

The Mataquí, Pimampiro River Micro Watershed Management Experience and its Problems Towards Sustainability

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Abstract

This research focuses on management experiences and the micro watershed management at Mataquí River, Pimampiro; it also analyzes its problems towards sustainability through the application of indicators for a rapid evaluation. It was found that, in relation to micro watershed's governance, citizens' participation is relatively scarce; and the existence of certain agro ecological activities inhibit agricultural frontiers to move forward.

Keywords

Sustainable Development, MicroWatersheds, Management, Sustainability

1. Introduction

There is a growing interest from state cooperation institutions and communities to improve the management of their watersheds, either through research, in order to improve the endowment and quality of the water they use or through a more comprehensive initiative, where objectives related to the water resources and beyond may be sought [1].

In general, in the Ecuadorian Andean region, rivers' watersheds are made up of moors and high montane forests in the upper part. These areas are of great importance due to their ability to store a large amount of water; and also because populations take advantage of these for human consumption, irrigation, and industrial use [2].

For this research, the Mataquí River's micro watershed was chosen as the study area. It is located in the Imbabura and Carchi provinces, in the northern highlands of Ecuador.

As a study area, Mataquí River's micro watershed is an emblematic case for the analysis of the water resource governance in the northern highlands of Ecuador. In this study, an analysis of the regulations related to the water resources was carried out, the key actors were identified

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and characterized in the management of this resource, and the current conflict raised in the watershed was analyzed.

With the information already collected, some strategies are proposed to help improve the management and proper governance of this resource in the study area.

2. Methodology

2.1. Study Approach

To meet these objectives, it is necessary to work with a descriptive approach.

Descriptive Approach. This type of approach will allow the collection of the information from the first baseline of indicators according to the rapid assessment methodology adopted by FAO [1], which are qualitative and they are based on the experiences and opinions from the key actors from influence areas. It also includes the observations of the technicians who visited the site.

This work consists of the description and theoretical explanation of the concepts of watershed management, sustainable livelihood, and micro watershed's governance.

2.2. Information Collection

The information was collected using measuring instruments such as questionnaires where the value of each variable was recorded.

3. Results

3.1. Focus on Sustainable Livelihood and Livelihood Analysis

In the micro watershed management framework, it is imperative to refer to sustainable livelihoods.

Approaches to sustainable livelihoods (EMVS, as per its initials in Spanish) place people and their goals at the center of the development process, as well as their scope and priorities.

Reflection on livelihoods began in the mid-1980s, since some development agencies adopted EMVS in their policies and programs to fight against poverty.

According to [3] "a livelihood includes the capabilities, assets (including material and social resources), and necessary activities for livelihood".

According to FAO [4], the Department for International Development defines a sustainable livelihood MVS, (as per its initials in Spanish) based on the necessary capabilities, assets and, activities to live. A livelihood is sustainable when it can face and recover from rupture and sudden falls, and maintains its capabilities and assets both in the present and in the future without deteriorating its natural resources basis. Thus, livelihoods are affected by external effects that allow them to increase their resilience and consequently decrease their vulnerability. The concern of environmental deterioration leads micro watersheds to sustainable livelihoods.

To achieve sustainability, DFID [4] establishes an analytical framework of sustainable livelihoods that shows the influence of assets such as human, natural, financial, material and social

