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Impact of women's political empowerment through gender quotas on improved drinking water access in Africa

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Access to safely managed drinking water is a fundamental human right, essential for human health and well-being. However, 2.2 billion people around the world still lack this access, with significant geographical disparities. In this study, we leveraged the implementation of gender quota laws—specifically reserved parliamentary seats for women across African countries—to examine its impact on improved water availability. Our findings reveal that the implementation of gender quotas is associated with a 4.71 percentage point increase, on average, in the likelihood of people accessing safely managed water infrastructure. This effect becomes even more pronounced, rising to a 12.25 percentage point increase, when the quotas mandate reserving more than 20% of seats for women. Households with lower wealth, female-headed households, those living in rural areas, and households with lower levels of women's empowerment and education benefit most from this policy. Further investigation into the underlying mechanisms, and anecdotal evidence, reveals that gender-reserved seat quotas lead to an increase in the proportion of women in parliaments and an expansion of women's political and social rights, although these effects do not extend to economic status.

women's political representation | gender quotas | improved water access | Africa

Significance

Improved drinking water availability, as a fundamental human right, is essential for human health and well-being. In contrast, there are still billions of people lacking the access. We empirically test the impacts of women's political representation on improved drinking water availability across Africa, leveraging the adoption of the reserved seat quota program. We find that an average 4.71 percentage point increase in improved drinking water, with a notable 12.25 percentage point increase in countries where the quota exceeds 20% due to an increase in the proportion of women in parliaments and spillover effects on women's political and social rights. Overall, these findings suggest that reserved seats for women are effective for coping with improved water access issues in Africa.

Access to improved water is not only a fundamental human right but also crucial for human health, as the use of unsafe water sources leads to waterborne disease (1–3). These diseases contribute to the annual deaths of over 1.5 million people from diarrhea, with infants and young children being the most affected (4). Moreover, the lack of access to safe water hampers poverty reduction and economic growth, particularly in some of the world's poorest countries (5). In the long term, exposure to toxic contaminants and malnutrition resulting from drinking unsafe water can hinder personal development (5–7). Even more concerning, household water insecurity has been found to increase women's and girls' vulnerability to emotional and physical forms of intimate partner violence, as shown by evidence from Nepal (8).

Despite the well-documented health benefits and critical gender equality outcomes associated with safely managed drinking water, a significant portion of the global population still lacks access to this essential resource.* In response to this challenge, the United Nations established several objectives aimed at expanding safe water coverage worldwide. The Millennium Development Goals (MDGs), introduced in 2000 following the United Nations Millennium Summit, set a target to halve the proportion of the population without sustainable access to safe drinking water between 1990 and 2015. During this period, global access to improved drinking water sources increased from 76% to 91%. While this represented significant progress toward the MDG target, substantial geographical disparities remained, particularly in developing regions. For instance, in sub-Saharan Africa (SSA), the percentage of the population relying on unsafe drinking water sources decreased from 52% in 1990 to 32% in 2015, falling short of the MDG target (9).

In 2015, Sustainable Development Goal (SDG) 6 was introduced, aiming for universal and equitable access to safe, affordable drinking water for all by 2030, as challenges such as water stress, increasing drought, and desertification continue to worsen.† By the end of 2022,

*According to the WHO's definition (https://data.unicef.org/resources/jmp-report-2023/), safely managed drinking water is water from an improved source that is accessible on premises, available when needed, and free from contamination. Unprotected dug wells and unprotected springs are categorized as unimproved water sources. For the purpose of this presentation, unimproved water sources exclude surface water, which refers to water directly collected from rivers, dams, lakes, ponds, streams, canals or irrigation channels. However, generalized unimproved water sources defined by the WHO do include surface water, as outlined in WHO/UNICEF (2018) (https://washdata.org/sites/default/files/documents/reports/2018-04/JMP-2017-update-methodology.pdf). In our study, we follow the generalized definition based on the DHS dataset manual (https://dhsprogram.com/Data/Guide-to-DHS-Statistics/index.cfm), improved water sources here include piped water, tube wells or boreholes, protected wells/springs, rainwater, tanker trucks, carts with small tanks, and bottled water. Unimproved water sources include unprotected wells or springs and surface water.

†https://www.undp.org/sustainable-development-goals/clean-water-and-sanitation.

