

Sustainability Analysis of malaria control policy at the municipality of El Bagre, Colombia: A Case Study

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Abstract

This study aimed to analyze the sustainability of the malaria control policy in El Bagre during 2011. An exploratory mix-methods research *QUAL*→*quan* was made. 14 interviews and a documentary research were carried out in order to identify social-ecological processes related to malaria dynamics. This study found that processes such as mining, migrations, social practices and cultural beliefs, armed conflict, and climatic variations were related to the disease behavior, and that the policy structure revealed a scarce capacity of actors to adapt control actions to such processes. Even though the malaria control policy has been effective, this is scarcely sustainable.

Keywords

Sustainable development, Public Policies, Malaria, Theoretical model, Systems Analysis

1. Introduction

Public health policies - PHP - are social control mechanisms used by systems of actors. These are expressed through their rules of actions and define ways to deal with health matters of public interest. Their aims are not always explicit neither benefits the whole society (Gómez-Arias, 2012). Usually PHP are influenced by complex networks of interactions that affect their results (Walt et al., 2008) and their possibility to accomplish objectives in relation to determined health issue.

A PHP is considered sustainable when the system of actors is able to adapt its set of rules and control mechanisms accordingly to the complex dynamics of the social-ecological environment, while keep the fulfillment of the original purposes in the policy (Salas-Zapata, 2012:115). Thus, when a policy becomes unsustainable there are risks of squandering public resources, deterioration of trust by the communities, lack of maintenance of health benefits and, in general, failure on the achievement of the objectives targeted by the public policy.

Regarding malaria control policies - MCP -, malaria and the need to keep it under control constitute a public health problem. In this context, it has been shown how MCP may be affected by social-ecological dynamics such as deforestation, migrations, sanitary reforms, poverty, climate change, as well as by the results of other social-environmental projects, among other factors (Carmona-Fonseca, 2003; Jiménez et al., 2007; Pattanayak et al., 2006; Poveda and Rojas, 1997). In that order of ideas, a MCP is sustainable when the system of actors is able to adapt its rules and control mechanisms in response to the social-ecological processes or dynamics related with malaria, in order to guarantee the policy objectives in terms of disease control. (Salas-Zapata, 2012:126).

In Colombia, the Bajo Cauca in Antioquia has been one of the most affected regions by malaria (Carmona-Fonseca, 2003). In the same region, the municipality of El Bagre is a territory that extends in an area of 1.653 Km² and which has a population of 47.875 inhabitants (DANE, 2012). It is a tropical rain forest area, at 50 m.a.s.l and with an average annual temperature of 26,8°C (Vargas et al., 2009). Such conditions are favorable for the transmission of the disease and this is evidenced through the high disease occurrence reported by the municipality. (SSSA, 2013). Thus, since the characteristics of the region represent difficulty for any public policy to accomplish effectiveness, this study aims to analyze the sustainability of the MCP observed during 2011.

2. Methods

- Theoretical model and type of study

A theoretical model developed by Salas-Zapata (2012) was used in this study as a means to analyze sustainability in a PHP. Such model assumes sustainability as the social-ecological resilience of systems and, in this case, the system that is the object of our analysis is the MCP in EL Bagre. The model served as a guide for both collection and analysis of information. (Figure 1)

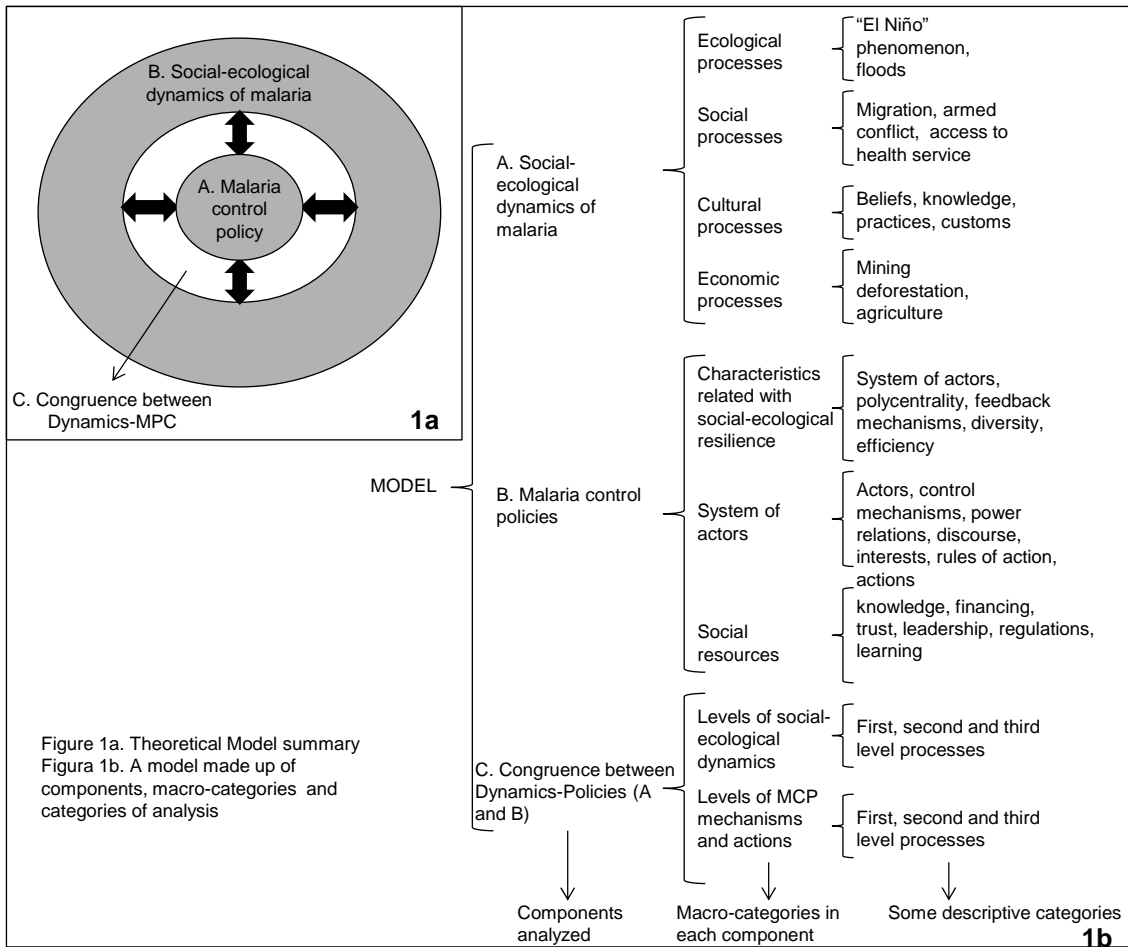


Figure 1. Sustainability analysis model for MCP (Salas-Zapata, 2012). This model is based in the concept of social-ecological resilience of systems, which is defined as the capacity a system has to adapt its set of social-ecological interactions to deal with disturbances that may alter its essential attributes. In this case, such disturbances refer to social and ecological processes that affect behavior of malaria and control in a locality, and the system is constituted by the MCP, while malaria control is assumed as an essential attribute. In this order of ideas, the model proposes the analysis of three components: the social-ecological dynamics of malaria and its control (Component A), the malaria control policy (Component B); and the Congruence between the MCP and the dynamics of the disease (Component C). Regarding this last component, one assumption here is that the more congruence between rules of action and social-ecological processes; there is more adaptive capacity in a policy. For this reason, components A and B direct both information collection and analysis, whereas component C directs only information analysis. For analyzing each component, it is necessary to account for certain macro-categories which, in turn, may be studied through the description of some emerging categories. Therefore, all categories referred in Figure 1 will not necessarily emerge.

