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Assessing water-use efficiency and conservation programs in the Department of Nariño, Colombia

Evaluación de los programas de uso eficiente y ahorro del agua en el Departamento de Nariño, Colombia

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Abstract

The rational use of water resources has been established as a global goal within the sustainable development goals (SDGs), offering numerous advantages to different stakeholders engaged in the comprehensive management of water resources. Water-use efficiency and conservation programs (PUEAAs, for their Spanish acronym) encompass a range of activities and objectives aimed at fostering the sustainability of water resources. Consequently, monitoring these programs through compliance indicators is of paramount importance, allowing data collection from companies and environmental authorities concerning their administration. This paper examines the implementation of the Law 373 of 1997, specifically focusing on the oversight of the PUEAA at the Department of Nariño from 2015 to 2018. For this purpose, an inventory of municipal terms of reference was compiled for projects developed and executed by water utility companies (ESPs, for their Spanish acronym). In addition, efficiency and effectiveness indicators were employed, and the indicators outcomes were assessed using a compliance matrix. The results indicated that the strategic initiative to reduce losses exhibited the most notable shortcomings in terms of the formulation and oversight of PUEAA within the department (0% compliance). Conversely, another strategic approach to educate and develop environmental awareness regarding the efficient use of water showcased more favorable outcomes in terms of its indicators (compliance exceeding 50%). In conclusion, it is evident that the deficient levels in the indicators stem from the mismanagement and disorganization of PUEAA records, on the part of the environmental authority and users (ESP). This deficiency is attributed to a lack of familiarity with the terms and stipulations outlined in the Law 373 of 1997.

Resumen

El uso racional del recurso hídrico está plasmado como una meta global en los objetivos de desarrollo sostenible (ODS), lo cual trae múltiples beneficios a los diferentes actores involucrados en la gestión integral de los recursos hídricos. Los programas de uso eficiente y ahorro del agua (PUEAA) contemplan una serie de actividades y metas que tienen por propósito contribuir a la sostenibilidad del recurso hídrico; de ahí la importancia de hacer un seguimiento a través de indicadores de cumplimiento que permitan recopilar información, tanto de las empresas como de las autoridades ambientales, con relación a su gestión. En este artículo se analiza la aplicación de la Ley 373 de 1997, en lo que se refiere al seguimiento de los PUEAA, en el Departamento de Nariño, durante el periodo 2015 a 2018. Para el desarrollo de esta investigación se realizó un inventario de los términos de referencia municipales de los proyectos formulados y ejecutados por las empresas de servicios públicos de agua (ESP). Se aplicaron indicadores de eficiencia y efectividad y se evaluaron los resultados con una matriz de cumplimiento. Los resultados mostraron que la línea estratégica de reducción de pérdidas presenta las deficiencias más significativas en la formulación y seguimiento de los PUEAA en el departamento (0% de cumplimiento). Mientras que la línea estratégica de educación y sensibilización ambiental para uso eficiente del agua presentó mejores resultados en sus indicadores (cumplimento mayor al 50%). Dentro de las conclusiones se tiene que, los bajos niveles observados en los indicadores están relacionados con la pérdida y falta de organización en la información de los expedientes de los PUEAA, tanto por la autoridad ambiental como por los usuarios (ESP), debido a la falta de conocimiento de los términos y exigencias de la Ley 373 de 1997.

Keywords: Water Resource Conservation, Effectiveness, Efficiency, Indicators, Water Use

Palabras clave: Conservación de Recursos Hídricos, Efectividad, Eficiencia, Indicadores, Uso del Agua

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Why was it carried out?
The research was carried out due to the lack of knowledge about the degree of compliance with the Water-use efficiency and conservation programs (PUEAAs, for their Spanish acronym). These programs are water management instruments that guarantee the sustainability of the water resource. Therefore, knowing the degree of compliance allows to identify areas that require adjustments or improvements in the program.

What were the most relevant results?
Deficiencies were identified in the formulation, approval and monitoring of the PUEAA. The actors involved, such as water utilities companies and environmental authority, are unaware of the terms established in current Colombian regulations, such as Law 373/1997, Decree 1090/2018 and Resolution 1257/2018, related to the PUEAA. In addition, insufficient mechanisms were found to carry out adequate monitoring of the activities contemplated in the PUEAA approved by the environmental authority. The most significant deficiencies in the formulation and monitoring of the PUEAA were observed in the activities related to loss reduction. It is highlighted that the strategic line of education and environmental awareness for the efficient use of water showed compliance of more than 50% in all its indicators, this being with the best performance in the formulation, approval and monitoring of the PUEAA.

