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Diversidad de género y escasez hídrica: estimación del uso de agua en grandes empresas

Gender diversity and water scarcity: Estimating water use in large companies*

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Abstract

Insufficient water availability is a concern for corporate and government management. In Latin America, some large companies have reported environmental statistics, which allows for the evaluation of their actions and results regarding water use for production. Greater participation of women in corporate decision-making has been identified as having served to increase efficiency and reduce water use. The aim of this article is to explain changes in water use in companies from two perspectives: 1) by measuring the influence of women on boards of directors, and 2) by estimating the effect of regional water conditions, which, if worsened, would foster changes in business practices. These approaches allowed us to validate how gender diversity in companies contributed to reducing water use and also to match firms' self-reported water figures with the region's water conditions. The sample consisted of 29 companies (87 observations) listed on the Mexican Stock Exchange and was estimated using a system of equations with data from 2017, 2020, and 2023. The variables came from business reports and government indicators on concessions, bans, and water quality. It was found that incorporating the region's water conditions into the analysis increases the level of water stewardship promoted by women executives. These findings contribute to the design of sustainable strategies and provide evidence on adaptive efforts due to water degradation.

Keywords: Water, gender diversity, sustainability, equation system, Mexico.
JEL Classification: Q56, Q57, R11, G40, J16.

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Resumen

La insuficiente disponibilidad de agua es una preocupación en las direcciones de empresas y de los gobiernos. En Latinoamérica, algunas grandes empresas han reportado sus estadísticas ambientales, lo que permite evaluar sus acciones y resultados sobre el uso de agua para producción. Se ha identificado que una mayor participación de mujeres en las decisiones corporativas ha servido para aumentar la eficiencia y reducir el uso de agua. El objetivo de este artículo es explicar desde dos perspectivas los cambios en el uso del agua en las empresas: 1) midiendo la influencia de las mujeres en los consejos de administración, y 2) estimando el efecto de las condiciones regionales del agua que, al agravarse, presionarían cambios a las prácticas empresariales. Este enfoque permitió validar cómo la diversidad de género en las empresas contribuyó a reducir el uso de agua y también a conciliar las cifras de agua autorreportadas por las empresas con las condiciones hídricas de la región. La muestra fue de 29 empresas (87 observaciones) que cotizan en la Bolsa de Valores Mexicana y se estimó usando un sistema de ecuaciones con datos de 2017, 2020 y 2023. Las variables provinieron de los informes empresariales y de indicadores gubernamentales sobre concesiones, veda y calidad del agua. Se encontró que, al incorporar al análisis las condiciones hídricas de la región, aumenta la cuantía del cuidado del agua impulsado por las mujeres directivas. Estos hallazgos contribuyen al diseño de estrategias sostenibles y aportan evidencia sobre los esfuerzos adaptativos debido a la degradación del agua.

Palabras clave: agua, diversidad de género, sustentabilidad, sistema de ecuaciones, México.
Clasificación JEL: Q56, Q57, R11, G40, J16

Cuando despierto y el agua
me cubre hasta la mitad
Leiva

1. Introduction

Current water management systems were designed in an era of relative abundance, making them unsuitable to handle modern pressures like extreme weather, overuse, and pollution (Barbier, 2022). Inefficient governance and corruption only compound these problems (Wheatley, 2024). While a few water-rich regions could theoretically benefit from growing scarcity, the reality is that most communities and ecosystems are already strained—and water stress is projected to intensify in the decades ahead (Dolan *et al*., 2021).

Beyond physical scarcity, economic barriers further limit water access—including high costs, lack of permits, and inadequate infrastructure (Wheatley, 2024). This reality ensures equitable access and mitigates conflict risks. Effective solutions require multi-stakeholders. Marston

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et al. (2020) examine the United States (US) case to demonstrate how public policies and self-regulation, when properly incentivized, can enable significant efficiency gains for businesses.

Water scarcity presents significant societal challenges. Building on this, Barbier (2022) conceptualizes this scarcity as both a catalyst and driver for innovation in water-use efficiency among both authorities and private actors. Worldwide, societies are increasingly managing to grow while reducing their water demands.

Marston *et al*. (2020) document a water-use trend: Between 1980 and 2015, absolute water withdrawals declined by 27%, while water productivity (measured as sales/water) increased five-fold. This counterintuitive achievement reflects both improved water management efficiency and structural economic shift –specifically, from water-intensive agriculture toward less demanding sectors like manufacturing and service sectors.

Despite escalating global water risks and mounting threat of water crises worldwide, current innovation remains inadequate to achieve meaningful water savings across major economic sectors. The widespread adoption of water-saving technologies –spanning agriculture, industry, and households- could significantly reduce per capita water demand while transforming global consumption patterns (Barbier, 2022).

These sustainability decisions –particularly water innovation strategies- are typically debated and approved at the corporate board level. Research consistently shows board diversity enhances innovation outcomes. For instance, Riley and Ruelas (2020) demonstrate that firms with more diverse boards exhibit greater innovation capacity and creativity.

This study quantitatively examines how gender diversity and regional water jointly shape corporate water-use efficiency, offering empirical support for sustainable water-scarcity strategies. First, we hypothesize that companies dynamically respond to local water conditions –including scarcity, restrictions, and quality degradation- by adapting production processes to enhance efficiency. Second, we propose that gender-diverse leadership strengthens water conservation efforts. Specifically, we posit that higher female representation in management roles correlates with reduced water intensity (use per $1 million dollars' sales).

This study makes three key contributions to the literature. First, it provides the first quantitative evidence linking gender diversity and regional water conditions to corporate water efficiency. While prior research established a correlation between gender diversity and environmental disclosure, the actual water-use outcomes remained empirically unverified. Second, we operationalize local water conditions as novel predictive variables, quantifying firms' adaptive responses to scarcity. Third, we precisely measure practice adjustments under regional water constraints.