This exploratory research used a mixed method design *QUAL* → *cuan* (Figure 2). A document review and interviews were simultaneously carried out for collecting information of components A and B. After identifying social-ecological dynamics by these methods, the relation among them and the behavior of malaria was established through statistical tests. In order to analyze these relations, Pearson correlations and cross correlation (Component A) were made. The description of MCP was also made by these methods (Component B), but in this case the results were triangulated with informants. The results obtained on both components were employed in the analysis of Component C.

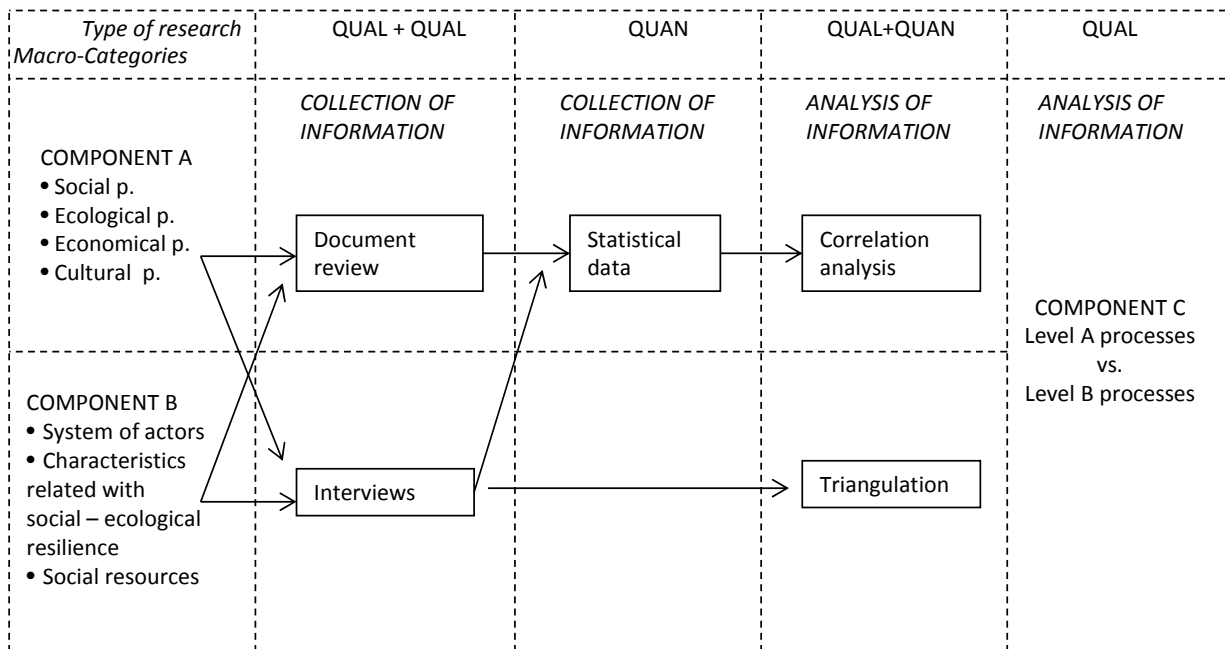


Figure 2. Methods.

- Collection and analysis of information

Regarding the interviews, the selection of key informants was carried out under the criteria “making part of the malaria control process in El Bagre”. The individuals under such criteria were identified through snowball sampling. The fourteen individuals interviewed make part of organizations as the Regional Health Secretary Office of Antioquia, the Municipal Health Secretary Office of El Bagre and the Pan American Health Organization, Microbiologists, Microscopists and people hired through the Universidad de Antioquia Foundation, currently performing control actions. Each participant was a part of an open interview with questions focused on three core elements: (i) their participation and relation with activities and processes related with control of malaria in the municipality, (ii) their knowledge and perception of MCP structure, actors and functioning, and (iii) their knowledge and perception regarding behavior of malaria in the region and social and ecological aspects in the municipality that affect its control. These three topics were explored for the time period between 1991 and 2010 approximately.

Articles from scientific journals, as well as manuscripts, press releases and reports owned by Governmental and Non-Governmental Organizations that dealt with the issue of malaria and its control in the municipality of El Bagre were reviewed in the document review stage.

The testimonies from the interviews were recorded and transcribed to Word documents. Next, the texts were organized according to the macro categories in components A and B. Once categorized, the identification of tendencies in the informant’s discourse was carried out in order to reveal emerging categories. Similarly, the content of the documents was selected in accordance to the macro-categories and categorized in accordance to A and B components.

The categories established through the interviews and the document review allowed the identification of social and ecological processes related with malaria and its control. The findings were also statistically analyzed to guarantee its validity. In particular, descriptive statistics, together with correlation and cross correlation analysis were performed by means of free R-software.

Similarly, the description of the system of actors, as well as the characteristics related with social-ecological resilience and the social resources on which the MCP depends was accomplished on the basis of the categories revealed by the interviews and the document review. Such MCP description was registered in a document and, for improving validity of findings, a triangulation was made with the participants who had better knowledge of the MCP and behavior of the malaria.

Once the results of the components A and B were gathered, the component C was analyzed by examining the congruence between A and B. Such analysis was performed through the classification of the social and ecological dynamics of malaria in three levels, as follows: (1) social and ecological processes with a direct effect on the possibilities of malaria occurrence –*first level processes*–, (2) those affecting the first level described, (3) and those affecting the second ones. Rules of action and control mechanisms were also organized in three levels in order to observe to what extent these rules and mechanisms match each one of the processes associated with malaria.

3. Results

3.1. Component A: Social-ecological dynamics related to malaria in El Bagre

Overall, at El Bagre it was found that mining, migration, cultural practices and beliefs, the armed conflict and climate changes are processes related to the existence of the disease in the locality.

- Malaria and mining

Interviews suggest that malaria's behavior in the town is related to mining. Interviewees said that *“the miners and the people who live closer to the mines are the ones that get malaria the most”* (E3) and that the increase of malaria cases began when mining boom started. They mention that *“some years ago there were many cases of malaria as well, but there were not as much as there are now that there is a mining boom. There are too many cases”* (E1). This relation between malaria and mining in the region is supported by interviewees when they say that during mining development, excavators create galleries that fill with water and become breeding grounds for mosquitoes. However, they also mention that these machines leave huge holes in their way that seem to be better breeding ground places for the *Anopheles*, because there the pools that form are covered by plenty of vegetation and organic matter.

After reviewing malaria cases that took place between January 1st and December 5th, 2011, near 30% of the 7705 cases reported occurred among population that work in mining (Figure 3). It is important to point out that, according to people interviewed, most affected miners are those dedicated to small, informal and illegal mining. In fact, this disease is very rare among the workers of Mineros S.A which is a large mineral mining industry.