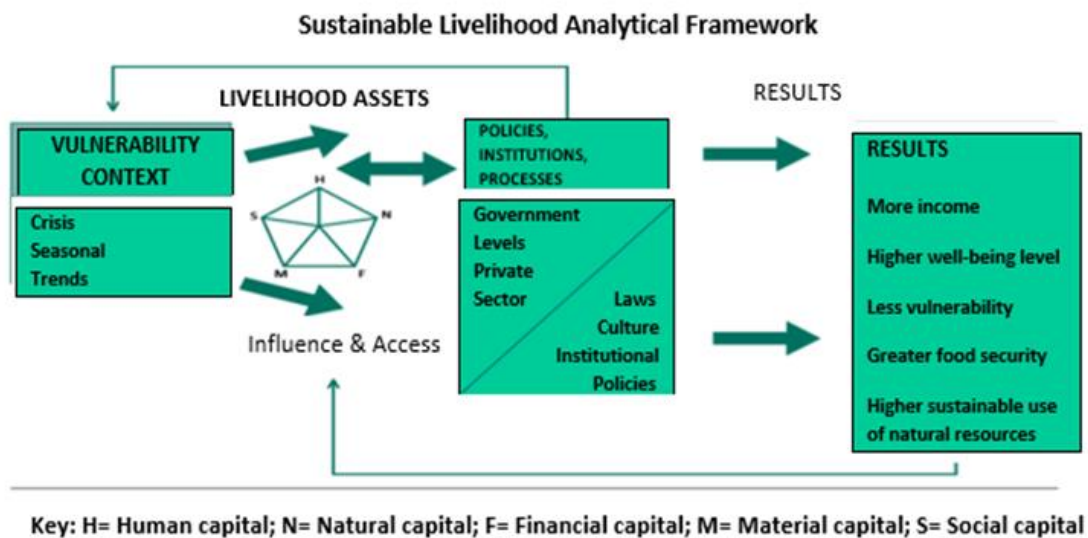


Figure 1: Sustainable Livelihoods Analytical Framework FAO [4]

capital; with the policies and laws that when well defined with participatory processes can lead to sustainable results (see Figure 1). UICN [5], defines the MVS when it can cope with and recover from the impact of any situation that has affected them, their capabilities and resources are maintained or improved both in the present and in the future, without destroying or affecting natural resources.

3.2. Case Study: Mataquí's River's Micro Watershed

General Description. The Mataquí's River's Micro Watershed (the hydrographic unit 15 494), is located in the Pimampiro canton, San Francisco de Sigüipamba parishes, Chugá, Mariano Acosta and Pimampiro parish, as well as part of the San Rafael parish belonging to the Bolívar canton in the province of Carchi [6]. In addition, according to the Secretaría Nacional del Agua del Ecuador [7], this micro watershed is the Hydrographic Unit 15 494 - Mataquí River watershed, belonging to the Hydrographic Unit 1 549 (Chota River's Subwatershed) (see Figure 2).

The Mataquí river micro watershed occupies a large part of the Pimampiro canton's territory, which is known for its agricultural production. Among the most outstanding products there, are tomatoes *Solanum lycopersicum*, peppers *Capsicum annuum*, onions *Allium cepa*, Tamarillo *Solanum betaceum*, mandarin orange *Citrus reticulata*, sweet granadilla *Passiflora ligularis*, peach *Prunus pérsica*, avocado *Presea americana*, among many more species; all these species demand different types of crop techniques such as the use of greenhouses, which is one of the most damaging, in terms of plant covering. [8]. This micro watershed has specific climatic characteristics that allow the differentiation between the lower, middle, and upper parts of the watershed, being in a range that goes from 1 670 m.a.s.l. up to 3 760 m.a.s.l.

The Pimampiro canton has an agricultural produce collection center (Mercado de Transfer-

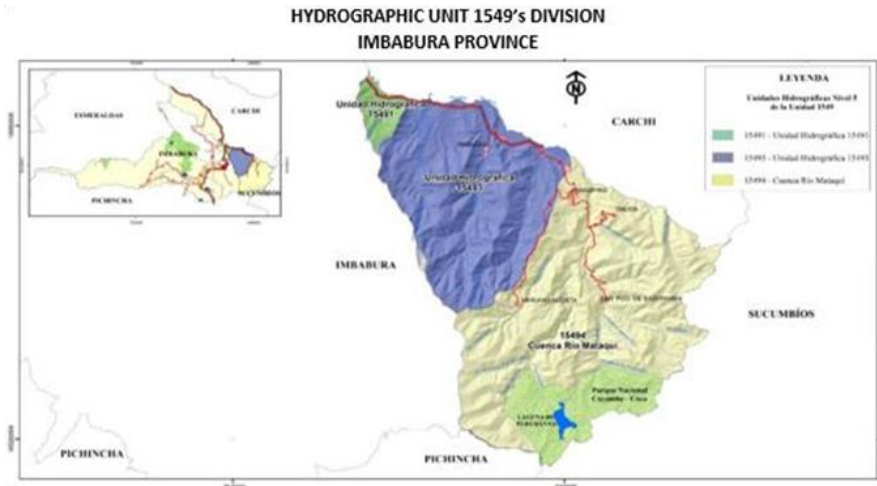


Figure 2: Hydrographic Unit 1549 Division from Imbabura Province.

encias) located in the Pimampiro parish at 2 079 m.a.s.l., in the coordinates WGS 84 UTM 17 south x = 841008, y = 10042439.

According to the 2015-2035 Imbabura's PDOT's Risks Map for Natural Resources [9], the Mataquí River's watershed is affected by landslides in the lower part of the parish of Chugá, and in the middle part in San Francisco de Sigsipamba parish, where it is considered a high vulnerability area due to the influence of the Pimampiro Fault and the sector called "El Infiernillo" located on the road that leads from downtown to Sigsipamba.