This study focuses on Mexico, where female representation on corporate boards and in top management remains significantly lower than in peer Latin American countries (Colombia, Chile, Brazil, and Argentina) (Riley and Ruelas, 2020). For comparative context, we contrast Mexico's voluntary approach with Colombia's legislative model. Unlike Colombia's quota system –

which established a 30% minimum for senior public sector positions (Law 581, 2000) and later extended it to congressional representation (Law 1475, 2011) (Moreno-Gómez and Calleja-Blanco, 2018) –Mexico lacks mandated gender quotas for corporate governance.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature, section 3 describes the data sources and estimation methods, and section 4 presents the empirical results. The final section discusses key findings and conclusions. Additionally, two appendices provide supplementary material supporting the main analysis.

2. Literature review

Extensive research demonstrates the organizational benefits of gender-diverse corporate boards, with numerous studies establishing a positive correlation between female leadership representation and improved financial performance (Valls-Martínez, Martín Cervantes, and Cruz Rambaud, 2020; Ionascu, Ionascu, and Minu, 2018; Campbell and Mínguez-Vera, 2008). This relationship holds consistently across Latin America, as evidence by studies from Colombia (Moreno-Gómez and Calleja-Blanco, 2018; Leyva-Townsend *et al*., 2021) and Mexico-Colombia comparative analyses (Reyes Bastidas, Briano Turrent, and Saavedra García, 2020). As Arora (2022) argues, these benefits stem from the diverse skillsets, competencies, and lived experiences that women directors contribute to strategic decision-making.

2.1 Gender diversity in corporations

The well-documented positive relationship between board diversity and sustainability disclosures reflects consistent global patterns. Research by Daniel-Vasconcelos, Souza-Ribeiro, and Lima Crisóstomo (2022) confirms this trend in Latin America, mirroring findings from developed markets: gender-diverse boards consistently demonstrate stronger environmental reporting and more robust sustainability practices compared to homogeneous boards.

This alignment is particularly evident in comparative studies. For instance, Valls-Martínez *et al*. (2020) analysis of S&P 500 and Euro Stoxx 300 firms (2015-2019) confirms that the sustainability benefits of gender-diverse governance observed in Latin America are similarly found in both US and European markets.

The study by Ardito, Dangelico, and Messeni Petruzzelli (2021) of 246 B Corp-certified firms yields nuanced insights into how female board representation influences Corporate Social Responsibility (CSR) performance. Specifically, their analysis reveals three distinct patterns: positive associations emerge with customer relations and community engagement; negative correlations appear with both environmental performance and employee wellbeing, contrary to expectations; and no statistically significant relationship is found with ethical governance practices. These findings suggest that while gender diversity generally benefits CSR outcomes at an aggre-

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gate level, its impacts vary substantially across specific responsibility dimensions, presenting both opportunities and challenges for sustainability-focused corporations.

Research similarly indicates that female CEOs enhance water-related disclosure practices. Santoso and Setiawan (2024), for instance, attribute this to women's stronger ethical orientation in leadership roles, yet they caution that this disclosure effect diminishes when female executives hold substantial equity stakes, suggesting ownership interests may override ethical motivations. Regarding water disclosure quality, Farooq *et al*. (2025) identify two key drivers: tightening regulatory requirements for environmental reporting, and enhanced corporate governance standards. Moreover, their findings reveal that superior water disclosure practices predominantly emerge in countries with lower corruption levels. This aligns with Pinheiro, Do Prado, and Salati Marcondes de Moraes (2024) evidence that effective government anti-corruption measures create institutional conditions that incentivize improved corporate water performance.

Pinheiro *et al*. (2024) further demonstrate that companies with larger, more independent boards show greater engagement in water performance and stronger social responsibility regarding water use. However, this finding contrasts sharply with Sa de Abreu *et al*. (2022) conclusion: while gender diversity positively impacts environmental disclosure, they found its effect size to be modest. These researchers attribute this limited governance impact to the weak alignment between national corporate governance codes and the United Nations (UN) sustainability standards in their studied countries.

Brazil serves as a crucial case study for corporate environmental governance. Despite the country's adoption of UN-aligned corporate governance codes and empirical evidence showing independent board members enhance environmental disclosure, research highlights a troubling gap between reported information and actual sustainability practices. This discrepancy points to the possibility that such disclosures may enable greenwashing, rather than promoting genuine environmental improvements.

The situation appears even more pronounced in Mexico, where independent boards show significantly lower adoption rates of concrete environmental measures even with existing reporting practices. This contrast highlights how governance quality and enforcement mechanisms ultimately determine whether transparency translates into real sustainability progress.

In addition to independent board members, another well-established driver of water-related disclosure is gender diversity on corporate boards (Riley and Ruelas, 2020; Peng *et al*., 2022; Taglialatela et al., 2023). Research shows that female board members significantly enhance a board's ability to identify water-related concerns raised by stakeholders, however, this impact can be amplified or diminished by cultural contexts (Peng *et al*., 2022). The prevailing academic consensus holds that women directors bring greater social awareness to corporate governance and actively advance the transition toward sustainable business practices (Taglialatela *et al.*, 2023).

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2.2 Corporate water use and hydrological conditions

Water analysis has evolved beyond purely environmental considerations, now occupying a prominent place in monetary policy discussions. Banco de Mexico (2024) has identified the country as a net importer of virtual water—the total water volume required to produce finished goods. This import dependence is especially acute in Mexico City's megalopolis and Monterrey's metropolitan area, two regions characterized by semi-arid conditions. Conversely, agricultural states predominantly function as virtual water exporters.

The Mexico City Valley exemplifies these pressures as one of the world's most densely populated regions, with aquifer overexploitation reaching critical levels. This spatial disparity highlights how hydrological stress intersects with economic activity patterns across Mexican regions.