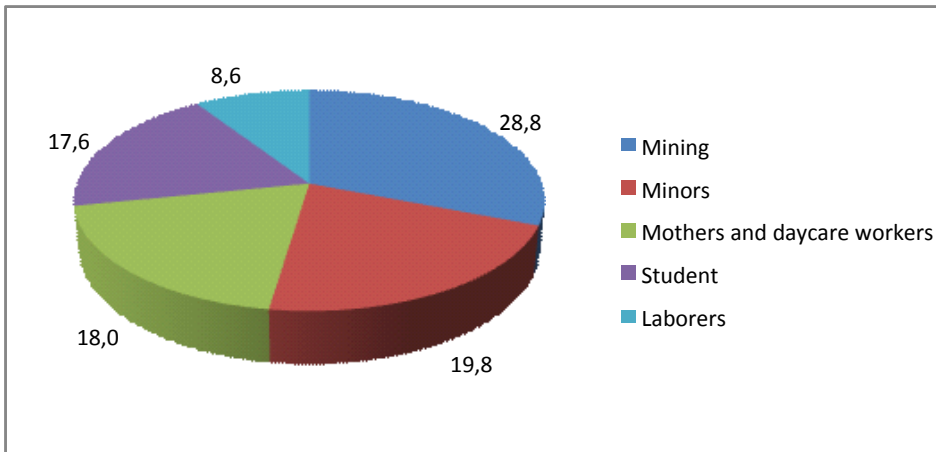


Figure 3. Percentage distribution (%) of malaria cases according to the 5 most frequent occupations at El Bagre (Antioquia) during 2011. These 5 occupations represent the 92,8% of all cases reported. This is why percentages in the graphic do not equal 100% but 92,8%. The database also suggest that these cases usually take place in areas where there is mining, such as Guamocó, Puerto López, and San Cayetano, as well as the west of town. Source: Database provided by the Municipal Health Secretary of El Bagre.

To establish a statistical relationship between malaria and mining, we took the assumption that the amount of money they get paid for gold is the incentive for people to go inside the jungle to find it. This is why the relationship between the international price of the gold ounce and the cases of malaria between 2000 and 2010 was analyzed (Figure 4). Through a Pearson correlation, we found a positive correlation between both variables (0.73). Also, Figure 4 shows similar trends in both variables, except for two points (2007 and 2010) where reductions in the number of malaria cases can be attributed to changes made in the strategies of control.

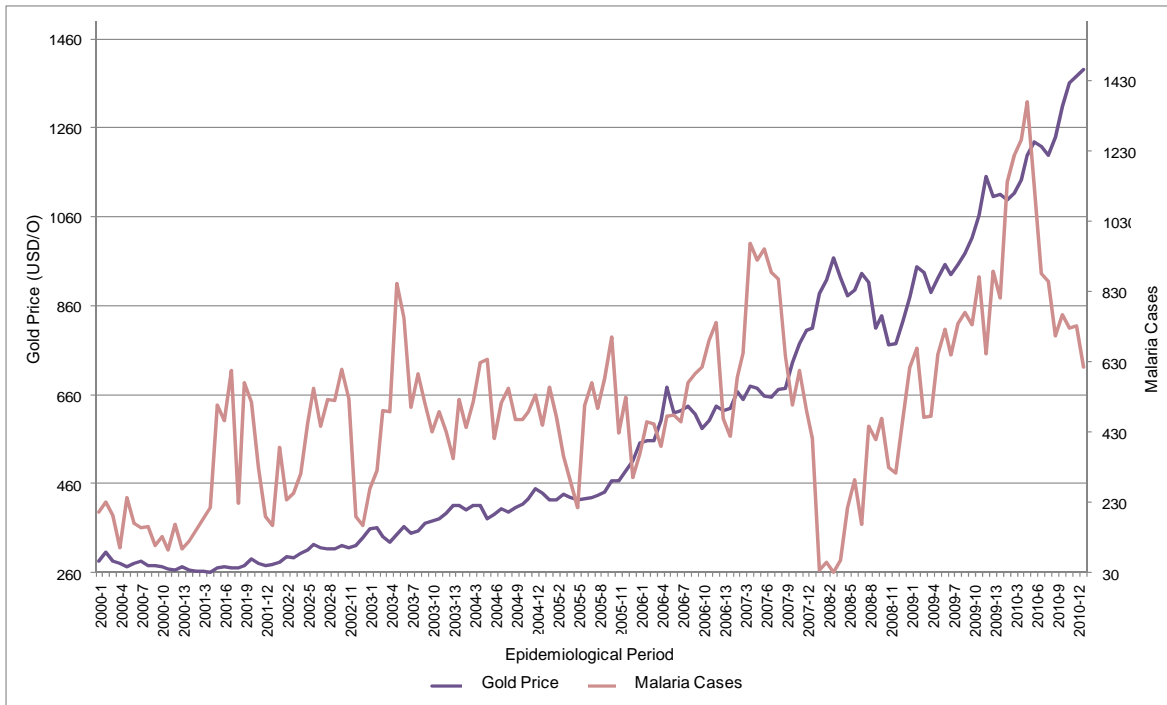


Figure 4. Dynamic of gold price and malaria cases. Source: malaria data was provided by the Regional Health Secretary Office of Antioquia, and the data on gold prices were obtained from the Kitco website (<http://charts.kitco.com/KitcoCharts/>). The data on malaria cases was organized by epidemiological periods (13 per year), and the gold price was estimated by the same periods. The data was taken from January 1st, 2000 to December 31st, 2010, in which 143 epidemiological periods took place. The analysis was made with a confidence interval of 95%, and a p-Value of <2.2e-16

- Malaria and migrations, practices and beliefs

From the interviews it is inferred that migration restricts malaria control and this, in turn, is related to mining activities in the region. *“Mining exists in most of communities...”*. Social participation is most difficult in these areas because miners... *establish in the jungle for a certain time*” and then they go in more and more, *“...and there is not a sense of belonging”* (E-5). Mining population *“is very floating. They stay three or four months, and then leave”* (E5), and they do not participate. One sentence that sums up the idiosyncrasy of miners (informal, small, illegal) may be *“I came to get some money at the mine, and when I get it I’ll leave”* (E5). It is very difficult to control malaria in this type of population because *“you give a mosquito net to a person, and tomorrow that person is gone”* (E-4). The high mobility of the population makes it more difficult for malaria to be controlled. This is why migration can be related to the persistence of the disease.

There may be villages around the exploitation areas, both permanent and temporary, that are built and inhabited while the mine is active. *“There are villages that are not dedicated to mining, but live from it in an indirect way...those who have restaurants or sell beer. There are groups of 30, 40, 50 houses. As they are strongly associated to mining, there are permanent groups of 40, 50 houses. However, there are others that depend on whether there is mining exploitation at the time. Then they build their shacks of plastic, but by the end of next month, or six months later they are gone”* (E-9). The fact that the population changes all the time also hinder maintenance of educational programs and it also makes it

difficult for these programs to teach and generate cultural changes in the population that help control the disease.

Interviewees also mentioned that it is common for people to believe that malaria is transmitted by “*washing with river water*” (E-3), or by drinking dirty water, but they do not associate getting the disease with the time of the day at which they wash in the river. This population, which usually works in country areas, takes a bath around 4 and 5 pm in the afternoon, around the time the mosquito bites. This suggests why people’s beliefs expose them to the disease at the areas and times when they are at most risk. However, people’s customs and behavior towards malaria can be very different from one community to another. For instance, indigenous communities have responded very well to interventions since they are organized and prepared communities, and have leaders and governors.

