Effect of women's inclusion on Collective Actions in Water User Associations in Latin America

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1. Introduction

Empirical evidence has suggested that women bring unique perspectives, experiences, and preferences to the table, profoundly impacting decision-making processes related to environmental conservation (Agarwal,2010; Cook et al. 2019). Studies in various contexts, from legislative bodies (Chattopadhyay & Duflo, 2004) to community organizations (Agarwal,2009) have demonstrated that increased female representation correlates with different policy decisions and, in particular, more comprehensive, and effective strategies for environmental sustainability. In political science, a large body of literature discusses the role of descriptive representation across a range of decision areas (Clayton,2021; Haider-Markel,2007). In water resource management, the gendered dimensions of decision-making and community involvement are increasingly recognized as essential factors shaping the sustainability and resilience of water management (Machado et al. 2022). The role that women play in water management, from household-level tasks to community-based initiatives, has often been undervalued (Nounkey & Dharod,2021).

As environmental challenges such as water scarcity and pollution continue to escalate globally, understanding the influence of women's participation on water resource management becomes increasingly important. Women, often tasked with responsibilities related to water collection, sanitation, and domestic water use, possess experiential knowledge that can potentially inform effective and contextually relevant water policies. Therefore, it is important to study the role of women in decision-making scenarios within community-managed water supply systems. Water User Associations (WUA) are one type of community water management common in rural areas of developing countries. Usually, they are the sole providers of water in rural areas (Delgado-Serrano et al., 2017). They are born from a self-supply water necessity because the location is inaccessible or in marginalized areas (OECD,2013).

This research aims to explore the potential effects of women's participation in the executive boards of Water User Associations on environmental conservation actions in rural contexts of developing countries, with a specific focus on Latin America. Utilizing data from the Rural Water and Sanitation Information System (SIASAR) database, I obtained information on the gender composition of the boards and the environmental and management activities promoted by the WUAs in Bolivia, Colombia, Honduras, Nicaragua, and Panama. Employing

cardinality matching to achieve a balanced sample, I tested the effect of having at least 30% women as members of the executive boards on the WUA's conservation and protection activities.

2. Literature Review

Women's influence on policies.

Over the past few decades, a notable shift has occurred in the political landscapes of Latin American countries. Since the late 1990s, the adoption of gender quotas for legislative elections has evolved from an idea to a reality (Peschard, 2002), opening a new branch of studies dedicated to exploring the effects of women as part of the political body in the policy field. Empirical studies have pointed out that women potentially influence attention to problems that can have higher economic and social effects on women (Clayton, 2021). This does not mean that all women have the same preferences; different women have different experiences based on their race, religion, partisanship, and other social factors (Celis et al., 2008; Beckwith, 2014). However, common issues that disproportionately affect women are generally brought to the attention of the policy scenario by women in parliament (Clayton, 2021), for example, water access in rural settings (Chattopadhyay & Duflo, 2004).

In Latin America, the increase of women in parliament has helped increase institutional resources to promote women's representation, promote public policies with a gender approach, and draw attention to issues rooted in gender disparities (Peschard, 2002). According to Inter-Parliament Union at the beginning of 2024, on average 31.3% of parliament seats were occupied by women in South America, while in Central American countries, on average, 30.3% of parliamentary seats were occupied by women.

The mechanisms by which women are influencing the policy field seem to be diverse (Clayton et al., 2019), but this influence seems to extend beyond the traditional realms of politics and can be perceptible in community organization settings. Empirical studies on common-pool resource management have shown a correlation between the presence of women in community committees and improved outcomes in environmental conservation (Agarwal, 1997; Agarwal, 2009). However, some studies in rural settings of developing countries have not found significant effects of women's participation in the success of water-related projects (Narayan, 1995; Prokopy, 2006). This difference in findings potential can be related to the different forms of participation, in Agarwal research (2009) women were active part of the executive committee of the community forest institutions, while in the Prokopy (2006) study women participation in local water committees were more of a token in the meetings than a meaningful participation. Similarly, Narayan (1995) mentioned in the review of 121 rural water projects, that most of the women involvement in the projects did not translate to high and meaningful participation.

Participation can take multiple shapes in a water management project. It is important to recognize that the presence or membership of women in a project is not enough to achieve

equality and effectiveness, or even that their voices will be heard (Grillos 2018). Cook et al. (2019) underscore the importance of comprehensive support for women's empowerment to achieve sustainable and desirable conservation outcomes in rural settings. As I acknowledge the importance of assessing different types of participation, this paper is focused on the participation of women in decision-making scenarios, specifically water boards.

