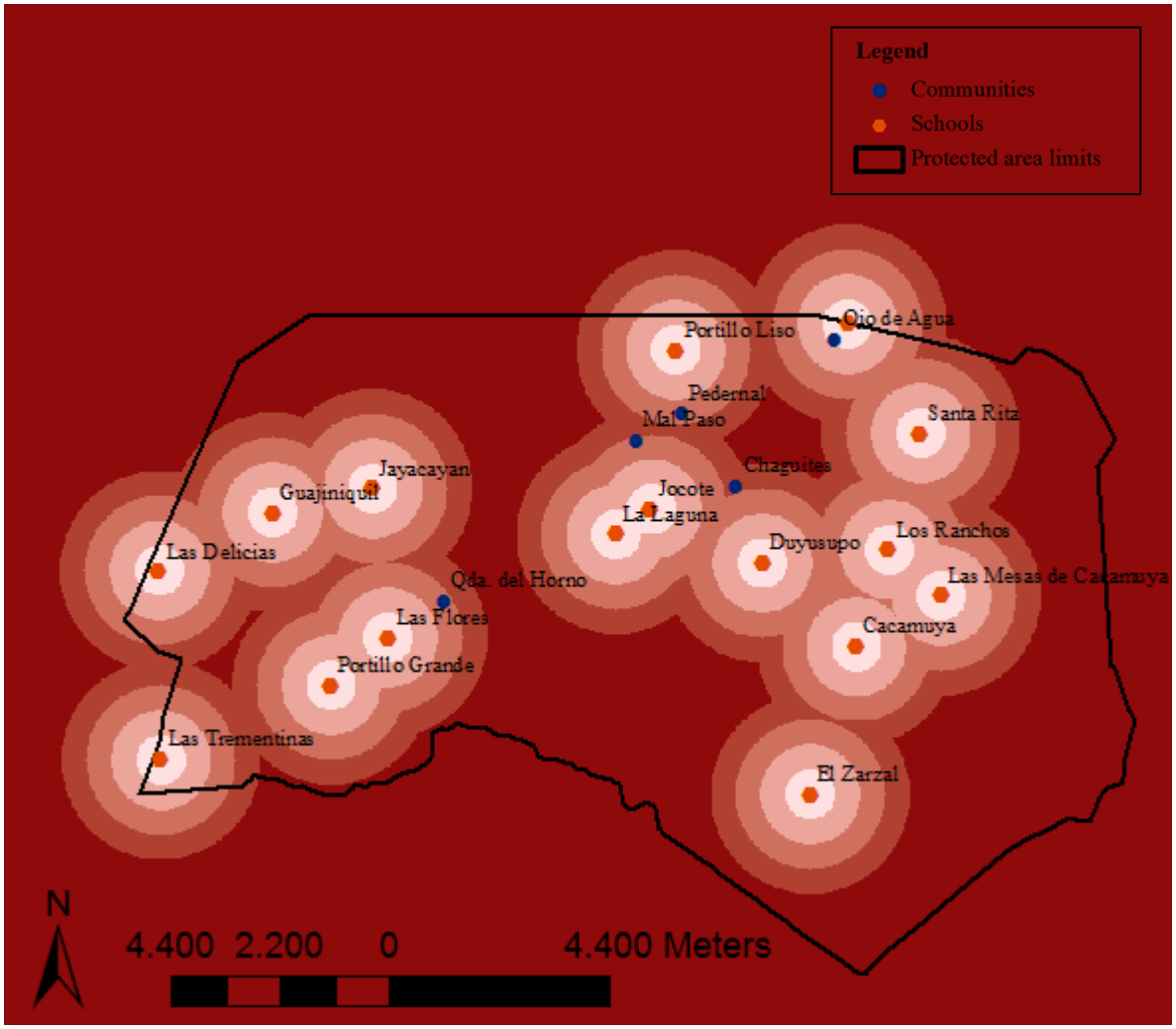
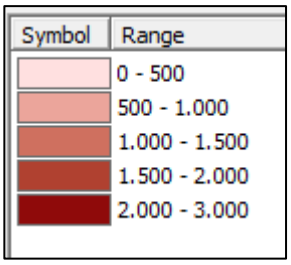
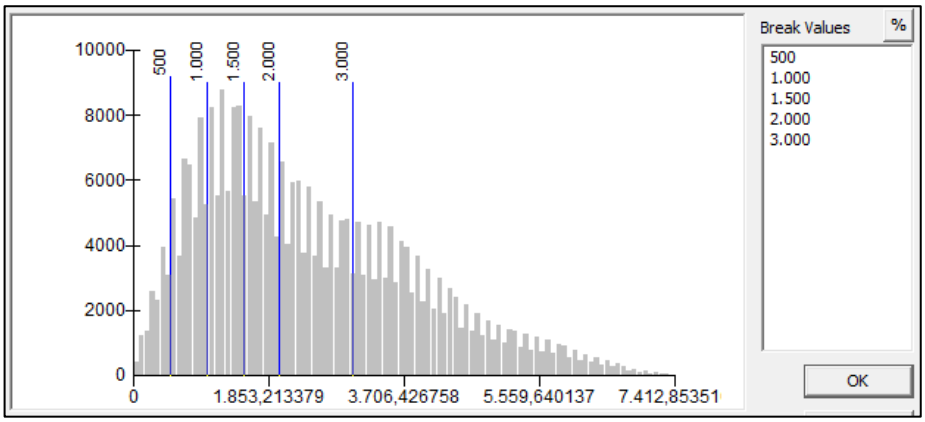


Figure 5.17 Distance from schools in 'La Botija' protected area.





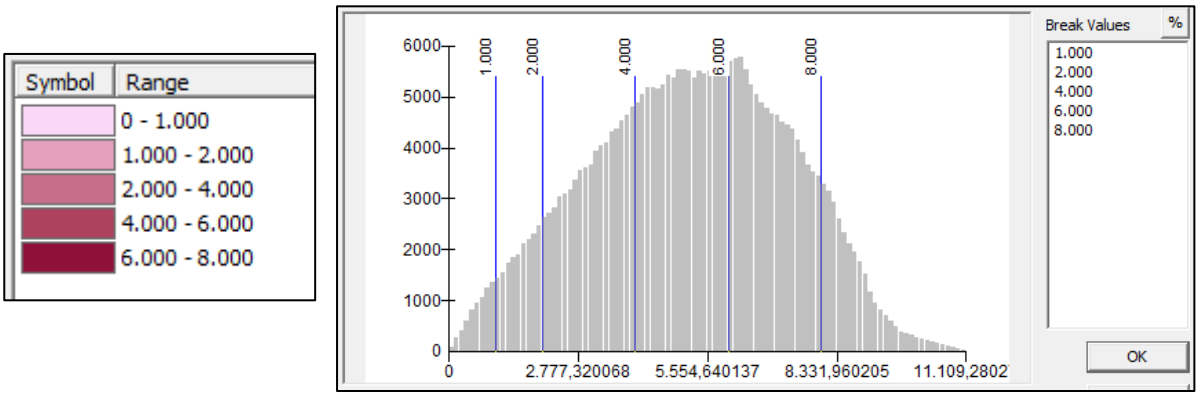
Figures 5.18 and 5.19 Legend of the values of distances from schools given to the shades of colors.

Score	Range of distance from school (meters)	Communities
1	0 - 500 m	Las Delicias, Guajiniquil, Jayacayan, La Laguna, El Jocote, Duyusupo, Santa Rita, Cacamuya, Portillo Liso, La Laguna, Los Ranchos, Las Mesas de Cacamuya, Las Trementina, Las Flores, El Sarzal, Ojo de Agua, Portillo Grande
2	500 - 1000 m	
3	1000 - 1500 m	Quebrada del Horno, Pedernal, Mal Paso
4	1500 - 2000 m	Los Chaguites
5	2000 - 3000 m	

Table 5.13. Classification of the communities based on the range of distance from schools.

5.2.1.5. Distance from Health Centers

The elaboration by GIS of the Euclidean distance from the health centers allows the creation of the following map (see Figure 5.22). The classification scale used for the elaboration of the map is shown in Figures 5.20 and 5.21. In particular, the five shades of pink correspond to dinstinct ranges of distances from the health centers. 'La Botija' protected area has only two health centers, located in Duyusupo and Las Trementinas. All the other communities of the protected area are located far from the health centers. Los Chaguites is set between 1000 and 2000 meters. The majority of the communities are located in a range of 2000-4000 meters, as shown in the third row of Table 5.14. Portillo Liso, Ojo de Agua, Santa Rita, Guajiniquil, Las Flores and El Sarzal are located between 4000-6000 m. The communities that are situated in the farthest position are Jayacayan and Quebrada del Horno.



Figures 5.20 and 5.21 Legend of the values of distances from helth centers given to the different shades of color.

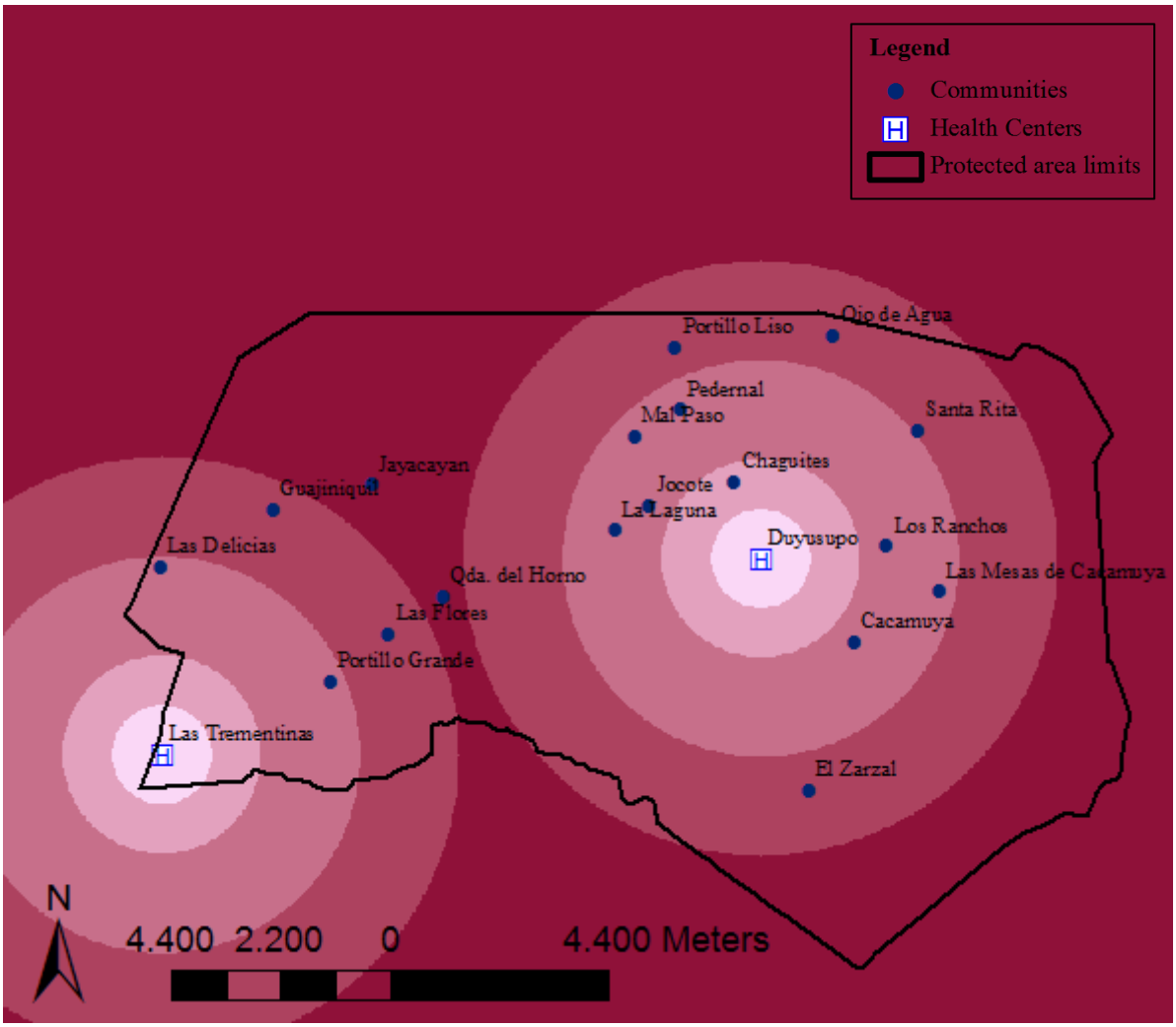


Figure 5.22 Distance from Health Centers in 'La Botija' protected area.

Score	Range of distance from health centers (meters)	Communities
1	0 - 1000 m	Duyusupo, Las Trementinas
2	1000 - 2000 m	Los Chaguites
3	2000 - 4000 m	Pedernal, Mal Paso, La Laguna, El Jocote, Las Delicias, Portillo Grande, Los Ranchos, Cacamuya, Las Mesas de Cacamuya
4	4000 - 6000 m	Portillo Liso, Ojo de Agua, Santa Rita, Guajiniquil, Las Flores, El Sarzal
5	6000 - 8000 m	Jayacayan, Quebrada del Horno

Table 5.14. Classification of the communities based on the range of distance from health centers.

5.2.2. Suitability maps developed by Kriging tool

The kriging tool permits to evaluate numerical data and to transform it into a graphic representation. The kriging tool was used for the realization of maps elaborating the quantitative and qualitative data collected and previously analyzed (see Chapter 4). Table 5.15

shows the typology of data (quantitative or qualitative) used for the creation of suitability maps.

CRITERIA	ATTRIBUTES	Quantitative data	Qualitative data
Infrastructures and communication	Sewer system	X	
	Water system	X	
Water	Water treatments	X	
Waste	Waste treatments	X	
Soil quality	Soil quality		X
Education	Schools density	X	
	Number of illiterates	X	
Cooperation and knowledge	Community cooperation level		X
	Number of community organizations		X
	Number of projects working in the community		X
	Organic agriculture knowledge		X
	Fire prevention knowledge		X
	Level of motivation		X

Table 5.15 The qualitative and quantitative data used for the construction of maps using the 'Kriging' tool.

5.2.2.1. Sewer system

The quantitative data on the sewer system of the communities of 'La Botija' protected area are shown in Table 5.16. The initial data consisted in the classification of the houses of the communities into the following four different typologies of sewer system:

(1) Number of houses without latrines: all the houses that do not have any type of sewer system;
(2) Number of houses with septic tank;
(3) Number of houses with washable latrines;
(4) Number of houses with toilet .

The first and second typologies of sewer system were considered as unsuitable. The third and fourth types were classified as suitable systems. Following this classification the number of houses of each community with an unsuitable sewer system were calculated by summing the number of houses without latrines and the number of houses with septic tank (see column 7 of Table 5.16). The number of houses with a suitable sewer system of each community were calculated summing the number of houses with washable latrines and the number of houses with toilet (see column 8 of Table 5.16). The following step consisted in the calculation of the percentage of houses with unsuitable sewer system for each community:

N° houses : 100 = N° of houses with unsuitable sewer system : x

Then the percentage of houses with a suitable sewer system for each community was calculated:

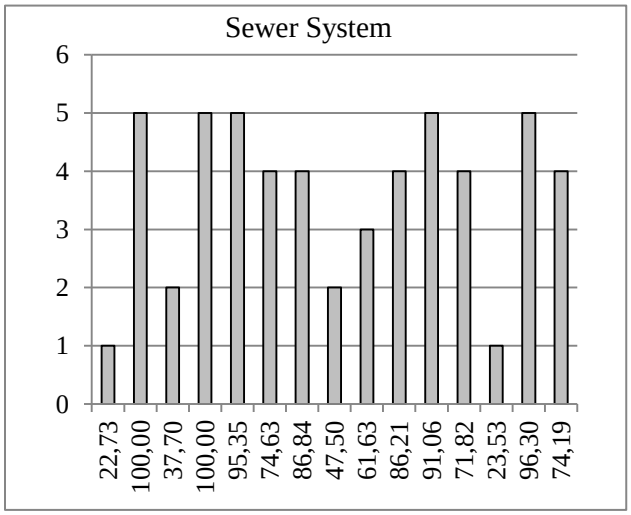
N° houses : 100 = N° of houses with suitable sewer system : x

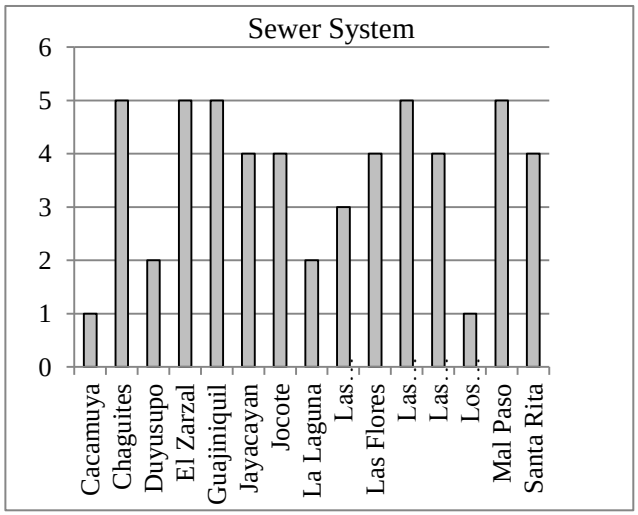
The calculation of both percentages is shown respectively in the columns 9 and 10 of Table 5.16.

The valuation scale was calculated each community of the investigated area starting from percentage in such a way to have a scale ranging from 1 to 5. (See column 11 of Table 5.16). The determination of the scores for each community based on the valuation scale (values from 1 to 5) was developed through another percentage:

% of houses with unsuitable sewer system :100 = x : 5

This percentage permitted to find the final value for each community of the investigated area (See column 11 of Table 5.16. The scores were rounded up to have whole values from 1 to 5 (See column 12 in Table 5.16). The relation between the percentage of houses with unsuitable sewer system and the assigned scores of each community is shown in the following graphs (Figures 5.23 and 5.24).





Figures 5.23 and 5.24 The relation between the percentage of houses with unsuitable sewer system and the valuation scale.

The final values for each communities were entered in the table of attributes of the ArcGIS project and a map was elaborated using the 'Kriging' tool (See Figure 5.25). The values of the valuation scale are represented in the map by four different shades of green. The areas identified by the lightest shade present the best sewer system. The areas with the darkest shade have the worst sewer system.