By reviewing the documentation, we found a study from 1996 (Vásquez, 1996) that also describes the relation between malaria and practices and beliefs at El Bagre. The study found that the communities included in the study, despite of relating malaria with mining activities, did not understand the transmission mechanism. They associated it to washing in the river or using dirty water, and with drinking water that had the parasite. The participation of these communities in control actions was also scarce due to the fact that they are mostly floating population.

- *Malaria and the armed conflict*

Testimonies from those interviewed suggest that the worsening of the public order situation due to the armed conflict reduces the possibilities of performing control actions against malaria. For instance, it is very difficult to follow malaria cases in members of illegal armed groups “*because people make up their ID’s numbers...(so they can hide from the State authorities) they change their names,*” change their data (E-4). Also, when there is a risk of confrontation between the army and illegal groups, there is no access to communities to perform control actions. In fact, selection criterion of communities to apply the Combi¹ strategy is that “*there are not public order issues, because we have had to change communities because of that during this year*” (E-5).

To establish a statistical relation between malaria and the armed conflict, the number of malaria cases at El Bagre and Bajo Cauca region was compared to the amount of confrontations that took place between 2000 and 2010 through a Pearson test. We obtained positive correlations of 0.79 and 0.7, respectively. (Figure 5).

¹ Communitary work strategy Combi, from its name in English: *Communication for Behavioral Impact*.

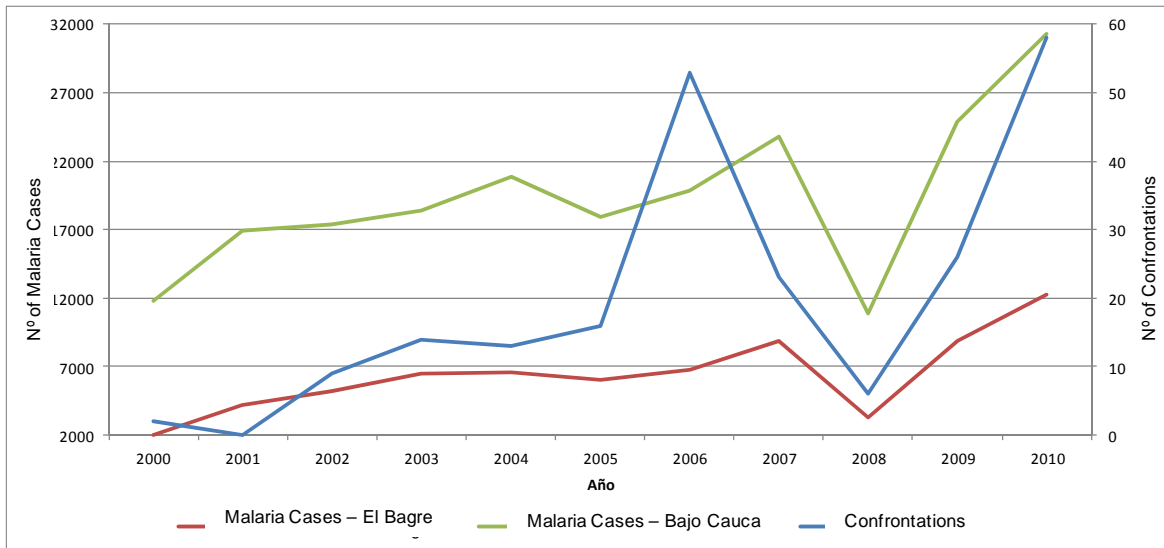


Figure 5. Trends of malaria cases at El Bagre and Bajo Cauca and the number of confrontations at Bajo Cauca, 2000-2010. Official population data show a vast reduction of 20% of the population of El Bagre between 2004 and 2005. This is not a real reduction. It is due to the fact that 2004 data are product of projections based on the 1993 census, whereas 2005 data came from 2005 census. The malaria rates were not used because, in this case, it would have had an even more disturbing effect on reality perception than the usage of the case data. Data about confrontations were provided by Ideas para la Paz Foundation. Confrontations vs. Malaria – Bagre: p-Value = 0.004 Confidence of 95%. Confrontations vs. Malaria – Bajo Cauca: p-Value = 0.007 Confidence of 95%

- Malaria and Climate Changes

People interviewed did not have a tendency to relate weather conditions to malaria. However, documented evidence has already proven the relation between malaria and climate changes at El Bagre (Ruiz et al., 2006).

As for the relation between temperature and malaria, it has already been proven that after El Niño events malaria peaks increase (Poveda and Rojas, 1997). This is why it was necessary to perform a cross-correlation analysis to establish a statistical relation. Temperature, relative humidity and precipitation records were taken between 2000 and 2010 by epidemiological periods in particular, and these were compared to the malaria cases behavior (Table 1). This analysis shows a weak relationship between climate changes and malaria cases, the strongest relation being between temperature and malaria cases. In this case, the biggest correlation reported comes from the backwardness of two epidemiological periods (0.336).

Table 1. Matrix of the Cross-Correlation of Climate Changes vs. Malaria

Backwardness (Epidemiological Period)	Temperature vs Malaria Cases	Precipitation vs Malaria Cases	Relative Humidity vs Malaria Cases
1	0.319	0.083	0.213
2	0.336	-0.004	0.161
3	0.301	-0.082	0.196
4	0.222	-0.132	0.217
5	0.173	-0.126	0.248

Weather information was provided by the IDEAM and corresponds to the Caseri station. In order to obtain epidemiological periods for all variables, those years in which information was incomplete were removed from the analysis. Having said this, the incomplete information for the epidemiological periods between 2007-1 to 2007-7 and 2009-6 to 2009-13 was removed from the database.

3.2. Malaria Control Policy at El Bagre

- System of Actors

In general terms, there are three types of malaria control actions. The first one corresponds to the diagnosis and treatment carried out by the microscopists at the rural districts, medical laboratories, and health centers. The second one corresponds to the risk research and vector control actions carried out by the Regional Health Secretary Office of Antioquia or by the Ces University and the staff hired by them. The third one corresponds to the education and prevention actions of communities carried out by Combi agents and other social sciences professionals that have been appointed by the Regional Health Office.

The staff in charge of education and prevention actions at a community level, as well as those in charge of vector control and risk research, must send reports directly to the Regional Health Office (see community agents in Fig. 6). On the other hand, microscopists report positive cases and request the necessary medication to the municipal Health Secretary Office (Fig. 6). In turn, the Municipal Health Secretary Office gathers all this information and sends it to the Regional Health Office, which is in charge of planning, coordinating and hire all control activities that are to be developed in the municipality (see regional level in Fig. 6). This means that, when it comes to malaria control, the Regional Health Office is very important as it receives the information related to all actions carried out at the municipality, can execute the budget resources, and decides how to proceed towards the disease. The Municipal Health Secretary Office acts as the information and report channel of microscopists, and supports the planning of activities.

This is how malaria control has worked in the municipality during the last decade. As of 2010, however, a new project for malaria control was implemented at El Bagre, called

“Proyecto Malaria Colombia”² (Malaria Project Colombia), better known among the interviewees as “Proyecto del Fondo Global” (Global Fund Project). Figure 6 describes the actors’ system.