The role of women in stakeholder positions or decision-making scenarios has been tested in different developing countries. Some of the main findings point to the positive effect of having women in an active role or in decision-making scenarios. For example, Sultan and Thompson (2008) found that community compliance with water regulation rules increased when both women and men had active roles in managing the resource in Bangladesh. Cook et al. (2019), using a field-based experimental game, found that groups with randomly assigned gender quotas tend to have a higher conservation ratio and equity in the gain distribution. Hence, it is possible that women's active and sizable participation in decision-making scenarios of water management can positively influence the water management outcome.

Community-Managed Water Supply

Zooming into the specific context of community-managed water supply in rural areas, a closer examination of studies conducted in rural areas of both Latin America and Africa highlights a critical dimension: the disproportionate impact of water management on women (Machado et al., 2022). Rooted in deeply ingrained social norms and gendered practices, the responsibilities associated with domestic labor, particularly water collection for rural household tasks often fall disproportionately on women (WHO,2017). This not only places a significant demand on their time but also exacts a toll on their physical well-being (Silva & Resende, 2022). Similarly, studies have found that conservation strategies that were design and implemented without women’s input do not always lead to better outcomes for women (Agarwal,2000). This suggests that women in rural areas of Latin America are being heavily affected by the water management decisions made in their territories and potentially motivated to influence the water management process in their communities.

Water User Associations (WUA) a form of community-managed water supply, have played a key role in rural Latin America as water providers for remote and dispersed rural communities (Romano et al., 2021). They usually emerge as community-born institutions to provide a solution to the lack of access to water because the government do not provide the service (Avina,2011). WUAs have been serving as the only water management institutions for decades in multiple rural areas of Latin America (Delgado-Serrano, 2017). These associations are in charge of several key decisions, from appropriation and provision choices - who and when gets water, to how much (if any) users have to pay for water, even how to maintain and protect the resource.

In the context of gender related research in the area of water management in rural areas, studies have been primarily focused on management of irrigation systems (Mwadzingeni et al., 2022; Bryan & Garner 2022; Balasubramanya, 2019; Nang et al.,2013; Revollo-Fernández

et al.,2015). Hence, there is a gap in the literature to solve questions related to WUA's that provide water for domestic consumption in rural areas and gender dimension. Furthermore, in the rural context, women might have a large impact on decisions about water management, due to the significant reliance on women for domestic activities in rural contexts (WHO, 2017), potentially positions them as the most knowledgeable members of the community to propose water management decisions. Therefore, it is important to study domestic water management in rural areas with a gender perspective.

This study aims to contribute to the ongoing discourse by exploring the effects of increased women representation in water management, specifically in the active participation on boards of community-managed water supply for domestics use in rural areas of Latin American countries. Through a comprehensive analysis of a multi-country quantitative dataset, I seek to explore a potential relation between women's participation in WUA boards and better water management practices in a rural context.

3. Theory

Water User Associations and Collective Action

Natural resources, such as water systems, are categorized as common pool resources (CPR), due to their subtractable nature and the difficulty in excluding access (Ostrom et al., 1992). These characteristics create a social dilemma, with short-run individual incentives at odds with the long-run collective good (Ostrom,1998). Water management, as a CPR, can suffer from overexploitation, asymmetries in appropriation, and free riding (Ostrom, 1992; Swallow et al., 2006; Cardenas et al., 2010), making cooperation among individuals necessary to achieve effective management of water.

Multiple studies have demonstrated that communities can overcome the social dilemmas of water management and organize themselves, often without external intervention (Ostrom, 1990), through collective action. Collective action can be characterized by four main conditions: 1) requiring a group of people 2) who have a shared interest or goal 3) agreeing to take a particular action to achieve that goal 4) voluntarily, without expecting any type of compensation. In water management, depending on context and scale, collective actions can take various shapes; they can range from the creation of institutions to coordination of a single activity (Markelova et al., 2009; Cardenas et al., 2010).

In rural Latin American communities, the need for domestic water access and resource management motivates community members to seek collaborative solutions, leading in some cases to the formation of community-based management (Delgado-Serrano, 2017). These management institutions often manifest in the form of Water User Associations, which can be considered as outcomes of collective action when they originate from community-driven organization rather than policy mandates. WUAs are tasked with managing water resources, including responsibilities like appropriation, distribution, maintenance, and quality of the resource; in other words, they consistently foster collective actions to achieve sustainable

water management practices, thereby having the potential to contribute to community development by fostering collective actions.