1	2	3	4	5	6	7	8	9	10	11	12
Community	**Number of houses**	**Number of houses without latrines**	**Number of houses with septic tank**	**Number of houses with washable latrines**	**Number of houses with toilet**	**Number of houses with unsuitable sewer system**	**Number of houses with suitable sewer system**	**% houses with unsuitable sewer system**	**% houses with suitable sewer system**	**Score**	**Final score**
Cacamuya	22	5	0	16	1	5	17	22,73	77,27	1,14	**1**
Chaguites	17	16	1	0	0	17	0	100,00	0,00	5,00	**5**
Duyusupo	61	22	1	29	9	23	38	37,70	62,30	1,89	**2**
El Zarzal	24	23	1	0	0	24	0	100,00	0,00	5,00	**5**
Guajiniquil	43	9	32	0	2	41	2	95,35	4,65	4,77	**5**
Jayacayan	67	23	27	9	8	50	17	74,63	25,37	3,73	**4**
Jocote	76	42	24	2	8	66	10	86,84	13,16	4,34	**4**
La Laguna	40	13	6	15	6	19	21	47,50	52,50	2,38	**2**
Las Delicias	86	39	14	27	6	53	33	61,63	38,37	3,08	**3**
Las Flores	29	17	8	1	3	25	4	86,21	13,79	4,31	**4**
Las Mesas de Cacamuya	123	26	86	1	10	112	11	91,06	8,94	4,55	**5**
Las Trementinas	181	101	29	38	13	130	51	71,82	28,18	3,59	**4**
Los Ranchos	17	4	0	11	2	4	13	23,53	76,47	1,18	**1**
Mal Paso	27	23	3	1	0	26	1	96,30	3,70	4,81	**5**
Santa Rita	62	44	2	16	0	46	16	74,19	25,81	3,71	**4**

Table 5.16 The quantitative data relating to sewer system attribute.

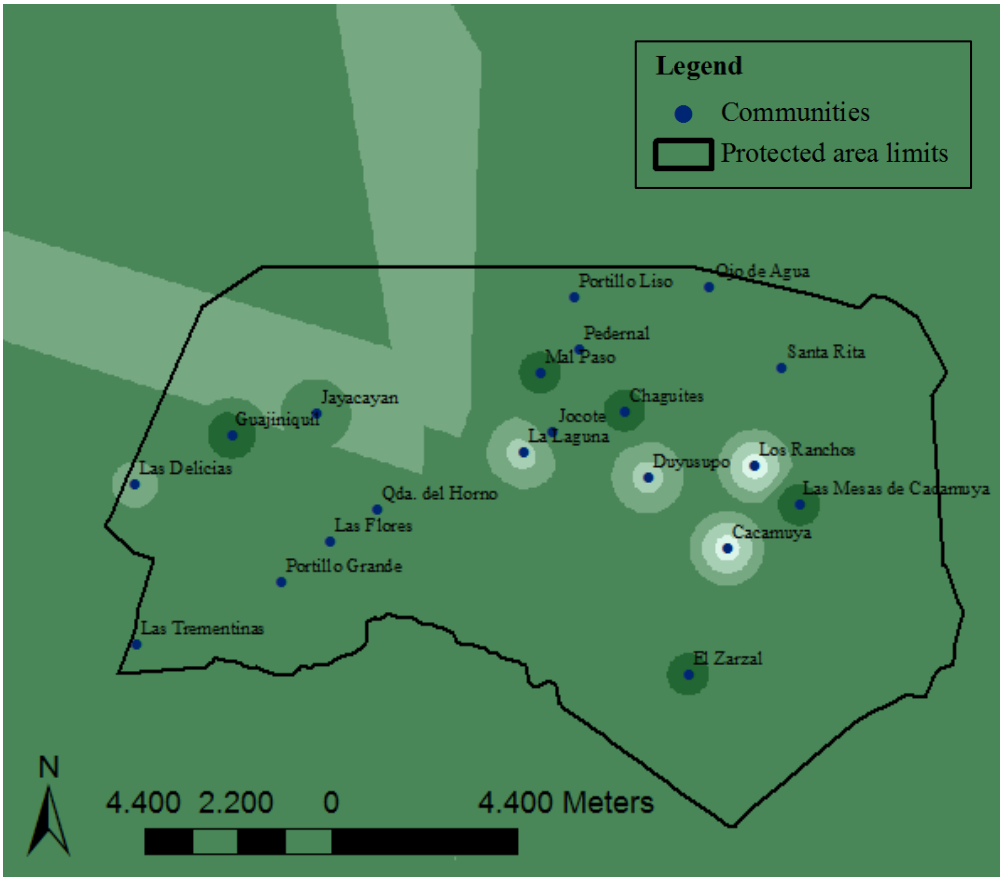


Figure 5.25 The map relating to the sewer system attribute.

5.2.2.2. Water system

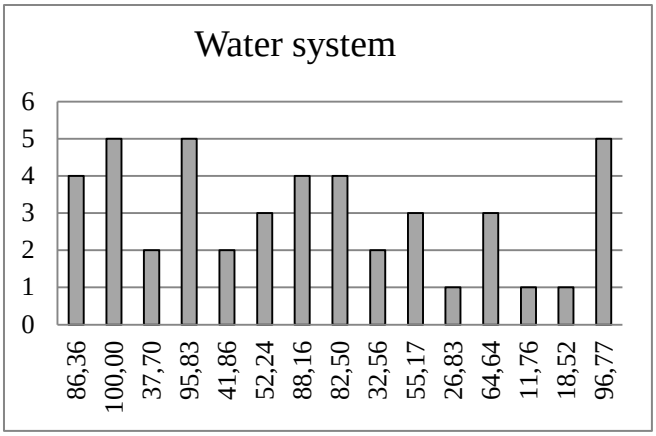
The quantitative data on water system provided by the Health Center of San Marcos de Colón offers information about multiple typologies of water system as shown in Table 5.17. The various types of water system of the rural communities of 'La Botija' are the following:

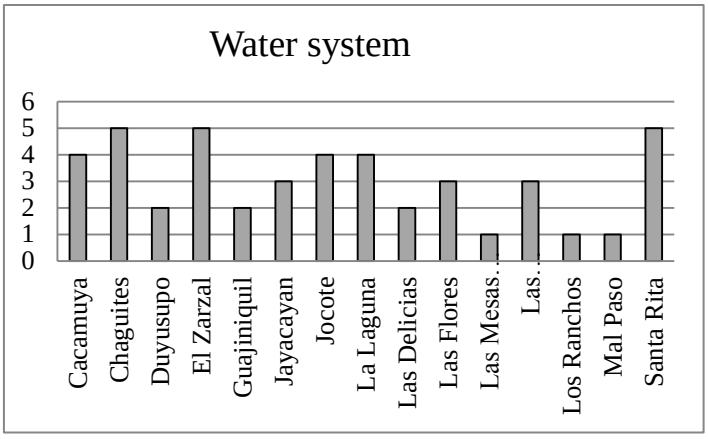
(1) Number of houses without water.
(2) Number of houses with well:
    - Well without pump;
    - Well with pump.
(3) Number of houses with Suitable Aqueduct: houses that have a connection with a suitable aqueduct that can be private or public.
(4) Number of houses with Unsuitable Aqueduct: houses that have a connection with an unsuitable aqueduct that can be private or public.
(5) Number of houses without aqueduct system: this type represents the houses that do not have a connection with an aqueduct and they use the water of rivers and streams.

The first, fourth and fifth water system types were considered as unsuitable water systems. The second and third typologies were classified as suitable water systems. The percentage of each category was calculated for each community (see Table 5.18). Subsequently the percentage of houses of each community with an unsuitable water system was determined summing the percentages of the typologies 1, 4 and 5 (see column 11 of Table 5.18). The percentage of houses with a suitable water system was calculated summing the percentages of the second and third categories (see column 12 of Table 5.18). The values from 1 to 5 of each community were calculated in the following way (see column 14 of Table 5.18):

Percentage of houses with unsuitable sewer system : 100 = x : 5

The following graphs show the interrelation between the percentage of houses with unsuitable water system of each community and the scores of the valuation scale (see Figures 5.26 and 5.27).





Figures 5.26 and 5.27 The relation between the percentage of houses with unsuitable water system in each community and the valuation scale.

The map elaborated by ArcGis that illustrates the water system quality of the territory of 'La Botija' protected area is shown in Figure 5.28.
The areas identified with the lightest shade have the best water system. The areas with the darkest shade have the worst water system.

1	2	3	4	5	6	7	8	9	10
Community	**Number of houses**	**Number of houses without water**	**Number of houses with well**		**With Suitable Aqueduct**		**With Unsuitable Aqueduct**		**Number of houses without aqueduct system**
			Well without pump	**Well with pump**	**Private aqueduct**	**Public aqueduct**	**Private aqueduct**	**Public aqueduct**	
Cacamuya	22	4	0	0	3	0	2	0	13
Chaguites	17	5	0	0	0	0	0	0	12
Duyusupo	61	15	0	0	38	0	0	0	8
El Zarzal	24	14	1	0	0	0	1	0	8
Guajiniquil	43	9	0	1	24	0	4	0	5
Jayacayan	67	20	2	1	29	0	0	0	15
Jocote	76	10	7	0	1	1	0	4	53
La Laguna	40	9	3	0	4	0	9	0	15
Las Delicias	86	15	16	1	40	1	0	0	13
Las Flores	29	4	7	2	4	0	5	0	7
Las Mesas de Cacamuya	123	20	3	2	82	3	3	2	8
Las Trementinas	181	78	0	0	64	0	38	1	0
Los Ranchos	17	1	0	0	15	0	0	0	1
Mal Paso	27	5	0	0	22	0	0	0	0
Santa Rita	62	21	2	0	0	0	24	0	15

Table 5.17 The quantitative data relating to the water system.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Community	**% houses without water**	**% houses with well without pump**	**% houses with well with pump**	**% houses with connection with a suitable private aqueduct**	**Number of houses with connection with a suitable aqueduct**	**% houses with connection with suitable aqueduct**	**Number of houses with connection with unsuitable aqueduct**	**% houses with connection with unsuitable aqueduct**	**% houses without aqueduct**	**% houses with unsuitable water system**	**% houses with suitable water system**	**Score**	**Final score**
Cacamuya	18,18	0,00	0,00	13,64	3	13,64	2	9,09	59,09	86,36	13,64	4,32	**4**
Chaguites	29,41	0,00	0,00	0,00	0	0,00	0	0,00	70,59	100,00	0,00	5,00	**5**
Duyusupo	24,59	0,00	0,00	62,30	38	62,30	0	0,00	13,11	37,70	62,30	1,89	**2**
El Zarzal	58,33	4,17	0,00	0,00	0	0,00	1	4,17	33,33	95,83	4,17	4,79	**5**
Guajiniquil	20,93	0,00	2,33	55,81	24	55,81	4	9,30	11,63	41,86	58,14	2,09	**2**
Jayacayan	29,85	2,99	1,49	43,28	29	43,28	0	0,00	22,39	52,24	47,76	2,61	**3**
Jocote	13,16	9,21	0,00	1,32	2	2,63	4	5,26	69,74	88,16	11,84	4,41	**4**
La Laguna	22,50	7,50	0,00	10,00	4	10,00	9	22,50	37,50	82,50	17,50	4,13	**4**
Las Delicias	17,44	18,60	1,16	46,51	41	47,67	0	0,00	15,12	32,56	67,44	1,63	**2**
Las Flores	13,79	24,14	6,90	13,79	4	13,79	5	17,24	24,14	55,17	44,83	2,76	**3**
Las Mesas de Cacamuya	16,26	2,44	1,63	66,67	85	69,11	5	4,07	6,50	26,83	73,17	1,34	**1**
Las Trementinas	43,09	0,00	0,00	35,36	64	35,36	39	21,55	0,00	64,64	35,36	3,23	**3**
Los Ranchos	5,88	0,00	0,00	88,24	15	88,24	0	0,00	5,88	11,76	88,24	0,59	**1**
Mal Paso	18,52	0,00	0,00	81,48	22	81,48	0	0,00	0,00	18,52	81,48	0,93	**1**
Santa Rita	33,87	3,23	0,00	0,00	0	0,00	24	38,71	24,19	96,77	3,23	4,84	**5**

Table 5.18 The elaboration of quantitative data relating to the water system.

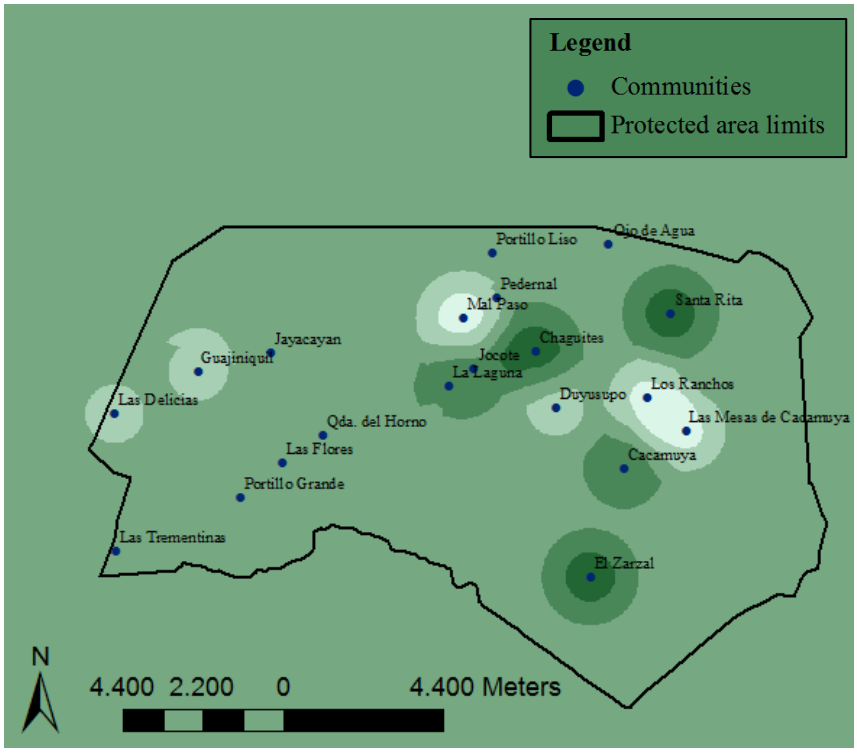


Figure 5.28 Map relating to the water system attribute.

5.2.2.3. Water treatments

The categories of water treatments of 'La Botija' protected area are the following:

(1) Number of families who use chlorine
(2) Number of families who boil the water
(3) Number of families who use other treatments
(4) Number of families who do not use any treatments for the water

In this case the data do not refer to all the families of the communities. The column 6 of Table 5.19 shows the number of analyzed families of the total families of the communities (column 7 of Table 5.19). The first, second and third typologies of water treatments used by the families of the rural communities were considered as unsuitable sewer systems. The second and third typologies were categorized as suitable systems. The percentage of families who use water treatments (column 9 of the Table 5.19) was calculated considering the first, second and third categories. The percentage of families who do not use water treatments was calculated considering the number of families who do not use any treatments for the water (fourth category). At a later stage the scores of the valuation scale were assigned to each community through the following calculation (column 12 of the Table 5.19):

$$1 + (\text{Percentage of families who do not use water treatments} : 100 = x : 5)$$

In this case in order to increase the final score, a 1 was added to the percentage. This choice was made because the situation in the reality is worse than in the data provided by the Health Center. During both interviews and workshops people explained that they would like to use chlorine to purify the water but they do not have economic resources to buy it. Additionally they said that the Health Center generally cannot provide them chlorine.
The map of Figure 5.29 shows the elaboration of the water treatments attribute.

1	2	3	4	5	6	7	8	9	10	11	12
Community	**Number of families who use chlorine**	**Number of families who boil the water**	**Number of families who use other treatments**	**Number of families who do not use any treatments for the water**	**Number of analyzed families**	**Number of houses of the community**	**Total families who use water treatments**	**% families who use water treatments**	**% families who do not use water treatments**	**Score**	**Final score**
Cacamuya	2	3	3	9	17	22	8	47,06	52,94	3,65	**4**
Chaguites	2	8	2	5	17	17	12	70,59	29,41	2,47	**2**
Duyusupo	30	4	0	14	48	61	34	70,83	29,17	2,46	**2**
El Zarzal	2	1	0	19	22	24	3	13,64	86,36	5,32	**5**
Guajiniquil	10	5	8	8	31	43	23	74,19	25,81	2,29	**2**
Jayacayan	7	6	43	11	67	67	56	83,58	16,42	1,82	**2**
Jocote	10	6	5	38	59	76	21	35,59	64,41	4,22	**4**
La Laguna	6	6	1	24	37	40	13	35,14	64,86	4,24	**4**
Las Delicias	5	3	11	51	70	86	19	27,14	72,86	4,64	**5**
Las Flores	1	4	2	12	19	29	7	36,84	63,16	4,16	**4**
Las Mesas de Cacamuya	16	16	19	54	105	123	51	48,57	51,43	3,57	**4**
Las Trementinas	32	21	8	104	165	181	61	36,97	63,03	4,15	**4**
Los Ranchos	2	0	0	10	12	17	2	16,67	83,33	5,17	**5**
Mal Paso	9	2	1	8	20	27	12	60,00	40,00	3,00	**3**
Santa Rita	7	4	4	35	50	62	15	30,00	70,00	4,50	**5**

Table 5.19 The quantitative data relating to the water treatments used by the families of ‘La Botija’ protected area.

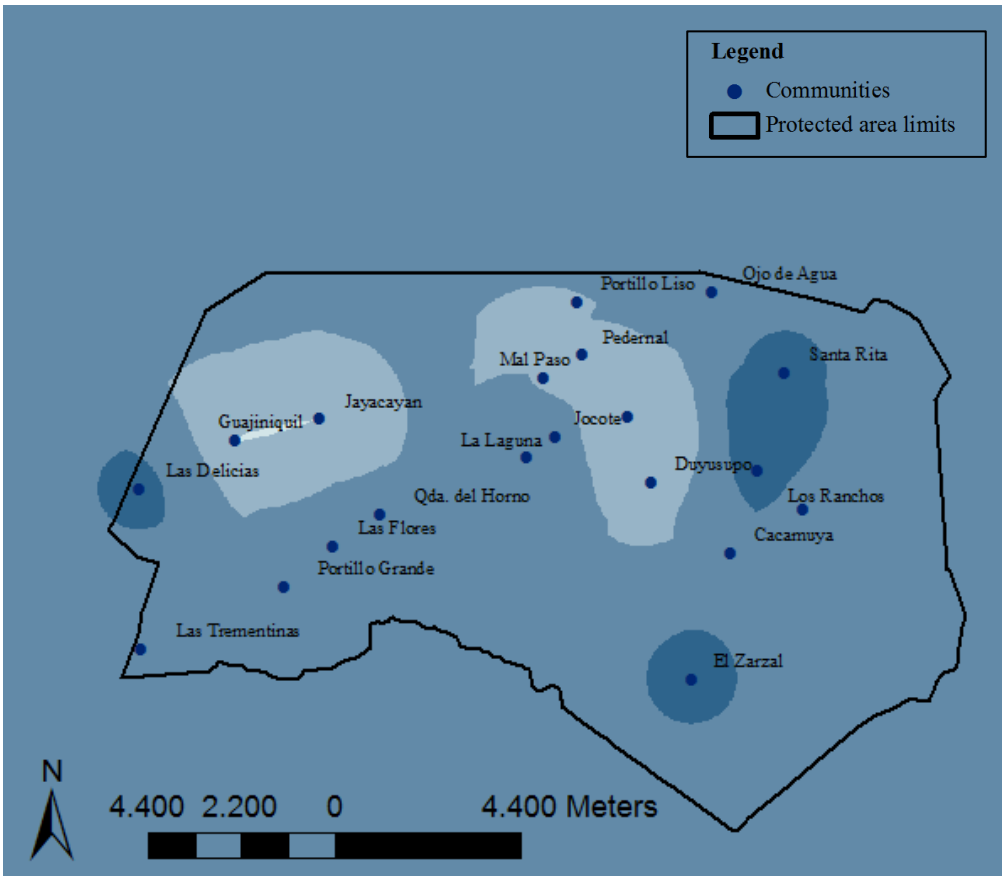


Figure 5.29 The suitability map relating to the water treatments attribute.