What do these results provide?
These results allows to identify areas for improvement in the formulation, approval and monitoring of the PUEAA. Firstly, the creation of a technical sheet with precise instructions for the two main actors involved in the process is suggested. Secondly, the need to decentralize the monitoring of activities and involve environmental centers in this function is proposed. Third, it is suggested to create an observatory of the PUEAA that facilitates the monitoring and collection of information. Finally, it is recommended to promote the voluntary certification of water utilities companies in the ISO 46001:2019 standard.

Graphical Abstract

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Introduction

One global appeal of the sustainable development goals (SDGs) is the rationalization of water resource usage, as outlined in SDG 6 and 12. These SDGs aim to "ensure availability and sustainable management of water and sanitation for all" and "ensure sustainable consumption and production patterns," respectively (1). Traditionally, the world's major water resources are allocated for agricultural, domestic/urban, industrial, and energy purposes (2). Therefore, the call is also to use water efficiently in these sectors of the economy as a strategy to address water scarcity, which affects more than 40% of the global population (3).

Since the 1992 Earth Summit in Rio de Janeiro, the concept of water-use efficiency has been promoted as "any measure that reduces the amount of water used per unit of any given activity, consistent with the maintenance of enhancement of water quality." Globally, efficient water use has numerous benefits, including the conservation of water resources, protection of wildlife and aquatic ecosystems, pollution reduction, water security, resource conservation, economic benefits, improved public health, and increased efficiency in water and energy use (4, 5).

Specifically, efficient water use enables cost savings for water utility companies (ESPs, for their Spanish acronym) by reducing the need for developing new infrastructure, decreasing commercial losses, cutting operational costs, and managing droughts and supply interruptions. For users, the most remarkable benefit is the cost savings on water consumption and sewer services. Environmental benefits include reducing pressure on resource demand and minimizing wastewater discharges into water bodies (6, 7).

Across the world, there are some standards that promote water conservation and efficient use, with the majority being voluntary. However, as denoted in Table 1, there is currently a predominant interest in developed countries in certifying companies for water efficiency. This interest aligns with the recent efforts by the International Organization for Standardization (ISO) to develop standards for efficient water management in businesses, namely ISO 46001:2019 and sanitary appliances ISO 31600:2022 (8, 9). These new international standards are expected to promote and enhance water-use efficiency and conservation globally, facilitating more countries to implement water-efficient management certification programs (10).

Table 1 Regulations and Certification Programs for Efficient Water Management in Developed Countries

Country	Regulations	Certification Program	Source
Australia	Water Efficiency Labeling and Standards Act 2005	Water Rating: www.waterrating.gov.au	(11)
USA	Water Efficiency, Conservation and Sustainability Act of 2023	WaterSense: www.epa.gov/watersense	(12)
Singapore	Public Utilities (Water Supply) Regulations 2004	Water Efficiency Labeling Scheme: info.pub.gov.sg/wels	(13)
European Union	Directive 2000/60/EC of the European Parliament and of the Council of the European Union	Unified Water Label: uwla.eu	(14)

At the national level, the administration of water resources falls under the jurisdiction of the Ministry of Environment and Sustainable Development (MADS, for its Spanish acronym) through the Directorate of Integrated Water Resource Management. One of the instruments

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that helps with the water resource administration is water resource planning, which guides water concessions and regulates water use and water-use efficiency and conservation programs (PUEAA, for their Spanish acronym) (15). Hence, PUEAAs are mechanisms designed to optimize, foster, control, and regulate the use of water resources. These mechanisms require development, submission, and adoption by users applying for or holding water concessions. At the municipal level, responsibility regarding efficient water use rests with the ESPs. In any case, the purpose of PUEAA is to prioritize actions for efficient water use and conservation for the benefit of the society, environment, and economy (15). Similarly, MADS states that the approval, implementation, and execution of PUEAA are the responsibility of the Regional Autonomous Corporations (CAR, for their Spanish acronym) in coordination with other environmental authorities (15, 16).

Additionally, the water resource information system (SIRH for its Spanish acronym) revealed that, in 2016, only 32% of CAR reported PUEAA. However, in 2018 and 2021, reported PUEAA increased to 68% and 74%, respectively (17, 18). Nevertheless, reporting does not necessarily indicate document approval because the information may pertain to the PUEAA either in its formulation or review stages. During 2012–2013, a total of 2,551 PUEAAs were submitted, with 876 under review and 1,143 approved. During the same period, 41.3% of the approved programs pertained to the water supply and sanitation sector while the agricultural sector accounted for 36% (19).