Gender and Collective Action

Empirical studies have demonstrated that collective action in natural resource management can be inefficient without genuine gender inclusion. Agarwal (2000) argued that communities' forestry groups (CFG) neglecting participation of women in CFG executive committees can lead to inequalities in the distribution of benefits granted from forestry protection, as women may be perceived as less active workers than men.

Moreover, initiatives may fail more often due to ineffective regulatory and enforcement mechanisms that fail to address women's needs. Agarwal (2000) argues that by ignoring women's needs of the resource, regulatory rules can be violated often because women still need to fulfill their necessities. Also, the assessment of resource depletion can be miscalculated; for example, women in the CFG areas spotted with higher precision than men the areas where illegal cutting occurred. Finally, Agarwal argues that the lack of active inclusion of women in the CFG can cause an asymmetry of information as well; women can potentially miss important changes in the rules because the information was not shared with them. This exclusion of women in decision-making scenarios can affect the level of cooperation.

In terms of resource conservation, empirical evidence suggests that women exhibit higher conservation attitudes than men (Agarwal, 2000; Revollo-Fernández et al., 2015; Cook et al., 2019). Different rationales, such as household roles and sensitivity to authority, have been proposed to explain these differences. For example, Agarwal suggests that the household roles typically held by women in rural areas potentially lead women to be more affected by the scarcity of the resource, resulting in a potential higher preference for conservation actions than men (Agarwal, 2000). Revollo-Fernández et al. (2015) conclude that women demonstrate higher adoption of suggestions for sustainable practices from the authority after implementing a behavioral game simulating irrigation practice in a rural context. On the other hand, Cook et al. (2019) found that gender group quotas of 50% led to fewer harvests in a lab-in-the-field experimental study, using payments for environmental services as a condition.

Vollan and Henry (2019) offer other explanation to results, they point out that according with the systemic theory environmental concern can be heavily influenced by societal norms and cultural education. According to this perspective, women may exhibit higher levels of environmental concern because they are socialized to be more empathetic and less dominant, traits that align with caring for the environment. The benefit of having gender quotas is the possibility of diversifying the worldview of the decision-making group. This raises an interesting question about the gender balance composition of the groups. Is there a minimum threshold that must be met to perceive an influence of women’s worldview in a decision-making group?

In the empirical study conducted by Cook et al. (2019) the authors enforce a gender quota of 50%, achieving significant and positive results in the conservation experiment. Comparably, Agarwal (2019) conclude that groups with at least two women or more in their executive committees had higher conservation rates than groups with less than two women. Chattopadhyay and Duflo (2004) found that having a gender quota of at least 33% of the parliamentarian seats reserved for women could lead to more infrastructure development for water access in rural areas of India.

Gender quota in multiple governments in Latin America are similar to does report by Chattopadhyay and Duflo (2004), as explained before; then, it is expected that in order to see a gender-based effect in collective actions there needs to be at threshold, a minimum number of women participating. Based, on the empirical evidence describe and the current gender quotas by most of the Latin American governments is reasonable to expect that at least 30% of the WUA board members participants should be women in order to see an effect.

Based on theoretical and empirical evidence, it is expected that women's participation in WUA executive boards will lead to better water management outcomes. This paper aims to explore the relationship between women's participation in WUAs executive boards and environmental and managerial actions implemented by the board. While understanding the mechanisms of potential influence is crucial, this paper focuses on establishing the direction and magnitude of the potential relationship between women and domestic water management in rural contexts of Latino American countries.

Hypothesis

I hypothesize that Water User Associations with at least 30% of women as members of the executive boards will promote more environmental conservation activities than boards with a lower percentage of women. These activities include any activity that can led to the conservation and/or protection of the freshwater ecosystem.

4. Methods

4.1 Data source

As an information source, I utilized the Rural Water and Sanitation Information System (SIASAR) database. SIASAR is a platform that provides free information on rural water supply and sanitation services in Latin America. Data is collected by a SIASAR technician in the field through surveys using four questionnaires, each designed to gather data on a different aspect of water services: 1) Community, 2) Water Supply System, 3) System Provider, and 4) Technical Assistance to the Provider, the surveys are directed to the services providers in the water systems, creating a dataset per water systems. After the data gathering process, the data is reviewed by the technical team and edited if necessary. Before publication, the technical team validates and analyzes the data to provide a classification of the water system, ranging from A to D, where A represents an optimal system and D indicates a deficient system. The validated

data can be downloaded by country, providing access to all four questionnaires along with the indicators calculated by SIASAR for classification.

