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Artículo de investigación

Evaluation of water services in Cubijies parish, Chimborazo Province, Ecuador

Evaluación de los servicios de agua en la parroquia Cubijies, Provincia de Chimborazo, Ecuador

Avaliação dos serviços de água na freguesia de Cubijies, província de Chimborazo, Equador

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Abstract

Water services in Cubijíes parish were evaluated base on stakeholders or users knowledge. The methodology included the identification and the social evaluation; the water services were identified through the consultation to principal actors of the parish, to subsequently evaluate the potential of aquatic ecosystems and vegetable coverage in the provision of water services by means of descriptive statistic. In addition, the existence of factors that modify perception of the capacity of studied ecosystems were determined using non-parametric tests. As a result, the interaction between proposed ecosystems in the provision of water services was recognized, aquatic forest had a predominant role in the supplying of provisioning services; also the factors which changed the perception of the capacity of ecosystems were: level of education, gender and community, social factors had the highest incidence in the scores issued by beneficiaries. It is concluded that water resource has a notorious incidence within the local economy and welfare, therefore inhabitants recognize the existence and importance of water services and related them to the proposed ecosystems.

Keywords: Environmental engineering; identification; evaluation; water services; cubijíes (parish).

Resumen

Los servicios de agua en la parroquia Cubijíes se evaluaron con base en el conocimiento de los actores o usuarios. La metodología incluyó la identificación y la evaluación social; Los servicios de agua fueron identificados a través de la consulta a los principales actores de la parroquia, para posteriormente evaluar el potencial de los ecosistemas acuáticos y la cobertura vegetal en la prestación de los servicios de agua mediante estadística descriptiva. Además, se determinó la existencia de factores que modifican la percepción de la capacidad de los ecosistemas estudiados mediante pruebas no paramétricas. Como resultado, se reconoció la interacción entre los ecosistemas propuestos en la provisión de servicios hídricos, el bosque acuático tuvo un rol preponderante en la provisión de servicios de aprovisionamiento; Asimismo, los factores que cambiaron la percepción de la capacidad de los ecosistemas fueron: nivel de educación, género y comunidad, los factores sociales tuvieron la mayor incidencia en los puntajes emitidos por los beneficiarios. Se concluye que el recurso hídrico tiene una notoria incidencia dentro de la economía

y el bienestar local, por lo que los habitantes reconocen la existencia e importancia de los servicios hídricos y los relacionan con los ecosistemas propuestos.

Palabras clave: Ingeniería ambiental; identificación; evaluación; servicios de agua; cubijíes (parroquia).

Resumo

Os serviços de água na freguesia de Cubijíes foram avaliados com base no conhecimento das partes interessadas ou dos utilizadores. A metodologia incluiu a identificação e a avaliação social; os serviços de água foram identificados através da consulta aos principais actores da freguesia, para posteriormente avaliar o potencial dos ecossistemas aquáticos e cobertura vegetal na prestação de serviços de água por meio de estatística descritiva. Além disso, a existência de fatores que modificam a percepção da capacidade dos ecossistemas estudados foi determinada por meio de testes não paramétricos. Como resultado, a interação entre os ecossistemas propostos no fornecimento de serviços de água foi reconhecida, a floresta aquática teve um papel predominante no fornecimento de serviços de abastecimento; também os fatores que alteraram a percepção da capacidade dos ecossistemas foram: nível de escolaridade, gênero e comunidade, os fatores sociais tiveram a maior incidência nas pontuações emitidas pelos beneficiários. Conclui-se que o recurso hídrico tem incidência notória na economia e bem-estar local, portanto os habitantes reconhecem a existência e importância dos serviços hídricos e os relacionam aos ecossistemas propostos.

Palavras-chave: Engenharia ambiental; identificação; avaliação; serviços de água; cubijíes (freguesia).

Introduction

Ecosystem services can be defined as (tangible or intagible) benefits that human beings receive from the ecosystems as result of their structure and the development of their natural processes (1-4), these benefits contribute direct or indirect (5, 6) to human welfare and economical development. Millennium Ecosystem Assessment (MEA) classified ecosystem services based on their rol in the ecosystem (function) and their properties (2); the categories are: provisioning, regulation, cultural and supporting services, the first three categories affect directly to people, while supporting

services are needed to maintain the other services, it is to say they contribute indirectly to human welfare (7).