3.3. Components and indicators for a rapid assessment of the micro watershed management at Mataquí River, Pimampiro.

The components for the rapid assessment for an integral development management are based on four systems: environmental, economic, sociocultural, and institutional political.

These are described in the FAO [1] *Experiencias de Manejo y Gestión de Cuencas Hidrográficas en el Ecuador*. These are described below:

- *Environmental System*. It refers to the natural heritage that supports and determines the different activities of the population. It can also be called the biophysical system.

- *Economic System*. It includes the system of factors linked to the development of the integral economy of the territory, the various forms of organization of the modes of production and the options or potentialities that can be exploited to promote the Good Living achievement.

- *Sociocultural System*. Within the social field, the set of social organizations in the province that comes from cantons or parishes, and their level of articulation and organization for an interrelated or joint work in the province must be identified. Also the tangible and intangible provincial patrimonial system, or set of patrimonial assets of the province; archaeological sites that can cover more than one canton; the level of application of public policies on heritage assets and the levels of coordination between the province, the cantons, and the governing institution.

Table 1

Weights for the assessment of indicators. FAO [1]

Weights	Numeric Value
<i>Very High</i>	5
High	4
Average	3
Fair	2
Low	1

- *Political System*. It is related to the capacity of the public institution and also the territorial actors, in order to guide and promote development-oriented processes and the management of the territory of that area.

3.4. Evaluation Indicators

FAO [1] determines the rapid assessment methodology with 45 indicators grouped into four components. The evaluation of indicators was carried out with 5 values ranging from 1 for the lowest to 5 for the highest.

Once these evaluation indicators were applied, the following results were obtained:

3.5. Ecological Component Indicators

From the 11 indicators related to ecological component, 4 of them were considered as “fair”,

5 indicators obtained lower weighting values from regular to low; however, there is a predisposition from the population to improve management in this component. The indicator related to the existence of water availability for domestic use permanently has a “Very High” value.

Note: Adapted from the United Nations Food and Agriculture Organization [1]. Watersheds’ Management Experiences Indicators in Ecuador for a Rapid Evaluation. Quito.

3.6. Economic Component Indicators

From the 11 indicators of the economic component, 5 of them were valued as “low”, because there is an absence of value-added products, small businesses have not been created, and there are no tourism offers. In the indicator that is related to markets for commercialization of products, it has a “five” rating, because the communities settled in the micro watershed have a Transfer Market, close to the city of Pimampiro.

Note: Adapted from the United Nations Food and Agriculture Organization [1]. Watersheds Management Experiences Indicators in Ecuador for a Rapid Evaluation. Quito.

Table 2
Ecological Component Indicator

Ecological Component Indicator	Weights
<i>There is a permanent availability of water for domestic use</i>	<i>Very High</i>
Residents perceive good water quality for consumption and domestic use	High
Activities that promote vegetation increase cover the impact 's area of the project	Average
Residents adopt soil conservation practices on their farms	
Producers replace chemical/inorganic fertilizers with organic	
Activities among the residents for the cleaning of rivers and streams are carried out.	Fair
Development of adaptation practices to climate change	
Residents perceive an increase in biodiversity in their property	
Activities among the residents for the cleaning of rivers and streams are carried out.	Low
River and creek protection areas are respected	
There are protection and conservation practices around water springs	

3.7. Sociocultural Component Indicators

In the social component of the 11 indicators evaluated, 5 of them were evaluated with “regular” to “low” weights, because there is low social participation at the community level, families’ entrepreneurship is created and they do not benefit all families.

Note: Adapted from the United Nations Food and Agriculture Organization. [1]. Watersheds’ Management Experiences Indicators in Ecuador for a Rapid Evaluation. Quito.

3.8. Political-Institutional Component Indicators

In the Political-Institutional component, out of the 12 indicators evaluated, 9 indicators presented a low weighting. This is the result of a lack of interaction with the community and with the institutions in order to manage a participatory process in the watershed area.

Note. Adapted from the United Nations Food and Agriculture Organization [1]. Watersheds’ Management Experiences Indicators in Ecuador for a Rapid Evaluation Quito.

Figure 3, shows the percentages of general weighting by component. In the ecological and economic component, the highest percentage of the indicators is in a low value. The socio-cultural component with a range from 35% to 40% is in a low and high values. The political – institutional component, with 50% of the indicators, has regular values.