5.2.2.4. Waste treatments

The quantitative data on waste treatments used by the families of the communities of 'La Botija' protected area are shown in Table 5.20. The types of waste treatments have been divided into four categories and the families have been classified accordingly to the type of treatment adopted:

(1) Number of families who burn waste
(2) Number of families who burrow waste
(3) Number of families who throw waste (in lands and rivers)
(4) Number of families who use other waste treatments

The percentage of families who burn waste (column 9 of the Table n.) was calculated as following:

Number of analyzed families : 100 = Number of families who burn waste : x

Additionally the calculation of the percentage of the families who do not burn waste is (column 10 of the Table n.):

Number of analyzed families : 100 = (Number of families who burrow waste + Number of families who throw waste (in lands and rivers) + Number of families who use other waste treatments) : x

The Municipality of San Marcos de Colón do not offer any service of waste collection and treatment in 'La Botija' protected area. For this reason the families of the investigated area have to treat waste by themselves burning or burrowing it. In any case the waste treatments used by the families have damaging effects to the environment and human health. The waste burning (1) provokes air pollution and health problems to residents, especially respiratory

diseases. The waste burrowing (2) produces the pollution of water, soil and consequently of aliments. This contamination causes high health diseases in the population and its damage continues for long times.
The waste throwing in lands, rivers and streets (3) is the worst treatment because damages human health, environment and increases communities blight. Additionally the presence of waste in the communities can be at the origin of dangerous epidemics. The other treatments (4) refer to the use of different typologies of waste burrowing that are anyway toxic and harmful for residents and environment.
The calculation of the scores about waste treatments for each community based on the valuation scale resulted more difficult than in the other attributes. The determination of the scores was made through the following percentage:

3 + (Percentage of families who do not use waste burning : 100 = x : 5)

The scores were incremented of a value of 3, considering that also the waste burning is a dangerous and damaging treatment.
The calculated scores were rounded up to find the final values (See column 13 in Table 5.20). The input of these final scores into the ArcGIS project and the use of the 'Kriging' tool permitted to create the map of the waste treatment (See Figure 5.30).

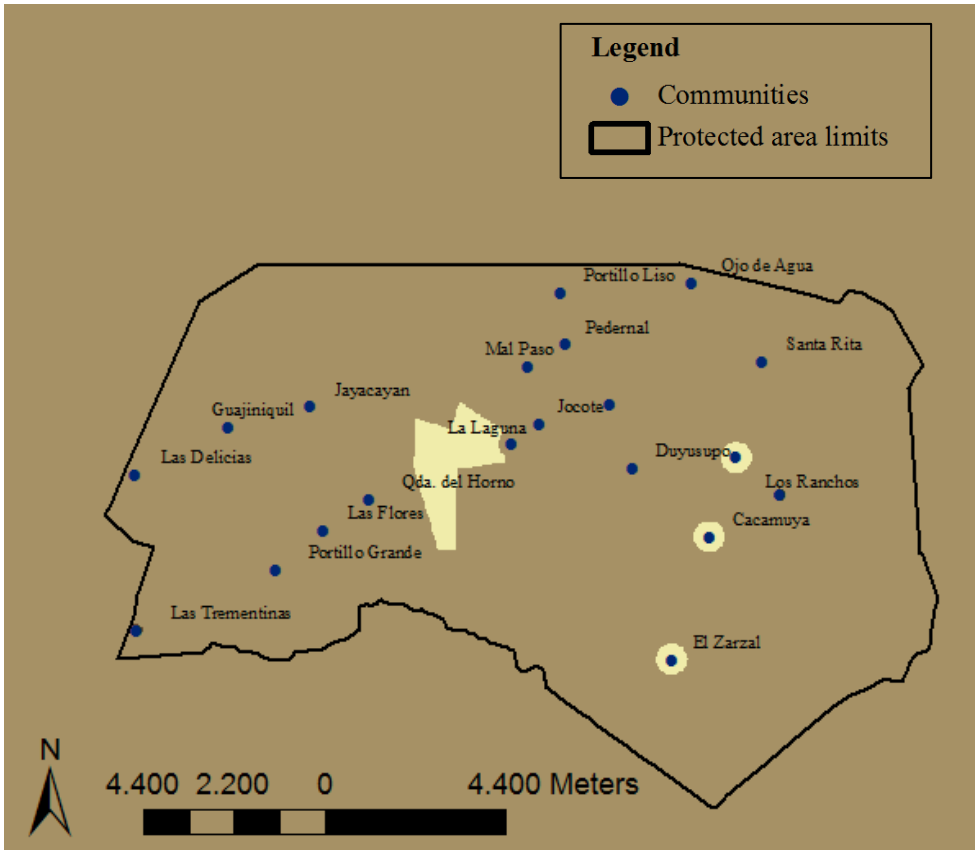


Figure 5.30 The map relating to the Waste treatments attribute.

1	2	3	4	5	6	7	8	9	10	11	12	13
Community	**Number of houses**	**Number of analyzed families**	**Number of families who burn waste**	**Number of families who burrow waste**	**Number of families who throw waste (in lands and rivers)**	**Number of families who use other waste treatments**	**Number of analyzed families**	**% of families who burn waste**	**Total families who do not burn waste**	**% of families who do not burn waste**	**Score**	**Final score**
Cacamuya	22	17	13	0	4	0	17	76,47	4	23,53	3,20	**3**
Chaguites	17	17	7	1	9	0	17	41,18	10	58,82	3,50	**4**
Duyusupo	61	48	30	2	16	0	48	62,50	18	37,50	3,90	**4**
El Zarzal	24	22	13	2	7	0	22	59,09	9	40,91	3,45	**3**
Guajiniquil	43	31	20	7	4	0	31	64,52	11	35,48	3,55	**4**
Jayacayan	67	67	54	7	6	0	67	80,60	13	19,40	3,65	**4**
Jocote	76	59	37	6	16	0	59	62,71	22	37,29	4,10	**4**
La Laguna	40	37	22	3	12	0	37	59,46	15	40,54	3,75	**4**
Las Delicias	86	70	57	6	6	1	70	81,43	13	18,57	3,65	**4**
Las Flores	29	19	7	4	7	1	19	36,84	12	63,16	3,60	**4**
Las Mesas de Cacamuya	123	105	43	36	26	0	105	40,95	62	59,05	6,10	**5**
Las Trementinas	181	165	91	10	64	0	165	55,15	74	44,85	6,70	**5**
Los Ranchos	17	12	8	1	3	0	12	66,67	4	33,33	3,20	**3**
Mal Paso	27	20	8	2	10	0	20	40,00	12	60,00	3,60	**4**
Santa Rita	62	50	21	4	22	3	50	42,00	29	58,00	4,45	**4**

Table 5.20 The quantitative data on the waste treatments used by the families of ‘La Botija’ protected area.

5.2.2.5. Soil quality

The soil quality attribute refers to the fertility of soil and its level of pollution.
Information about the soil quality of the communities were provided by the residents of the investigated area during interviews and workshops developed during the fieldwork. The qualitative data were transcribed and analyzed (see Chapter 4) and a score of the valuation scale was assigned to each investigated community.
The following table shows the values given to each community and the description of the soil quality of each community (Table 5.21).

Community	Soil quality score	Description
Cacamuya	**5**	Dry soil and use of chemical fertilizers
Chaguites	**5**	Dry soil and use of chemical fertilizers
Duyusupo	**4**	Moderately dry soil but use of chemical fertilizers
El Zarzal	**5**	Dry soil, use of chemical fertilizers, acidity by Pine forests
Guajiniquil	**5**	Dry soil and use of chemical fertilizers
Jayacayan	**5**	Dry soil and use of chemical fertilizers
Jocote	**5**	Dry soil, use of chemical fertilizers, acidity by Pine forests
La Laguna	**5**	Dry soil, use of chemical fertilizers, acidity by Pine forests
Las Delicias	**5**	Dry soil and use of chemical fertilizers
Las Flores	**2**	No utilizzo di chimici a causa della presenza di una azienda che produce caffè in modo organico: hanno proibito l'utilizzo di fertilizzanti chimici a tutta la comunità: il suolo è molto fertile
Las Mesas de Cacamuya	**2**	Fertility soil and few use of chemical fertilizers
Las Trementinas	**4**	Moderately dry soil but use of chemical fertilizers
Los Ranchos	**5**	Dry soil and use of chemical fertilizers
Mal Paso	**5**	Highly dry soil not for the use of chemical fertilizers but especially for the strong forest vocation.
Santa Rita	**5**	Dry soil, use of chemical fertilizers,

Table 5.21 The scores given to the communities of the investigated area regarding the soil attribute.

At a later stage, with the elaboration of the qualitative data by ArcGIS, the following map was created (Figure 5.31).

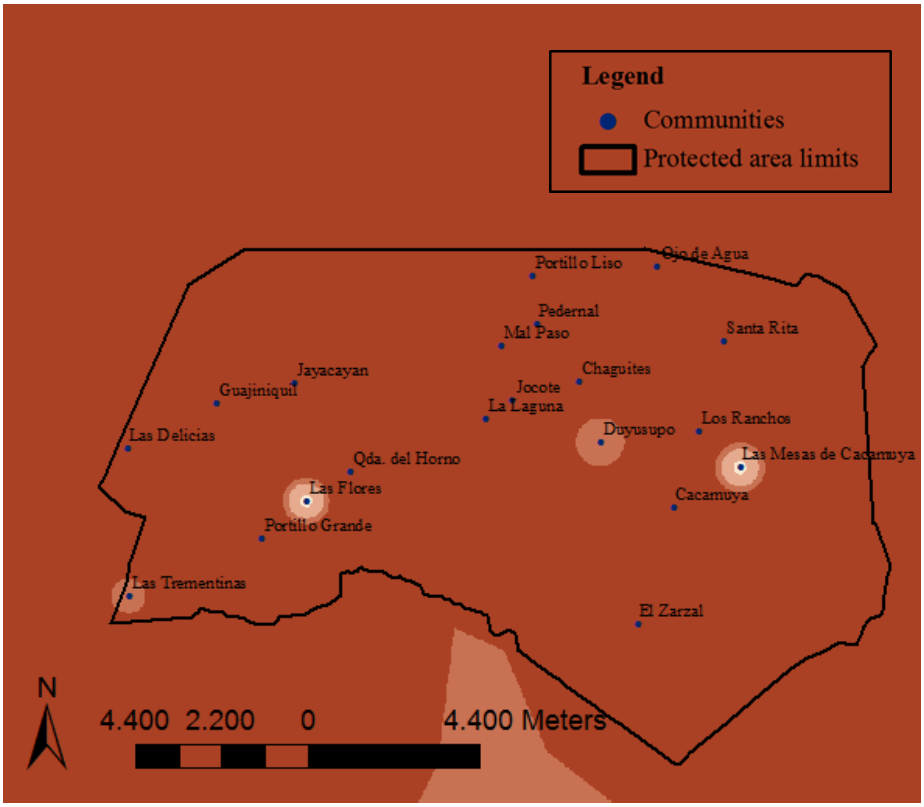


Figure 5.31 The map relating to the soil attribute.

5.2.2.6. Schools density

In the case of the school density, the data on the number of classrooms located in each school of 'La Botija' communities were considered (see Table 5.23).
The final scores of the valuation scale were assigned to each community following this approach: communities without any classroom (any school) was given the worst score (value of 5); communities with an unique classroom received a score of 4; the ones with two classrooms obtained a value of 3; communities with 3 or 4 classrooms was assigned a value of 2 and finally communities with more than four classrooms acquired a score of 1 (see Table 5.22). From the elaboration of the assigned scores was originated a suitability map (Figure 5.32).

Number of classrooms	Score
0	**5**
1	**4**
2	**3**
3	**2**
4	**2**
>4	**1**

Table 5.22 The approach used for the scores assignment to the communities of 'La Botija' protected area regarding the schools density attribute.

Community	Number of classrooms	Score
Cacamuya	1	**4**
Chaguites	0	**5**
Duyusupo	2	**3**
El Zarzal	1	**4**
Guajiniquil	2	**3**
Jayacayan	2	**3**
Jocote	10	**1**
La Laguna	2	**3**
Las Delicias	4	**2**
Las Flores	1	**4**
Las Mesas de Cacamuya	4	**2**
Las Trementinas	2	**3**
Los Ranchos	1	**4**
Mal Paso	0	**5**
Santa Rita	2	**3**

Table 5.23 Scores assignment to the communities of 'La Botija' protected area regarding the school density attribute.

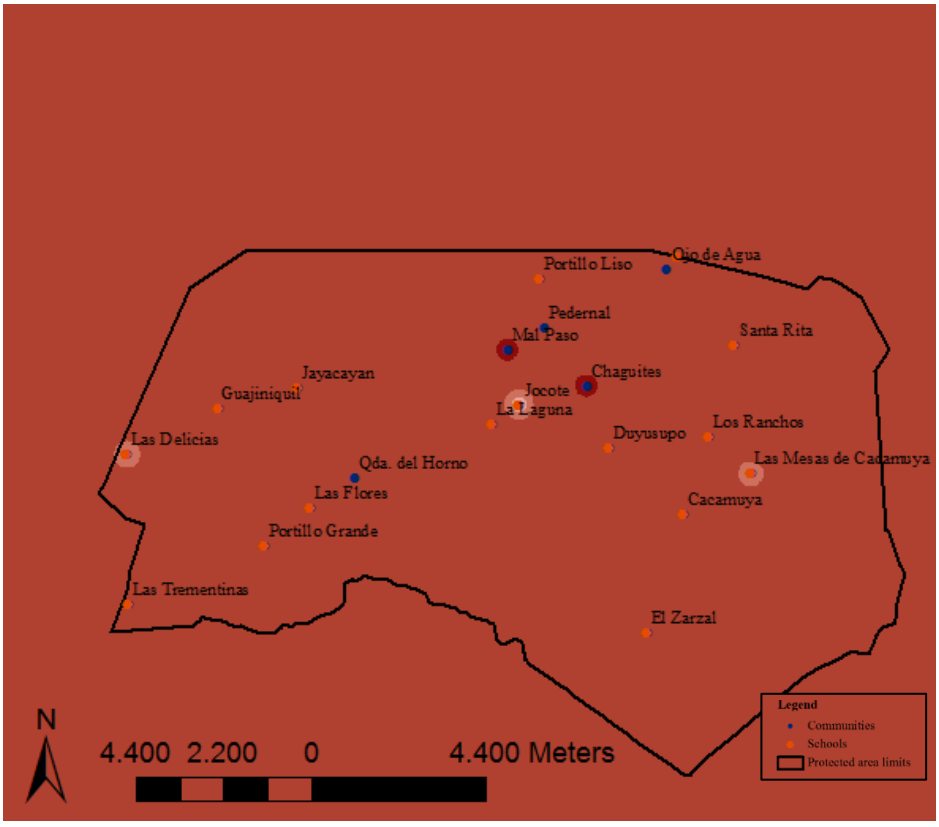


Figure 5.32 The map relating to the schools density attribute.

5.2.2.7. Number of illiterates

The number of illiterates attribute considers the percentage of illiterates of each community, as shown in the quantitative data provided by the Health Center of San Marcos de Colón.
The percentage of illiterates (see column 4 of Table 5.25) of each community was calculated as following:

Number of Illiterates: Population density = x : 100

At a later stage the scores referring to the valuation scale were assigned using the approach described in the following table where a specific score was given to each range of percentages of illiterates (Table 5.24).

Percentage of Illiterates	Score
3-5%	1
6-8%	2
9-11%	3
12-14%	4
15-17%	5

Table 5.24 The approach used for the scores assignment to the communities of 'La Botija' protected area regarding the number of illiterates attribute.

Community	Population density	Number of Illiterates	% of Illiterates	Score
Cacamuya	104	8	7,69	**2**
Chaguites	78	8	10,26	**3**
Duyusupo	227	31	13,66	**4**
El Zarzal	120	11	9,17	**3**
Guajiniquil	171	14	8,19	**3**
Jayacayan	326	37	11,35	**3**
Jocote	286	38	13,29	**4**
La Laguna	241	21	8,71	**2**
Las Delicias	393	13	3,31	**1**
Las Flores	125	20	16,00	**5**
Las Mesas de Cacamuya	489	65	13,29	**4**
Las Trementinas	1054	91	8,63	**2**
Los Ranchos	66	11	16,67	**5**
Mal Paso	109	8	7,34	**2**
Santa Rita	250	26	10,40	**3**

Table 5.25 Scores assignment to the communities of 'La Botija' protected area regarding the number of illiterates attribute.

The assigned scores of the valuation scale were elaborated through ArcGIS and the following map was created (Figure 5.33).