Ecosystem services related to water are the most important for human well-being (8), aquatic ecosystems provide fresh water, fishes and other products, also other services are related to hydrological cycle and water regulation (e.g. water purification, climate regulation, water recharge and control of erosions) (5, 9), moreover water resources has been earmarked for recreation and cultural purposes (8). Most of these services are appreciated and quantified directly by people (users), while categories such as: regulating and supporting services are less evident for the beneficiaries, nevertheless for the management and sustainable use of water resources must be considered all services (5).

The evaluation of ecosystem services allows to understand the complex and dynamic relations between humans and the environments (2), in consequence, identifying and assessing the most important ecosystem services for a community constitute references for decision-maker about defining strategies and actions (10-12). The management of natural resources requiers of implementing mesuarement indicators for each category; provisioning services are linked to the productivity (flow and amount of goods), regulating services are associated with the capacity of ecosystems to regulate particular processes, in contrast, cultural and supporting services are difficult to measure because they are linked to other services like provision (7).

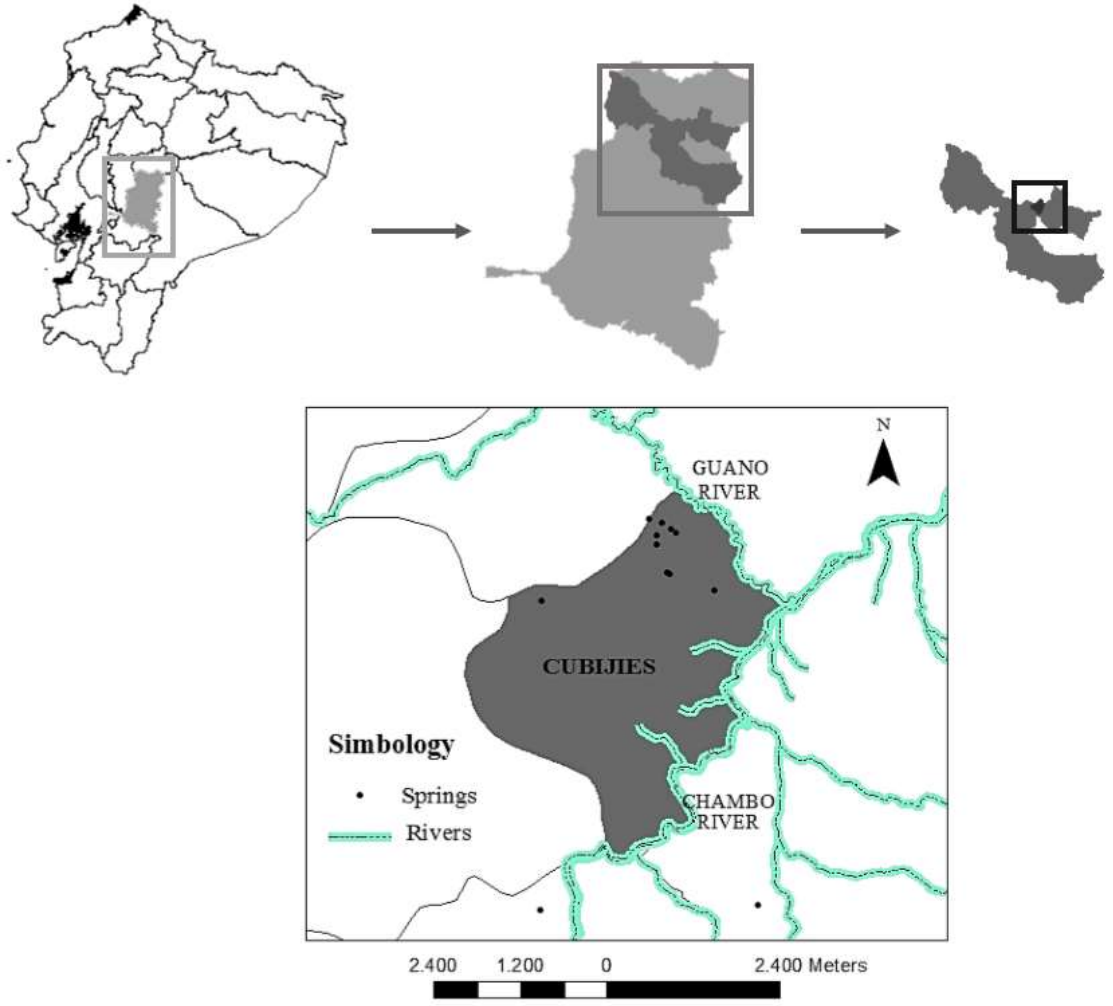
This paper aims to evalute water services in Cubijíes parish due to this place has many water springs which have not been conserved and protected despite they are indispensable for inhabitants. Ecological outputs can be considered like ecosystem services only when these outputs are demanded and valued by people, it is to say they get a social value (13). In this research, water services were identified and evaluated base on stakeholders' knowledge; the assessing was focused in the potential of ecosistems to provide water services, as well as in the analysis of the factors that modified the perception of beneficiaries.