Researchers have examined how aquifer overexploitation in the Mexico Valley impacts corporate efficiency levels (Revollo-Fernández and Rodríguez-Tapia, 2021). Using Data Envelopment Analysis (DEA) on 2013 economic census data, compared firms operating in areas with overexploited versus non-overexploited aquifers. Findings reveal a 10% efficiency gap, with companies in non-overexploited zones demonstrating superior performance. This evidence strongly suggests that hydrological conditions significantly influence business operational efficiency.

While Revollo-Fernández and Rodríguez-Tapia (2021) do not identify the specific transmission mechanism linking aquifer overexploitation to operational inefficiency, financial constraints emerge as one plausible pathway. Zheng, Gao, and Wang (2024) offer empirical support for this channel, demonstrating how water vulnerability adversely impacts business prospects (e.g., profitability and sustainability). Their research indicates that water scarcity not only disrupts operational continuity but also elevates financing costs: firms in water-stressed areas face higher interest rates stemming from perceived risk when compared to counterparts in water-secure locations.

The scarcity of both groundwater and surface water is linked to the enormous water demand from the agricultural industry. In Mexico, agricultural activities consume 76% of the total water supply, consequently restricting availability for other industries. Furthermore, Ochoa-Noriega *et al*. (2020), referencing the National Water Plan 2019–2024, assert that water usage is highly inefficient, evidenced by a 40 percent water loss rate. Therefore, reducing pollution and enhancing water-use efficiency in agriculture will augment water availability for households and businesses in other industries.

3. Methodology

3.1 Data description

Our analysis evaluates corporate water-use efficiency in Mexico through three key dimensions: 1) regional hydrological conditions, 2) board-level gender diversity metrics, and 3) sector-specific water intensity factors. Building on Colombia's established gender representation framework (discussed in section 2), we focus specifically on Mexican firms.

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The study combines data from two sources: 1) the LSEG Workspace database of corporate disclosures from publicly traded companies, and 2) official statistics from Mexico's National Water Commission (CONAGUA). The water-related variables include:

a) Water bans: Geographic locations and implementation dates sourced from the Aquifer Geographic Information System (SIGAGIS, CONAGUA 2025b). These bans designate areas where new water extraction permits are suspended due to quantity or quality deterioration (Appendix 1, CONAGUA 2024), with each ban officially published in the Federal Gazette. CONAGUA's operational standards follow its Manual of Integration and Operation (2015).
b) Water concessions: The second water-condition variable, sourced from Mexico's Public Registry of Water Rights (REPDA, CONAGUA 2025a). These long-term government-granted concessions authorize usage of national waters (Appendix 1), with disaggregated state-level data by concession type: surface water, groundwater, or wastewater discharge.
c) The third variable measured water quality through Mexico's official traffic-light classification system (RENAMECA, CONAGUA 2024). Monitoring stations evaluate multiple parameters (Appendix 2), assigning color-coded ratings: green (optimal quality), yellow (intermediate quality), and red (poor quality) based on compliance thresholds. This systematic evaluation covers all major water bodies.

Our initial screening identified 106 Mexican firms. While all companies report financial data, environmental and governance disclosures remain inconsistent. To ensure data completeness, we selected only those firms reporting both water usage metrics and gender diversity indicators. The final dataset comprised 29 publicly traded companies meeting these criteria.

The total number of observations was 87, covering three analyzed years (2017, 2020, and 2023) and 29 companies. This sample size is sufficient to detect statistically significant differences as long as the between-group differences are substantial, as is the case in the present study (see Figures 2, 3, and 4 below) (Stata Corp, 2025).

An additional data source was the financial reporting system of Mexico’s National Banking and Securities Commission (CNBV, 2025), which archives corporate annual reports. These documents contain detailed profiles of board members—including gender, professional background, and appointment dates—providing qualitative insights into governance diversity.

As an exploratory exercise, we analyzed the profiles of female directors at six representative firms: Aleatica, Bimbo, Chedraui, CYDSA, Peñoles, and Vesta. This qualitative data supplements our quantitative analysis by characterizing the individuals shaping gender-diverse corporate decision-making.

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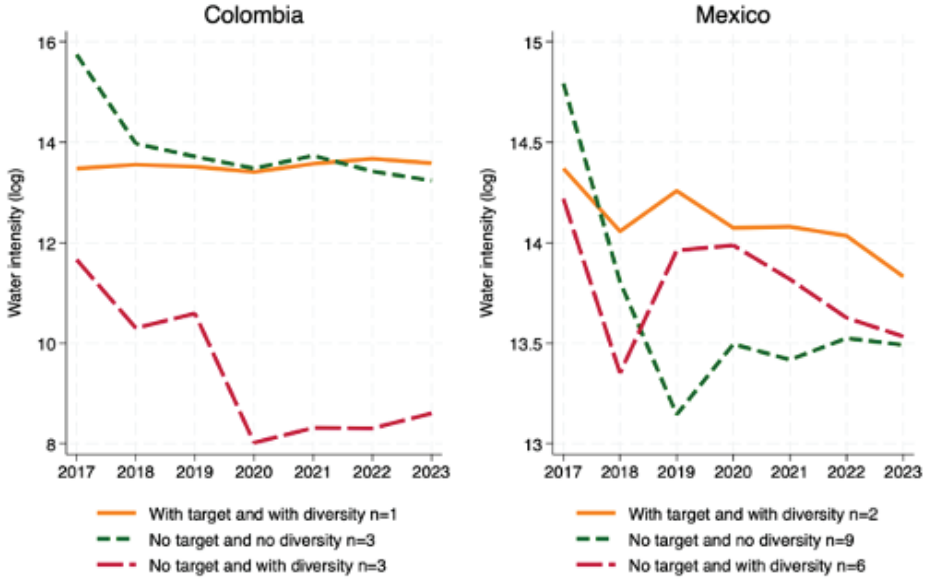
To align corporate water use with local hydrological conditions, we documented each company's operational locations across Mexico. This enabled us to obtain the average of regional water conditions (bans, concessions, and quality) for all the states where sample firms operate. Primary sourcing came from corporate websites, supplemented in eight cases by the National Statistical Institute's Business Directory (https://www.inegi.org.mx/app/mapa/denue/default.aspx).