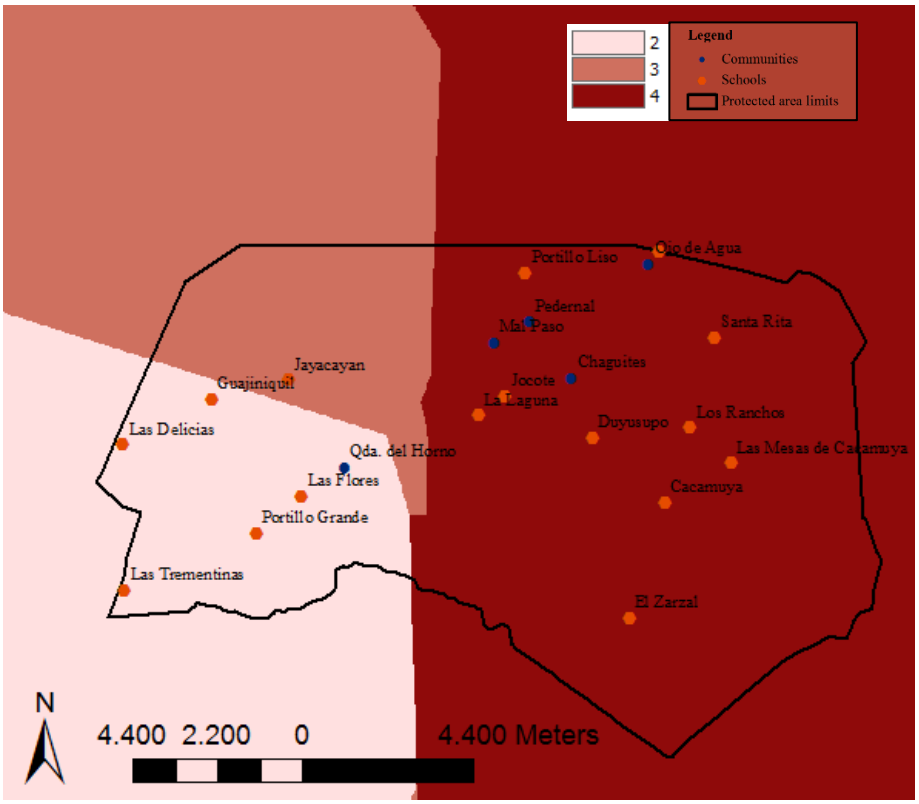


Figure 5.33 The map relating to the number of illiterates attribute.

5.2.2.8. Community cooperation level

The community cooperation level attribute considers the collaboration and cooperation existing in each community of 'La Botija' protected area. During the fieldwork residents were asked to describe the level of cooperation of the community. The results of this qualitative data collection permitted to give a score to each community based on its cooperation level, as shown in the following table (Table 5.26).

Community	Score
Cacamuya	**3**
Chaguites	**4**
Duyusupo	**3**
El Zarzal	**5**
Guajiniquil	**2**
Jayacayan	**3**
Jocote	**5**
La Laguna	**3**
Las Delicias	**3**
Las Flores	**2**
Las Mesas de Cacamuya	**1**
Las Trementinas	**2**
Los Ranchos	**3**
Mal Paso	**2**
Santa Rita	**4**

Table 5.26 Scores assignment to the communities of 'La Botija' protected area regarding the community cooperation level attribute.

The elaboration of the scores referring to the community cooperation level of each community in ArcGIS permitted to develop the following map (Figure 5.34).

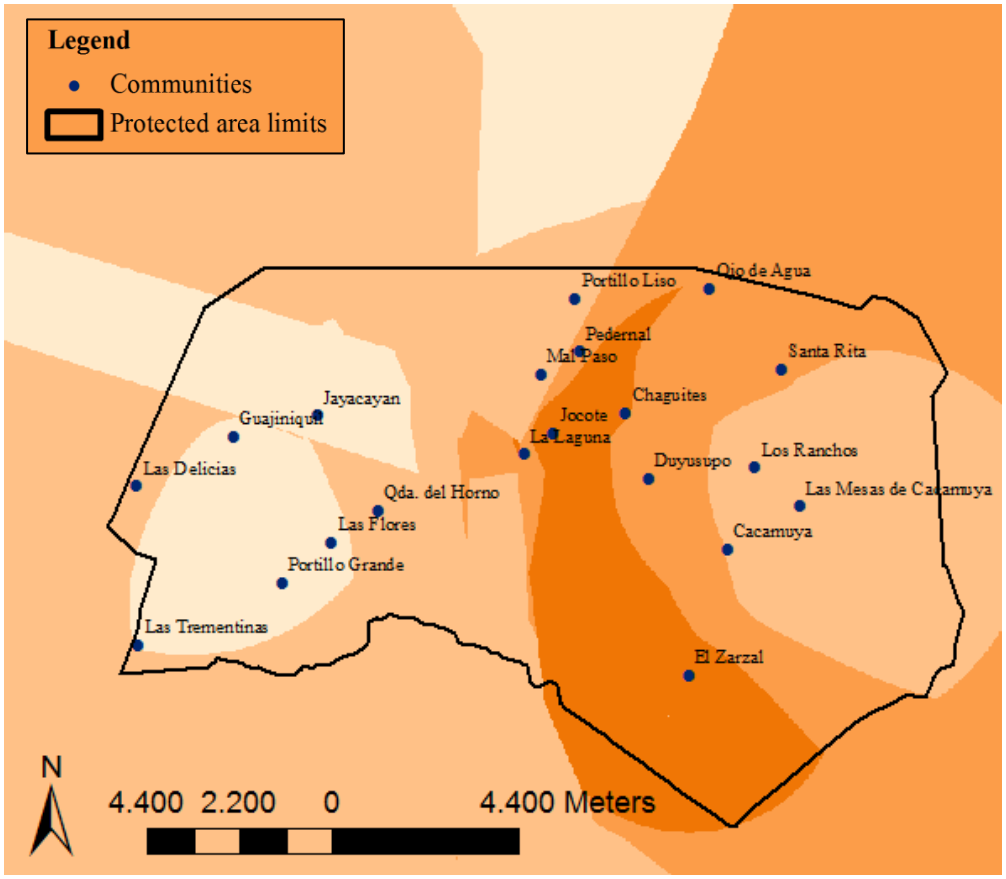


Figure 5.34 The map relating to the community cooperation level attribute.

5.2.2.9. Number of community organizations

During the interviews and workshops in the different communities of the investigated area people were asked to list and to speak about the organizations existing in the community. The outcomes of this investigation permitted to know the number of community organization of each rural community, as shown in the second column of Table 5.28.
Subsequently a score was assigned to each community based on the number of organizations (see third column of the Table 5.28). The different scores of each community were determined using the approach described in the following table, where a specific value was given to each number of community organizations (Table 5.27).

Number of community organizations	Score
3	**5**
4	**4**
5	**3**
6	**2**
>6	**1**

Table 5.27 The approach used for the scores assignment to each community regarding the number of community organizations.

Community	Number of community organizations	Score
Cacamuya	5	**3**
Chaguites	4	**4**
Duyusupo	5	**3**
El Zarzal	3	**5**
Guajiniquil	6	**2**
Jayacayan	5	**3**
Jocote	5	**3**
La Laguna	5	**3**
Las Delicias	6	**2**
Las Flores	5	**3**
Las Mesas de Cacamuya	6	**2**
Las Trementinas	6	**2**
Los Ranchos	5	**3**
Mal Paso	5	**3**
Santa Rita	5	**3**

Table 5.28 Scores assignment to the communities of 'La Botija' protected area regarding the number of community organizations attribute.

The elaboration by ArcGIS of the assigned scores allowed to create the following map (Figure 5.35).

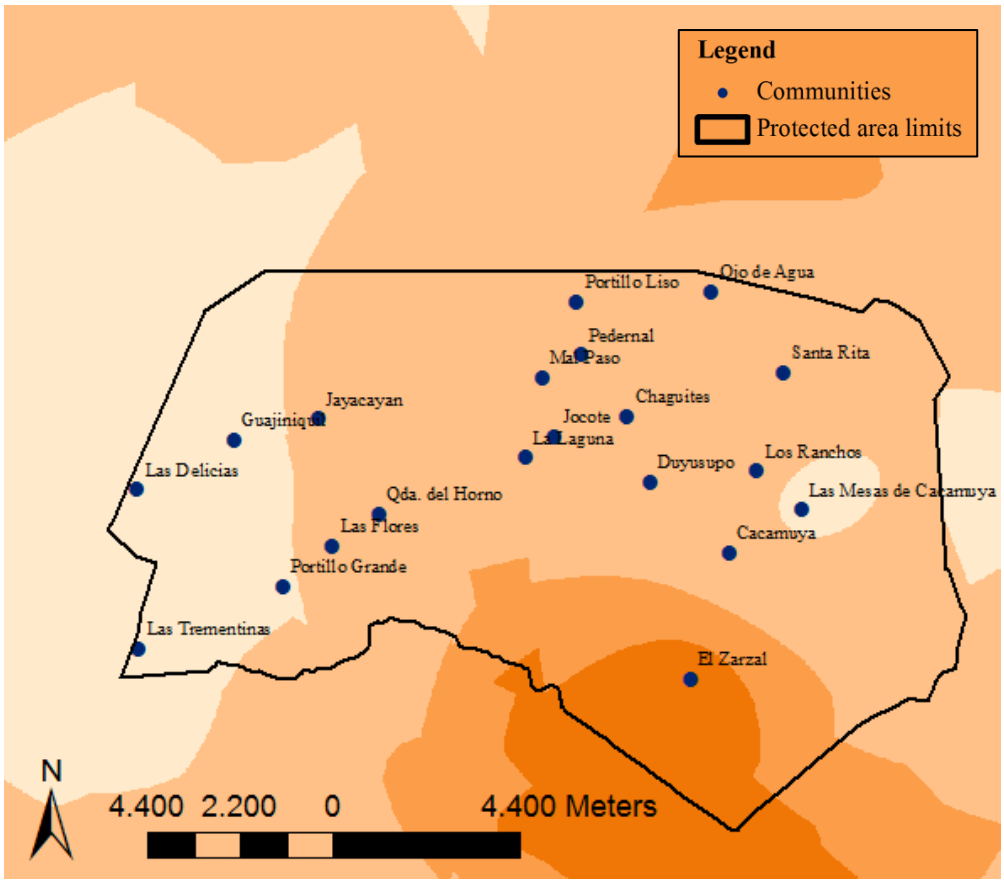


Figure 5.35 The map relating to the number of community organizations attribute.

5.2.2.10. Number of projects working in the community

As in the case of the number of community organizations attribute, during interviews and workshops participants were asked to list and to speak about the projects working and operating in the community. The elaboration of this information allowed to define the number of projects working in each community (second column of Table 5.30). At a later stage a score was assigned to each community corresponding to the number of organizations (third column of Table 5.30) using the approach shown in Table 5.29. The elaboration by ArcGIS of the given scores allowed the construction of a suitability map (Figure 5.36).

Number of classrooms	Valuation scale
1	5
2	4
3	3
4	2
>4	1

Table 5.29 The approach used for the scores assignment to each community regarding the number of projects working in each community.

Community	Number of Projects working in the community	Score
Cacamuya	1	**5**
Chaguites	1	**5**
Duyusupo	2	**4**
El Zarzal	1	**5**
Guajiniquil	4	**2**
Jayacayan	2	**4**
Jocote	2	**4**
La Laguna	2	**4**
Las Delicias	3	**3**
Las Flores	1	**5**
Las Mesas de Cacamuya	2	**4**
Las Trementinas	2	**4**
Los Ranchos	2	**4**
Mal Paso	2	**4**
Santa Rita	1	**5**

Table 5.30 Scores assignment to the communities of 'La Botija' protected area regarding the number of projects working in the community attribute.

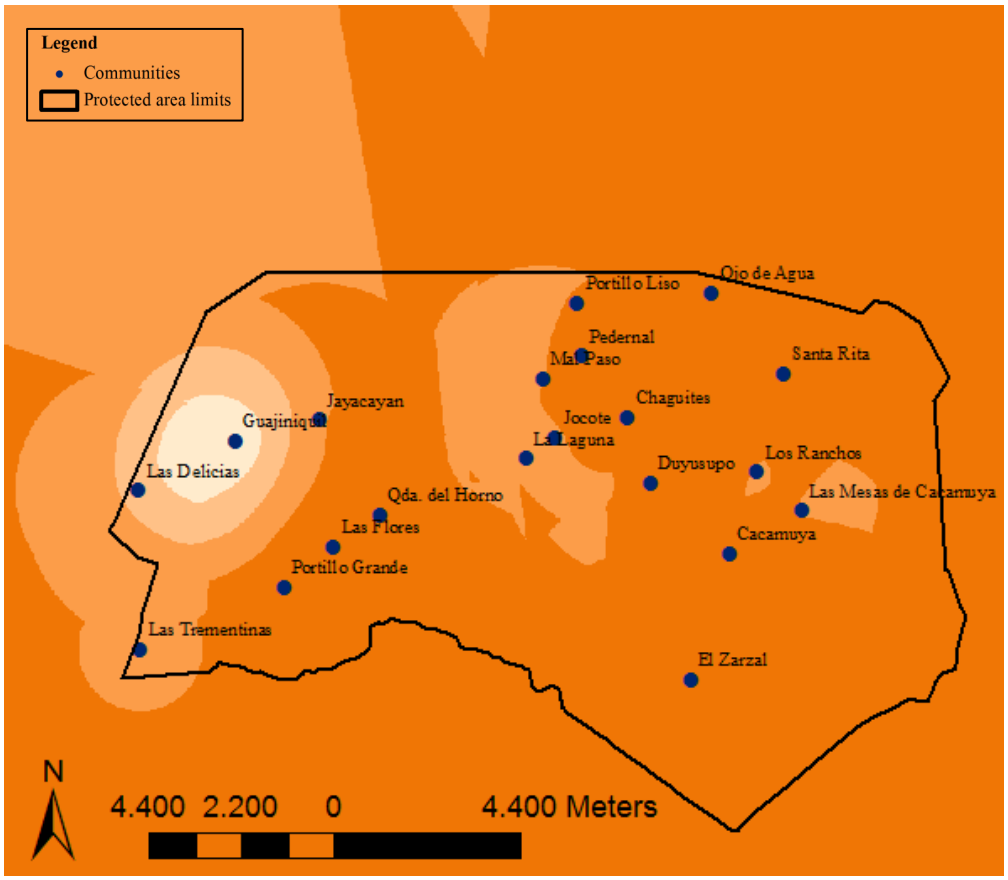


Figure 5.36 The map related to the number of projects working in the community.

5.2.2.11. Organic agriculture knowledge

The Organic agriculture knowledge attribute reflects the level of knowledge of the citizens on organic and sustainable agriculture practices and technics (e.g. use of compost, organic remediation to plants diseases, etc.). The information referring to this issue were collected during the fieldwork through interviews and workshops. This qualitative data collection allowed to assign a score to each community according to the rating scale (See Table 5.31).
The elaboration by GIS of the assigned scores of each community permitted to create a suitability map, as shown in Figure 5.37.

Community	Score
Cacamuya	**5**
Chaguites	**5**
Duyusupo	**4**
El Zarzal	**5**
Guajiniquil	**2**
Jayacayan	**3**
Jocote	**5**
La Laguna	**2**
Las Delicias	**3**
Las Flores	**3**
Las Mesas de Cacamuya	**2**
Las Trementinas	**2**
Los Ranchos	**3**
Mal Paso	**3**
Santa Rita	**5**

Table 5.31 Scores assignment to the communities of 'La Botija' protected area regarding the organic agriculture knowledge attribute.

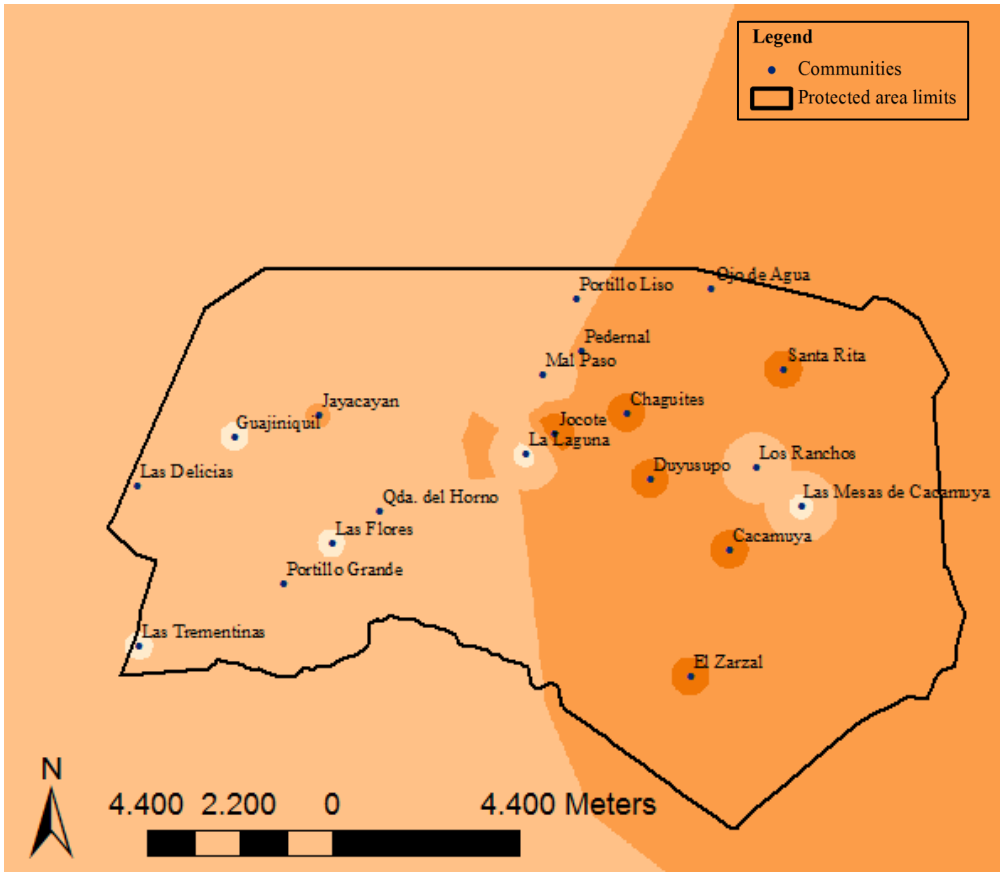


Figure 5.37 The map related to the organic agriculture knowledge attribute.

5.2.2.12. Fire prevention knowledge

The fire prevention knowledge attribute is based on the level of knowledge of the residents of investigated area about practical activities to prevent fire and soil erosion. The qualitative data that concern this theme was collected by the author during the fieldwork. In accordance with the collected qualitative data was possible to assign a score to each community (See Table 5.32). At a later stage, the elaboration of the scores of the fire prevention knowledge for each community allowed to create the suitability map shown in Figure 5.38.

Community	Score
Cacamuya	5
Chaguites	5
Duyusupo	4
El Zarzal	5
Guajiniquil	2
Jayacayan	3
Jocote	5
La Laguna	4
Las Delicias	2
Las Flores	3
Las Mesas de Cacamuya	2
Las Trementinas	2
Los Ranchos	4
Mal Paso	3
Santa Rita	5

Table 5.32 Scores of each community relating to the fire prevention knowledge.