Materials and Methods

Study area:

Cubijíes parish is located in the center of Ecuador (Chimborazo province – Riobamba canton) (Fig. 01), it includes the following communities: "Cubijíes" (the head of parish), "Socorro", "San Clemente" and "San Jerónimo de Porlón" (14). Its predominant climate is semi-humid mesothermic, the average of temperature ranges between 12 and 18°C and the annual precipitation varies from 500 to 1000 mm (15).

Figure 1: Geographic location of Cubijíes parish and its water compound



Regarding to water resources, this parish is supplied from "Chambo" and "Guano" rivers, as well as from natural springs that are situated inside or outside the parish. In the communities of Cubijíes

parish there is an unequal distribution of water so the springs are concentrated in certain places, in addition their flows are variable and have decreased with the passage of time as inhabitants of the indicated sector.

Identification of water services:

The methodology proposed by Brown, and others (1) was applied for the identification of water services. The steps were:

First: Identification and consultation to stakeholders

The term "stakeholder" refers to an individual or group of individuals that are interested in ecosystem services that are provided by a specific natural resource, given that they are the beneficiaries, they influence actively or passively in the delivery of ecosystem services (16). The stakeholders of the present study were Decentralized Autonomous Government of Cubijíes Parish, entities that administer water for consumption and irrigation and users of this resource, spite of they are the beneficiaries, the consultation process was directed to main actors of the parish through interviews and surveys.

Second: Identification of ecosystem services

The information provided by principal actors during the consultation phase was used for the water services identification. The surveys included questions related to the different categories of water services: provisioning, regulating, supporting and cultural. A list of water services was made base on two references: the study of Grizzeti and others (5) and the document published by EPA (7); it was analyzed by the respondent (main actors) in order to determine if these water services are important for the parish or not.

Evaluation of water services:

Data Collection

To estimate the sample, the current population (2018) of Cubijíes parish was calculated through the exponential method, the used information was got from the Population and Housing Census realized by National Institute of Statistics and Censuses of Ecuador in 2010: initial population of

2514 inhabitants and annual growth rate of 1,45% (17). After, the sample was 338, only people over the age of 18

Finally, the sample was distributed in four communities of Cubijíes parish depending on their population density.

Table 1: Distribution of surveys

Community	Population (2018)	Relative frequency	N° surveys
Head of parish	747	0,26	88
Socorro	1280	0,45	152
San Jerónimo de Porlón	101	0,04	14
San Clemente	695	0,25	84
TOTAL	**2823**	**1,00**	**338**

About surveys, they were structured in two sections: socioeconomic aspects and the evaluation of the potential of ecosystems to provide water services, the evaluated ecosystems were: (a) Rivers and springs, and (b) forests and/or vegetative cover close to water sources. To evaluate the potential of ecosystems a numerical scale between 1 and 10 was used, where 1 referred to a low capacity and 10 to a high capacity, also in the case that the ecosystem was not linked to the water service its capacity was considered as null.

Data analysis

Data from surveys were digitized and uploaded to the SPSS statistical program.

Descriptive statistic was used to analyze the potential of ecosystems, thus the mean and the standard deviation were calculated for each analyzed variable. For a better visualization of the results, a color scale was made base on the employed numeric scale.