4. Conclusions

As a result of the evaluation in the indicators of the ecological component, a “fair” weighting is observed, because in the study area there is a marked presence of monocultures and agricultural activities on riverbanks, streams, and slopes in ranges from 40 % to 80%.

- In the lower part species such as eucalyptus and agro-ecological activities such as Bee-keeping and Adventure Tourism have been introduced.

Table 3
Economic Component Indicator

Economic Component Indicator	Weights
The residents have access to markets to trade their products	Very High
There is an exchange of goods and services in the communities (barter)	High
Internal production allows a reduction in the expenses of the residents in the purchase of articles	Average
Community products are marketed more directly, reducing intermediaries	
Local opportunities for access to credit are given to producers and entrepreneurs	Fair
There is an incentive to property owners for environmental services provided to the community	
There is an improvement in the agricultural productivity of the goods generated in the community	
The products generated in the community have elements that provide added value to them.	Low
The community generates goods and services as an innovation	
Small businesses and local business opportunities are created in the community	
There is a tourist offer in the area of influence of the project	

Table 4
Sociocultural Component Indicator

Sociocultural Component Indicators	Weights
<i>Community social organizations are positively recognized by the residents</i>	High
Community cooperation spaces are generated (collective work)	
Residents have time to develop community and family activities	
There are spaces for exchanging knowledge and ancient wisdom among community members	Average
Participation of women in the production of goods and generation of services	
Community participation in external projects that involve the community	Fair
There is social disposition towards the conservation of natural resources	
New and different leaderships emerge continuously in the community	Low
There is development and increase of local Capabilities	
Participation of women in dialogue and community decision spaces	
Sociocultural customs of the community are maintained	

- Plant covering has been increased with planting of fruit trees such as avocado and tangerine, but in soils with a steep slope that should only be for conservation purposes.
- It should be noted that crop wastes are no longer burned. They are used as an organic matter contribution to other crops.

Table 5
Political-Institutional Component Indicator

Political-Institutional Component Indicators	Weights
<i>There are decision-making processes within communities</i>	High
There are accountability processes performed by local organizations	
There is a high rate of land legalization	Average
There is a proactive link between the parish council and the community	Fair
There is a relationship between the parish council, the canton's mayor's office and the Provincial Government (among GADs, as per its initials in Spanish)	
State institutions and their extension agents participate jointly and they plan in the communities	
There is an infrastructure with state contributions or cooperation	
There are state agricultural programs that are implemented in the communities (ERAs, as per its initials in Spanish)	Fair
There are landholding conflicts among residents	
There is environmental education for the population	Low
The lessons learned are recognized in other places, even with the interest of replicating and exchanging experiences.	
Locally based governance structures are generated	

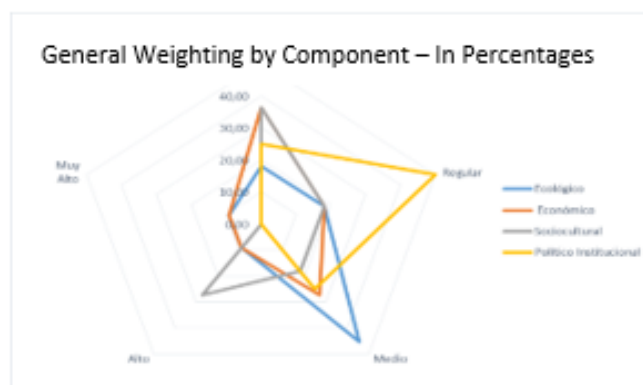


Figure 3: The percentages of general weighting by component.

- The use of organic fertilizers in agriculture is reduced only to the incorporation of waste from previous crops.
- The quality of water for human consumption comes from piped water, but the presence of livestock on the agricultural frontier is evident. For this reason, it is necessary to analyze the location of water, although the perception differs from the opinion of the inhabitants, who consider it to be of good quality.
- Due to the slope of the soil there are no activities that compact the soil, such as grazing

and use of agricultural machinery.

- In the watershed's upper part there are no irrigation systems, but in the lower part some of these are evident.
- There is a strong presence of monoculture.
- There is no respect for the protected zones. There is the presence of crops in the protected zones, with a distance between 10 and 20 meters, on the banks of streams and rivers.

In the economic component indicators, the most relevant is accessibility in local and regional markets. However, there are certain characteristics that have not reached an adequate economic management.