After obtaining the datasets, I filtered the observations by type of service provider. Since the unit of analysis is the WUA, referred to as Community Organizations in the downloaded datasets, service providers classified as *Public Institutions* and *Others-Private* were excluded from the data, leaving observations only from service providers classified as *Community Organizations*. Additionally, observations from service providers that were surveyed but not yet providing a service were also excluded. The filtered dataset I obtained included observations from five countries: Bolivia, Colombia, Honduras, Nicaragua, and Panama, totaling 5,234 observations. Table 1 shows variations in observations across the countries; this is a result of the filtration process based on the type of service provider and the original number of surveyed providers by SIASAR.

Observations per country

	Country	n
1	Bolivia	500
2	Colombia	2,576
3	Honduras	426
4	Nicaragua	1,670
5	Panamá	62

Table 1. Observations per country

As of the date of this research, none of the mentioned countries have a specific national water policy that mandates a gender quota for the WUA's executive board. The gender composition of the WUAs is likely the result of the regular dynamics of the community, rather than being influenced by a predetermined gender quota.

4.2 Independent Variable and Treatment

The gender composition of the WUA executive board was obtained from the SIASAR dataset. The Service Provider survey reports the total number of management committee representatives (executive board), along with their names and genders. Dividing the total number of women by the number of members, I calculated the gender composition of the executive board. Our primary analysis focuses on the 30% cutoff that is most commonly cited in the literature on legislative gender quotas, but also, I included an exploratory analysis that looks at how results change at different cutoff levels. Using the gender composition of the board as a continuous variable, different treatment cutoffs were tested, ranging from 10% to 90% of women being members of a WUA executive board. For each cutoff, I created a binary treatment variable, where a value of 1 indicated being 'treated' by having a gender composition equal or

greater to the cutoff. A value of 0 represents our 'control' group, meaning that the WUA had a gender composition less than the cutoff.

4.3 Dependent Variables

The broader dataset includes variables relating to water, sanitation and hygiene, system infrastructure, service provider management, technical assistance, and schools/ hospitals access. Examining the variables in this observational dataset, I identified those which meet two key criteria: (1) they are likely to result in better environmental conservation outcomes, and (2) they reflect management actions that can be taken directly by the WUA board that could impact the overall management of the resource. Using this selection criteria, I designated our key dependent variables.

Conservation Variables

Two variables were identified to provide information about conservation activities that could lead to better conservation outcomes: Source Protection and Environmental Sanitation. The data for these variables was obtained from the Service Provider Survey as a binary response (Yes or No) based on the following questions:

- Source protection: "*Does the provider promote environmental protection in the area near the water source or intake?"*

- Environmental Sanitation: *"Does the provider promote environmental sanitation and community hygiene practices?"*

Environmental protection activities and sanitation activities could indeed lead to better conservation outcomes, as both are related to ecosystem preservation through different methods. Environmental protection activities, such as reforestation, protects the actual intake area, such as rivers or groundwater sources. On the other hand, sanitation activities focus on preventing wrongful waste disposal and pollution, thereby safeguarding the overall ecosystem health. Both types of activities contribute to conservation efforts by preserving natural resources through different approaches. Both can be considered forms of collective action that the WUA is in a position to help facilitate in its leadership position within the community. Across all the WUAs in the dataset 67% engage with sanitation and hygiene promotion and 74% promote source protection activities.

Management variables

Actions that can be directly taken by the WUA board, potentially impacting the overall management of the resource, were identified through four variables in the Service Provider Survey: Accountability, Tariff, and Minutes were variables derived from binary responses (Yes or No), while Legal status was obtained from a selection question.

- Accountability: *"Is the provider accountable to the community?"*
- Tariff: "*Has a tariff structure been defined?"*
- Minutes: *"Are there minutes from community meetings?"*
- Legal: "*Legal Status of Provider? Legally established | In process of legalization| Not legally established*"

All variables were recoded to follow a format where 1 represents 'Yes' and 0 represents 'No'. For the Legal variable, the coding was adjusted as follows: 1 represents 'Legally Established', 0.5 represents 'In process of legalization', and 0 represents 'Not legally established'.

These variables could significantly impact the overall management of water resources. For instance, tariffs might lead to a reduction in water consumption (Cristiano et al., 2020; Vollaro et al., 2014). Accountability improves overall water resource management according to the review of water resource management interventions (Hepworth et al., 2022), potentially resulting in better sustainable outcomes. Record-keeping, such as minutes of meetings, is consider an important instrument for fostering trust and transparency, thus enhancing accountability (Sundqvist,2011). Additionally, in certain cases, legally established community-based management institutions may better regulate resource access, as suggested by Agarwala & Ginsberg's (2017). This regulation could enhance control over resource consumption. Therefore, these variables play a crucial role in shaping the effectiveness and efficiency of water resource management within WUAs. Across all WUAs in our dataset 67% report they do minutes recording of community meetings, 74% declare they are accountable to the community, 59% are legally establish and 88% have implemented some form of tariff.