To analysis the factors that modify the perception about the potentiality of ecosystems, the respondents were clustered by the following criteria: community, gender and level of education. The type of distribution of the studied variables was determined by means of Kolmogorov Smirnov

test, given that all distributions were no normal, nonparametric statistic was used: Mann Whitney test for the variable "gender" and Kruskal Wallis test for "community" and "level of education".

Results and discussion

Identification of water services

Identification of ecosystem services according to the importance and interest of principal actors allows to understand the relation between ecosystem services and local welfare, this is based on trade-offs (18-20), it is to say in the analysis of advantages or disadvantages of water uses. The percentages of positive responses (table 02) indicated that the majority of proposed water services are important to a greater or lesser degree for Cubijíes parish, with the exception of cultural or spiritual rituals.

Provisioning services presented 100% of positive responses due to population recognizes and values mainly tangible water services. Pettinotti, De Ayala and Ojea (3) mentioned that ecosystem services whose outputs are consumed and contribute to the subsistence of societies, are fully identified by users.

Regulation and supporting water services exhibited variable percentages, given that not all respondents identified the relation between the presented ecosystem service and water resources, this is due to both categories are less evident for beneficiaries (5). Probably scientific knowledge is essential to understand the role of some regulating and supporting services (21).

In regard to cultural services, recreation and scenic beauty reported variable percentages, while cultural and spiritual rituals presented a null percentage because in the study place there are no water services linked to this purpose, consequently this aspect was not considered in the subsequent evaluation. Manzanares (22) pointed out that cultural and spiritual rituals related to water points are relevant within rural communities, however in Cubijíes this water service is not considered because it is a rural parish that has been involved in a process of urbanization, so several cultural and religious practices relating to water have been lost.

Table 2: Results of consulting process to main actors of Cubijíes Parish

Category	Ecosystem service	Importance (% positive responses)
Provisioning	Water for consumption	100
	Water for irrigation	100
Regulation	Water regulation	28,6
	Nutrients retention	14,3
	Climatic regulation	71,4
Supporting	Conservation of biodiversity	57,1
	Pest control	57,1
	Agroforestry productivity	57,1
Cultural	Cultural and/or spiritual rituals	0
	Recreation	57,1
	Scenic beauty	14,3

Table 3: Mean of perceptions about the potential of aquatic ecosystems and vegetable cover to provide water services

Very low	*Low*	*Moderate*	*High*	*Very high*
0-1	*1,001- 3*	*3,001- 6*	*6,001-8*	*8,001- 10*

	ECOSYSTEM SERVICES									
	Provisioning		Regulation			Supporting			Cultural	
ECOSYSTEM	Water for consumption	Water for irrigation	Nutrients retention	Water regulation (recharge of groundwater)	Climatic regulation (precipitation)	Conservation of biodiversity	Pest control	Agroforestry productivity	Scenic beauty	Recreation
Aquatic ecosystems: Rivers and springs.	*8,77*	*8,37*	5,00	5,67	6,58	6,88	5,26	6,76	*6,75*	*5,91*
Forests or vegetable cover close to water sources.	*6,69*	*6,64*	5,36	5,42	6,81	7,05	5,29	6,57	*7,03*	*6,34*

Table 4: Standard deviation of potential of aquatic ecosystems and vegetable cover to provide water services

	ECOSYSTEM SERVICES									
	Provisioning		Regulation			Supporting			Cultural	
ECOSYSTEM	Water for consumption	Water for irrigation	Nutrients retention	Water regulation (recharge of groundwater)	Climatic regulation (precipitation)	Conservation of biodiversity	Pest control	Agroforestry productivity	Scenic beauty	Recreation
Aquatic ecosystems: Rivers and springs.	**1,709**	**2,113**	3,499	3,507	2,926	2,859	3,265	3,046	2,986	3,363
Forests or vegetable cover	3,422	3,221	3,587	**3,623**	2,997	3,079	3,431	3,143	2,983	3,287

Evaluation of water services

Socio-demographic characteristics of the sample

Of the 338 respondent, 54.7% were women while 45.3% were men. Regarding to age, the group of 30 to 45 years presented the highest percentage (35.2 %), followed by a group of young people (18 to 29 years) and the group of 46 to 60 years with an equal percentage of 24.9%, finally the group of 61 years or more with a 15.1%.