In the case of the Colombian department of Nariño, which comprises 64 municipalities, from 2015 to 2018, only 15 ESPs responded to the environmental authority regarding the formulation of water-use efficiency and conservation programs. Following this period, these programs were not renewed, and by 2020, none of them had an approved PUEAA. These statistics might suggest national-level deficiencies in the implementation of the Law 373 of 1997 and in the management of water resources within the water supply and sanitation sector. Gómez-Rendón (20) attributes variations in the water resource management figures to factors such as the scale of water supply systems, infrastructure, measurement techniques, and loss management.

Considering the vital role that compliance indicators play in objective planning and monitoring (21), specifically concerning the Law 373 of 1997 and PUEAA, these indicators can be viewed as tools or mechanisms that enable CAR and other environmental authorities to oversee, in accordance with Executive Order 1090 of 2018, the monitoring of PUEAA and actions taken by ESPs and municipal administrations regarding law implementation.

Within the realm of compliance indicators, efficiency and effectiveness verify the degree of goal achievement in appropriately planned and executed projects with fewer economic and physical resources (22). Efficiency revolves around resource utilization, gauged by the ratio of resources/results under actual conditions, and is assessed through comparisons (23, 24). Conversely, effectiveness pertains to the degree of approximation of the proposed objective, estimated by the ratio of objectives/results under actual conditions (22–24). According to Bouza-Suarez (24), when actions are executed to achieve a purpose previously attained under ideal conditions and are now realized under real conditions, the resources invested for that purpose are deemed effective.

Consequently, this study assessed the level of compliance with PUEAA in the urban areas of the Colombian department of Nariño from 2015 to 2018. For this purpose, efficiency and effectiveness indicators were adapted and applied in three aspects dimensions or strategic lines (SLs) established by the Law 373 of 1997 (16): (i) loss reduction and efficient water use, (ii) conservation, and (iii) education and environmental awareness. Furthermore, considering the results, suggestions or managerial mechanisms were developed to improve the oversight of PUEAA in the Colombian department of Nariño.

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Methodology

The methodological approach employed in this study is characterized as descriptive, longitudinal, retrospective, and observational, aligning with the classification of a "case-review" study, as defined by Hernández-Sampieri et al. (25). To conduct the study, an initial sample was chosen randomly, aiming for representativeness, encompassing 21 urban centers within the Department of Nariño during 2015–2018. From this pool, 12 urban centers were identified as a pertinent sample, including 11 with approved PUEAA and 1 undergoing review by the environmental authority. In Nariño, with a total of 64 municipal seats, the selected sample constituted 19% of the overall population. Table 2 provides details on the municipality names (municipal centers), corresponding ESP, and current status of the municipal PUEAA.

Table 2 Study Sample Identification

No.	Municipality	Water Utility Company	Current PUEAA Status
1	Aldana	E.S.P. COOPSERPAL	Approved
2	Ancuyá	E.S.P.D. A.A.A. S.A.S., Municipality of Ancuyá	Approved
3	Arboleda	E.S.P AGUAS DEL ROBLE S.A.S.	Approved
4	Barbacoas	EMBARBACOAS A.A.A. S.A.S E.S.P	Approved
5	Buesaco	E.S.P Administración Pública Cooperativa de Servicios Públicos Domiciliarios de Buesaco	Approved
6	Córdoba	E.S.P COOPSER San Francisco	Approved
7	Cuaspud Carlosama	E.S.P EMPOCARLOSAMA S.A.S.	Approved
8	Cumbitara	E.S.P DE CUMBITARA	Approved
9	El Contadero	E.S.P COOPSERCONT	Approved
10	San José de Albán	E.S.P de Albán - EMPOALBAN	Approved
11	San Pedro de Cartago	E.S.P de Acueducto, Alcantarillado y Aseo de San Pedro de Cartago	Approved
12	Consaca	E.S.P Administración Pública Cooperativa de Servicios Públicos Galeras - COOPSERGALERAS LTDA	Being processed: A PUEAA is already in place
13	Belén	Empresa de Servicios Públicos de Belén - EMPOBELEN E.S.P.	Under renovation
14	Leiva	Empresa de Servicios Públicos de Leiva ESP SAS	Under renovation
15	El Charco	Empresa de Servicios Públicos Domiciliarios de Acueducto Alcantarillado y Aseo del Municipio de El Charco	No PUEAA available
16	Francisco Pizarro	Not a water utility company	No PUEAA available
17	La Tola	Not a water utility company	No PUEAA available
18	Magui Payan	Empresa de Acueducto Alcantarillado y Aseo ESP del Municipio de Magui Payan SAS	No PUEAA available
19	Olaya Herrera	Empresa para la Prestación de los Servicios Públicos de Acueducto Alcantarillado y Aseo del Municipio de Olaya Herrera SAS	No PUEAA available
20	Policarpa	Empresa de Servicios Públicos del Municipio de Policarpa ESP SAS	No PUEAA available
21	Santa Bárbara - Iscuandé	No Water Utility Company	No PUEAA available