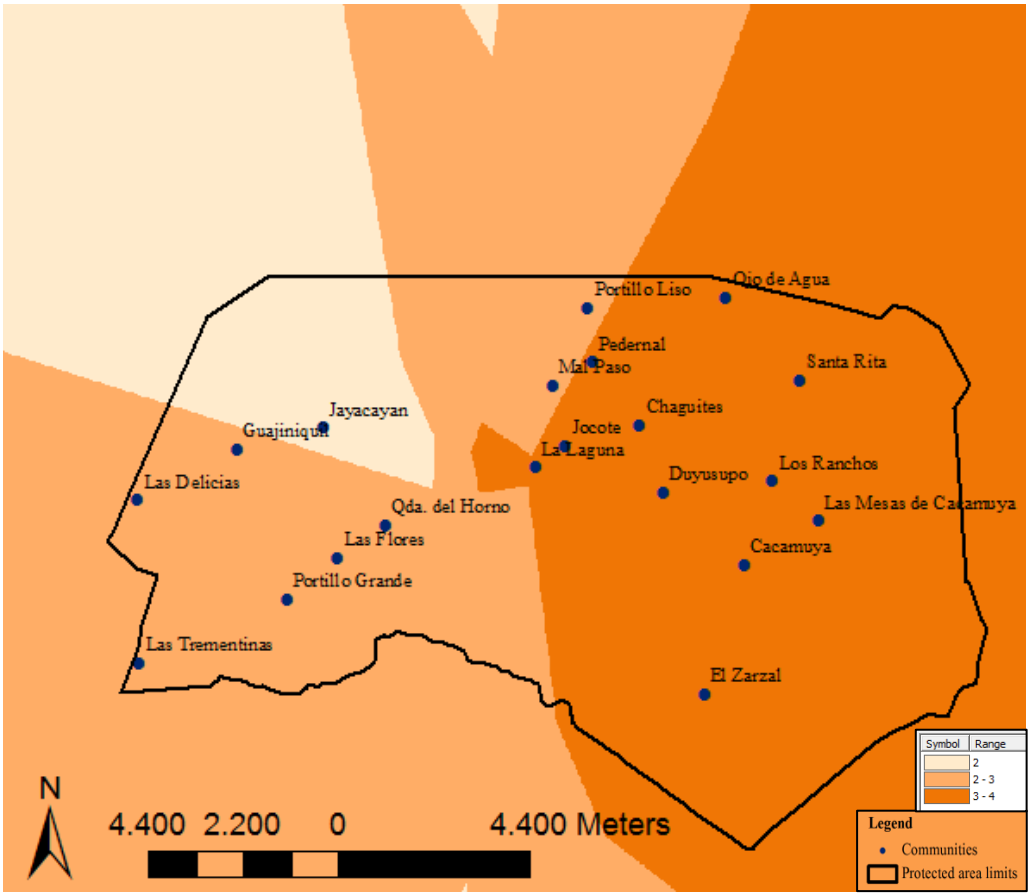


Figure 5.38 The map relating to the fire prevention knowledge attribute.

5.2.2.13. Level of motivation

The level of motivation attribute concerns the level of motivation and self-awareness of the residents of the investigated communities. As in the attributes previously describes, the qualitative data on the level of motivation of each community was collected during the fieldwork. Particularly this data was gathered from the organized workshops. Additionally the interviews with NGO's organizers and project managers were fundamental to understand the level of motivation of each community. The collected data permitted to assign different scores following the valuation scale (values from 1 to 5) to each community depending on their level of motivation (Table 5.33). The map shown in Figure 5.39 was created by the elaboration of the scores of each community into the ArcGIS project.

Community	Score
Cacamuya	5
Chaguites	4
Duyusupo	3
El Zarzal	5
Guajiniquil	2
Jayacayan	2
Jocote	4
La Laguna	3
Las Delicias	4
Las Flores	3
Las Mesas de Cacamuya	1
Las Trementinas	1
Los Ranchos	4
Mal Paso	2
Santa Rita	5

Table 5.33 Scores assignment to the communities of 'La Botija' protected area regarding the level of motivation.

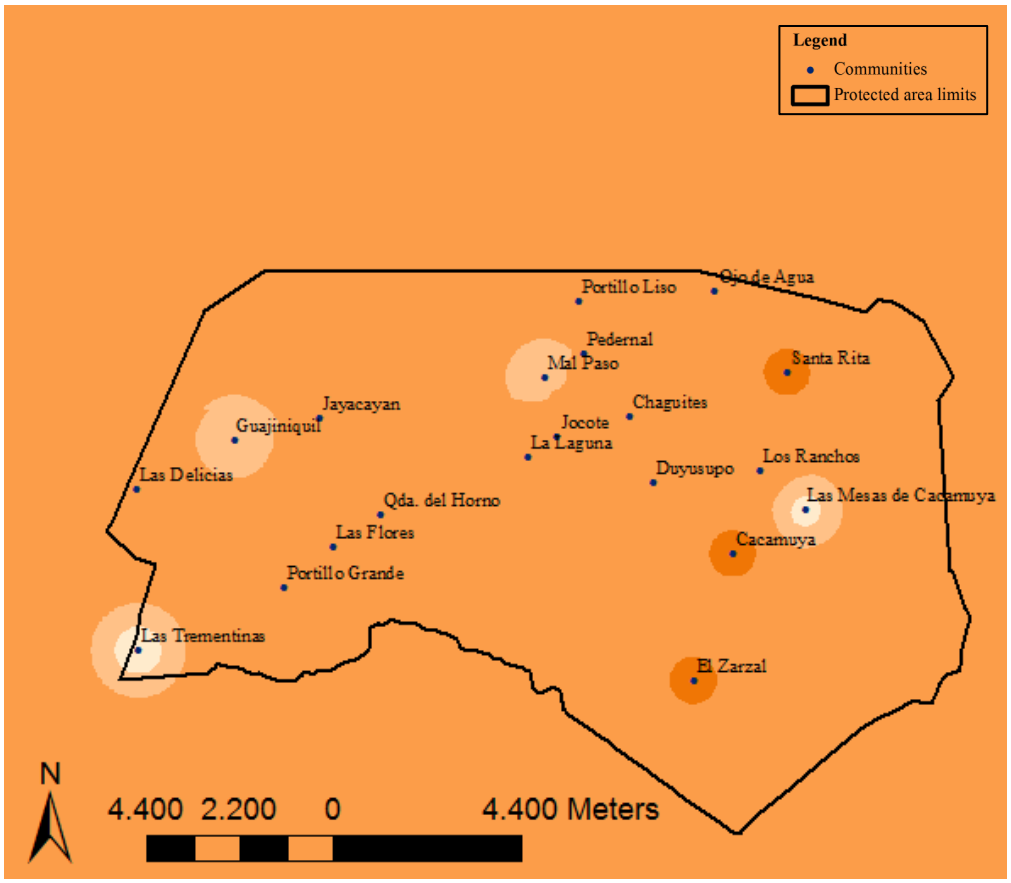


Figure 5.39 The map relating to the level of motivation attribute.

5.3. Elaboration of multi-criteria analysis (MCA) by GIS

Once created the maps for each criteria both through the 'Euclidean distance' tool and the 'Kriging' tool was possible to develop the multi-criteria analysis (MCA) by GIS.
The geo-processing tool used for the elaboration of MCA by GIS is the 'Raster calculator' tool of the Spatial Analyst tool, as shown in Chapter 3.
The weights of each attributes calculated in a previous phase during the development of the pairwise comparison method (see Paragraph 5.1.3.) were assigned to each elaborated attribute map.
The following table (Table 5.34) shows the normalized weights of each attribute of each criteria used to calculate the weighted sum by ArcGIS.

Criteria	Attributes	Normalized weight
Infrastructures and communication	Distance from San Marcos de Colón	0,1
	Distance from bus route	0,3
	Sewer system	0,2
	Water system	0,4
Water	Distance from rivers, streams and water sources	0,5
	Water treatments	0,5
Education	Schools density	0,12
	Schools distance	0,42
	Number of illiterates	0,42
Cooperation and knowledge	Community cooperation level	0,24
	Number of projects working in the community	0,14
	Number of community organizations	0,19
	Organic agriculture knowledge	0,12
	Fire prevention knowledge	0,10
	Level of motivation	0,21

Table 5.34 Normalized weights of the attributes of the proposed model.

The weighted sum between the attributes of each criteria was calculated using the 'Raster calculator' tool. The weighted sum permitted to develop 2 maps for each criteria that graphically represent the weighting of each attribute of each community. The following section describes the weighted sums determined for each criteria.

5.3.1. Preference map of infrastructures and communication criterion

The preference maps of infrastructures and communication criteria were elaborated through the weighted sum between the attributes of this criterion. This calculation was made using the normalized weights of the attributes and the maps developed for each attribute:

(Distance from San Marcos de Colón map * 0,1) + (Distance from bus route map * 0,3) + (Sewer system map * 0,2) + (Water system map * 0,4)

The first map was develop by the 'Stretched' ArcGIS property (Figure 5.40) while the second map using 'Classified' property (Figure 5.41).

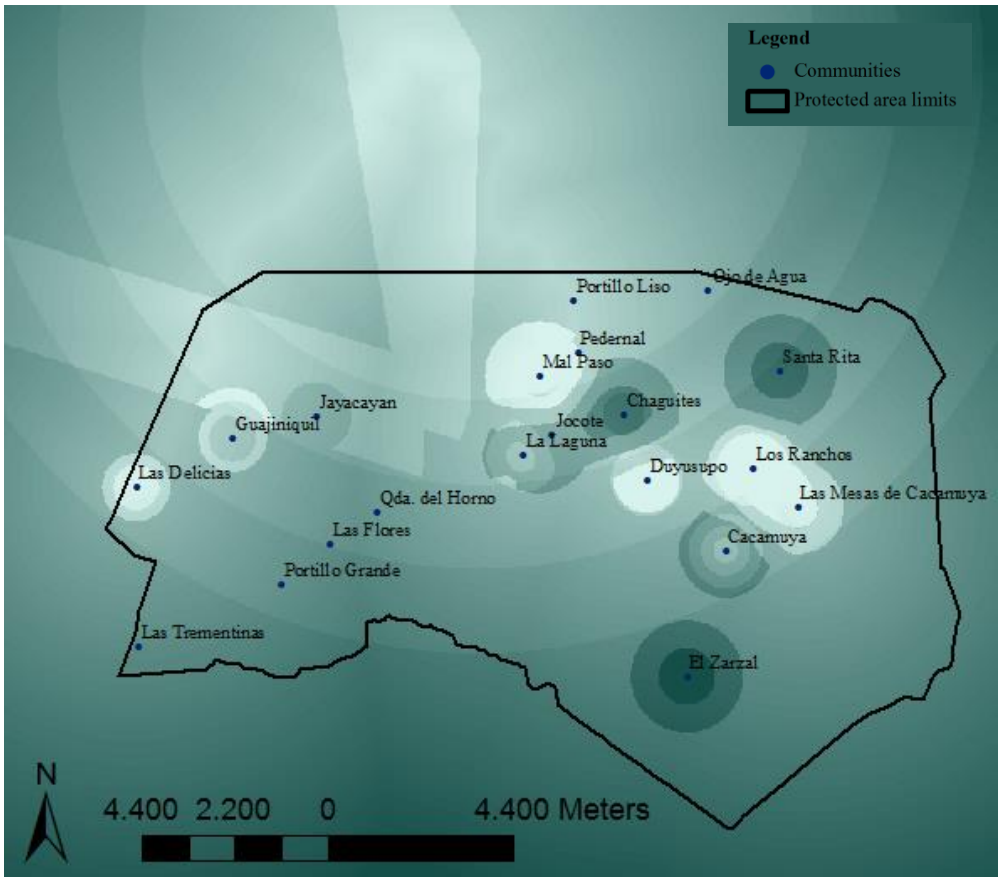


Figure 5.40 Preference map relating to infrastructures and communication criterion using 'Stretched' property.

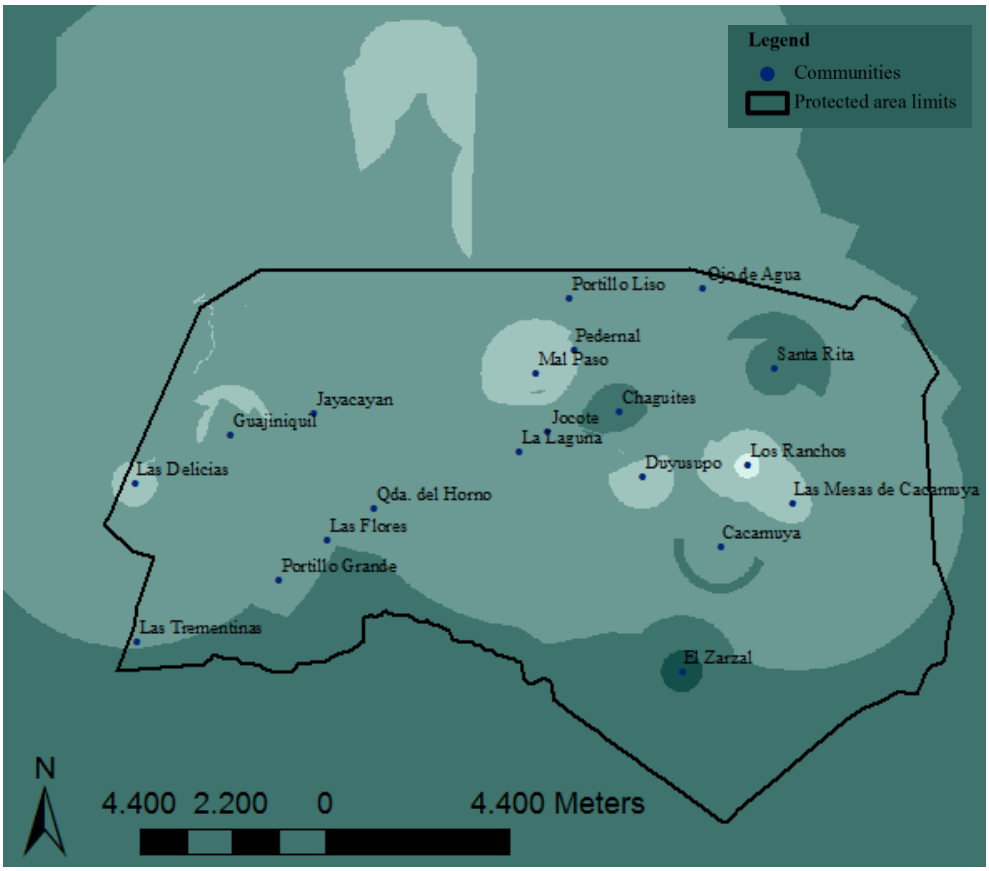


Figure 5.41 Preference map relating to infrastructures and communication criterion using 'Classified' property.

5.3.2. Preference map of Water criterion

The preference maps of water criterion were created calculating the weighted sum between its attributes. This determination was made using the normalized weights of each attribute and the attribute maps previously created (Figures 5.42 and 5.43).

(Distance from rivers, streams and water sources * 0,5) *+ (Water treatments * 0,5)

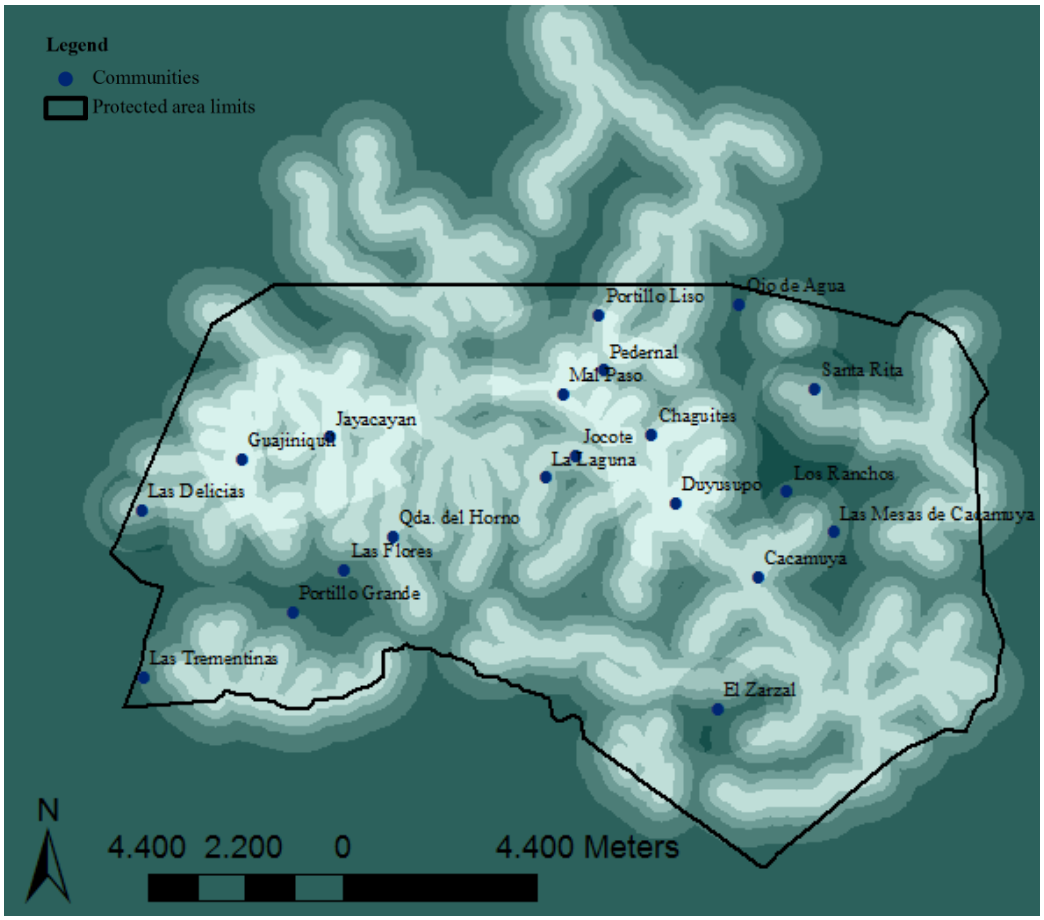


Figure 5.42 Preference map relating to the water criterion using 'Stretched' property.