According to education level, the major percentage (43.8%) had primary instruction, followed by 25.6% that had secondary instruction, in contrast higher levels exhibited lower percentages. Also the predominant activities or occupations were: housework (32%) and agriculture (16.3%).

Potential of ecosystems to supply water services

The potentiality of two ecosystems was analyzed: (a) Aquatic ecosystems: rivers and springs, and (b) Forests and/or vegetation close to water sources; it was considered both ecosystems because there is a dependency relationship between them. Several investigations indicate that vegetable cover determines the quantity and quality of water sources (mainly groundwater), therefore forests and vegetable cover are cataloged as the main regulators of water cycle (23, 24).

According to table 03, the means of responses about capacity of ecosystems indicated that aquatic ecosystems (rivers and springs) had a greater capacity to supply water services of provisioning category, while forests and vegetable cover had a greater capacity to provide cultural services due to they complement the landscape of water sources. At the same time, it could be appreciated that users linked to both ecosystems in the provision of water services, highlighting: supplying of water for human consumption and irrigation, climatic regulation, conservation of biodiversity, agroforestry productivity and scenic beauty, ecosystem services that were associated with higher values; that was corroborated with the results of Affek y Kowalska (25), who indicated that respondents assign high values to ecosystem services whose outputs are tangible or not.

Many research have demonstrated the multi-functionality of ecosystems (5, 12, 25) in the simultaneous supplying of water services of provisioning and cultural categories. According to the results it was determined that aquatic ecosystems and vegetable cover of the study place are multifunctional, characteristic that can be exploited in management programs, which may be aimed in two fronts: 1) supplying, and 2) tourist development (cultural component). Anthropogenic activities and other preferences linked to the recreation may modify the conditions of ecosystems, their biodiversity (species composition), and other processes (4, 9); thus, the projects linked to the cultural component must be geared to mimic natural conditions and processes.

The values of standard deviation (table 04) indicated that there was a lower variability in the responses referred the potential of aquatic ecosystems to supply water for human consumption and irrigation, in contrast a high variability was recorded in the capacity of forests to intervene in the processes of water regulation, such as: groundwater recharge, this is due to the fact that certain individuals did not recognize it as a dependent benefit of vegetable cover.

Factors modifying the perception of ecosystems potentials

According to table 05 (significance → p), there was a difference between medians of the analyzed groups.

Table 5: Factors that modify the perception about the ecosystems potential

FACTOR	*ECOSYSTEM*	*CATEGORY*	*WATER SERVICE*	*SIGNIFICANCE*
Community	Aquatic ecosystems	Regulation	Climatic regulation	***0,028***
		Supporting	Conservation of biodiversity	***0,004***
			Agroforestry productivity	***0,006***
		Cultural	Scenic beauty	***0,000***
	Forests and/or vegetable cover	Provisioning	Water for irrigation	***0,002***
		Regulation	Nutrients retention	***0,027***
		Supporting	Agroforestry productivity	***0,023***
		Cultural	Scenic beauty	***0,000***
Education level	Aquatic ecosystems	Regulation	Nutrients retention	***0,004***
			Climatic regulation	***0,032***
		Supporting	Conservation of biodiversity	***0,018***
		Cultural	Recreation	**0,012**
	Forests and/or vegetable cover	Regulation	Nutrients retention	***0,002***
Gender	Aquatic ecosystems	Supporting	Agroforestry productivity	***0,030***
	Forests and/or vegetable cover	Supporting	Conservation of biodiversity	***0,050***

Stakeholders that are required to express their opinions can be clustered by some criteria (age, gender, place of residence, profession, education, , etc.), of which each might assign different values to ecosystem services depending on their views and needs (16). It was identified that the factors that modified the perception of respondents were: a) geographical: Each community of Cubijíes parish and (b) Social: level of education and gender.

Numerous studies have shown that variables such as gender, age and education level modify the perception relating to the importance of ecosystem services and the ecosystems capacity to supply them (25-29). Allendorf y Yang (26) analyzed the age as another factor that modifies the perception, however they concluded that variations around “age” are an immediate consequence of individuals knowledge that is linked to education and familiarity with the environment, so in the present study the factor “age” was not assessed. Lau and others (30) manifested that ecological knowledge is got more from the experience than through formal education.