The sample of 29 companies demonstrates significant operational diversity across Mexico's geographic regions. Twelve firms maintain nationwide operations spanning all 32 states, while five others operate facilities across 11-21 states (approximately half of the country). The remaining twelve companies show more localized presence, with operations concentrated in fewer than ten states (representing at most one-third of Mexican territory).

Figure 1 presents comparative water usage data in millions of cubic meters for Colombia (panel a) and mexico (panel b) from 2017-2023, analyzing the relationship between water consumption and gender diversity. We classified firms as having high diversity (≥20% female representation) or low diversity (<20%), focusing specifically on three 2021 corporate groupings: 1) companies with both water targets and diverse leadership, 2) those lacking both water targets and gender diversity, and 3) firms without formal water targets but demonstrating gender diversity in leadership.

Figure 1. *Water use in Colombia and Mexico, 2017-2023*



Notes: The figure compares corporate water use patterns between both countries, analyzing the relationship with water targets and gender diversity in leadership positions. Notes: 1) Target (yes/no): Classification based on whether firms established short- or long-term water efficiency goals in their operations. 2) Gender diversity thresholds: High diversity (≥20% female representation) vs. Low diversity (<20%), measured at board or executive management level.
Source: Own elaboration using LSEG Workspace data (LSEG, 2024b).

The figure reveals contrasting trends: Colombian firms with targets and gender diversity maintained stable water use, while those without targets reduced use regardless of diversity. In Mexico, target-setting, diverse firms (yellow line) saw a decrease in water use but remained the highest users, whereas firms without targets and diversity achieved the largest reductions.

3.2 Variable definitions

Table 1 presents the definitions of all variables used in the study. The independent variable, water intensity, along with regional water condition variables (concessions, poor water quality, and water bans), were obtained from company reports through the LSEG Workspace platform and CONAGUA.

Table 1. *Definition of variables*

Variable	Definition	Source
Independent variable		
Water intensity	Logarithm of total water extraction (in cubic meters) divided by net sales or revenue (in million USD)	LSEG
Key explanatory variables		
Diversity	Percentage of women on the board	LSEG
Water targets	Dummy variable indicating if the firm established water efficiency goals	LSEG
Control variables		
Concessions	Logarithm of granted long-term permits	CONAGUA
Poor water quality	Percentage of surface water rated as poor quality	CONAGUA
Ban seniority	Logarithm of years since water extraction bans were implemented	CONAGUA
Board size	Logarithm of members of the board of directors	LSEG
Board size^2	Logarithm of the squared of members of the board of directors	LSEG
Assets	Logarithm of assets	LSEG
Cash flow	Logarithm of cash flow	LSEG
ROA	Pre-tax income / total assets (%)	LSEG

Source: Own elaboration using data from LSEG Workspace (LSEG, 2024a) and Mexico's National Water Commission (Secretaría de Gobernación, 2015; CONAGUA, 2025a, 2025b).

Key variables of interest include gender diversity, water targets, and board size, while financial control variables (X) consist of assets, cash holdings, and return on assets (ROA). Previous research on corporate water disclosure (Lavin and Montecinos-Pearce, 2021; Quintero García, Gaitán Riaño, and Saavedra Najar, 2024) and water use efficiency (Pinheiro *et al*., 2024; Rosas-Rodríguez and Kato-Vidal, 2025) has consistently used these same financial indicators (assets and ROA) and governance factors (board size and diversity).

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3.3 Model specification

To address our research objectives, we employed structural equation modeling (SEM). This approach enables simultaneous analysis of multiple variable relationships across different model types (including continuous and binary response models) while accounting for causal pathways.

Our analysis examines how three key factors—gender diversity, water targets, and regional water conditions—affect water use intensity. Equations (1) through (3) present the estimated model:

$$Water\ intensity_{it} = \beta_0 + \beta_1 Diversity_{it} + \beta_2 Target_{it} + \beta_3 (Target_{it} \times Diversity_{it})_{it} + \beta_4 Board_{it} + \beta_5 Board_{it}^2 + \beta_6 Concessions_{it} + \beta_7 Ban_{it} + \beta_8 Quality_{it} + \beta_9 (Concessions_{it} \times Quality_{it}) + \beta_{10} (Ban_{it} \times Concessions_{it}) + \beta_{11} X + \varepsilon_{it} \quad (1)$$

$$Water\ target_{it} = \alpha_0 + \beta_1 Board_{it} + \alpha_3 X + \alpha_4 Year_{it} + e_{it} \quad (2)$$

$$Gender\ diversity_{it} = \gamma_0 + \gamma_1 Board_{it} + \gamma_3 X + \gamma_4 Year_{it} + u_{it} \quad (3)$$

The dependent variable, water intensity, is calculated as the logarithm of total water use (in cubic meters) divided by sales revenue, with subscripts i and t representing, respectively, the 29 firms and study period (2017-2023). Our key independent variables include: gender diversity (percentage of women on the board), water targets (a binary variable equaling 1 if the firm established water efficiency goals), board size (number of directors) and its squared term, water concessions (count of long-term permits), ban seniority (years since water extraction restrictions), and poor water quality (percentage of surface water rated substandard).

We control for financial factors (X), including assets (log), cash flow, and return on assets (ROA), along with year-fixed effects. All corporate data comes from LSEG Workspace (2024a), while water statistics derive from Secretaría de Gobernación (2015) and CONAGUA (2025a, 2025b).

Equation 2 employs relative risk ratios (RRR) to estimate outcome probabilities compared to the baseline category. These ratios quantify how the likelihood of observing the independent variable changes when firms establish water targets versus when they do not.