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SSA ranked second only to Oceania in the proportion of the population without access to improved water sources, with 21% of the SSA population lacking access compared to 38% in Oceania (10). This indicates that approximately 245 million people in SSA still rely on unimproved water sources.[‡] In this study, we aim to provide evidence that the implementation of reserved seats as a political policy tool, a form of gender quota program, can enhance access to safe water in Africa.

African countries face shortages in basic water amenities and social service infrastructure due to several factors, including financial and human capacity limitations, structural constraints, and poor governance (11, 12). These challenges are further compounded by rapid population growth and urbanization, which have not been matched by corresponding economic growth or investment in urban water infrastructure (13). In rural areas, underdeveloped road infrastructure and pervasive poverty exacerbate transportation challenges and contribute to poor service quality (14).

Political improvements, particularly through enhancing women's voice and accountability in policy-making, can potentially increase the provision of water infrastructure. This is largely due to the gendered nature of household roles, where women are often responsible for water management (15, 16). Millions of women and school-aged girls spend hours walking long distances to fetch water, which is often of poor quality, limited in quantity, and unaffordable (4). As a result, women are more attuned to the risks of unsafe water and possess greater insight into the challenges of water acquisition (17). In the later part of this study, we provide robust empirical evidence that women in Africa are more likely than men to identify water-related issues as the most pressing problem facing their country. When women participate in parliament, they are more likely to address issues related to women's needs (18, 19), potentially policies and regulations that promote investment in water infrastructure and improve safe water access (20). Additionally, women legislators tend to be less prone to corruption and political opportunism, demonstrating higher levels of efficacy in managing public funds, which enhances the quality of public services (21, 22). We also found evidence that people—particularly women—tend to have a more favorable impression of female leaders in countries that implemented the gender quota in Africa.

A key challenge in examining the impact of women's representation in parliament on improved water access is the endogeneity problem, which arises from the influence of various factors that simultaneously affect the quality of water infrastructure and women's empowerment, such as cultural attitudes toward gender equality. To address this issue, we leveraged the staggered implementation of gender quota legislation worldwide since 1985, with a particular focus on Africa. The timing of the adoption of gender quotas was often driven by idiosyncratic factors that were unrelated to a country's access to safe drinking water, thereby satisfying the exogeneity requirement of policy shocks. Using a staggered difference-in-differences (DID) method, we uncovered several key insights into how women's representation in parliament contributed to improved water access.

Our analysis revealed that, following the adoption of reserved seat legislation, African countries experienced a 4.71 percentage points (pp) increase in access to improved water compared to those that did not implement such policies. Further examination of varying reserved seat quota sizes showed that countries with a quota exceeding 20% experienced the greatest increase at 12.25 pp. These findings suggest that the positive impact of women's political empowerment, driven by reserved seats, on safe water access in Africa depends on having a sufficiently large quota, specifically greater than 20% in our research context. This observation supports the hypothesis that women's political empowerment contributes to advancements in areas for which women are responsible. Additionally, our analysis identified specific subpopulations that benefited more from the policy, including households with lower wealth, female-headed households, those residing in rural areas, and those with lower levels of women's empowerment and education. These findings reinforce the idea that reserved seat legislation effectively enhanced the welfare of disadvantaged populations.

In terms of mechanisms, we provided empirical evidence that women are more likely than men to prioritize water access as a key national issue, particularly in rural areas. Following the adoption of gender quotas, public perceptions of female leaders and government efforts to empower women improve, especially among women. We also documented that the implementation of reserved seat policies elevated women's political and social rights and status. Overall, our findings imply that women's political empowerment can enhance civilians' access to safe drinking water, particularly for disadvantaged individuals. Reserved seats legislation—especially when reserving more than 20% of parliamentary seats for women—emerged as an effective policy tool to address the scarcity of improved drinking water in Africa.

Background on Reserved Seats: Paving the Way for Women's Political Empowerment

During the 1990 s, significant progress was made in women's participation in education and politics. However, disparities persisted in leadership positions, with women still facing disadvantages compared to men. In conjunction with an active civil society movement and heightened awareness of women's rights, the UN Economic and Social Council established a target in 1990 for 30% female representation in decision-making bodies by 1995 (23). The subsequent 1995 UN Beijing Conference on Women urged governments to ensure equal representation of women at all decision-making levels in national and international institutions, laying the ground for quota policies (24). In this global context, political quotas emerged as a viable and popular policy option in countries around the world.