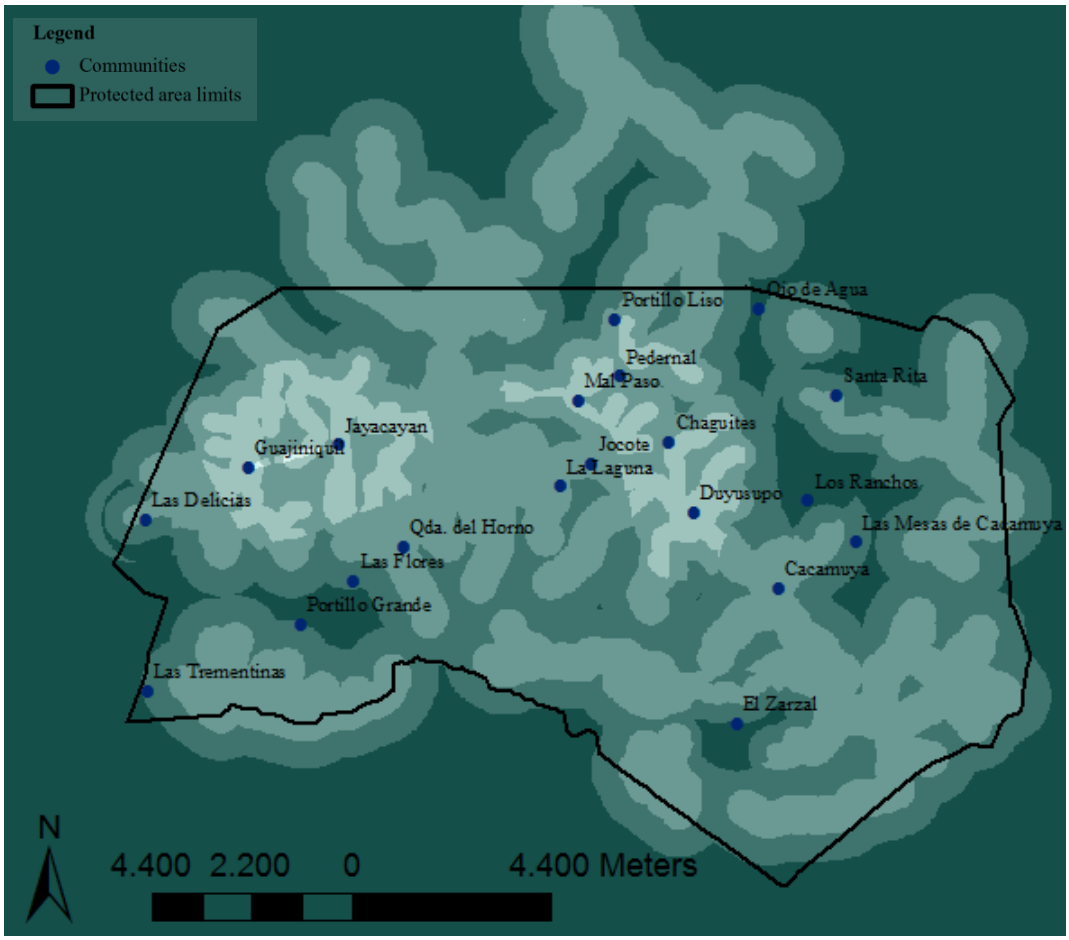


Figure 5.43 Preference map relating to the water criterion using 'Classified' property.

5.3.3. Preference map of Education criterion

In the case of the Education criterion the preference maps (Figures 5.44 and 5.45) were created through the following calculation:

(Schools density * 0,12) + (Schools distance * 0,42) + (Number of illiterates * 0,42)

The calculation is the weighted sum of the attributes using the normalized weights and the suitability maps developed for each attribute.

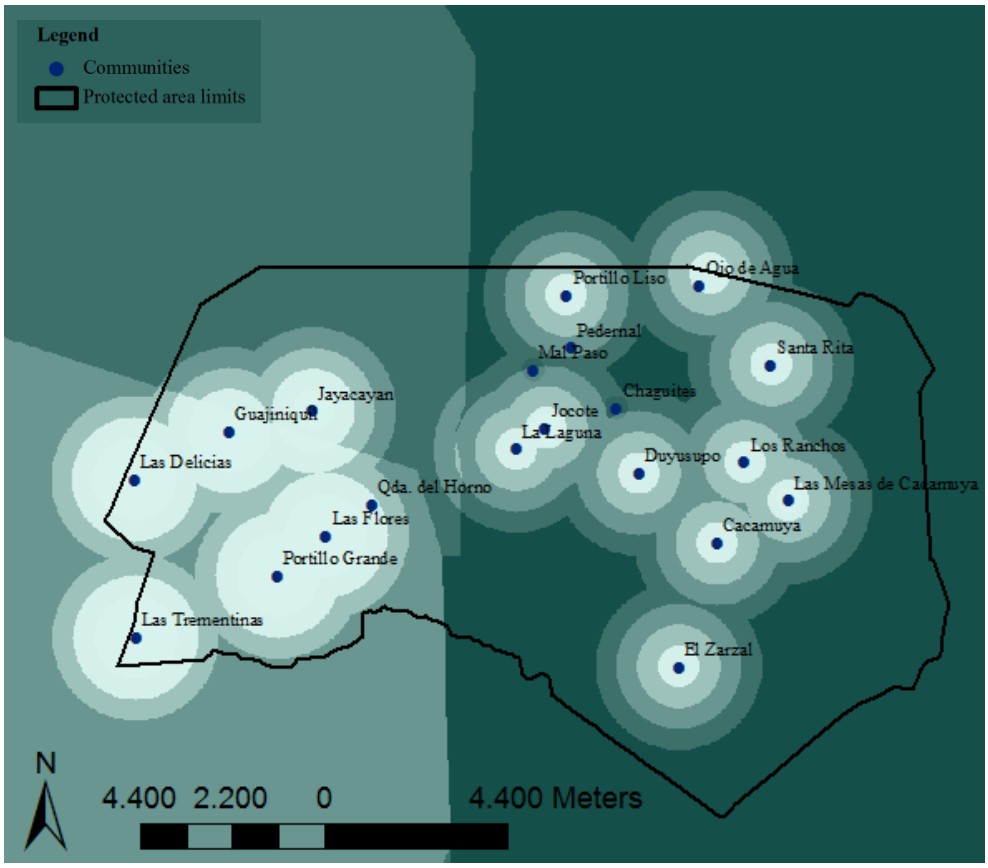


Figure 5.44 Preference map relating to the education criterion using 'Stretched' property.

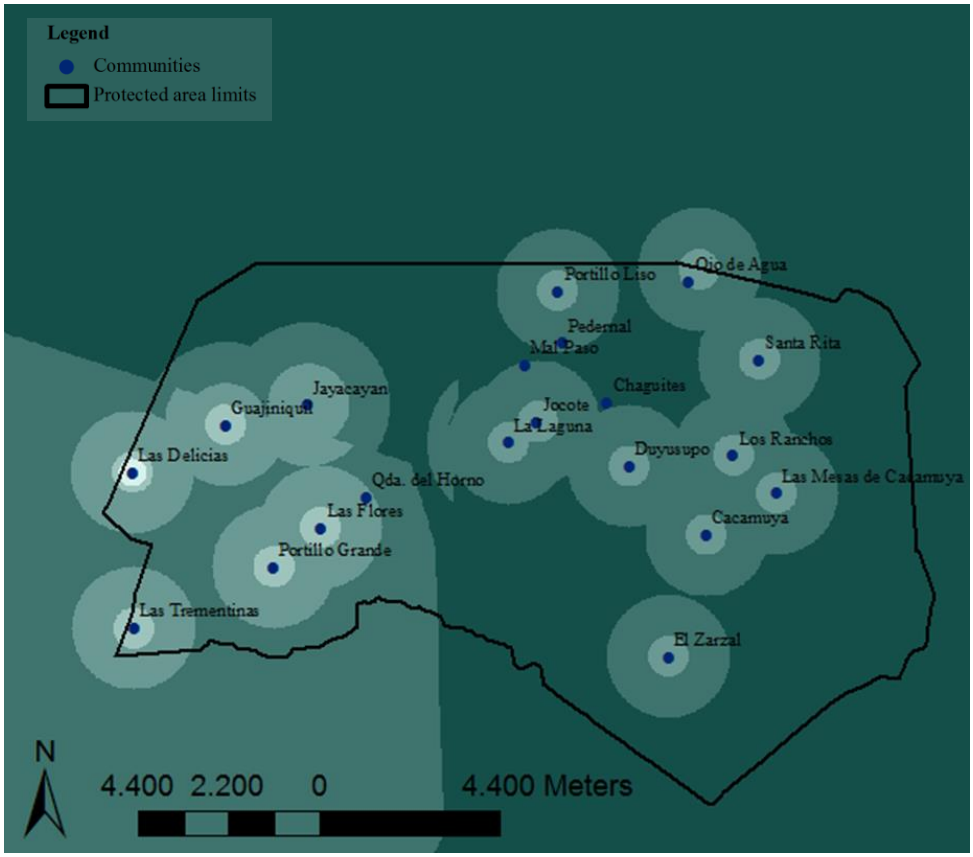


Figure 5.45 Preference map relating to the education criterion using 'Classified' property.

5.3.4. Preference map of Cooperation and knowledge criterion

The preference maps (see Figures 5.46 and 5.47) of Cooperation and knowledge criterion were elaborated developing a weighted sum of the attributes, as following.
(Community cooperation level * 0,24) + (number of community projects * 0,14) + (Number of community organizations * 0,19) + (Organic agriculture knowledge * 0,12) + (Fire prevention knowledge * 0,10) + (Level of motivation * 0,21)

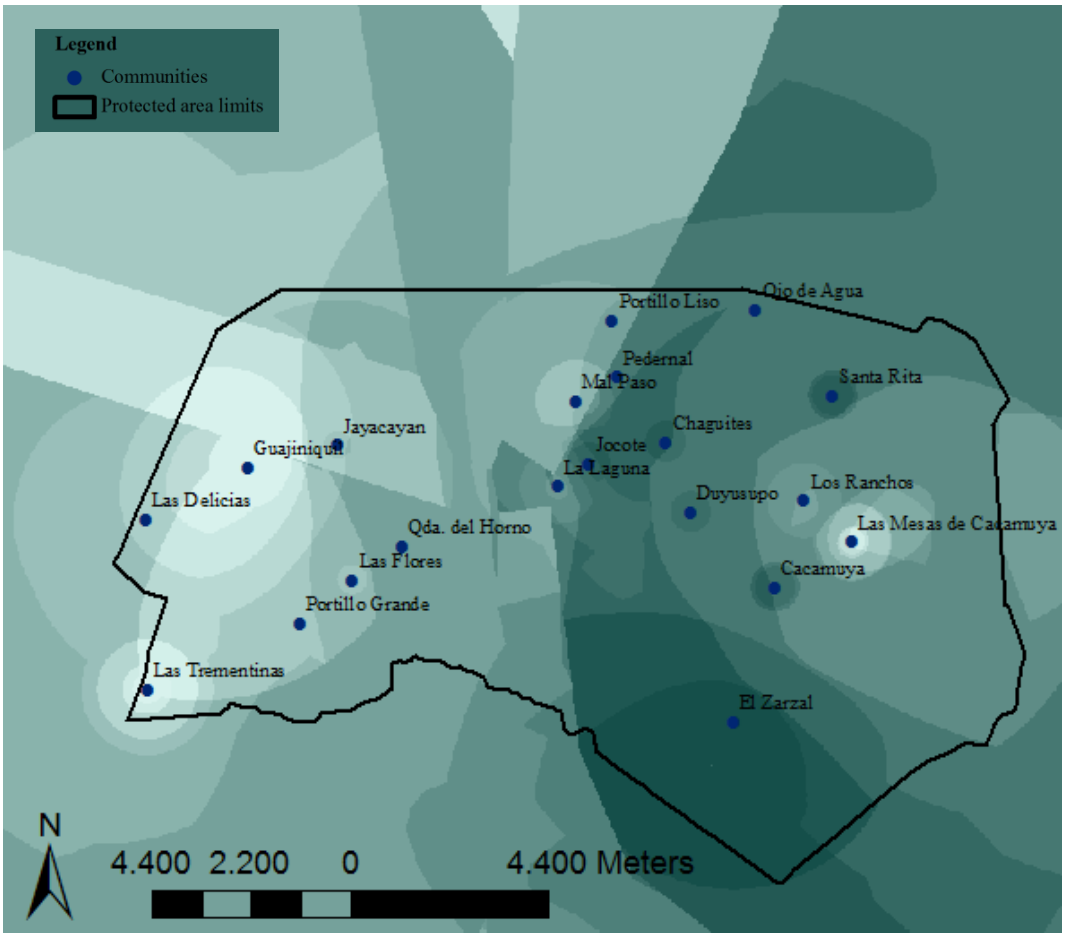


Figure 5.46 Preference map relating to cooperation and knowledge criterion using 'Stretched' property.

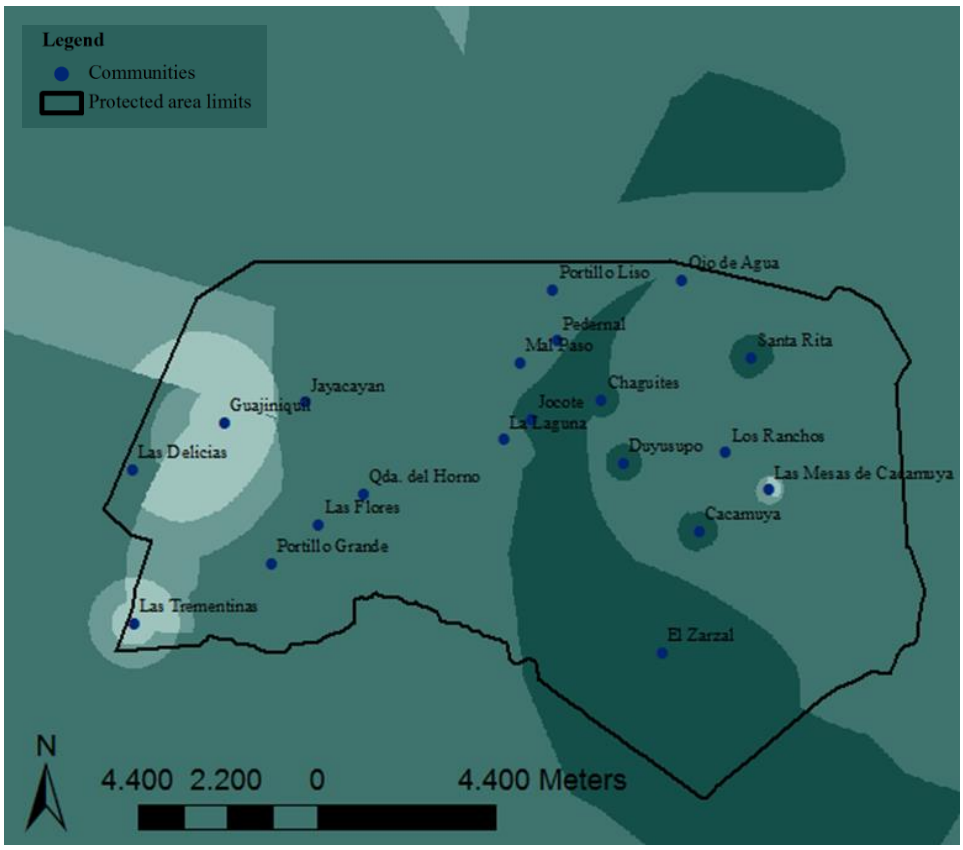


Figure 5.47 Preference map relating to cooperation and knowledge criterion using 'Classified' property.

5.3.5. Elaboration of the final map and identification of the priority intervention areas

The final stage of the research consisted in the creation of the conclusive map identifying the priority intervention areas of the investigated area. This elaboration consisted in weighted sum of the criteria. This calculation was develop using the maps previously created (calculated by the weighted sum between each attribute of each criteria) and the normalized weights of each criteria. The following table (Table 5.35) reports the normalized weights of each criteria as previously calculate with the pairwise comparison (Paragraph 5.1.3.).

Criteria	Normalized weights
Infrastructures and communication	0,23
Water	0,07
Waste	0,09
Education	0,21
Health	0,14
Cooperation and knowledge	0,20
Soil quality	0,05

Table 5.35 The normalized weights of the criteria.

The weighted sum of the criteria by GIS was made through the 'Raster calculator' tool of ArcGIS and consisted in the following calculation:
Infrastructures and communication * 0,23) + (Water * 0,07) + (Waste * 0,09) + (Education * 0,21) + (Health * 0,14) + (Cooperation and knowledge * 0,20) + (Soil quality * 0,05).
In the case of the criteria with multiple attributes (i.e. infrastructures and communication, water, education, cooperation and knowledge) were used the preference maps previously elaborated. In the case of the criteria without attributes (i.e. waste, health, soil) were used the suitability maps elaborated by GIS using the analyzed data (Paragraph 5.2.).
The application of the GIS-based MCA process described above permitted to obtain the maps that identify the priority intervention areas of 'La Botija' protected area according to the weights defined for each criteria.
The first map (Figure 5.48) was develop by the 'Stretched' ArcGIS property while the second map (Figure 5.49) using the 'Classified' property.

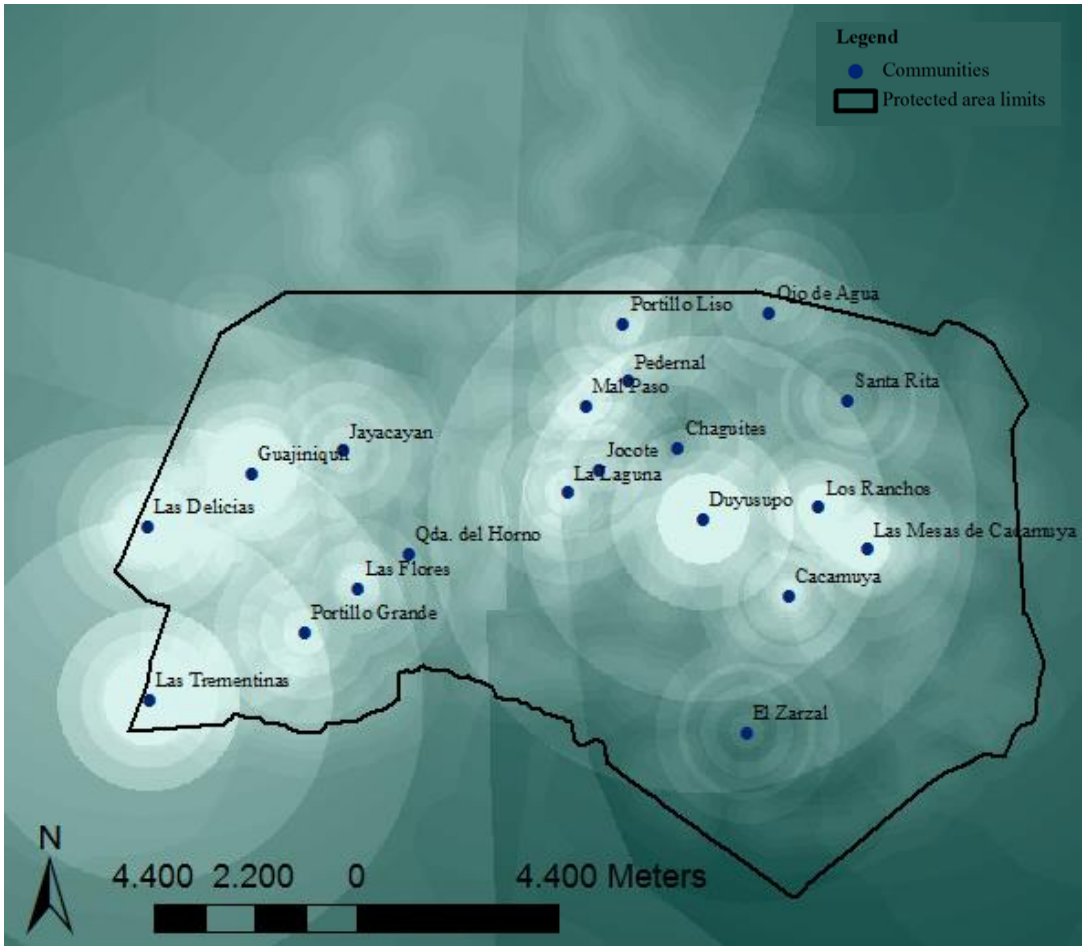


Figure 5.48 Final map identifying priority intervention areas ('Stretched' property).