3.4 Descriptive statistics

Table 2 presents the dataset's key characteristics. The analysis reveals a significant 2.5-fold reduction in corporate water use in Mexico between 2017 and 2023. Regarding gender diversity - our key variable of interest - Mexico showed substantial progress: average female board representation increased from 8.63% to 18.64% over the seven-year study period.

The study period also saw notable advancements in water target adoption, with the percentage of firms establishing water efficiency goals rising sharply from 20% in 2017 to 70% in

2023. Concurrently, board sizes decreased across the sample, reflecting broader adoption of corporate governance best practices. These parallel trends suggest that Mexican firms are increasingly aligning their operational and governance strategies with sustainability objectives.

Table 2. *Summary Statistics, 2017 and 2023*

	2017						2023					
Variable	Mean	Med	SD	Min	Max	N	Mean	Med	SD	Min	Max	N
Water intensity	14.65	14.85	1.25	11.76	16.76	19	13.69	13.76	1.62	10.77	16.61	29
Diversity	8.43	7.18	9.35	0.00	38.10	26	18.14	18.75	10.93	0.00	45.45	29
Targets Water Efficiency	0.27	0.00	0.45	0.00	1.00	26	0.66	1.00	0.48	0.00	1.00	29
Board Size	2.65	2.56	0.30	2.20	3.22	26	2.54	2.56	0.23	2.08	3.00	29
Assets	8.58	8.67	1.17	6.47	11.08	29	8.70	8.69	1.03	6.77	11.04	29
Cash Flow	6.20	6.27	1.19	4.16	9.16	27	6.43	6.31	1.10	4.01	8.82	27
ROA	8.41	6.93	6.49	-6.77	21.27	29	8.98	8.13	8.14	-7.77	29.23	29
Concessions	9.19	9.11	0.36	8.38	10.41	29	9.19	9.11	0.36	8.38	10.41	29
Poor Quality	29.66	29.60	10.07	14.00	71.72	29	29.66	29.60	10.07	14.00	71.72	29
Water bans	4.06	4.04	0.05	3.94	4.16	29	4.06	4.04	0.05	3.94	4.16	29

Source: Own elaboration using data from LSEG Workspace (LSEG, 2024b). Complete variable definitions are provided in Table 1.

4. Analysis and discussion

This study examined how gender diversity and hydrological conditions influence corporate water-use efficiency, providing evidence for sustainable water management strategies. To characterize the professional backgrounds of female board members, we analyzed annual reports from six randomly selected Mexican publicly traded companies (CNBV, 2025). This exploratory review identified unique attributes of women in leadership that could contribute to water stewardship decisions.

Our data reveal that female board members in Mexico predominantly hold specialized backgrounds in administrative fields such as marketing, finance, business administration, and law, while remaining significantly underrepresented in operational roles. The average board composition of 12 members includes just two women, who demonstrated markedly shorter tenures than their male counterparts (7.7 years versus 16.7 years).

These female directors possessed exceptional educational and professional trajectories, significantly different from the typical Mexican woman's experience. They largely graduated from elite private national universities, subsequently enhancing their credentials with international graduate degrees and leadership roles in multinational corporations or foreign positions. Although formal education at prestigious universities provides women with the skills for corporate board service, networking often proves equally, if not more, critical; board vacancies arise and are

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frequently filled via endorsements from current board members (Manzo, 2025). This distinct profile underscores that board appointments are still predominantly accessible only to women from privileged socioeconomic backgrounds, thus revealing persistent structural barriers to broader gender inclusion in corporate governance.

As shown in Table 3, the estimation results confirmed our hypotheses regarding water efficiency. Specifically, gender diversity significantly reduces water intensity: each percentage-point increase in board diversity correlates with up to a 10.74% decrease in water use. Furthermore, firms establishing formal water targets achieve dramatic reductions, using 99.6% less water than comparable firms without such targets.

Additional determinants included hydrological factors: while greater water concessions are associated with reduced usage, the presence of poor water quality increases use by 15% among target-setting firms compared to those without water efficiency goals. These results demonstrate how governance decisions and environmental conditions interactively shape corporate water stewardship.

To facilitate quantitative interpretation, the results for equation 2 (column 2) are presented as relative risk ratios (RRR), which indicate the probability of observing the independent variable when firms have water targets versus when they do not. Regarding gender diversity, the equation established that each percentage point increase in board diversity raises the probability of adopting water targets by 1.01%. Likewise, the control variables -board size, assets, and ROA- also exhibited positive associations with target adoption.

The regression model in Table 3 analyzed how gender diversity and water efficiency targets affect corporate water use per million dollars of sales, with these results forming the basis for Figure 2 (see below). Panel a displays our preferred specification, showing predicted water use while incorporating regional water conditions into the model. For comparison, panel b presents predictions from a reduced model that excluded these hydrological factors (i.e., water concessions, quality, and bans), thus demonstrating how omitting these critical environmental variables affects the estimates.

The analysis revealed two key differences between Figures 2a and 2b: first, including regional water conditions as predictive variables reduced the confidence intervals, leading to more efficient estimates. Second, in the absence of water conservation targets, the decrease in water use became more pronounced, underscoring gender diversity's stronger influence on environmental decisions when formal targets are not established.

Additionally, the overlapping confidence intervals in Figure 2 suggest no statistically significant difference in water use intensity between firms with and without water efficiency targets, except when gender diversity falls below approximately 10% (Figure 2a). Crucially, in these low-diversity cases, the lack of interval overlap clearly shows the effectiveness of establishing water targets, leading to an approximate 46% reduction in water use. These findings underscore how the combination of governance factors and hydrological conditions shapes corporate water management outcomes.