There are three main types of political gender quotas. The first type is voluntary party quotas, adopted by various political parties, which commit to nominating a specific percentage of female candidates for electoral lists. The second type, candidate quotas, is mandated by law and requires that a certain number of candidate positions be reserved for women. The third one is reserved seats, which allocate specific positions exclusively for female candidates (23).

Existing empirical research suggests that gender quotas offer several benefits. For example, they have increased women legislators' focus on addressing women's needs and demands in Uganda and France (18, 19) and contributed to a global reduction in maternal mortality (25). In India, quotas have resulted in a rise in documented, though not overall, crimes against women (26), and in cases where they significantly boost female representation, they have improved the competence of male politicians by prompting the resignation of less-qualified male leaders (27). However, gender quotas have been ineffective in certain contexts, such as the Congo (28). Given the limited research on the impact of gender quotas in the African region, we examine this issue using data from the Demographic Health Surveys (DHS) and the staggered implementation of gender quota legislation to investigate their effect on improved drinking water access and women's political empowerment in African countries.

[‡]https://data.unicef.org/resources/dataset/drinking-water-sanitation-hygiene-database.

Our study focused on reserved seat quotas, which more directly regulate the number of women in elected positions and parliaments compared to other quota types. Since 1985, 25 countries worldwide have implemented constitutionally protected quotas that reserve parliamentary seats for women. *SI Appendix*, Fig. S1 in the SI illustrates the geographic distribution of countries in our sample that implemented either reserved seat quotas or legislated candidate quotas. Specifically, our study includes nine African countries that have introduced reserved parliamentary seats between 1989 and 2020.[§] By combining data on household access to improved water from the DHS datasets—covering 75 surveys conducted between 1996 and 2020—with the timing of reserved seat legislation, we compiled a dataset of 965,482 household observations from 30 countries and 419 regions across Africa.

Results

Reserved Seats for Women in Parliament and Increased Access to Improved Drinking Water. Leveraging the unexpected implementation of reserved seat quotas for women in parliament, we employed the following staggered DID regression (details in the *Materials and Methods*) to evaluate the impact of these quotas on access to improved drinking water in African countries. Specifically, we compare changes in water access between reserved seats adopters and nonadopters before and after the implementation of the legislation, using a logistic estimator.

$$ln\left(\frac{P_{ijt}}{1-P_{ijt}}\right)=\alpha_0+\alpha_1 Quota\ reserved_{ijt}+\beta Controls_{ijt}+region_j+year_t+\varepsilon_{ijt}. \quad [1]$$

In practice, we regressed a dummy variable indicating whether a household uses improved drinking water on an adopter-after-adoption indicator using a logistic model. Household and country-level characteristics are controlled to account for potential confounding factors that could influence the relationship. Additionally, we included country-region fixed effects to account for region-specific and time-invariant factors, as well as year fixed effects to take out macroeconomic time shocks. The coefficient of interest α_1 captures the association between the implementation of reserved seats legislation and access to safe or improved water sources. While we present our results obtained with the logistic estimator, our results remain unchanged if we use a linear probability model.

The first two columns in Fig. 1*A* and columns 1 and 2 in *SI Appendix*, Table S3 present the results of the primary DID analysis, showing that the implementation of reserved seat quotas for women was associated with a 4.71 pp increase in access to improved water for adopters, compared to control countries, with the effect significant at the 10% level.

As the percentage of seats reserved for women varies across, the level of women's representation in parliaments also differs, which implies varying degrees of influence in policymaking. The higher the percentage of reserved seats, the more power women are likely to hold in parliament. Given that the size of the quota may affect the degree of impact on households' access to improved water, we categorized the treated countries into three groups based on the range of the reserved quota size, representing the intensity of the legislation: less than 10%, between 10 and 20%, and more than 20%. We then reran the DID regression for each group using model 1 (see the *Materials and Methods*).

The results, presented in Fig. 1*A* and *SI Appendix*, Table S3, show that only adopters in countries with a quota size greater than 20% experienced a significant increase in access to improved water. In this group, the likelihood of improved water access rose by 12.25 pp after the adoption of the reserved seat quota program, compared to nonadopters. The other two groups did not exhibit significant changes following the adoption of the quotas. Moreover,