4.4 Matching Design

Given the use of observational data, simply comparing the treatment and control groups would leave open the possibility of confounding. Any observed correlation between the percentage of women on WUAs and their management practices could possibly be explained by some third variable. For example, systems with worse hydrological conditions might both motivate more women to be involved in the committee and motivate more actions to solve the problem, even if the presence of women per se is not what drives the conservation activities. In order to address this potential confounding and reduce potential bias in estimate effects from imbalances in observable covariates, I used cardinality matching as proposed by Visconti & Zubizarreta (2018). With this approach the largest matched sample that had a covariate difference between the treatment and control group of less than 0.1 was found for each treatment cutoff (i.e. 10%, 20%,30%...etc.)

Covariate balance

To mitigate potential bias in the estimates caused by observable covariates, two different sets of covariates were used in the matching procedure. For conservation variables, I considered: water source condition, system infrastructure condition, financial state, and external help

endowment. If the water intake exhibits severe quality issues, such as an excess of sediments, it is more likely that the board will support conservation activities to address these issues. Similarly, regarding the system infrastructure condition, better quality of intake water would result in fewer infrastructure problems occurring. Additionally, the financial state of the WUA can either promote or discourage investment in conservation activities. Likewise, external assistance from NGOs or public institutions can incentivize conservation activities.

Regarding the management variables, I believe that external assistance, type of water treatment used, and number of houses served can influence actions such as tariff determination, accountability, minutes archival, and legalization status and could simultaneously influence the number of women on the board (especially in the case of external assistance). For instance, certain water treatments may require higher costs, potentially impacting the tariff or legalization status of the WUA. Moreover, WUAs tasked with providing water to a larger number of houses are likely to prioritize accountability and maintain records of the meetings.

After the matching process a linear regression was used to obtain an estimate of the effect of our treatment (gender composition) on the different dependent variables. With our binary outcome variables, this takes the form of a linear probability model, and should tell us the effect of the treatment on the probability that the behavior measured by the outcome variable is observed or not.

4.5 Placebo test

The involvement of women in the board is hypothesized to improve pro-environmental behaviors and management practices of the board. However, it is possible that improving environmental conditions partly motivates the selection of more women into the board. In order to rule out this form of reverse causality, a placebo test was performed. I identify variables that are closely related to environmental outcomes but that are not likely to be strongly correlated with decisions of the board, due to many other influences that have a much more direct influence on these outcomes. If better environmental conditions cause more women to join the board, then I might expect some of the placebo variables to correlate significantly with our primary independent variable. On the other hand, if more women on the board leads to more pro-environmental management practices, as hypothesize, then these placebo tests likely will not yield significant results, since many things outside of the direct control of the board influence these particular outcomes.

The placebo tests were selected based on the following criteria: (1) They are likely to correlate with environmental outcomes but (2) they are not likely to be directly influenced by the board. The variables I chose to meet these criteria were: *water flow* and *dry season resource*. Water flow refers to the catchment water flow and dry season resources was a Yes or No answer to the question "*Are there adequate water resources (at the source) to meet demand?".* The WUA board cannot directly influence the quantity available of the original resource (at least not over

the time scale of this data collection) and yet the availability is related with environmental outcomes, these variables fulfil the requirements for the test.

Of course, this placebo approach does not rule out the possibility that specific activities of the board, rather than environmental success, are what might be directly motivating more women to join the board. I cannot analytically eliminate the possibility of this form of reverse causality. However, theoretically I argue this is not an insurmountable problem for our main conclusions. First, I argue that this is unlikely. If boards are already making decisions people agree with, this should generally be less motivation to incur additional individual costs by participating directly for no expected change in outcomes. Second, I note that even in the unlikely event that it is true that women are attracted to join WUAs due to specific management practices, that is still a strong indicator that women are on average more supportive of those management practices. This would still have similar policy implications as it strongly suggests that if women were motivated to join through other means (for example, explicit quotas) that once on the board, they would be likely to support such practices.

5 Results

5.1 Descriptive Statistics

WUA's from Colombia and Nicaragua had the higher average members women in the board, with 33% and 40% respectively. Bolivia on average had boards with 18% of women representing the lower average from the dataset. All tested WUA's provide water on average of 116 users, Colombia had the WUA with more users providing water to 38218 homes. WUA's executive boards had on average 5 members.