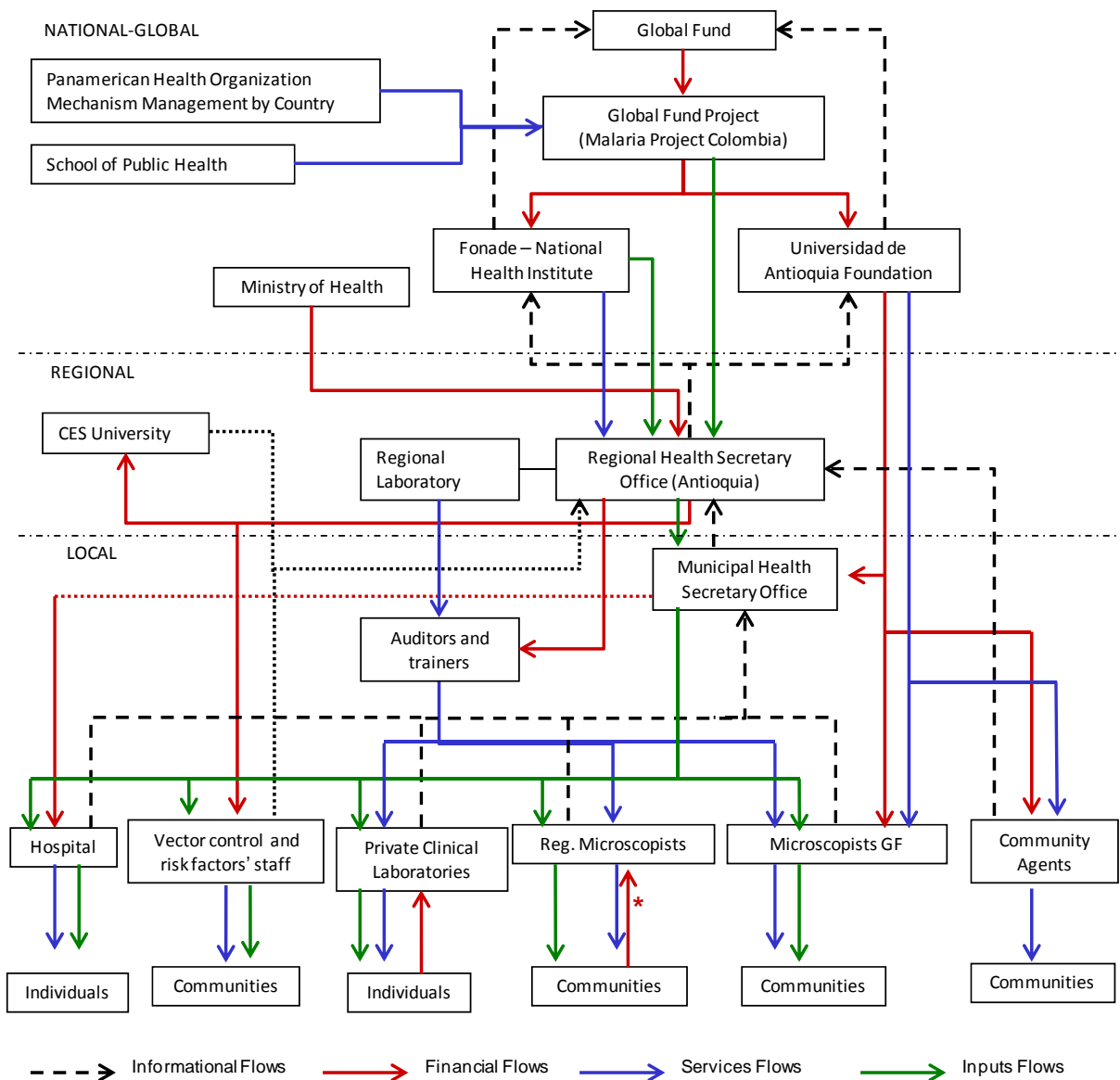


Figure 6. System of Actors. Relationships among actors can be summarized through information flows, financial resources flows, services flows that actors can provide to each other, and supply flows. The actor that gathers all types of flows is the Regional Health Office of Antioquia.

When the actions promoted by the Global Fund started, there were some problems generated by conflicts between the project and the regular program of malaria control of the Regional Health Office. These had a negative effect in the development of control actions. This was due to several reasons. The parallel intervention of different work teams is one of

² The name of the project is: “Use of epidemiological intelligence with social participation to strengthen the management program, the diagnosis and treatment access, as well as to carry out effective interventions for malaria control and prevention.”

them. People interviewed pointed out that these “*were completely different things*”, “*the project was being carried out on its own, and without many support [from the Regional Health Office of Antioquia] due to the information issue*”, “*there were two different managements*”, “*when the Global Fund started, everything turned into chaos*”. The staff at the regular program felt as if the Global Fund Project were unaware, or disapproving of their work. Some people said that the project “*said the old staff hadn’t done anything*”. “*They say that in Antioquia long-term mosquito nets were given to people, but that we didn’t know how to do it.*” People also mentioned that the Global Fund Project, for instance, “*dealt with the malaria problem in Antioquia as if it was the same as the malaria problem in [other regions like] Choco, Cordoba, Cauca or Valle. So then, they [assumed]... that they were here to build the microscopy network, when in fact it already existed.*”

On the other hand, different from other departments in Colombia, the microscopy network was made up of volunteers. When the Global Fund Project began, interviewees say that “*they paid the microscopists, and our structure weakened.*” For instance, “*we were doing a training [course], and they arrived and offered them a job, so those [the microscopists] that were left... what a problem! Were those that charge 10.000 or 15.000 (COP)³, those that will have to close their microscopy centers [because of charging for doing something that was supposed to be free]*” Many of them already left the program, and those that charge have already been hired.” Other person said that “*when I started [arranging the meetings], they didn’t show up anymore. Why? Because they get paid for everything, such as ticket expenses [to go to the trainings].*” Those in favor of paying the microscopists for their job, say that their work has become a job, because they no longer make 3 or 4 thick blood smears a day but many more, and that in many cases, they have had to pay for transportation and other supplies. Also, they point out that payment will reduce the incentive to sell the medication, which is also free.

Some of the problems described have already been solved, and others have been partially solved. The manager of the Global Fund for Antioquia resigned, and from then on, the activities of the project have been coordinated directly by the manager of the control program at the Regional Health Office. The information flow has now improved between the staff of every side, and activity management has allowed the program to be implemented in more rural districts. Overall, malaria control at El Bagre has strengthened.

- Characteristics related to social-ecological resilience

Overall, it was found that the system of actors is mostly centralized; it has a limited diversity, and has just a few feedback mechanisms. Regarding the polycentric organization, Figure 6 shows that the organization of the system of actors tends to be centralized. In this case, the central actor is the Regional Health Office, because is the only actor that has control over all of the flows or processes related to the other actors. Autonomous groups of actors in a local level were not found.

On the other hand, Table 2 describes the institutional arrangement that creates the MCP. A scarce institutional *diversity* can be appreciated: there are only a few complementary rules

³The microscopy activity is voluntary. They should no charge for it.

(in bold) that allow the replacement of actors in a determined role or of alternate processes conceived to work for the same objective. This means that actors can be replaced only under some rare conditions, which makes it very difficult to find other courses of action to control malaria when one course of action has been used with no results or when perturbations prevent them to achieve expected results. Also, there are only a few *feedback mechanisms* (marked with an asterisk*). One of the mechanisms found is the ‘report and notification of cases’, as well as the ‘auditing to microscopists in the field’, although the latter is in its early stages. There are no mechanisms to check on the influence of mining, weather, armed conflict, and migration, which are the factors responsible for the persistence of the disease. Contradictory rules in use appear in red.