- The population of the micro watershed has been drastically reduced by migration due to lack of employment sources, and because of young people who look for work in other activities different than agriculture, which is the main economic activity.
- There are no local business opportunities, but family businesses do work, as is the case of Beekeeping in the Quinta Yuquin community.

The following aspects can be observed in the sociocultural component:

- At the Quinta Yuquin community there is a school that is no longer being used, and the few school-age children are forced to travel to larger populated places to study. The community is not legally organized. However, there is an agreement to perform joint activities such as collective work. There are no new leaderships within the community, because the new generations have migrated.
- There is not a notorious participation of women in dialogue spaces.
- The community has bus transportation service twice a day, and there is also a truck company that goes to the sector. They have garbage collection service done by the municipality, electricity, telephone with radio operators.
- There is no sewer service, latrines are used.

In the political component, according to the residents, NGOs aid is scarce. This has been reduced to the participation of a Swiss NGO, for more than 15 years, working on reforestation with introduced species such as eucalyptus. There is a presence of State agencies such as MAG (Ministry of Agriculture, as per its initials in Spanish) and *BanEcuador* in support of agricultural and credit activities.

4.1. The Challenges of Moving Towards Sustainability

There is a clear and notable skepticism from the authorities about the effectiveness of citizen participation in government management. Public workers mention that participation hinders their work, and coupled with this, they have a series of beliefs against participation [10].

Tradition states that consulting people, involving them in collective decision-making processes, only causes headaches, obstacles, and delays. Authority and hierarchy without consent, and absolute respect for the decisions of authority and hierarchy arising through the mechanisms of democratic representation, are the constants that have influenced this skeptical view on participation [11].

Even though there are these observations on participation, it is important to reflect, as [12] points out: *“We have to forget about the solutions and think about the problems. And do it by transforming our access to democracy into a democracy of deliberation and debate, understanding that it is not about asking people what they think about what we have decided, but about incorporating the opinions and reasons of the social actors involved in their own problem determinations. But incorporating into the discussion not only the issues related to “how”, but also elucidating the respective protagonists of administrations and actors, or directly asking the question of whether or not we need those administrations”.*

National governments across the developing world have advanced strong claims about the imperative to establish and strengthen partnerships in which local administrative and organizational arrangements complement or substitute for more central efforts to govern environmental resources. In many cases, they have backed these claims with changes in renewable resource policies [13]. Likewise, between the different groups and organizations involved in the mechanisms there must be a minimum sense of identification and responsibility for the whole, in a word, a common identity. The nation can culture the reference framework for that identity, but its basis must be social and cultural integration" [14].

4.2. Towards a Proper Governance of a Micro Watershed

Governance is not the same as government. It includes the actions of the state and, in addition, encompasses actors such as communities, businesses, and NGOs. Key to different forms of environmental governance are the political-economic relationships that institutions embody and how these relationships shape identities, actions, and outcomes [15].

Governance is related to the strengthening of vertical structures for the proper exercise of power and decision-making by governments, whether at the local or national levels [16]. Becomes “continuous dynamic reconstruction of social elements (diversity) in their interrelationships (complexity)” [17].

[18] defines governance as decision-making processes on collective affairs. It is remarked that unlike traditional approaches that are based on hierarchical and unilateral decisions, governance gives an innovative style of government. “The system of formal and informal rules (regulations, procedures, customs) that establish the patterns of interaction and cooperation between relevant actors in the decision-making process, considers as “relevant actors” both to the public authorities and to the various Social and economic agents. Therefore, a good governance scheme requires the society to have a certain level of social capital and civic culture to

improve collective action and coordination”.

It refers to the broad method of "governing" which includes but is not restricted to the more limited perspective of "government". It refers to the interrelation of formal and informal structures, procedures and processes [19]; to the systems of creating the rules, the networks of actors at all levels of society (from local to global), within the context of sustainable development, which implies a very significant change in the socio-economic model [20].

For some authors, these solidary values and responsible behaviors demand to overcome a “clearly anthropocentric positioning that prioritizes the human with respect to the nature” for the sake of a biocentrism that “integrates the human, as one more species, in the ecosystem” [21].

4.3. Conclusions

There are certain agroecological activities that prevent the agricultural frontier progress.

The site under study shows a high tourism potential, due to the presence of a virgin forest and its activities may include bird watching and adventure tourism.

Citizen participation is scarce in the aspects of governance of the micro watershed.

4.4. Recommendations

Generate a thematic cartography, performed by institutional actors, especially climate and hydrological information. This will have a greater precision in the interpretation of the data.

Encourage citizen participation in terms of micro watershed’s governance.