Descriptive Analysis Gender Composition

	Country	n	Min women	Median women	Mean women	Max women	St. Dev women
1	Bolivia	500	0	0	0.18	1	0.27
2	Colombia	2576	0	0.33	0.34	1	0.25
3	Honduras	426	0	0.29	0.27	1	0.22
4	Nicaragua	1670	0	0.4	0.39	1	0.26
5	Panamá	62	0	0.14	0.23	0.83	0.25

Table 2. Descriptive statistics of ratio of women in the board per country

All the covariates mean differences after the cardinality matching process were lower than 0.1, guaranteeing a covariate balance treatment and control (Appendix A). After matching, the treatment of 90% of women in the board had the lowest number of observations with only 366 (T= 183, C=183), which represents only 7% of the full dataset. I ultimately decided to exclude

this 90% cutoff from the analysis due to the substantial decrease in sample size which would make it difficult to draw conclusive insights.

Observations per treatment

	Treatment	n
1	0.1	2,436
2	0.2	3,044
3	0.3	4,918
4	0.4	4,688
5	0.5	3,178
6	0.6	1,888
7	0.7	864
8	0.8	644
9	0.9	366

Table 3. Observations after matching per treatment cutoff.

The placebo test using water flow and water availability during dry season suggest that the environmental conditions do not cause more women to join the board, as neither of the variables correlated with the percent of women on the board (see Appendix B).

5.2 Effect of gender composition at 30% cutoff

Table 4 shows the estimated effect of having at least 30 percentage of women members of the executive board on conservation and management practices implemented by the WUA as direct test of our hypothesis.

	Dependent variable:							
	Source Protection	Sanitation	Legal status	Accountability	Tariff	Minutes Record	Placebo Water flow	Placebo Dry Season
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
30% cutoff	0.046***	0.076***	0.108***	0.033***	0.019**	0.039***	1.142	0.021
	(0.013)	(0.013)	(0.013)	(0.013)	(0.009)	(0.013)	(8.295)	(0.026)
Constant	0.712***	0.623***	0.563***	0.719***	0.867***	0.648***	8.761**	0.642***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.007)	(0.009)	(3.430)	(0.011)
Observations	4,918	4,918	4,918	4,918	4,918	4,918	4,913	4,918

R^2	0.003	0.006	0.013	0.001	0.001	0.002	0.000	0.0001
Residual Std. Error	0.441 (df = 4916)	0.472 (df = 4916)	0.462 (df = 4916)	0.441 (df = 4916)	0.329 (df = 4916)	0.471 (df = 4916)	151.524 (df = 4911)	0.477 (df = 4916)

Note: $^{*}p<0.1$ $^{**}p<0.05$ $^{***}p<0.01$

Table 4 Effect of having at least 30% of women on the executive board on conservation, management, and placebo variables.

Having 30% or more women as members of the executive board of a WUA shows a significant effect on all of the tested variables and no effect on the placebo. The conservation variables, source protection, and sanitation show statistical significance less than $p<0.01$. Similarly, most of the management variables resulted in $p<0.01$, except for Tariff, which, even though significant, had a p-value close to 0.05. The lack of statistical significance ($p>0.05$) from the placebo variables at the cutoff, even though the variables underwent the same matching procedure and regression, and the statistically significant results for the dependent variables, indicate that is unlikely that the obtained results are product of random chance. This suggests that when WUAs have at least 30% of women as members of the executive committee, they could potentially have a positive influence and increase conservation practices, such as environmental protection activities near the source of water.

In terms of the effect size that women's participation might have Table 4 illustrates that Legal status, a variable with three possible outcomes (1 = legalized, 0.5 = in the process of legalization, 0 = not legalized), the estimated effect is 0.1, meaning that WUAs with at least 30% of women on the board are 10% more likely to become legalized. As pointed out before, legalization in some scenarios might help these institutions better control access to the source (Agarwala & Ginsberg, 2017), potentially aiding the WUA in achieving better control and clarity regarding resource consumption.

The results also suggest that WUAs that maintain at least a 30% women ratio in their executive boards are 7.6% more likely to promote environmental sanitation practices, such as proper disposal of solid waste. To contextualize these effects, according to the Joint Monitoring Program (JMP) between 2000 and 2022, sanitation coverage increased by 26% in Colombia, 33% in Bolivia, 22% in Panama, and 25% in Honduras. This indicates that, at the country level, sanitation, understood as the safe management of waste in domestic settings, grew at an average rate of approximately 1% per year in the countries reference in this study. Therefore, it is logical to underscore the significance of women's participation in potentially increasing sanitation practices by 7.6% in rural communities. It is important to note that the JMP report focuses on establishing basic sanitation practices; however, it is plausible to assume that these established practices may have born from promotion of better sanitation practices, such as use of septic tank or ventilated improved pit latrine, strategies that might been promoted by the WUA's in this study (SIASAR,2018).