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The study was conducted in four phases. Initially, an inventory was compiled using the municipal terms of reference for the selected PUEAA. This allowed the extraction of general information about the municipality, diagnosis, objectives, and action plan, which included projects for infrastructure improvement, water loss reduction, conservation of natural resources, land acquisition, as well as educational initiatives for operators and water users. Subsequently, difficulties in applying the Law 373 of 1997 were identified. To achieve this, the indicators of each SL presented in Table 3 were applied to the projects presented by the evaluated ESP. This involved considering the planned and executed activities by users and monitoring conducted by environmental authorities. Further, the indicators were analyzed and interpreted using a compliance matrix, with the following classifications: complies, partially complies, and does not comply. Ultimately, recommendations were established to enhance the application of the law based on the identified weaknesses.

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Table 3 Loss Reduction and Efficient Water-Use Indicator Sheet

SL	Indicator (I)		Description	Formula	Indicator Type
1	1.1	Production and Billing	The volume of water extracted from the source compared to that billed by the environmental authority.	m^3 produced/m^3 billed	Efficiency
	1.2	Production and Consumption	The volume of water produced compared to that consumed.	m^3 produced for the aqueduct treatment system/m^3 consumed by the population	Effectiveness
	1.3	Loss Reduction	Water loss reduction in the system during the fiscal year.	Annual m^3 reduction goal/m^3 reduced in the fiscal year	Effectiveness
2	2.1	Conservation Area	Proposed hectares compared to the progress of hectares implemented for conservation.	No. of conservation hectares/No. of proposed hectares	Effectiveness
	2.2	Reforestation and/or Restoration Area	Proposed hectares compared to the progress of hectares implemented for reforestation and/ or restoration.	No. of reforestation and/or restoration hectares/No. of proposed hectares	Effectiveness
	2.3	Payment for Environmental Service (PES) Processes	Number of incentives in money or in kind provided by territorial entities to regular property owners and holders located in strategically important areas.	No. PES Processes/No. of Proposed Processes	Efficiency
3	3.1	Water Management Training with Educational Institutions	Number of integrated processes with a pedagogical model where the variables of thinking, learning, and acting generate an environmental culture.	No. of processes executed for educational institutions/No. of processes proposed for educational institutions	Effectiveness
	3.2	Water Management Training with Grassroot-level Organizations	Number of integrated processes planned for short, medium, and long terms, aimed at grassroot-level organizations for contributing to the proper management and use of water.	No. of processes executed for grassroot-level organizations/No. of processes proposed for grassroot-level organizations	Effectiveness
	3.3	Water Management Training with Local Authorities	Number of interaction processes between the water utility companies and local authorities, planned for the short, medium, and long terms, aimed at local authorities for contributing to the proper management and use of water.	No. of processes executed for local authorities/No. of processes proposed for local authorities	Effectiveness

At the national level, the Law 373 of 1997 proposes nine indicators: three for each SL, responding to efficiency and effectiveness. The indicators were adapted for (i) SL 1: loss reduction and efficient water use, (ii) SL 2: conservation of water resources, and (iii) SL 3: education and environmental awareness for efficient water use.

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For SL 1, the adapted indicators are oriented toward measuring the reduction in losses in the aqueduct system. In this regard, flow measurement conducted through macro and micrometers determines the achievements of this line type. Regarding SL 2, the indicators were adapted to determine the recovery, protection, and conservation process of water resources based on the proposed area for reforestation and/or restoration and the processes for payment for environmental services (PESs) associated with water resources. Finally, indicators were adapted for SL 3 considering the provisions from article 12 of the Law 373 of 1997 (16) as well as the recommendation from the Ministry of National Education (MEN, for its Spanish acronym) (26) regarding the integration of educational institutions and grassroot-level organizations for developing effective education strategies, complemented by local authorities to make education campaigns more effective and selective.