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Table 3. *Mexico: Water use estimation*

Variables	(1) Water Use		(2) Water Target		(3) Gender Diversity	
Gender Diversity	-0.1074	***	1.0112	***	--	
	(0.0209)		(0.0034)		--	
Water Target	-5.5465	***	--		--	
	(1.9381)		--		--	
Water Target x Diversity	0.0437	*	--		--	
	(0.0257)		--		--	
Concessions (log)	-48.0265	**	--		--	
	(23.6616)		--		--	
Poor Water Quality	-0.7802	***	--		--	
	(0.2912)		--		--	
Concessions x Poor Quality	0.0677	**	--		--	
	(0.0278)		--		--	
Water Quality x Poor Quality	0.1622	**	--		--	
	(0.0630)		--		--	
Ban Seniority	-111.1402	**	--		--	
	(54.2897)		--		--	
Ban x Concessions	11.7584	**	--		--	
	(5.7905)		--		--	
Board Size	38.5507	***	2.1398	***	16.2702	***
	(12.3163)		(0.5400)		(5.6893)	
(Board Size)^2	-7.1136	***	--		--	
	(2.2947)		--		--	
Assets(log)	0.4798		1.4041	*	-4.9303	**
	(0.4388)		(0.2514)		(2.4766)	
Cash Flow (log)	-0.5562		0.8642		--	
	(0.5226)		(0.1703)		--	
ROA	0.0590		1.0315	**	--	
	(0.0367)		(0.0159)		--	
Intercept	421.7300	*	0.0172	***	9.4559	
	(218.7508)		(0.7388)		(27.1080)	
Time effects	No		Yes		Yes	

Notes: *** p<.01, ** p<.05, * p<.1. Standard errors in parentheses.
Note that the coefficients in equation (2) are expressed as relative risk ratios (RRR), which compare the probability of outcomes between firms with and without water efficiency targets while controlling for other variables. See supplementary table -at the end of the paper- to compare the estimation excluding water conditions.
Source: Own elaboration using proprietary data from LSEG Workspace (LSEG, 2024b).

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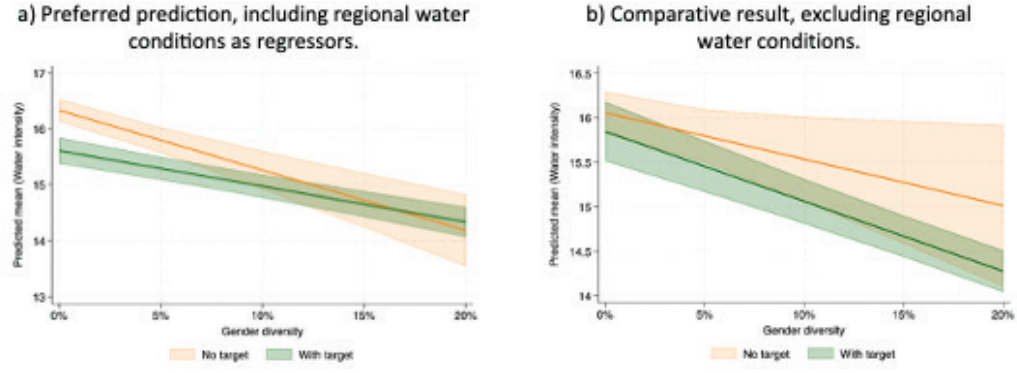
Our analysis identified a novel finding: greater gender diversity on corporate boards is consistently associated with reduced water allocation for production purposes. This result appears unprecedented in the literature, as we found no prior studies demonstrating this specific relationship. While existing research (section 2) indicates that gender-diverse boards are more likely to disclose environmental statistics—such as water withdrawals, CO_2 emissions, or conservation targets— it does not establish a direct link to actual resource use reductions. This distinction underscores our contribution, demonstrating how diversity influences not merely reporting practices but substantive environmental outcomes in water management.

The analysis revealed substantial gender diversity effects on water efficiency. Specifically, each percentage-point increase in board diversity reduces water use per million dollars of sales by 6% for firms with water conservation targets, and by an even greater 11% for those without such targets (Figure 2a). These effects were calculated by first converting the logarithmic water-use variable back to its natural scale, then evaluating the function around the 15% diversity benchmark to derive interpretable percentage changes. The results demonstrate that gender diversity serves either as a complement to formal water targets when present, or as a compensatory mechanism when absent, consistently driving meaningful reductions in corporate water consumption.

Figure 3 included an external regulatory factor - the number of water concessions granted per state by government authorities. The analysis reveals two compounding effects: first, a direct increase in total water extraction volume due to more concessions being issued, and second, an indirect competitive effect where existing concession holders extract more water per company as participation grows. These findings align with the classic tragedy of the commons framework, where increasing numbers of participants both strain regulatory agencies' capacity to monitor compliance with concession terms, and erode individual firms' perceived accountability for water conservation. The results suggested that as more participants enter a watershed, monitoring becomes increasingly difficult, creating perverse incentives that collectively undermine sustainable water management despite individual concessions.

Figure 2. *Predicted values: Firms that use less water have greater gender diversity or water saving goals*



Notes: Estimation based on the results of Table 3.
Source: Own elaboration with data from 29 large firms listed on the Mexican Stock Exchange, LSEG Workspace (LSEG, 2024b) and CONAGUA (2024, 2025a and 2025b).