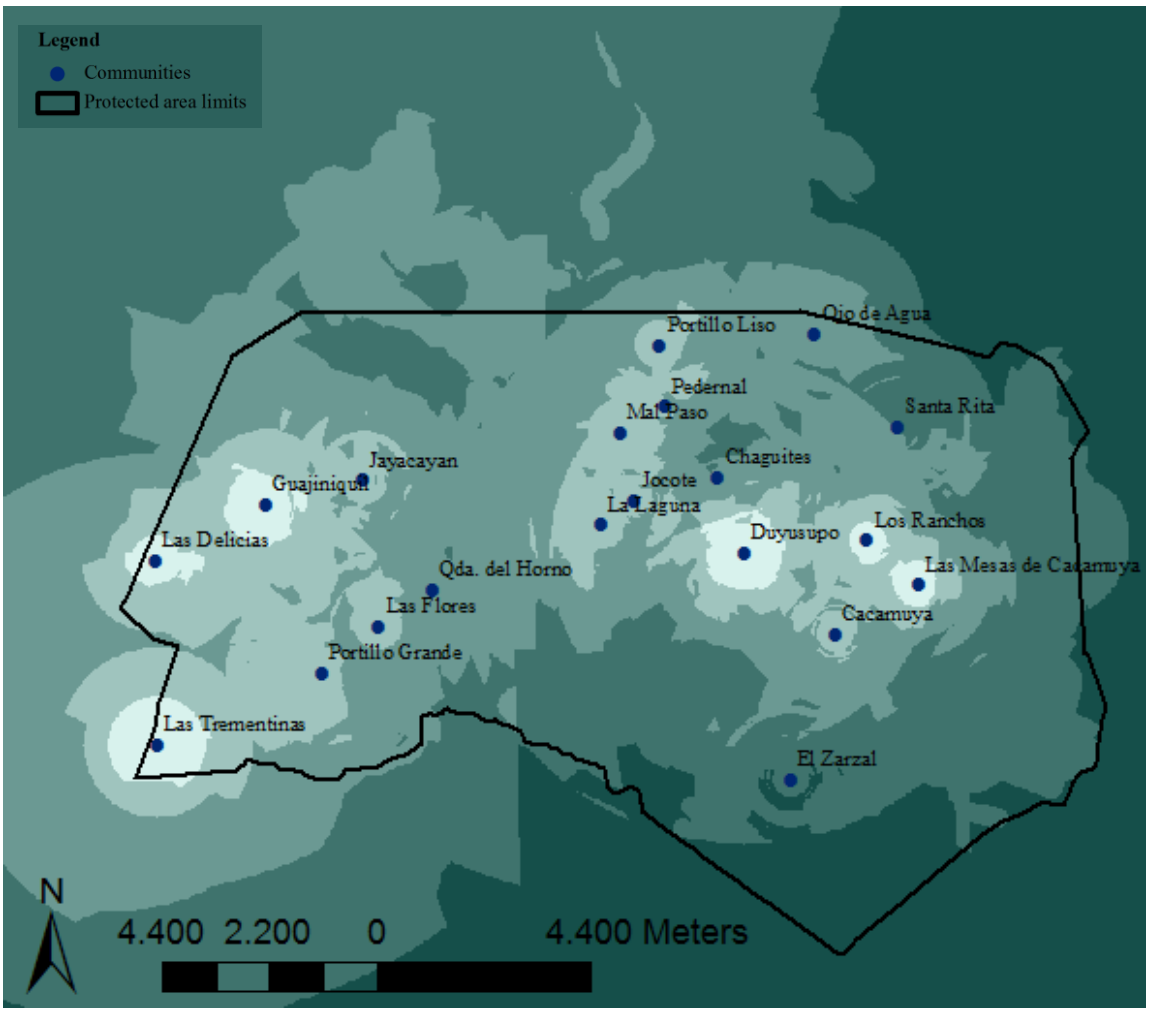


Figure 5.49 Final map identifying priority intervention areas (‘Classified’ property).

In particular the map using the ‘Classified’ property (Figure 5.49) is considered the conclusive map of this research. This map shows the level of priority intervention of the investigated area using the valuation scale (values from 1 to 5) applied in this research. In fact each value of the scale corresponds to a different tone of green. In this way is possible to classified the communities of ‘La Botija’ protected area based on the graphic representation of the valuation scale. The lighter parts corresponds to the less priority intervention areas. The darkest color identify the priority intervention areas. The communities that present the worse situation and need priority actions are ‘El Sarzal’ and ‘Santa Rita’. ‘Los Chaguites’, ‘Ojo de Agua’ and ‘Quebrada del Horno’ received a score of 3. The majority of the communities received the score of 2 (‘Portillo Liso’, ‘Las Flores’, ‘Jayacayan’, ‘Portillo Grande’, ‘El Pedernal’, ‘Mal Paso’, ‘El Jocote’, ‘La Laguna’ and ‘Cacamuya’. Finally the community that are in the best situation are ‘Las Trementinas’, ‘Las Delicias’, ‘Guajiniquil’, ‘Duyusupo’, ‘Los Ranchos’ and ‘Las Mesas de Cacamuya’. The classification of the communities by the scores is shown in the following table (Table 5.36).

Score	Communities
1	Las Trementinas, Las Delicias, Guajiniquil, Duyusupo, Los Ranchos, Las Mesas de Cacamuya
2	Portillo Liso, Las Flores, Jayacayan, Portillo Grande, El Pedernal, Mal Paso, El Jocote, La Laguna, Cacamuya,
3	Los Chaguites, Ojo de Agua, Quebrada del Horno
4	El Sarzal, Santa Rita
5	

Table 5.36 The classification of the communities of 'La Botija' protected area according to their level of intervention priority.

CHAPTER 6. CONCLUSIONS

The main aim of this thesis was the development of both the system analysis and the analysis model of the investigated area, i.e. 'La Botija' protected area. The analysis model proposed by this research integrates a specific participatory approach called 'Transition Management' with Geographic Information System (GIS) and multi-criteria analysis (MCA).

Before presenting the conclusion on the results of this research and in order to better understand them, a summary of the objectives and phases of the research, which have been already presented in details in Paragraph 1.4. and Paragraph 3.2, is given.

After the above mentioned summary, the results of both the system analysis and the analysis model are presented. The last part regards the future research challenges.

The system analysis aimed at investigating both the problems and the actors of the investigated area in accordance with both quantitative and qualitative data collected during the fieldwork.

The main purpose of the proposed analysis model consisted in the identification the priority intervention areas of 'La Botija' protected area. Additionally the development of the model aimed:

- to create suitability maps that characterize the territory elements of the investigated area;
- to promote an action by local citizens, public authorities and local stakeholders;
- to support decision making processes and to give advices to policy makers, public administrators and project managers.

The research thesis was based on the data collected during a fieldwork in 'La Botija' multiple-use protected area, San Marcos de Colón, Honduras (February-May 2014). The fieldwork permitted to develop two different typologies of data collection:

- Qualitative data collection: the conduction of 57 in-person semi-structured interviews, the participation in 14 meetings and public events, the participatory observation of the rural life of 13 rural communities of 'La Botija' protected area and the realization of 13 workshops with the local citizens of the protected area permitted to collect multiple qualitative data.
- Quantitative data collection: various typologies of quantitative data were provided by local institutes and organizations (e.g. demographic, social, infrastructural data, chemical analysis data, topographic maps of Honduras, etc.).

On the base of collected data, an elaboration of geographical data of 'La Botija' protected area using of Geographic Information System (GIS) was performed. These elaborations permitted a first analysis of the territory elements of the investigated area (e.g. roads, bus road, rivers, schools, etc.). After that, there was a further phase regarding the analysis of both qualitative and quantitative data.

- Qualitative data analysis: in total 20 reports of the investigated communities were developed and provided to each community and analyzed.
- Quantitative data analysis: information referring to different factors were

The result of the integration between qualitative and quantitative data analysis consisted in the System Analysis including the problems analysis and the actors analysis.

During the last stage of the thesis was developed the analysis model that followed three different stages:

a) The development of the multi-criteria analysis (MCA) framework.
b) The use of GIS to create 18 suitability maps by elaborating the previously analyzed qualitative and quantitative data .
c) The use of GIS to elaborate multi-criteria analysis with the aim to create 4 preference maps and a conclusive map able to identify the priority intervention areas of 'La Botija'.

The system analysis provided results about both the problems affecting the investigated area and the actors and organizations operating in the protected area.

The problem analysis revealed that the protected area is affected by several connected problems, as shown in the 'problems tree'. The main problems of the investigated area are the lack of infrastructures, the environmental contamination, the destruction of forests, the lack of employment and economic resources, the lack of motivation and self-confidence and the lack of cooperation.

In the first case, i.e. the lack of infrastructures, the main needs among the inhabitants are the creation or improvement of both water and sewer systems. The lack of a suitable water system was one of the most important needs expressed by the residents during both interviews and workshops.

The environmental contamination is brought about by several factors such as the lack of suitable waste treatments, produced both by inhabitants and livestock, the excessive use of chemical fertilizers, the lack of infrastructures, the low cultural level of citizens, the deforestation and fires. All these factors are causing the pollution of water, soil and aliments and consequently health diseases.

The deforestation and the fire are critical problems for the area because they have been getting worse over the years and they provoke the destruction of food crops and the soil erosion. The quality of soil is another serious problem in the area and it is caused not only by the forest destruction (through fires and deforestation) but also by the excessive use of chemical fertilizers by local farmers.

The water pollution by fecal coliforms was confirmed by the chemical analyses data provided by the Health Center of San Marcos de Colón. The water pollution by fecal coliforms is caused both by livestock waste and by the lack of suitable latrines in several houses of the investigated area. However, analysis and detection of chemical contaminants in the water were not made in the area and they would be fundamental to understand the level of water pollution by waste and chemical fertilizers.

Regarding the lack of employment and economic resources, these problems affect each community of the investigated area. The majority of families live on subsistence farming products or on the wages of temporary works during the coffee and corn harvest.

Additionally during the fieldwork it was possible to understand the low level of motivation, self-confidence and collaboration among the residents of the majority of the communities. In fact, in most of the cases, people needed to be motivated to action and change of practices as well as cooperation into the community.

Furthermore the level of knowledge about ecological practices (e.g. composting, organic agriculture, practices to prevent fires, etc.) is often low.

Anyway some communities are more organized than others and they present a higher collaboration and cooperation (e.g. Las Mesas de Cacamuya, Mal Paso, Las Trementinas and Guajiniquil and Las Flores).
The actor analysis showed the presence of several stakeholders, institutions and organizations working in the area, such as ICF (Institute for the Conservation of Forests), the Municipality of San Marcos de Colón, ODESA NGO, COCASAM cooperative, 'Red de Mujeres' association, Enrich the World NGO, APROBOSQUE association, etc. The main existing problems among these different organizations and stakeholders are the lack of communication, cooperation and sharing of information. These problems are especially relevant between the managers of the protected area (ODESA, Enrich the World, INADES, APROBOSQUE, Municipality of San Marcos de Colon, ICF).
The governmental institutions are characterized by several problems such as the inability/ unwillingness to support communities and residents (e.g. providing them with infrastructures), the corruption, the lack of organization, the lack of communication with other governmental institutions and organizations.
One chance for the investigated area consists in the 'Red de mujeres' association, since both the organizers and the participants of this association have shown an interest in increasing the cooperation and actions among the residents, as well as in achieving the sustainable development and the improvement of the quality of life into the communities. Anyway also in the case of this association, there are some problems that should be solved to achieve its goals for the future. The women of the association need a continuous motivation and inspiration by the organizers, and, at the same time, they need constant training on practical activities and theoretical issues.
A strategy that could be implemented by the 'Red de mujeres' association could be the improvement of communication and collaboration among the women both inside each community but especially between different communities. In fact in each community there are some active and motivated women that often cannot find cooperation from the other women of their community. The creation of contacts and collaborations between active women of different communities could represent an opportunity for the sustainable economic development of the area, creating, for example, microbusiness and improving self-confidence and motivation of residents.
Another potentiality of the area is represented by the presence of COCASAM cooperative. This cooperative sells organic coffee to foreign countries (especially USA and Germany) and represents an opportunity for the improvement of organic coffee production in the area.
Referring to the analysis model developed by this thesis, it integrates Geographic Information System (GIS), multi-criteria analysis (MCA) and participatory methods allowing the creation of 18 suitability maps of the attributes, 4 preferences maps of the criteria and a conclusive map that identifies the priority intervention areas of the investigated area. The quantitative and qualitative analyzed data and the maps developed by GIS were reclassified using a valuation scale with values ranging from 1 to 5 in order to allow the MCA calculations.
The 18 maps relating to the attributes allowed to classify the different rural communities of the investigated area based on their situation in accordance with the different territory elements and factors (attributes). This means that the creation of suitability maps has permitted to understand the conditions of each community relating to, for example, the

distance from schools and health centers, the quality of infrastructures (e.g. sewer system and water system, etc.), the level of motivation, the organic agriculture knowledge, etc.
Additionally the elaboration of MCA by GIS permitted to create 4 preference maps calculating the weighted sum of the attributes belonging to each criterion. These maps graphically represent the level of importance given to each attribute of each criterion through the pairwise comparison method. The classification into 5 values according to the valuation scale permitted to classify the communities depending on their situation at criterion level (i.e. infrastructures and communication, water, education, cooperation and knowledge criteria).
During the last phase of the research the conclusive map identifying the priority intervention areas of 'La Botija' protected area was created. This elaboration consisted in the weighted sum of all the criteria of the MCA structure. This final map reveals that the south-east part of 'La Botija' protected area represents a priority intervention area. In fact the graphic representation with different shades for each score of the valuation scale permitted to classify the communities of 'La Botija' based on their situation considering all the attributes of the hierarchical tree of MCA (e.g. presence of infrastructures; cultural, cooperation and education level, water quality, etc.). The communities that resulted in the worst situations and consequently need priority actions are 'El Sarzal' and 'Santa Rita'. The communities characterized by the best situations are 'Las Trementinas', 'Las Delicias', 'Guajiniquil', 'Duyusupo', 'Los Ranchos' and 'Las Mesas de Cacamuya'.

The model developed in this thesis has permitted to investigate the territory both focusing on one attribute (a territory element or factor) and looking at the whole system considering all the attributes of the multi-criteria analysis (MCA) framework.
The analysis of the maps relating to a specific attribute may provide very valuable information on the strategies to improve that particular factor considered as attribute. For example the study of the map referring the motivation, the cooperation and knowledge and the number of illiterates in the community can give an advice on which communities mostly need the development of workshops aiming at improving education, motivation and collaboration among the residents. In the case of the lack of infrastructures (e.g. sewer and water systems), the map could be used to identify which areas need a priority infrastructural project. This kind of evaluation can be developed for each attribute and for each area of 'La Botija' protected area.
The involvement of local residents through the Transition Management participatory approach permitted to support transformative change, action and empowerment of the residents of the investigated area. In fact the workshops developed during the fieldwork aimed to support the change of their practices, to improve their awareness about environmental and social issues and to motive them to collaboration and action. Furthermore the needs and wishes of residents analyzed in this thesis represent useful information for policy makers, public administrators and project managers that could develop projects closer to demands and desires of local residents.
For the above described reasons, the analysis model developed by this thesis represents a useful tool to support the development of strategies and actions by local policy makers and project managers.

To conclude, the analyses developed by this thesis, consisting in the system analysis and the analysis model, although carried out in a relatively short time and with few human resources (see Paragraph 3.2.4.1.2.), is in our opinion able to support sustainable development policies and can be used for discussions and decision making processes.
The present thesis has shown that there are several research challenges that could be developed in the future.

- Creation of suitability maps using Ortho photos to compare with the maps created in this thesis from a topographic map.
- Development of a Digital Terrain Model (DTM) or Digital Elevation Model (DEM) to analyze the altimetry of 'La Botija' protected area. The creation of a DTM is also fundamental for the calculation of the real distance travelled and the time spent on the journey. This typology of distance is more precise in comparison to the Euclidean distance used in this study.
- Organization of a meeting with local actors and residents of the investigated area in order to elaborate another pairwise comparison between the criteria and attributes, which would be able to take into account the local stakeholders thoughts and visions. In fact, in this thesis the pairwise comparison between criteria and attributes was elaborated directly by the author without the participation of local stakeholders, due to the lack of time and resources.

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Appendices

Appendix A. Interview guidelines

GOVERNANCE LEVEL & ASSOCIATED ACTIVITIES (POLICY MAKERS)		
Operational includes implementing and managing policy action plans, explaining roles, capacities and assets	1.	What are the **existing policy action plans** for 'La Botija' protected area?
	2.	What is the **existing policy** for for 'La Botija' protected area ?
	3.	What are your **role** and **responsibilities**?
	4.	What is your **capacity** (in managing) regarding 'La Botija' protected area ? * capacity means: knowledge, skills, expertise, time, money, network, management, people
	5.	Who (else) is **responsible for managing** 'La Botija' protected area ?
Tactical includes designing steering activities, programs, funding, establishment of networks and/or partnerships	6.	With whom do you **cooperate (work with)** for managing 'La Botija' protected area ?
	7.	What are the **existing programs and projects** for 'La Botija' protected area ?
	8.	Are there existing **funding mechanisms/structures** for managing/operating 'La Botija' protected area? If so what are they?
	9.	Are there existing **networks** between **governmental organizations/departments** for managing (or contributing to) urban agriculture features/ local food initiatives in your city?
	10.	Are there existing **networks** of **NGOs, communities** for managing urban agriculture features/ local food initiatives in your city?
	11.	Are there existing **networks/organization** of **corporate/businesses** for managing (or contributing to) urban agriculture features/ local food initiatives in your city?
Vision includes the perception of change agents and bottom-up initiatives	12.	Which are you **visions** about the future of 'La Botija' protected area?