Results and Discussion

SL 1. Loss Reduction and Efficient Water Use

Figure 1 illustrates the level of compliance with the indicators related to SL 1. The overall result shows that there was no compliance with any of the three indicators (I#1.1, I#1.2, and I#1.3). This is primarily because the installation of macro and micrometers was not scheduled in seven of the PUEAA approved by the environmental authority. In the remaining five cases, where it was outlined as an activity within the program, implementation did not occur during the assessed period. Alternatively, the water consumption measuring device was not operational. Therefore, the absence of flow records for production and consumption indicates that none of the evaluated municipalities met the criteria for the three adapted indicators in SL 1.

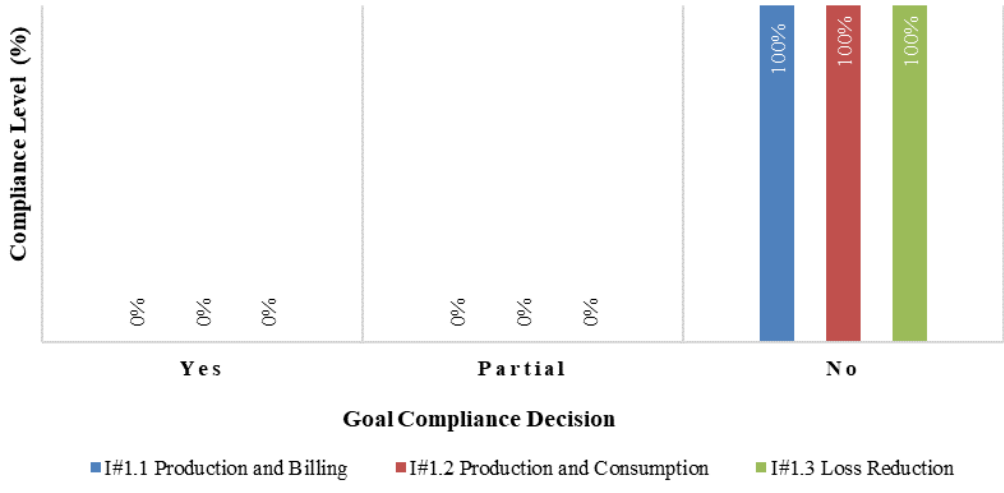

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Figure 1 Indicators Related to Loss Reduction and Efficient Water Use

From the perspective of the water resource management, macro and micromeasurements are fundamental elements for maintaining efficient and effective control in water distribution systems. The implementation of increasingly efficient billing systems, collection procedures, and network and user registries depends on these measurements (27). In this context, Salazar-Adams and Lutz-Ley (28) positively correlated micromeasurements with the physical efficiency (water loss indicator) of an ESP, suggesting that the implementation of measurement instruments is connected to a more efficient water resource management. The absence of these instruments in the case of department of Nariño, even from the formulation of PUEAA, clearly indicates deficiencies in the water resource management.

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In addition, Reyes-Mata et al. (27) asserted that the collection percentage and average income per cubic meter are lower in locations without micromeasurement. Therefore, the lack of water consumption measurement in the municipal heads of Nariño may indicate the commercial inefficiency of the ESP. Regarding the above, Alfaro-Herrera (29) proposed that in situations where water consumption is not measured, ESPs following SL1 strategic approach cannot charge fees for water services, potentially leading to an economic imbalance in the water supply management.

The deficiency or absence of water consumption records may be linked to the limited access and availability of technological, economic, and administrative resources for ESPs in the department. As mentioned by Correa-Restrepo (30), this situation is common in small towns (less than 12,000 inhabitants) and/or rural areas of the country. To resolve this issue, countries such as Bolivia, Brazil, and Cuba consider proportional measurement as a viable and cost-effective option for monitoring water volumes used in different components of a water supply system (31–33).

According to Fuentes-Barrera et al. (34), the cost of a proportional water measurement prototype is 2.5 times lower than that of a mechanical macrometer. Furthermore, León-Méndez et al. (33) suggested that introducing a certain level of automation in proportional flowmeters can improve the efficiency and quality of the provided services. Consequently, these instruments can serve as reliable and competitive technological alternatives to other measurement systems, addressing the issue of flow consumption records in the department's water supply systems and providing an accurate assessment of water usage or loss figures.