Table 2. Rules structuring Malaria Control Policy

Global-national Rules

The Regional Health Office must carry out the inspection, surveillance and control of malaria actions at El Bagre

The Global Fund Project must reduce the mortality and the sickness rate of malaria by improving Regional programs

The Regional Health Office must manage the actions of the Global Fund Project

The Universidad de Antioquia Foundation -UdeA- and the National Health Institute -INS- must manage the project's finances

The PAHO may advise the Global Fund Project

The State must provide the resources to the department in order to carry out the actions of inspection, surveillance, and control of malaria

Regional Rules

The Regional Health Office must deliver reports to the University of Antioquia and the NHI

The Regional Health Office must distribute and deliver mosquito nets to the communities

The Regional Health Office must fumigate areas for entomological control

The Regional Health Office must train the microscopists

The Regional Health Office must perform thick blood smears at the rural districts of El Bagre

The Regional Health Office must deliver the medication to the Health Secretary Offices

The Global Fund Project must implement Combi

The Regional Health Office must implement Combi

The Global Fund project must buy mosquito nets and send them to the Regional Health Office

The Global Fund project must train the microscopists

The Regional Health Offices must notify any malaria cases to the National Health Institute

The School of Public Health must advise the implementation of the Combi strategy

Local Rules

The laboratory of the department must perform quality control to the blood examinations made by the microscopists

The auditor must perform quality control to the blood examinations made by the microscopists

The Municipal Health Secretary Office must deliver the medication to the microscopists and diagnosis locations

* The Municipal Health Secretary Office must notify the malaria cases to the Regional Health Office

The Universidad de Antioquia Foundation may hire staff to support notification, the Combi implementation and perform thick film exams

Operational rules

The thick blood smears are free to all people

The thick blood smears may be charged for by private laboratories

Microscopists may receive voluntary money compensation for procedures and expenses

The microscopists' labor is voluntary and they should not receive a salary

The microscopists' labor is hired and they must receive a salary

Microscopists must report all positive malaria cases to the Health Secretary Office

Microscopists must deliver the medication to the people with malaria

* Auditors must supervise the job of the microscopists

Medication to treat malaria is free to all people

If a microscopist charges for the thick blood smears and medication delivery, his spot will be closed

A professional in the social field must implement the Combi strategy in the communities

The community agent must promote community organization to enhance the Combi's labor

The community agent must be hired by the Global Fund Project

The community agent must live in the community he/she works at

The Combi must be implemented in communities where malaria rates are high

* Combis should not be implemented in areas where there are public order problems

* There should be campaigns against malaria when projections indicate risks may be high

- Efficiency and social Resources on which control policy depends

The data taken during 2011 (the Global Fund Project started in 2010) shows a reduction in malaria cases, which suggests that control actions have been effective. Among the social resources that may influence the possibilities to maintain a steady reduction in malaria cases are:

Financing and staff. The Global Fund Project participation meant an increase in the financial resources, staff and supplies in general for the actions that are being developed. If it ends in 2015, it would mean a reduction of this kind of resources, which will end up affecting the possibility of maintaining the positive results that have been reached so far.

Willingness. It may have been the biggest support for the microscopy network. But it seems to have been affected from the moment some of them started to get paid.

Leadership. It is a necessary social resource for community agents (support community leaders) to be able to enhance the development of the Combis, as well as the activities of vector control within their communities. The hiring of leaders by the Global Fund Project, might affect the leadership of these agents.

Social memory and collective learning. In such a floating population like that of the El Bagre, the opportunities to generate collective learning that is transmitted through their culture are scarce. Collective memory exists among people interviewed at the Regional Health Office, although it was not present on those individuals that have a short-term contract or a temporary relationship with the other actors.

Regulations. There are rules, such as the Resolution 412/2000 which enables local participation in the activity development. In fact, epidemiological surveillance methods show that the population participation is necessary for the development of educational activities. However, this regulation does not enable local authorities to make decisions about malaria control.

3.3. Congruence between the Control Policy and the Social-Ecological Dynamics of Malaria

The processes or actions of control policy and the dynamics or social-ecological processes related to malaria were classified in first, second, and third-order processes. The first-order processes are those that affect directly the possibility of malaria cases developing. The second-order processes are those that affect the first-order processes, and so on.

When comparing the connection between the processes of the control policy and the dynamics or social-ecological processes related to malaria, the processes of the control policy only respond to the first-order dynamics (Figure 7). This means that, even though the MCP develops activities such as the diagnosis, report and case notification, buying and distributing mosquito nets, the quality control performed to the slides and the medication delivery, these actions do not have the necessary reach to intervene, influence or counteract the effect of the social and ecological processes that are related to the persistence of malaria in the community, such as mining, public order, and El Niño phenomenon.

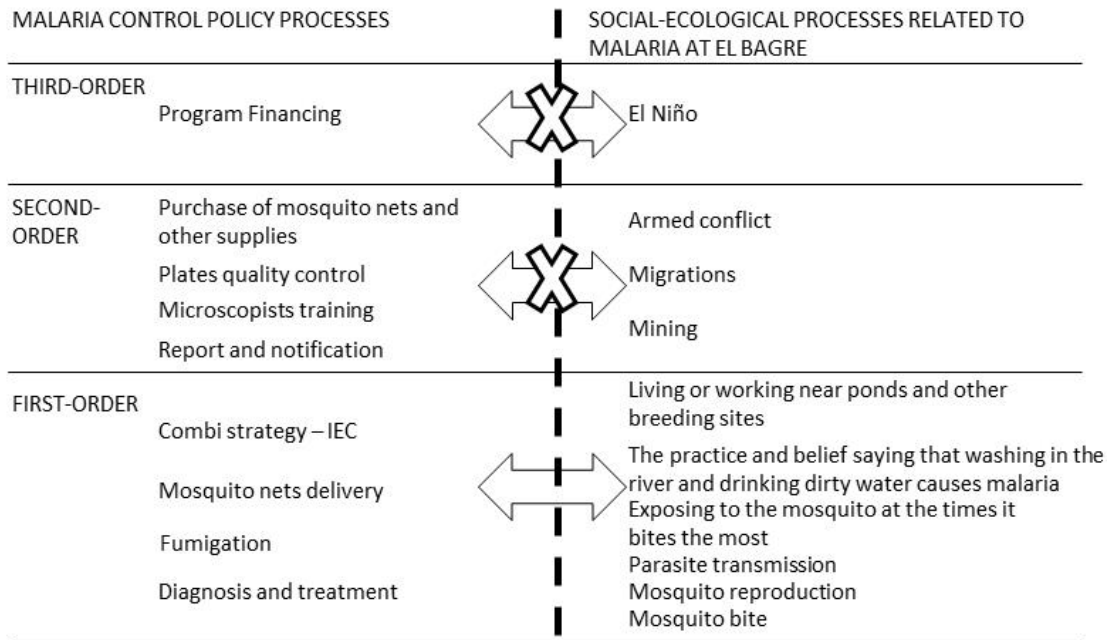


Figure 7. Congruence between malaria control policy processes and the social-ecological processes related to malaria.