Reflexive includes monitoring, assessing and evaluating existing policies and assets and their interaction with change agents	13.	What do you consider the biggest **challenge** in improving 'La Botija' protected area and support its sustainable development? ** obstacle or missing condition(s)
	14.	What do you consider the biggest **problems and needs** of 'La Botija' protected area and its communities? • Are there community in a worst situation than others?
	15.	What do you consider the biggest **opportunities** in improving 'La Botija' protected area and support its sustainable development ?
	16.	What is your view/opinion about **the way policy/programs/projects** work in 'La Botija' protected area?
Strategic includes setting long-term goals, policy development, planning, vision, values, identity, culture of the city	17.	What **actions** can be developed in 'La Botija' protected area?
	18.	What are the **activities/projects that would help** the sustainable development of 'La Botija' protected area?
	19.	What do you think are the **future opportunities** for the sustainable development of 'La Botija' protected area?
	20.	What are the main **resources** that are important for the sustainable development of 'La Botija' protected area and its communities? ****resources means: people, space, funds, collaborations
	21.	What are the **actors/organizations/governmental agencies that you suggest us to contact** and why?
	22.	Is there anything else you think it would be helpful for me to know about 'La Botija' protected area ?

APPENDIX B Interviews

The following tables specifies all the interviews conducted in this research. The interviews are divided by typology: individual and collective interviews. For each interviews are specified the date, the place, the position and the gender of the interviewee.

B.1 Individual interviews

Number	Date	Place	Position Interviewee	Gender
1	05/02/14	Community of El Zarai (close to Las Moras) one of the two houses (Los Chaguites)	Farmer	Male
2	05/02/14	Community of El Zarai (close to Las Moras) one of the two houses (Los Chaguites)	Farmer	Male
3	06/02/14	Community of 'Las Moras' (Los Chaguites)	Farmer	Male
4	06/02/14	Community of 'Las Moras' (Los Chaguites)	Farmer	Male
5	06/02/14	Community of 'Las Moras' (Los Chaguites)	Farmer	Male
6	09/02/14	El Jocote	Farmer	Male
7	11/02/14	Cucumuya	Teacher	Male
8	11/02/14	Cucumuya	'Patronato' Secretary	Male
9	11/02/14	Duyusupo	Teacher	Male
10	11/02/14	Los Ranchos	Teacher	Female
11	11/02/14	Los Ranchos	'Patronato' President	Female
12	11/02/14	Los Ranchos	Worker of PMA	Female
13	11/02/14	Las Mesas	Farmer	Female
14	11/02/14	Las Mesas	Grocery store worker	Female
15	11/02/14	Las Mesas	'Patronato' President	Male
16	11/02/14	Santa Rita	Teacher	Female
17	11/02/14	Santa Rita	'Patronato' President	Male
18	13/02/14	Portillo Liso	Teacher	Female
19	13/02/14	Portillo Liso	'Patronato' Vice-President	Male

20	14/02/14	Event on Nutrition	'El Jocote' 'Patronato' President	Male
21	14/02/14	Event on Nutrition	ODESA NGO President	Male
22	17/02/14	El Jocote	School Director	Female
23	18/02/14	Las Flores (El Sarzal)	Teacher	Female
24	18/02/14	Las Flores	'Patronato' President	Male
25	18/02/14	Portillo Grande	Teacher	Male
26	20/02/14	San Marcos de Colon	President of the Women office of San Marcos de Colon	Female
27	20/02/14	San Marcos de Colon	Ulda	Female
28	25/02/14	Duyusupo	Farmer	Male
29	09/02/14 25/02/14	El Jocote	Farmer, inside 'ICARO' cooperative	Male
30	26/02/14	San Marcos de Colon	Worker at nutrition program of Health Center	Male
31	27/02/14	San Marcos de Colon	COCASAM Erente de Cocasam	Male
32	27/02/14	San Marcos de Colon	Vice-Alcalde Municipal	Male
33	12/03/14	Las Delicias	Maestra	Female
34	12/03/14	Las Delicias	Preside school	Male
35	17/03/14	San Marcos de Colon	ICF officer (Ridoniel)	Male
36	2/04/14	Choluteca	ICF Regional Office interviews to an officer	Male

37	2/04/14	Choluteca	ICF Regional Office interviews to Armando	Male
38	3/04/14	El Jocote	President of APROBOSQUE	Male
39	4/04/14	La Laguna	Teacher	Female
40	4/04/14	El Jocote	'Enrich The World' officer	Male
41	7/04/14	El Jocote	Resident	Female
42	10/04/14	El Jocote	Resident	Female
43	10/04/14	El Jocote	Resident	Female
44	10/04/14	El Jocote	Resident	Male
45	13/04/14	El Jocote	Resident	Male
46	13/04/14	El Jocote	Resident	Male

B.2 Collective interviews

Number	Date	Area	Position Interviewee	Number of Interviewees
1	14/02/14	Event on Nutrition	Community of Santa Rita (group interview)	3 women
2	14/02/14	Event on Nutrition	Community of Guanijiquil (group interview)	4 women
3	14/02/14	Event on Nutrition	Community of Mal Paso	4 women
4	14/02/14	Event on Nutrition	Community of Las Trementinas	3 women
5	14/02/14	Event on Nutrition	Community of El Jocote	2 women
6	17/02/14	El Jocote	2 teacher of the school	2 women
7	17/02/14	El Jocote	2 women of the community	2 women
8	18/02/14	Jayacayan	Preside of the school and three men of the community	4 men
9	19/02/14	Los Chaguites	Focus group with the women of the community	13 women
10	24/02/14	Duyusupo	Health Center Doctor and two nurses	3 women
11	26/02/14	San Marcos de Colon	2 workers UMA Unidad Medioambiental Municipal	2 men
12	27/02/14	San Marcos de Colon	President and two workers DISTRITAL Education Department	3 women
13	13/03/14	Different communities of San Marcos de Colon (Ojo de agua, etc.)	Eolic project of Terra, interview to two ingeneers of the project	1 men and 1 woman
14	1/04/14	San Marcos de Colon	Interview to Doctor and Project manager of Health Center of San Marcos de Colon	2 women

Riassunto in Italiano (Summary in Italian)

Lo sviluppo sostenibile è attualmente riconosciuto come una possibile base per la risoluzione di problemi complessi, come la sovrappopolazione, la scarsità d'acqua, la povertà, il cambiamento climatico, o la perdita di biodiversità. Questi problemi si verificano in diversi sistemi naturali e socio-economici caratterizzati da molteplici elementi (Folke, C., et al, 2002;. Pearce, D., 1988; Zaman, G. & Goshin, Z., 2010). Il miglioramento di tali sistemi e l'incremento della loro sostenibilità richiede l'analisi approfondita dell'insieme di fattori che li costituiscono. Infatti la valutazione di tutti i diversi elementi territoriali deve fare riferimento alle analisi delle interazioni sociali, economiche, culturali ed ambientali, nonché dei processi di 'governance' e degli specifici interessi ed opportunità di stakeholders e residenti locali (Olazabal, M. et al., 2007). In altre parole lo sviluppo di decisioni adeguate è possibile solo attraverso l'analisi e la considerazione simultanea ed olistica dell'intero sistema complesso. Pertanto, l'attuazione di azioni e strategie specifiche dovrebbe essere proceduto da ricerche ed indagini tecniche adeguate. In relazione a queste ultime, gli strumenti di analisi e pianificazione territoriale devono avere la capacità di integrare gli aspetti legati alla sostenibilità (fattori ambientali, sociali, economici, ecc.) e, allo stesso tempo, fornire utili informazioni per lo sviluppo di determinate strategie e azioni. Per tutti i motivi sopra descritti, l'utilizzo di metodologie GIS e analisi multi-criterio (AMC), integrati con approcci partecipativi dei cittadini, sono considerati strumenti di analisi adatti alla valutazione dei molteplici elementi territoriali (Graymore, M. et al. 2007; Greene, R., et al, 2011;.. Mohamed, A. et al, 2006). Inoltre l'uso di modelli che integrano sistemi GIS, AMC e approcci partecipativi sono in grado di fornire un supporto alla definizione di strategie ed azioni innovative. In particolare, il coinvolgimento, con forme di partecipazione, dell'insieme degli attori territoriali contribuisce alla corretta gestione del territorio e al successo dei progetti (Alshuwaikhat, H. & Aina, Y. 2006; Gerrit J. & Ligtenberg, A. 2007; Jankowski, P., & Richard, L., 1994; Kamal A. & Rashed-Ali H., 2013; Malczewski J. 2006; McCall, MK & Minang PA, 2005).

Il caso studio della presente tesi è l'area protetta di uso multiple de 'La Botija', situato nel comune di San Marcos de Colón, nella parte sud-est di Honduras, al confine con il Nicaragua. L'area indagata è caratterizzata da problemi complessi di natura sociale, ambientale ed economica (ad esempio l'inquinamento delle acque, la scarsità di risorse economiche, la mancanza di infrastrutture, l'assenza di cooperazione e di motivazione dei residenti locali, ecc.).

La seguente ricerca si propone di sviluppare un modello di analisi territoriale che integra metodologie GIS, analisi multicriterio (AMC) ed uno specifico processo di pianificazione partecipativa strategica. L'utilizzo integrato di tali differenti metodi è volto ad analizzare i molteplici elementi e problemi della zona analizzata. L'obiettivo principale del modello di analisi proposto è quello di individuare le aree di intervento prioritarie dell'area protetta de 'La Botija', analizzando contemporaneamente sia i dati quantitativi nonché qualitativi raccolti durante la ricerca sul campo di tre mesi.

La finalità della tesi consiste nel supportare i processi decisionali e offrire una guida direzionale ai decisori politici, agli amministratori pubblici ed ai responsabili di progetti. Infatti, il modello di analisi proposto rappresenta un sistema di supporto decisionale (DSS)

utile per la concretizzazione di strategie ed azioni utili allo sviluppo sostenibile ed al miglioramento della zona. Grazie al modello di analisi sviluppato i decisori pubblici ed i manager di progetti potranno comprendere quali aree della zona in esame necessitano di interventi prioritari. Il modello permette di analizzare l'area protetta sia a livello generale, indagando l'intera zona, sia a livello specifico, esaminando le comunità rurali. Il modello ha permesso di realizzare sia diciotto mappe incentrate su temi specifici (es. il sistema idrico, il sistema fognario, la densità di scuole, i trattamenti idrici, ecc.), sia una mappa conclusiva che, tramite l'analisi multi-criteri (AMC), analizza complessivamente l'insieme degli elementi territoriali indagati.

L'approccio partecipativo specifico utilizzato in questa ricerca è definito come un 'processo di pianificazione strategica per la pianificazione trasformativa' ed è stato sviluppato dall'Istituto DRIFT (The Dutch Research Institute for Transitions) dell' Università Erasmus di Rotterdam (Paesi Bassi) e dal Monash Water for Liveability Institute dell'Università Monash di Melbourne (Australia). Il coinvolgimento dei residenti locali attraverso l'utilizzo di tale metodo partecipativo rappresenta una chiave fondamentale della tesi. L'utilizzo di questo specifico approccio mira a promuovere il coinvolgimento dei cittadini delle comunità rurali nel processo decisionale e nello sviluppo di azioni. Infatti i cittadini locali sono supportati sia a modificare determinate pratiche a livello individuale e comunitario sia a migliorare la loro consapevolezza su temi ambientali e sociali. Inoltre, l'analisi delle esigenze e delle visioni dei cittadini potrebbero essere presi in considerazione da responsabili politici e amministratori locali per lo sviluppo di progetti più vicini ai loro bisogni, desideri ed interessi.

L'approccio metodologico della presente ricerca può essere suddiviso in diversi passaggi. In una prima fase (aprile-dicembre 2013), il ricercatore ha appreso metodologie di approccio partecipativo e il metodo chiamato 'Transition Management' durante un tirocinio presso l'Istituto di ricerca DRIFT (The Dutch Research Institute for Transitions) dell' Università Erasmus di Rotterdam (Paesi Bassi). In una seconda fase la ricerca si è focalizzata sulla revisione della letteratura scientifica e la formulazione degli obiettivi della ricerca e del caso studio (dicembre 2013-gennaio 2014). In una fase successiva è stata definita la struttura sia delle interviste sia dei workshops (gennaio 2014). Da febbraio a maggio 2014 il ricercatore ha condotto la ricerca sul campo nella zona protetta de 'La Botija' (Honduras). Durante questo periodo sono stati raccolti i dati qualitativi e quantitativi. In particolare, la raccolta dei dati qualitativi è stata possibile in seguito alla realizzazione di cinquantasette interviste semi-strutturate, la partecipazione a quattordici riunioni ed eventi locali e l'osservazione partecipata della vita rurale di tredici comunità rurali dell'area protetta de 'La Botija'. Inoltre il ricercatore ha organizzato e realizzato tredici workshops con i cittadini dell'area protetta. Questi workshops erano finalizzati a raccogliere dati qualitativi e, al tempo stesso, a promuovere l'azione e la responsabilizzazione dei cittadini locali riguardo a temi di sostenibilità e sviluppo ambientale e sociale. Durante il periodo di ricerca in situ, sono state elaborate mappe relative agli elementi territoriali dell'area indagata tramite l'uso dei Sistemi Informativi Geografici (GIS). Nello specifico è stato creato un progetto tramite 'ESRI ArcGIS' per realizzare mappe che analizzano nello specifico molteplici elementi del territorio analizzato (ad esempio le comunità, i fiumi, le strade, le linee di autobus, le scuole, i centri sanitari, ecc.). In una fase successiva sono stati analizzati sia i dati quantitativi che qualitativi precedentemente raccolti. Tutte le informazioni registrate e scritte sono state analizzate e trascritte in lingua spagnola. In

totale sono state realizzate dodici relazioni in lingua spagnola delle comunità indagate che sono state messe a disposizione di ogni comunità. Successivamente, le relazioni sono state tradotte dallo spagnolo all'inglese e analizzate nello specifico. L'ultima fase della ricerca ha riguardato la costruzione del modello di analisi (maggio-giugno 2014). Lo sviluppo del modello può essere suddiviso in ulteriori tre fasi: (a) costruzione della struttura dell'analisi multicriteri (AMC), (b) analisi dei dati sia qualitativi che quantitativi attraverso il modello e costruzione di diciotto mappe, (c) elaborazione dall'analisi multi-criteri (AMC) tramite GIS e definizione delle aree prioritarie di intervento. Nella prima fase sono stati definiti gli elementi della struttura gerarchica dell'AMC: l'obiettivo, sette criteri e diciotto attributi. Il metodo 'Analytical Hierarchy Process' (AHP) è stato utilizzato come metodo di ponderazione dei molteplici criteri ed attributi. Nella seconda fase i dati qualitativi e quantitativi precedentemente analizzati sono stati inseriti nel modello di analisi e sono stati create diciotto mappe tramite GIS. Nella terza fase l'analisi multicriteri (AMC) è stata elaborata tramite GIS e sono state create sia quattro mappe intermedie di analisi degli attributi di quattro criteri, sia una mappa finale che individua le aree a priorità di intervento.

In conclusione, la presente tesi ha sviluppato un modello di analisi integrando analisi GIS, analisi multicriteri (AMC) e metodi partecipativi. La creazione della mappa conclusiva rivela che la parte sud-est dell' area protetta de 'La Botija' rappresenta l'area a priorità di intervento. Inoltre le mappe inerenti gli specifici elementi territoriali, forniscono un'analisi approfondita delle principali problematiche ed esigenze dell'area indagata. In questo modo, il modello di analisi rappresenta uno strumento di informazioni utili all'elaborazione di strategie ed azioni di pianificazione e allo sviluppo sostenibile del territorio.

La seguente ricerca rivela quanto sia auspicabile, in futuro, promuovere lo sviluppo di una serie di ricerche ed approfondimenti correlati alla ricerca. Nell'ordine potrebbero essere create mappe a partire da ortofoto, e, successivamente, essere confrontate con le mappe del presente lavoro, realizzate con alla base una mappa topografica. In secondo luogo potrebbe essere sviluppato un modello digitale del terreno (DTM) per analizzare l'altimetria della zona protetta de 'La Botija'. La creazione di un DTM è fondamentale anche per il calcolo dei tempi reali di percorrenza delle vie di comunicazione della zona indagata. Infine, il processo di pesatura dei criteri e degli attributi è stato elaborato direttamente dall'autore senza il coinvolgimento degli attori locali. Per questo motivo, a posteriori, potrebbe essere utile organizzare un incontro e far elaborare la pesatura degli elementi dell'AMC tramite il coinvolgimento dei molteplici attori, stakeholders e residenti locali.

Riguardo alla strutturazione della presente tesi, questa è composta da sei capitoli ed è articolata come segue. Il primo capitolo presenta il contesto teorico della ricerca, concentrandosi sull'uso di specifici metodi di pianificazione territoriale che integrano l'uso di GIS, analisi multi-criteri (AMC) e di tipo partecipativo nei paesi in via di sviluppo e introduce gli obiettivi della ricerca. Il secondo capitolo descrive l'approccio metodologico. Il terzo capitolo definisce il contesto del caso studio. Il quarto capitolo consiste nell'analisi qualitativa e quantitativa dei dati raccolti. Il quinto capitolo presenta il modello di analisi: una prima parte illustra la struttura dell'analisi multi-criteri (AMC), una seconda parte descrive le mappe elaborate tramite il modello e l'ultima sezione illustra le mappe costruite tramite l'utilizzo integrato di analisi multi-criteri (AMC) e GIS. Il sesto capitolo fornisce le conclusioni della

tesi sulla base della discussione dei risultati della ricerca, comprendendo anche le riflessioni critiche della ricerca, le possibili ricerche e gli approfondimenti da sviluppare in futuro.

Parole chiave: Sviluppo sostenibile, GIS, Analisi multi-criteri (AMC), AHP, Pianificazione territoriale, Approcci Partecipativi, Sistemi di Supporto Decisionale (DSS), Honduras.