SL 2. Conservation

Regarding SL 2, indicator I#2.1 was applied to nine of the twelve municipalities, representing 75% of the sample, and the result was partial compliance. Meanwhile, for the remaining three municipalities, i.e., 25% of the sample, the result was noncompliance with the indicator, as illustrated in Figure 2. Furthermore, although I#2.2 could be applied to seven municipalities, only three approved by the environmental authority had planned activities related to conservation or reforestation. The indicator reported only 58.3% in partial compliance and 41.7% in noncompliance, as shown in Figure 2. Moreover, none of the twelve PUEAA recorded information related to the PESs; therefore, I#2.3 could not be verified.

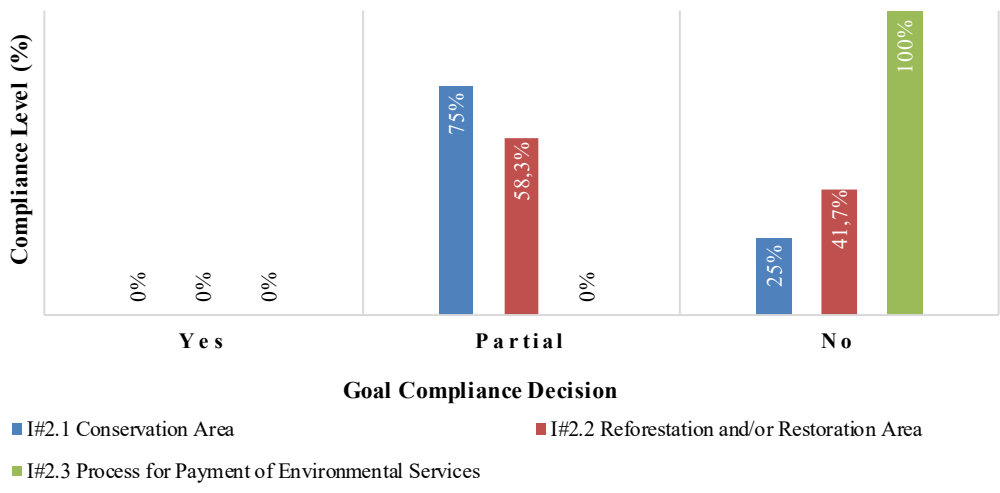

Figure 2 Indicators related to the Conservation of Water Resources

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Because the environmental authority presents favorable statistics in its institutional management report regarding initiatives undertaken by the department of Nariño for the advancement of biodiversity conservation, ecosystem services, and environmental well-being, the reported outcomes might be connected to a potential deficiency in the information management (35). Hence, it can be inferred that certain accomplishments could not be discerned using the reviewed PUEAA records.

Conversely, partial compliance with conservation indicators could result in heightened pressure on water-regulating ecosystems (15). In an agriculture-oriented region such as the department of Nariño, demand for water for diverse activities may lead to soil overuse, consequently causing the loss of vegetation cover and an imbalance or reduction in water supply (36, 37). However, this can be mitigated through PUEAA, contemplating activities such as the acquisition of land with hydrological significance for conservation purposes.

In relation to the above, Gentes y Madriga (38) established that acquiring properties through ecological easements (SEs, for their Spanish acronym) is a recommended instrument in terms of control and guarantees over water resources; however, they agree with Retamal et al. (39), who stated that it is a very expensive option. SE is a legal mechanism by which landowners voluntarily commit to preserving existing forests in their property. In Latin America, SE is a widely employed conservation tool based on the PESs (40).

Another applicable mechanism to foster actions for the benefit of conservation, reforestation, or restoration of watersheds is the ecological loan fund. Through this fund, communities, with the intermediation of ESP, gain access to interest-free loans to purchase lands with hydrological importance. Due to the absence of interest payments, communities are accountable for executing the restoration, protection, and monitoring of environmental services provided by the acquired lands (38). The ecological loan fund model is not restricted to the water sector but has also been effectively incorporated into policies supporting the energy rehabilitation of houses in France and Germany (41).

In relation to the process indicator for PESs, Puerta-Fernández et al. (42) highlighted that the adoption of this environmental protection philosophy faces two primary obstacles: limited demand for payments for environmental services and a lack of knowledge on the relationship between demand and willingness to pay. This might explain why this methodology is not considered, even in the formulation of PUEAA. Martínez-Callejas et al. (37) disclosed that, generally, the population of deparment of Nariño comprehends the importance of conserving water resources for operating productive systems. Therefore, this aspect could be leveraged to encourage one of the most renowned environmental services, such as the protection of watersheds, where payment is made for land use to curtail deforestation, soil erosion, and flood risks (39, 42).