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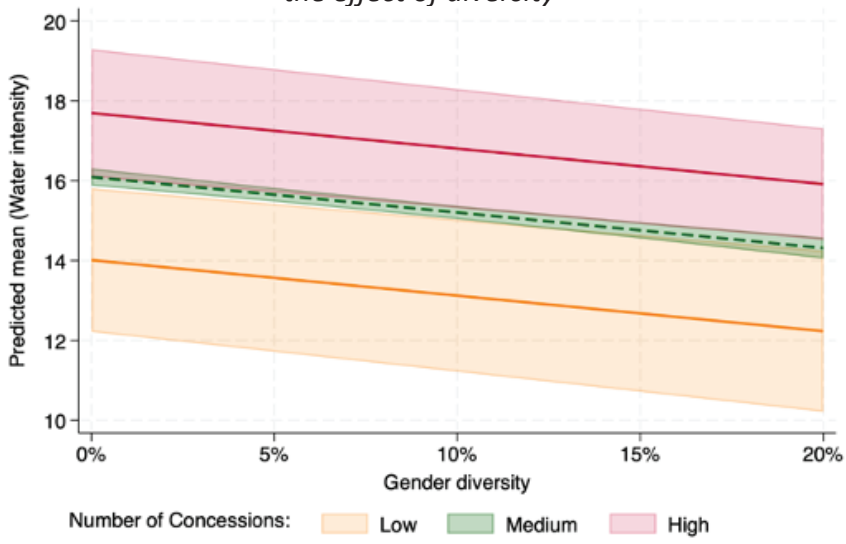
Figure 3. *Predicted values: Concessions stimulate greater water use and counteract the effect of diversity*



Notes: The figure demonstrates a clear positive relationship between the number of water concessions and average water use. The analysis classifies concession levels as: high (approximately 30 000 concessions per state), medium (~11 000), and low (~3 000), based on the regression results from Table 3. Notably, each percentage-point increase in gender diversity corresponds to a 9% reduction in water intensity, as estimated from Table 3 results and evaluated around the 15% diversity benchmark.
Source: These findings derive from proprietary analysis of 29 major companies listed on the Mexican Stock Exchange, combining corporate data from LSEG Workspace (2024b) with official water records from CONAGUA (2024, 2025a, 2025b).

The analysis joined two complementary data sources - government records of water concessions (CONAGUA, 2025a) and corporate self-reported data (LSEG, 2024b) - revealing both the potential and limitations of corporate water stewardship. While firms can internally foster gender-diverse leadership teams that demonstrate greater environmental innovation, they ultimately operate within externally determined hydrological constraints. This dual perspective highlights how corporate governance initiatives (like diversity programs) and government water resource management must work in tandem: firms can optimize their water efficiency within given conditions, but only regulatory intervention can fundamentally alter the regional water availability and allocation frameworks that shape all users' behavior. From a research perspective, a growing interest exists in sustainable water use and climate-resilient practices (Ochoa-Noriega *et al*., 2020).

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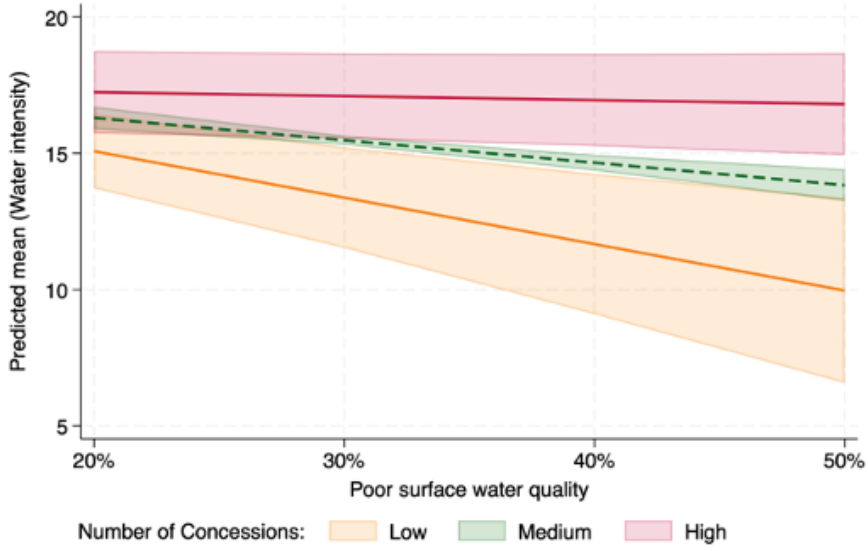
Figure 4. *Predicted values: When numerous concession holders operate in a region, water use remains unchanged regardless of water quality deterioration*



Notes: Estimation based on results from Table 3.
Source: Own elaboration using data from 29 major companies listed on the Mexican Stock Exchange. Source: LSEG Workspace (LSEG, 2024b) and CONAGUA (2024, 2025a, 2025b).

The analysis further demonstrated how concession systems shape competitive dynamics by examining demand responses to deteriorating water quality. Figure 4 reveals that poor water quality discourages demand predominantly in territories with few concession holders: here, reduced usage may indicate either public health precautions or aquifer recovery strategies. These conservation-oriented behaviors emerge specifically in low-competition contexts (characterized by limited participants). Conversely, regions with more concession holders show no significant demand reduction despite quality declines. This contrast highlights how competitive pressures in oversubscribed watersheds can override both environmental and public health considerations in corporate water-use decisions.

5. Conclusions and policy implications

The global water crisis has intensified due to climate change. Although households and corporations demonstrated partial reductions in water use between 2017 and 2023, our working hypothesis was that women influencing corporate decisions promote water conservation strategies. The results confirm this: Gender diversity contributes to reducing water intensity (water/sales). The analysis is further enriched by incorporating regional water conditions (concessions, bans, and quality).

From a longitudinal sample of 29 companies, we gathered 87 observations across three

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years (2017, 2020, and 2023). This provided a sample size with sufficient statistical power (>0.80). Figures 2, 3, and 4 (predictive results) clearly illustrate statistically significant differences, as their confidence intervals show no overlap within certain ranges.

Our findings reveal a significant effect on gender diversity on water conservation: a percentage-point increase in diversity reduces water use intensity by 9% on average. This quantitatively expands upon existing literature, which has primarily focused on the association between female participation and environmental disclosure, lacking metrics for actual performance (Peng *et al*., 2022; Riley and Ruelas, 2020; Taglialatela *et al*., 2023). Interestingly, at 20% or more female board representation, companies maintain similar water use per million dollars of sales, even without formal water conservation targets. This suggests that at this diversity threshold, sustainability initiatives benefit from robust institutional support and effective implementation. In contrast, when gender diversity falls below 10%, firms with water targets demonstrate significantly lower water use than those lacking such targets.