4. Discussion

In the field of health public policies, the interest on the subject of sustainability in public policies is recent and it has been scarcely explored. Even though the importance of understanding how economic and social crises may affect policies, or how these can be adjusted to deal with unexpected events has already been acknowledged (Ricciardi & Corrao, 2012), the model this study followed had not been previously applied.

In an exploratory search we found a small number of articles centered on sustainability analysis of health public policies. The databases consulted were PubMed and Science Direct; the terms entered on the abstract and title fields were ‘*Sustainability AND public health policies*’, ‘*Sustainability AND health policies*’, ‘*Sustainability AND health policy*’. Without a time range criteria, the search was carried out up to October 9th, 2013. Seven out of 331 articles reviewed were centered on research dealing with institutional aspects that facilitated effectiveness of policies and provision of the health benefits, in spite of crises. The remaining articles can be classified in four large categories: (i) environmental impact of public policies, (ii) effects on human health of certain public policies, (iii) sustainability of public health programs and interventions, (iv) and financial aspects of public health policies and health systems.

None of these articles explored the characteristics of institutional design that influence the sustainability of public policies. A significant contribution to this subject may be provided by Gruen and collaborators (2008), who reviewed studies on sustainability of diverse health programs and provided a model provided from it. However, their findings do not seem to be sufficient for the interpretation of ours since, firstly, its scope is smaller and more concrete *-programs-* than the scale at which policies are developed. Consequently their results and conclusions may not necessarily be relevant to public policies. Secondly, power is not considered in that study as an essential category of public policies. Finally, the definition of sustainability that supports the model presented by them lacks clarity.

In the field of sustainability research, the concept of resilience and in particular, social-ecological resilience has motivated the use of an approach to understand the sustainability of social-ecological systems (Folke, 2006). Such perspective, which has been mostly developed through the study of common goods and natural resources management systems, suggests that systems tend to have an adaptive capacity to face disturbances when their institutions give origin to polycentric organizations (Gunderson, 2003:47; Janssen et al., 2006; Low et al., 2003:97; Norberg and Cumming, 2008c:81; Ostrom, 2011; Webb and Bodin, 2008:86), have diversity (Fiksel, 2003; Holling, 1973; 1994; 2001; Levin et al., 1998; Norberg and Cumming, 2008b:8-12; Norberg et al., 2008:47; Walker et al., 2006), feedback mechanisms (Berkes et al., 2003:2; Holling, 2001; Levin et al., 1998; Norberg and Cumming, 2008a:149; Ostrom, 2011) and are efficient (Fiksel, 2003).

Even if public malaria control policies are not based on common goods but public goods, the employment of the model used in this study is adequate. MCP may be considered a kind of public goods management system since the health benefits caused by the disease control are shared by the whole community and exclusion of beneficiaries is not possible. Some characteristics of institutional design of sustainable common goods management systems have been previously reported (Ostrom, 2011). Some of them are similar to certain features of efficient public goods systems. Local economies and police service in urban areas with polycentric structures, monitoring mechanisms, diversity and efficiency has more adaptive capacity to social and ecological dynamics than those lacking of them (Ostrom, 2008).

In the context of malaria control policies, the disturbances in the system are the social-ecological dynamics related with malaria and its control. This research could establish that mining, climate variations, armed conflict, migrations and sociocultural practices constitute processes related with malaria in El Bagre. However, these dynamics are not necessarily the same occurring in other municipalities and may change over time. In fact, the world policy for malaria eradication in the mid-twentieth century was not successful due partially to the implementation of standard intervention models that did not consider the variability

of local conditions (Nájera, 2001:45-47) and to a planning process that was not adjusted to such variations (Nájera, 2001:63-65).

In the case of El Bagre, the characteristics of the institutional design of the system of actors cause a lack of adaptive capacity to adjust control rules and mechanisms to the changeable dynamics, and consequently, the MCP is not considered sustainable enough from our point of view. Besides, the system of actors does not have a polycentric configuration, its diversity is scarce, there are few feedback mechanisms, and despite the effectiveness observed during 2011, its efficiency has not been proven.

Polycentricity is considered a characteristic of sustainable systems because it allows the system of actors to set up forms of government in accordance to the problems faced (Ostrom, 2008; McGinnis and Ostrom, 2011). It also gives origin to diversity, to the extent the local gatherings have more variety. Such features allow the system of actors to solve the wide range of problems that they may have to tackle locally, in an expeditious way.

In contrast to centralized forms, the existence of polycentric institutions entails the systems of actors count with more delivery service units at a local level, conflicts are solved faster because of the proximity of authorities, and diversity is guaranteed since autonomy generated in different jurisdictions gives rise to different ways to approach a problem (Ostrom, 2008). In the case of El Bagre, there is a central actor - *the Regional Health Secretary Office* - which controls financial resources, information, and provides services directly to beneficiaries in the localities. In this way, the other actors, such as the *Local Health Secretary Offices*, lose their autonomy and authority in service provision. Thus, such distance between beneficiaries and service providers makes it difficult to solve conflicts.

In part, this centralized organization explains the scarce diversity found in the system of actors, since the actions for malaria control in the localities reflects the central directives instead of local ones. This fact limits the generation of alternative courses of action, in as much as the solutions applied in the localities are provided by the same actor, which reduces the possibilities for learning and innovation in decisions and procedures of actors in response to the changeable social-ecological dynamics related with malaria, at local and regional levels.

In addition, the regulations of the system of actors described in this study revealed little presence of feedback mechanisms. The notification of cases and audits to the microscopists exemplify some of them. However, mechanisms that allow practitioners and policy makers to realize the social and ecological dynamics of malaria do not exist. This absence of feedback mechanisms hinders the adjustment of the policy to problem level and reduces the possibilities of performing effective control actions in accordance to local characteristics. In

part, this explains why the rules of action of the MCP in El Bagre do not fit the social - ecological dynamics of the disease in such locality.

The MCP that is being carried out in the municipality of El Bagre has proven effective as long as the cases in 2011 have decreased. This decrease is related, in part, to the intervention of the Global Fund project. Due to its implementation, there are more financial resources, bed nets, rapid testing, portable devices for the online report of cases, better information management and distribution, more staff, including microscopists and professionals in different areas. Nevertheless, it is worth clarifying that the regular malaria control program in Antioquia had already been improving.

The social and financial costs of such effectiveness make it difficult to guarantee its continuation. The Global Fund project is due to finish by 2015, which means a future reduction of resources. Moreover, the fact that the measures of the project include microscopists and staff in the payroll, may hinder willingness in community members to work voluntarily. These are the reasons why it is not clear how efficient the control policy will be in future.

In general terms, it is also worth noting that the presence of central actors inside the structures ruling the social-ecological systems cannot be directly related with adverse effects. In fact, systems require central actors that, especially in the case of distant localities, avoid the formation of “*local tyrannies*”. These are local leaders or elites whose power allows them to change rules in favor of them (Ostrom, 2005:282).

Likewise, multi-leveled and decentralized structures cannot be automatically understood as polycentric institutional designs. In a study carried out by Lieberman (2011) to test whether polycentric structures of governance benefit or hinder infectious disease control, the author concludes that polycentric structures are related to gaps of responsibility by authorities and lack of effectiveness in the services delivery. However, one of the limitations in Lieberman’s work is his assumption of polycentricity as decentralization, and the absence of an analysis of the rules giving rise to such decentralized structures in the system of actors. The polycentric government in a system is identified through the rules in use by the system of actors, and not through the identification of the number of actors by responsibility. Modularity or polycentricity, and their contribution to the sustainability of the system, is not a quantitative matter but a qualitative one (Janssen et al., 2006).