SL 3. Education and Environmental Awareness for Efficient Water Use

The results for the indicators established for SL 3 are presented in Figure 3. Indicator I#3.1 revealed that only one municipality (8.3%), complied with the proposed indicator; six municipalities (50%), partially complied; and five municipalities (41.7%), did not comply with the indicator. As for indicator I#3.2, ten municipalities (83.3%), partially complied and two municipalities (16.7%), did not comply with the indicator. Finally, for I#3.3, only one municipality (8.3%), complied and eleven municipalities (91.7%), did not comply with the indicator.

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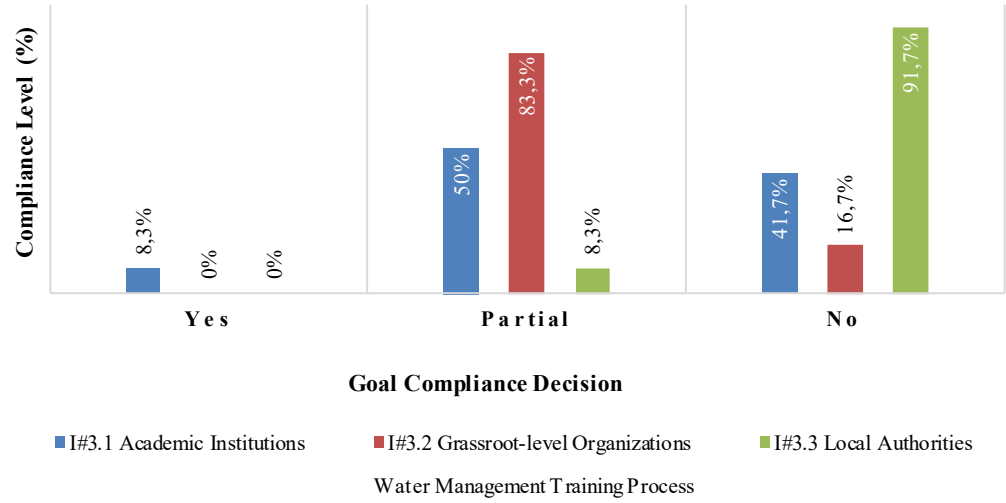

Figure 3 Indicators related to Education and Environmental Awareness for Efficient Water Use

Upon detailed record examination, training processes were noted to be conducted with grassroot-level organizations or educational institutions, potentially ensuring the expansion of knowledge and spreading awareness regarding the complexity and global nature of environmental issues. This approach can foster attitudes, values, and behaviors in individuals (43). However, sessions focusing on this aspect have short durations, conducted for hours or days, overlooking the fact that environmental education is an ongoing process within communities. Such sessions are essential for developing environmental behaviors and sustaining long-term motivation, ensuring that individuals are convinced of the effectiveness of their actions toward water conservation and care (6). In addition, two isolated cases related to the establishment of water clubs were observed.

According to Moreira-Segura et al. (44) to achieve high compliance values in training indicators, strategies for more efficient and rational water use should extend beyond technological training. Furthermore, they should encompass activities that lead to increased actions linked to lifestyles. Therefore, environmental awareness and education must be complemented by continuous social pedagogy. This emphasizes the need for sessions to be organized as part of the ongoing processes within PUEAA.

Hernández-Cruz et al. (43) proposed a two-phase approach for environmental training processes when formulating training processes for different age groups. The first phase involves preparation to define the focus areas, and the second phase includes strategic planning, where goals and action plans are defined to contribute to the established goal of reducing water consumption and advancing toward social transformation. This proposal is intriguing, given the evidence that Nariño society understands the importance of water resource conservation (37), thereby paving the way for enhanced environmental education.

Meanwhile, Muñoz-Montilla and Páramo-Bernal (45) asserted that in Colombia, there is no formulation of indicators to evaluate the effectiveness or impact of interventions and processes for environmental education. Therefore, this deficiency of indicators could be observed in environmental education and awareness for efficient water use, coupled with the evidence for shortcomings in the document management and information flow in monitoring PUEAA and actions performed by ESPs and municipal administrations related to law enforcement.