The medians of the potential of forests and vegetable cover in conservation of biodiversity, and aquatic ecosystems in agroforestry productivity were slightly greater in the case of male gender (See fig 02). This is due to men have an important role within the management of forests, an aspect that contributes to the understanding of their functions (25) and their links with other ecosystems.

Figure 2: Factor "gender" modifying the perception of ecosystems potentials

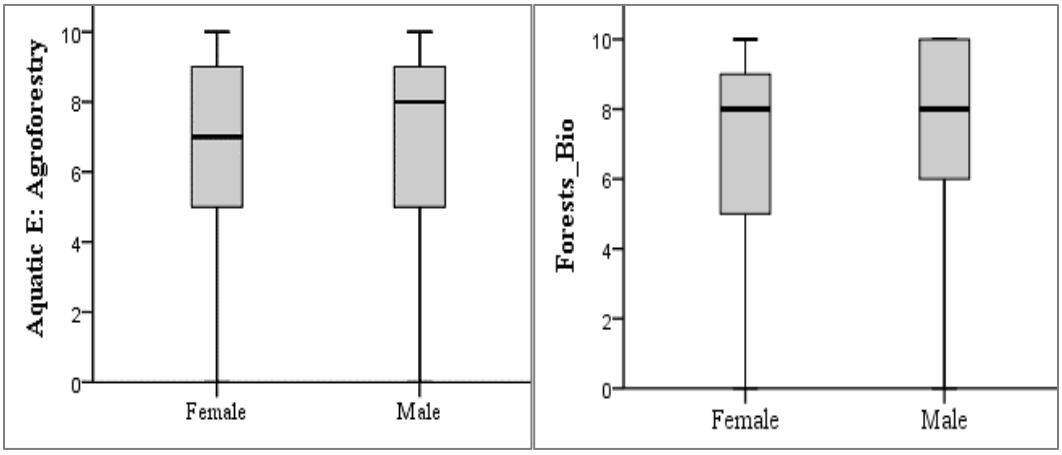
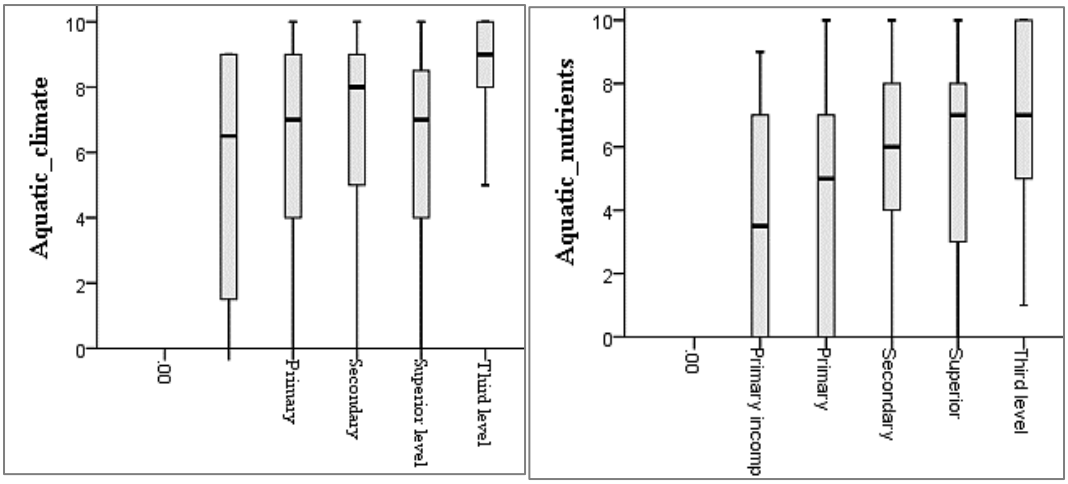
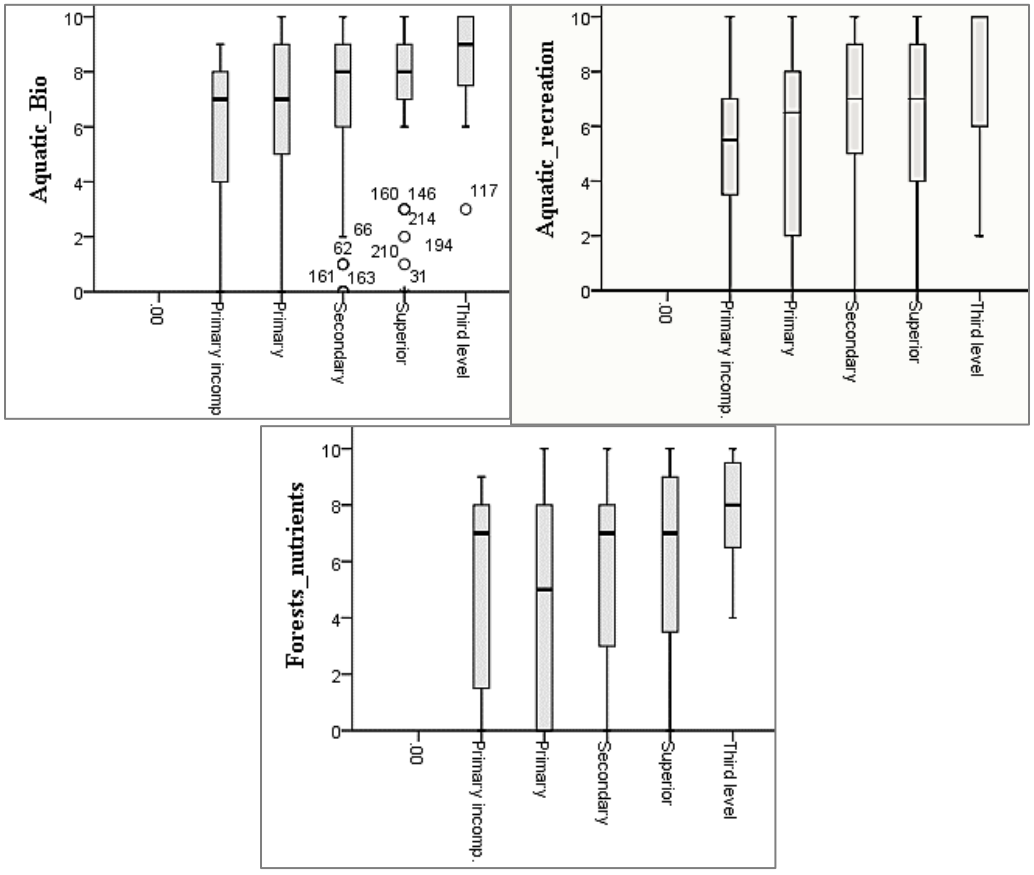