Furthermore, these WUAs are 4.6% more likely to promote environmental protection in the area of water intake areas. These protection activities may include safeguarding fauna and flora near the intake area, preventing deforestation, promoting reforestation, and implementing soil conservation practices (SIASAR, 2018). Therefore, even though the effect size does not seem large, it is 4.6% more likely that WUA's with at least 30% of women in the board, will promote these key strategies for water protection (EPA).

Accountability and tariff compliance can be 3.3% and 1.9% more likely, respectively, in this type of WUAs, indicating that the size of the effect is not as substantial as with other variables that could potentially have a more direct impact on resource conservation. Similarly, the likelihood of minutes being recorded is 3.9% higher in WUAs with 30% or more women on their board. It is notable that accountability and minutes exhibit similar effect sizes. This similarity may be attributed to the likelihood that WUAs accountable to the community tend to maintain minutes of meetings as this practice can be associated with transparency (Sundqvist, 2011), and serves to enforce accountability.

The results indicate that all estimates on the outcome variables were significant. Given that this holds true for all the tested variables, it is reasonable to suggest that having at least 30% of women participating in the executive board of a WUA that provides domestic water in rural contexts of Latin American countries can influence the board's decisions about promoting activities that will benefit the ecosystem in a direct or indirect way.

5.3 Other cutoffs

To test the cutoff variation, different cutoffs were examined using the same strategy described previously. The inclusion of each cutoff was based on the number of observations. The 90% cutoff, having less than 7% of the observations, lacked meaningful representation. Figure 1 illustrates the estimated effects of various cutoffs of women on executive boards on the source protection variable.

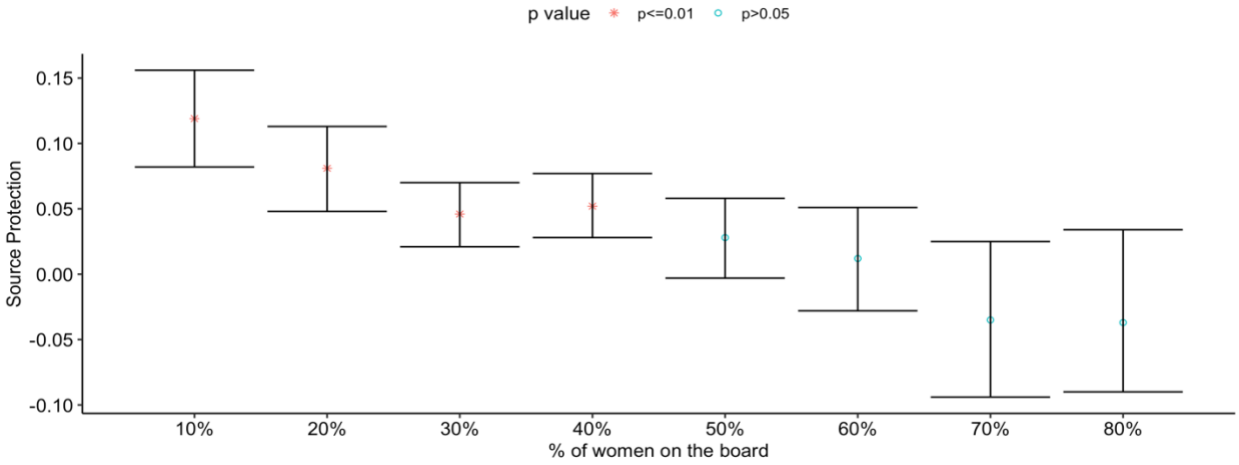

Figure 1. Estimated effect of percent of women on an executive board, with 95% CI.

There is a significant effect ($p < 0.01$) on the promotion of source protection activities when the cutoff for women's representation is set between 10% to 40%. In addition, at a 90% confidence level ($p < 0.1$), the 50% cutoff could also be statistically significant ($p = 0.07$). It is evident from figure 1 that the size effect reduces across the different cutoffs. It appears that the largest impact of women's representation occurs with the addition of any woman to the board compared with those that have none, but that there are additional improvements from adding more women to the board up to around 40% or 50% where the effects begin to wane. This result can potentially be explained by the socialization theory rationale, as noted in Vollan and Henry (2019). The theory suggests that the benefit from having gender quotas is due to the diversification of the worldviews, rather than due to some inherent pro-environmental inclination among women. In this sense, the reduction of the size effect after the 10% cutoff, can be explained by the fact that as boards begin to include women as members, the worldview starts to change. However, this effect of worldview exposure logically diminishes as more women join the boards. Similar results were obtained from the sanitation variable, our other primary pro-environmental behavior outcome (Appendix C). However, further analyses are needed to confidently determine this effect.