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Proposals to Improve the Monitoring of PUEAA in the Nariño's department

Throughout the process of documenting and constructing an inventory of PUEAA as well as in the application of indicators, it was noted that there are procedural gaps concerning the interpretation and applicability of the Law 373 of 1997. This issue primarily stems from a lack of awareness within the environmental authority, particularly among its officials, regarding which entity or entities in the department should be mandated to submit PUEAA. Inconsistencies were identified in various aspects, including the number of subscribers, users, measurement units, budget, and other related factors. The absence of a comprehensive database reflecting the organization of PUEAA poses challenges in swiftly identifying crucial details such as the municipality, an ESP, a date, administrative approval and water concession dates, expiration date, and field monitoring (verification of management and impact indicators), among other aspects.

Building upon the aforementioned observations and results of previously presented compliance indicators, the following proposals are proposed to improve the monitoring of actions and regulation of efficient water use and conservation in the department of Nariño.

Technical Data Sheet

Develop a technical sheet that enables the environmental authority at the department of Nariño to closely monitor PUEAA and provide precise instructions to ESPs regarding the execution evidence during review visits by the authority.

Inclusion of Environmental Centers in the Reception, Monitoring, and Evaluation of PUEAA

Enhance the technical capabilities of the environmental authority's team and delegate specific responsibilities to environmental centers regarding controlling and monitoring implementation of indicators. Decentralize the monitoring of PUEAA by entrusting this role to environmental centers within the organization. This initiative can run concurrently with the supervision of various water concessions managed by environmental centers, thereby establishing a seamless coordination between the concession oversight and water resource management.

Observatory for PUEAA

Establishing an observatory is pertinent for recognizing the importance of adhering to the actions outlined in the PUEAA and crucial role of the information management. This mechanism would: (i) facilitate the monitoring of actions undertaken by ESPs and municipal administrations and (ii) compile information from various stakeholders engaged in efficient water use and conservation in the region. Additionally, it could be utilized to disclose the state and evolution of efficiency and effectiveness indicators, such as those previously presented or others deemed relevant. This approach aids in preventing document loss, thereby enhancing the control and monitoring of progress toward the objectives set by ESPs.

Physical and Digital Database

To streamline the organization of PUEAA documentation submitted by water users, it is advisable to create a physical and a digital database. This dual approach ensures easy and secure access to information for the assessment and monitoring of programs. Moreover, this approach facilitates continuous improvement and an immediate response from the environmental authority for water users. While the use and application of the digital platform can be executed by several environmental centers in conjunction with the central office, the collection of physical records would be centralized at the main headquarters of the environmental authority of the department.

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Certification in the ISO 46001:2019 Standard

Although compliance with the ISO 46001:2019 standard is voluntary for the efficient water management in companies, it is recommended to the department of Nariño and generally in Colombia to promote the certification of companies to this standard. This is because this approach offers environmental benefits for sustaining water resources. Encouraging the implementation of certification could involve updating the Law 373 of 1997 to offer economic incentives to companies voluntarily seeking certification.

Conclusions

The sustainability of ecosystems and basic human needs can be protected to a certain extent when actions align with laws and regulations. Hence, to guarantee efficient water use and conservation, environmental authorities and ESPs must work together effectively.

The application of indicators for management models, particularly in the context of PUEAA, has offered valuable insights into their relevance and impact on the water resource management. This understanding can prove beneficial for public entities and decision-makers engaged in water-use regulation.

The efficiency and effectiveness indicators have highlighted that the absence of mechanisms for tracking the volume of water produced and consumed in water supply systems considerably hampers compliance with the SL of loss reduction, identified as a notable deficiency in formulating and monitoring PUEAA in the department of Nariño. Furthermore, the SL of conservation can be improved by encouraging the mechanism of PES programs, which can be more economical than purchasing properties with hydrological importance for reforestation or restoration activities. Regarding the education line, although the indicators showed better performance in achieving compliance and have a long-term effect, PUEAA shall indicate that actions in this line must be permanent throughout the validity period.

The observed low indicator levels are attributed to deficiencies and disorganization in PUEAA records within the environmental authority and among users (ESP), along with a general lack of awareness regarding the terms and requirements of the Law 373 of 1997.

This paper proposes several measures to enhance compliance monitoring based on the national guidelines for regulating efficient water use and conservation in the department of Nariño. These measures encompass the creation of a technical data sheet, involvement of environmental centers, establishment of an observatory for PUEAA, development of the physical and digital database, and encouraging companies to obtain certification under the ISO 46001:2019 standard.

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