Train the population in proper agriculture and conservation practices, with the use of new technologies, in order to balance the natural disadvantages, reflected in soil wear.

A water quality analysis for human consumption is required.

References

- [1] FAO, Experiencias de manejo y gestión de cuencas en el Ecuador indicadores para una evaluación rápida, Quito (2014).
- [2] R. Hoftedec, J. Calles, V. López, R. Polanco, F. Torres, J. Ulloa, M. Cerra, Los páramos andinos what do we know? state of knowledge on the impact of climate change on the páramo ecosystem, UICN: Quito, Ecuador (2014).
- [3] R. Chambers, G. Conway, Sustainable rural livelihoods: practical concepts for the 21st century., IDS Discussion Paper No. 296. Londres. Institute for Development Studies (IDS) (1991).
- [4] FAO, Herramienta para formular, monitorear y evaluar los proyectos de administración de tierras en América Latina. Módulo 1: Propuesta Metodológica y Experiencia de los PAT en LAC. Roma, Italia, Retrieved from: <http://www.fao.org/in-action/herramienta-administracion-tierras/modulo-1/propuesta-metodologica/medios-vida-sostenibles/es/> (2018).
- [5] UICN, IUCN red list of threatened species. Version 2011.2, 2012.

- [6] J. D. Aguilar-Cadena, Estrategias de restauración para el aprovechamiento apícola en la microcuenca del río Mataquí, provincia de Imbabura (master's thesis), Retrieved from: <http://repositorio.utn.edu.ec/handle/123456789/8164> (2018).
- [7] SENAGUA, Secretaría Nacional del Agua del Ecuador (2009). Delimitación y codificación de unidades hidrográficas del Ecuador, Escala 1:250.000. Nivel 5. Metodología Pfafstetter. Quito, Ecuador <http://aplicaciones.senagua.gob.ec/servicios/descargas/archivos/delimitacion-codificacion-Ecuador.pdf> (2009).
- [8] Gobierno Autónomo Descentralizado Municipal de Pimampiro, Informativos municipales, Retrieved from: <http://www.pimampiro.gob.ec/noticias-sp28725/212-informativos-municipales.html> (2017).
- [9] Gobierno Autónomo Descentralizado Provincial de Imbabura, Atlas cartográfico, Mapa de riesgos a peligros naturales (2015-2035).
- [10] A. Guillen, M. Badii, M. Blanco, K. Sáenz, Civil participation in sustainable development context, *Innovaciones de Negocios* 5(1): 131 - 146, México (2008).
- [11] J. Subirats, Nuevos mecanismos participativos y democracia: promesas y amenazas, *Ciudadanos y decisiones públicas*, Ariel, Barcelona. pp. 33-42 (2001).
- [12] M. Crozier, *La crise de l'intelligence, Essai sur L'impuissance des elites a se reformer*, Paris, Interedition (1995).
- [13] E. Weber, A new vanguard for the environment: grassroots ecosystem management as a new environmental management, *Soc. Nat. Resour.*13:237-59 (2000).
- [14] R. Mayntz, El estado y la sociedad civil en la gobernanza moderna, *Reforma y Democracia* 21, Revista del CLAD (2001).
- [15] A. Agrawal, *Environmentality: Technologies of government and the making of subjects*, Durham, NC:Duke Univ. Press (2005).
- [16] B. Revesz, *Gobernanza, procesos participativos y desarrollo territorial local. congreso internacional gobernabilidad y gobernanza de los territorios en América Latina - Cochabamba*, 9-21 septiembre 20 p (2006).
- [17] J. Kooiman, *Gobernar en gobernanza*. En A. Cerrillo (Coord.), *La gobernanza hoy: 10 textos de referencia* (pp. 57-81). Madrid: INAP (2003).
- [18] J. Prats, *Gobernabilidad democrática para el desarrollo humano. marco conceptual y analítico*, *Revista Instituciones y Desarrollo* (10), 103-148 (2001).
- [19] A. Hoekstra, *The global dimension of water governance: Nine reasons for global arrangements in order to cope with local water problems*, Value of water research report series No. 20, UNESCO-IHE Institute for Water Education, Delft, the Netherlands (2006).
- [20] M. Murga, *Desarrollo Sostenible*, McGraw-Hill Interamericana. Tomado de <https://www.ebooks7-24.com:443/?il=7577> (2013).
- [21] J. E. García, Una hipótesis de progresión sobre los modelos de desarrollo en educación ambiental, *Investigación en la Escuela*, 37, 15-32 (1999).