Limitations

This study is based on external databases constructed from multiple surveys conducted at specific points in time, which limits access to longitudinal information. Consequently, the data collected represents a snapshot at a particular moment, disregarding the dynamic nature of the WUA. Moreover, the survey-based data collection strategy introduces the possibility of response bias from participants and potential inaccuracies, although the validation process of SIASAR likely reduces measurement error.

The gender composition of the board was utilized under the assumption that women serving as board members are active participants, though this may not hold true in all cases. Some of the limitations of the study could be mitigated by future research conducting interviews with board members, thereby reducing potential biases inherent in survey data. Additionally, there may be unaccounted confounders influencing the results, as the methods employed only consider observable covariates.

These limitations underscore the need for cautious interpretation of the findings and suggest further research to enhance the validity and comprehensiveness of the analysis.

6. Conclusion

This study reveals compelling evidence regarding the significant relation of gender composition within Water User Associations on conservation and management practices, particularly in rural contexts of Latin American countries. It contributes to the general knowledge of the diverse factors that can influence water management in these settings. This study is one of the few in the literature that focuses on WUAs providing domestic water in rural settings, where women's participation in decision-making scenarios can be impactful due to their roles in households,

likely providing them with experiences and knowledge pertinent to domestic water consumption.

The study also makes a methodological contribution to this literature, as prior studies on this topic have tended to either use descriptive data (with no clear claim to causal inference) or experimental approaches (which make it difficult to compare many differing potential cutoff levels). The use of observational data with matching techniques is thus a useful addition for purposes of triangulation across research studies in this field.

Specifically, the study demonstrates that WUAs with at least 30% female representation are more likely to engage in activities promoting source protection, sanitation practices, environmental protection, accountability, tariff compliance, and minute records. These findings highlight the potential positive influence of women's participation in decision-making processes, suggesting a positive correlation between gender diversity and environmental protection and conservation.

Moreover, the analysis of different cutoff thresholds for source protection and sanitation variables, highlights that an increase in the percentage of women on executive boards might not translate to an increase of the estimated effects, indicating potential wear off of benefits beyond a certain threshold. This observation aligns with theory of gender socialization. However, there is a need to further analyze this potential mechanism, to provide a convincing claim.

Even though there is no national gender quota policy being implemented at the level of community-based water management institutions in various Latin American countries, these institutions should strive to have executive boards that include both women and men. Approximately 23% of the WUAs in the database (1218) do not have any women on the board at the time of the survey. These institutions could benefit from having at least 10% of the board composed by women and providing space for meaningful participation.

In conclusion, women's active participation in decision-making scenarios, such as WUAs executive boards, can lead to better conservation practices and management strategies of water resources in rural settings of developing countries. By testing the nuanced effects of women's participation, this research contributes to the ongoing discourse on gender equity and water management.

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Appendix A

Table A. Covariate table difference T and C after matching.

	Mis	Min	Max	Mean T	Mean C	Std Dif	P-val
Financial Management	0	0	1	0.44	0.49	0.09	0.01
Structure Type0	0	0	1	0.42	0.39	0.10	0.01
Infrastructure state	0	0	1	0.66	0.69	0.10	0.01
External Help	0	0	1	0.43	0.39	0.10	0.01
Source state	0	0	1	0.74	0.72	0.10	0.01

Appendix B

Table B. Linear regression of the effect of percentage of women on the executive board and two placebo variables, water flow and dry season resource availability.

Placebo Test

	Dependent variable:	
	Water Flow	Dry Season
	(1)	(2)
Gender Compostion	10.904	0.034
	(44.727)	(0.024)
Constant	17.153	0.639^{***}
	(18.967)	(0.010)
Observations	5,422	5,427
R^2	0.00001	0.0004
Adjusted R^2	-0.0002	0.0002
Residual Std. Error	881.157 (df = 5420)	0.477 (df = 5425)
F Statistic	0.059 (df = 1; 5420)	1.944 (df = 1; 5425)
Note:		*p<0.1; **p<0.05; ***p<0.01

Appendix C

Figure C. Estimated effects on Sanitation and Hygiene variable at different cutoffs of women on the board.