Figure 3: Factor "education level" modifying the perception of ecosystems potentials



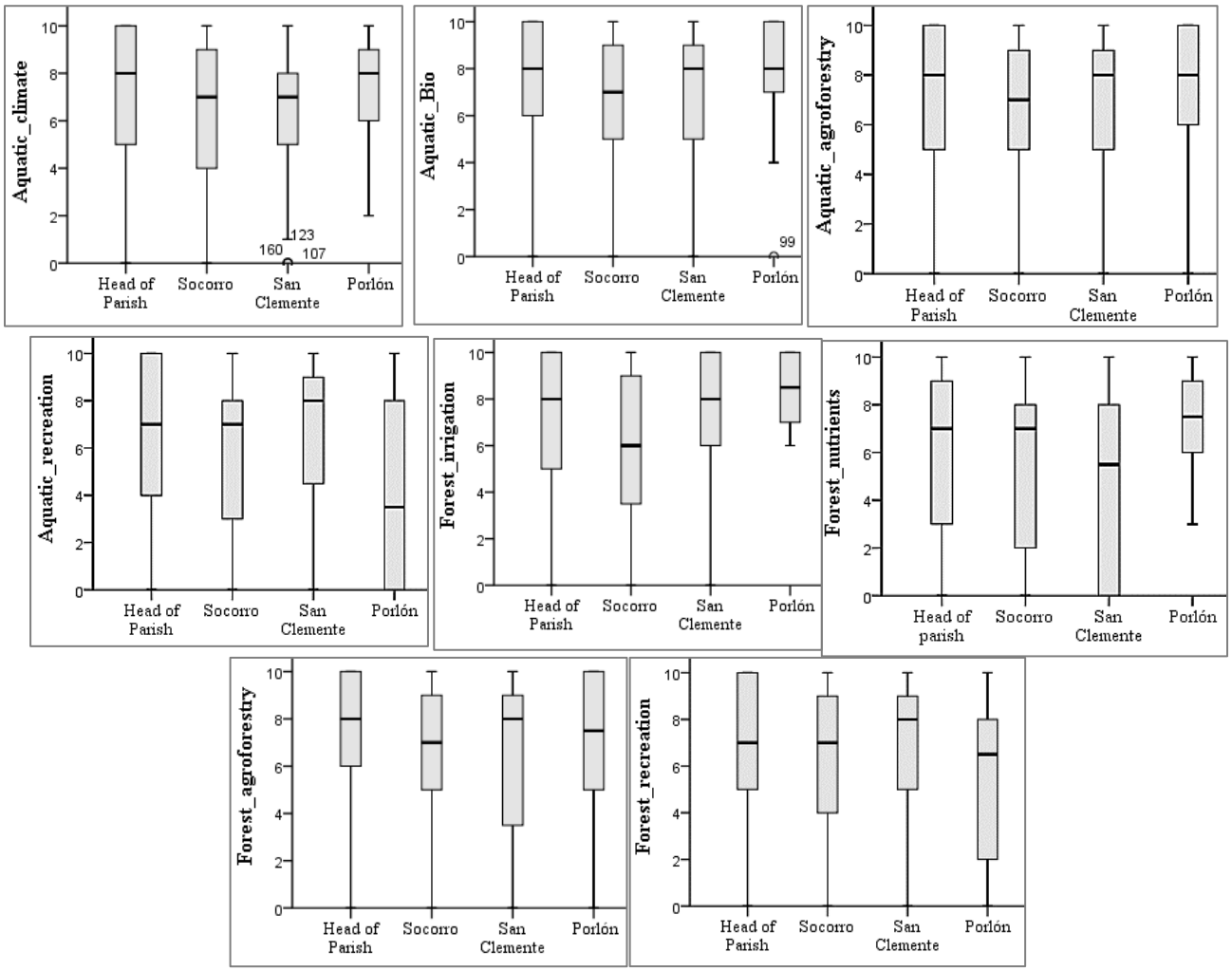


The medians of regulation services (nutrients retention and climatic regulation) and supporting services (conservation of biodiversity), in which take part aquatic ecosystems and vegetable cover were greater at the same time education level of respondents increased (fig 03); this is due to in academic education, issues relating to ecological aspects and natural processes are studied, consequently individuals with a higher level of education recognized the existence of these benefits and linked them with certain components of nature. A study of the role of natural parks and reserves realized by Allendorf and Yang (26) indicated that the knowledge degree about protected areas is linked to the formal education of an individual, an aspect that modifies the perception of ecosystem services. Velasco and others (31) determined that people with university studies or postgraduates scores high most of environmental aspects (changes, risks, services).

The tendency of cultural services medians (aquatic ecosystems: recreation) was that individuals with higher academic degree scored high to the capacity of the rivers and springs in recreation activities. Affek and Kowalska (25) reported that respondents with a better level of schooling attributed high potentials to supplying cultural services.

Regarding to geographical factor "community" (Fig. 04), the medians of the potentials of ecosystems vary depending on the communities, given that the perceptions depend on the social component that is heterogeneous from one community to another.

Figure 4: Factor "community" modifying the perception of ecosystems potentials



Conclusion

The identified water services included the following categories: provisioning or supplying (water for consumption and irrigation), regulation (nutrients retention, water and climatic regulation), supporting (conservation of biodiversity, pest control and agroforestry productivity) and cultural (cultural and spiritual rituals, scenic beauty and recreation), discarding of the last category cultural and spirituals rituals in the absence of water sources linked to this purpose in Cubijíes parish.

Through the evaluation of water services, it was determined that aquatic ecosystems have a higher potential to supply provisioning services in compared to forests and vegetable cover, moreover users or beneficiaries related both ecosystems in the provision of water services. The factors that modified the perception of the potential of ecosystems are physical or geographical: community and social: gender and education level, the last group of factors conditioned to the geographical factor.

The present research could be useful to future studies about prioritization and valuation of water resource in Cubijíes parish, also it may be a reference to decision-making in aspects related with water management.

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