5. Conclusion

Despite the effectiveness of the MCP analyzed, the possibilities of keeping malaria under control in long term are scarce, due to three main reasons: Firstly, the resources employed to finance the activities carried out in 2011, and that were provided by the Global Fund, are expected to suffer a reduction as the project carried out by the institution finishes in 2015. Secondly, social-ecological dynamics such as El Niño phenomenon, mining and migrations

are related with malaria in the municipality of El Bagre. However, these are not considered in the rules and actions of the system of actors, they are not object of the MCP and there does not seem to be incentives that change such reality. Finally, the system of actors does not have enough adaptive capacity to adjust its rules and modes of action in response to the social-ecological dynamics of malaria. Nevertheless, there is a need for further studies in this matter and with other public health policies.

References

- Berkes, F., Colding, J. and Folke, C., 2003. Navigating social-ecological systems: Building resilience for complexity and change. Cambridge University Press, New York, 393 pp.
- Carmona-Fonseca, J., 2003. La malaria en Colombia, Antioquia y las zonas de Urabá y Bajo Cauca: panorama para interpretar la falla terapéutica antimalárica. *Iatreia*, 16(4): 299-318.
- DANE, D.A.N.d.E., 2012. Boletín Censo 2005. Departamento Administrativo Nacional de Estadística, DANE.
- Fiksel, J., 2003. Designing resilient, sustainable systems. *Environ Sci Technol*, 37: 5330-5339.
- Folke, C., 2006. Resilience: the emergence of a perspective for social-ecological systems. *Global Environ Chang*, 16(3): 253 - 267.
- Gómez-Arias, R., 2012. Gestión de políticas públicas. Aspectos operativos. *Rev Fac Nac Salud Pública*, 30(2): 223-236.
- Gruen, R. et al., 2008. Sustainability science: an integrated approach for health-programme planning. *Lancet*, 372(1): 1579 - 1589.
- Gunderson, L., 2003. Adaptive dancing: interactions between social resilience and ecological crises. In: F. Berkes, J. Colding and C. Folke (Editors), *Navigating social-ecological systems: Building resilience for complexity and change*. Cambridge University Press, Cambridge, pp. 33-52.
- Holling, C., 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, 4: 1-23.
- Holling, C., 1994. Simplifying the complex: the paradigms of ecological function and structure. *Futures*, 26(6): 598-609.

- Holling, C., 2001. Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4: 390 - 405.
- Janssen, M. et al., 2006. A network perspective on the resilience of social-ecological systems. *Ecology and Society*, 11(1): 1-15.
- Jiménez, M., Hinestroza, Y. and Gómez, R., 2007. Reformas sanitarias e impacto del control de malaria en dos áreas endémicas de Colombia. *Colombia Médica*, 38(2): 113-131.
- Levin, S. et al., 1998. Resilience in natural and socioeconomic systems. *Environ Dev Eco*, 3: 222-235.
- Lieberman, E. 2011. The perils of polycentric governance of infectious disease in South Africa. *Social Science & Medicine*, 73: 676-684
- Low, B., Ostrom, E., Simon, C. and Wilson, J., 2003. Redundancy and diversity: do they influence optimal management? In: F. Berkes, J. Colding and C. Folke (Editors), *Navigating social-ecological systems: Building resilience for complexity and change*. Cambridge University Press, Cambridge, pp. 83-114.
- McGinnis, M., Ostrom, E. 2011. Reflections on Vincent Ostrom, *Public Administration and Policentricity*. *Public Administration Review*, 72(1): 15-25
- Nájera, J.A., 2001. Malaria control: achievements, problems and strategies. *Parassitologia*, 43(1-2): 1-89.
- Norberg, J. and Cumming, G., 2008a. Information Processing. In: J. Norberg and G. Cumming (Editors), *Complexity theory for a sustainable future*. Columbia University Press, New York, pp. 149-154.
- Norberg, J. and Cumming, G., 2008b. Introduction. In: J. Norberg and G. Cumming (Editors), *Complexity theory for a sustainable future*. Columbia University Press, New York, pp. 1-14.
- Norberg, J. and Cumming, G., 2008c. Networks. In: J. Norberg and G. Cumming (Editors), *Complexity theory for a sustainable future*. Columbia University Press, New York (USA), pp. 81-84.
- Norberg, J., Wilson, J., Walker, B. and Ostrom, E., 2008. Diversity and resilience in social-ecological systems. In: J. Norberg and G. Cumming (Editors), *Complexity theory for a sustainable future*. Columbia University Press, New York, pp. 46-80.
- Ostrom, E., 2005. *Understanding institutional diversity*. Princeton University Press, Princeton, 376 pp.

- Ostrom, E., 2008. Polycentric systems as one approach for solving collective action problems, Working papers.
- Ostrom, E., 2011. El gobierno de los bienes comunes. La evolución de las instituciones de acción colectiva. Universidad Nacional Autónoma de México, México DF, 403 pp.
- Pattanayak, S. et al., 2006. Deforestation, malaria, and poverty: a call for transdisciplinary research to support the design of cross-sectoral policies. *Sustainability: science, practice & policy*, 2(2): 45-56.
- Poveda, G. and Rojas, W., 1997. Evidencias de la asociación entre brotes epidémicos y el fenómeno de El Niño-Oscilación del Sur. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 21(81): 421-429.
- Ricciardi, W; Corrao, G. 2012. Walking across evidence and sustainability of public health policies - do we need a new journal?. *Italian Journal of Public Health*, 9(3):1-2
- Ruiz, D. et al., 2006. Modelling entomological-climatic interactions of Plasmodium falciparum malaria transmission in two Colombian endemic-regions: contributions to a National Malaria Early Warning System. *Malaria Journal*, 5(66): 1-30.
- Salas-Zapata, W., 2012. Diseño de un modelo de análisis de sostenibilidad de políticas públicas en salud, Universidad Politécnica de Cataluña, Barcelona, 192 pp.
- SSSA, 2013. Eventos en salud pública. Enfermedades Transmitidas por Vectores 2000 - 2010 por municipio. Secretaría Seccional de salud y protección social de Antioquia, Medellín.
- Vargas, J., Arias, G. and Arcila, L., 2009. Perfil de la región del Bajo Cauca de. Dirección de Planeación Estratégica Integral, Medellín, pp. 246.
- Vasquez L, Rodriguez A, Calvo Y, Benavides A. Los saberes y las practicas de la poblacion sobre la malaria y su influencia en la efectividad de los tres puestos de diagnostico y tratamiento: Municipio de El Bagre, Antioquia, Colombia 1994. Medellín: Universidad de Antioquia; 1996
- Walker, B. et al., 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society*, 11(1): 13.
- Walt, G. et al., 2008. ‘Doing’ health policy analysis: methodological and conceptual reflections and challenges. *Health Policy and Planning*, 23(5): 308-317.
- Webb, C. and Bodin, Ö., 2008. A network perspective on modularity and control of low in robust systems. In: J. Norberg and G. Cumming (Editors), *Complexity theory for a sustainable future*. Columbia University Press, New York, pp. 86-118.