We also confirm that companies respond to regional water conditions by adjusting production processes to reduce water use. However, our findings reveal a compounding effect: increased competition for water resources drives higher average water use per company, leading to greater direct and indirect extraction—a pattern strikingly consistent with the tragedy of the commons framework. This dynamic underscores the competing pressures inherent in corporate water stewardship.

The response of firms to declining water quality varies significantly with market conditions: a substantial decrease in usage (-17.4%) is observed in low-competition areas, but only a minimal reduction (-1.47%) occurs in regions with numerous concessions. This limited response in concession-rich areas accelerates ecosystem damage by slowing aquifer replenishment. Beyond environmental harm, aquifer pressure also reduces business efficiency (Zheng, Gao, and Wang, 2024; Revollo-Fernández and Rodríguez-Tapia, 2021). Our findings thus underscore the necessity of policies that consider both market incentives and ecological limits.

Our analysis was limited by the available data, specifically the small number of firms disclosing water use metrics for their production processes. Future research should build on these findings to develop a more comprehensive perspective, incorporating agricultural and livestock activities. Additionally, it would also be valuable to assess how the results might differ if data were available from the many large companies that currently do not report their water use.

Corporate water management effectiveness is tied to both gender diversity and water conservation targets. To address water scarcity, improved corporate governance and expanded sustainability initiatives are essential. Yet, in Latin America, a significant gap in regional sustainability practices persists, as companies actively measuring and reporting their environmental, social, and governance (ESG) activities remain a minority.

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Appendix 1. Definitions of water concessions and bans

• Concession: A permit issued by the Federal Executive Branch authorizing individuals or legal entities (public or private) to exploit, use, or benefit from national waters and related public assets, excluding water allocation titles.

• Water ban zone ('veda'): Designated areas within hydrological regions, basins, or aquifers where no new water extraction permits are granted beyond legally established limits. These zones enforce strict regulations due to (1) water quantity/quality deterioration, (2) threats to hydrological sustainability, or (3) damage to surface/groundwater bodies.

Source: Ley de Aguas Nacionales, artículo 3º, fracciones XIII y LXV (Secretaría de Gobernación, 2023).

Appendix 2. Water Quality Classification System for Surface and Groundwater

(a) *Surface Water*

The water quality classification system ("traffic light system") is based on the concentration ranges of each indicator parameter at monitoring sites, establishing a compliance scale with three color categories:
• Green: Optimal quality (full compliance with all indicators)
• Yellow: Intermediate quality
• Red: Poor quality

Surface Water Indicators (8 parameters):
• Biochemical Oxygen Demand at 5 days (DBO5)
• Chemical Oxygen Demand (DQO)
• Total Suspended Solids (SST)
• Fecal Coliforms (CF)
• Escherichia coli (E_COLI)
• Fecal Enterococci (ENTEROC_FEC)
• Dissolved Oxygen Saturation Percentage (%OD)
• Acute Toxicity (TOX)

Classification Rules:
• Red: When one or more of these parameters fail compliance: DBO5, DQO, ENTEROC_FEC, and/or TOX

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• Yellow: When the above parameters comply, but one or more of these fail: SST, %OD, CF, and/or E_COLI
• Green: When all indicators meet compliance standards

(b) *Groundwater*
Groundwater Indicators (14 parameters):
Primary indicators (trigger Red classification if non-compliant):
• Fluorides (Fluo)
• Fecal Coliforms (CF)
• Nitrate Nitrogen (N_NO3)
• Total Arsenic (As_Tot)
• Total Cadmium (Cd_Tot)
• Total Chromium (Cr_Tot)
• Total Mercury (Hg_Tot)
• Total Lead (Pb_Tot)

Secondary indicators (trigger Yellow classification if non-compliant):
• Total Alkalinity (Alc_Tot)
• Electrical Conductivity (Cond_elec)
• Total Hardness (Dur_Tot)
• Total Dissolved Solids (SDT)
• Total Iron (Fe_Tot)
• Total Manganese (Mn_Tot)

Classification Rules:
• Red: Non-compliance with ≥1 primary indicator
• Yellow: Compliance with all primary indicators but non-compliance with ≥1 secondary indicator
• Green: Full compliance with all 14 parameters

Source: CONAGUA (2024).

Supplementary table. *Mexico: Estimating water use, excluding regional conditions*

Variables	(1) Water use		(2) Water Target		(3) Gender Diversity	
Gender Diversity	-0.0523	**	1.0111	***		
	(0.0236)		(0.0034)			
Water Target	-0.2107					
	(0.1695)					
Water Target x Diversity	-0.0263					
	(0.0259)					
Board Size	15.7608		2.1398	***	16.2702	***
	(15.3235)		(0.5409)		(5.9168)	
(Board Size)^2	-3.0666					
	(2.7595)					
Assets (log)	0.4562		1.4041	*	-4.9303	**
	(0.3804)		(0.2514)		(2.4766)	
Cash Flow (log)	-0.6413		0.8642			
	(0.4566)		(0.1703)			
Roa (%)	0.0667	**	1.0315	**		
	(0.0301)		(0.0159)			
Intercept	-4.4118		0.0172	***	9.4550	
	(21.8766)		(0.0127)		(27.1080)	
Time effects	No		Yes		Yes	

*** p<.01, ** p<.05, * p<.1. Standard errors between parenthesis

Notes: The coefficients in equation (2) are expressed as relative risk ratios (RRR), which compare the probability of outcomes between firms with and without water efficiency targets while controlling for other variables.

Source: Own elaboration using proprietary data from LSEG Workspace (LSEG, 2024b).