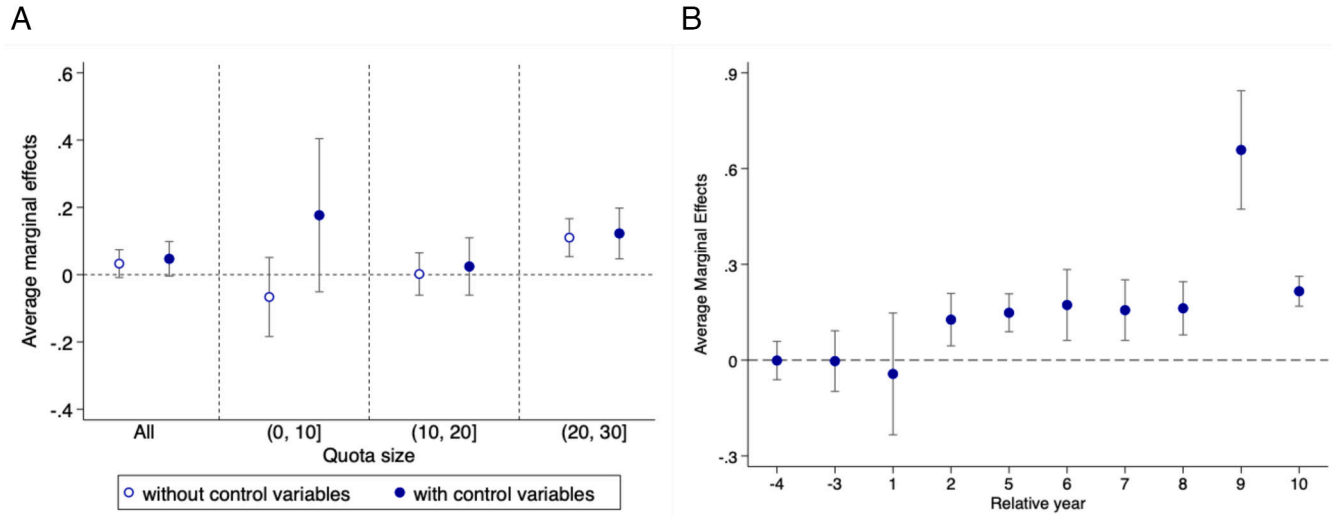

Fig. 1. Impact of reserved seat quotas on improved water availability: results from DID and dynamic DID analyses. This figure presents the response of improved water availability to the implementation of reserved seat quotas using the Logit model. (*A*) The average marginal effects from DID regressions for the total sample and subgroups of treated countries with quota sizes of less than 10%, 10 to 20%, and 20 to 30% are displayed. The regressions control for household characteristics (such as whether the household head is female and whether the household is located in a rural area) and country-level covariates (including the logarithm of GDP per capita, democracy status, control of corruption, political stability, and voice and accountability). (*B*) The average marginal effects from a dynamic DID regression are shown, focusing on countries with more than 20% reserved seats. The sample includes eleven relative years, ranging from year −4 to year 10, with year −2 (one year before the policy passage) used as the benchmark. Improved water access is regressed on the interaction terms between the treated country dummy and indicators for each year before and after legislation (relative years beyond −4 and 10 are censored). In both panels, region and year fixed effects are controlled, and SE are clustered at the region level. The error bars represent 95% CI.

[§]Burundi (2005, 30%), Eswatini (2005, 30%), Kenya (2010, 13.4%), Morocco (2002, 9.23%), Niger (2000, 10%), Rwanda (2003, 30%), Tanzania (2000, 29.1%), Uganda (1989, 25.5%), and Zimbabwe (2013, 22.2%).

the magnitude of the effect (12.25 pp) is higher than that observed in the total sample (4.71 pp), indicating that reserved seat quotas were only effective when the quota size is sufficiently large—specifically, greater than 20% in our study. This finding is consistent with previous research on heterogeneity in policy impact (25). In terms of economic significance, the implementation of reserved seat quotas increased access to improved drinking water by 6.36 pp (0.0471/0.74) for "all-quota-size" adopters, and by 16.55 pp (0.1225/0.74) for adopters in countries with quota size greater than 20%, compared to nonadopters. We also performed our analyses at the DHS-cluster (i.e., community) level and present our results in *SI Appendix*, Table S4.

A key requirement for using DID analysis is that the variable of interest must exhibit parallel trends between the control and treated countries, meaning no significant differences should exist in the dependent variable before the policy's implementation. If this condition is violated, the exogeneity of the policy shock is compromised, making the DID analysis results unreliable. To test the parallel trend assumption and track the treatment effect over time, we applied a dynamic DID regression model (model 2 in the *Materials and Methods*). This model regressed the improved drinking water dummy for each household on interactions between an adopter dummy and a series of lead and lag year dummies relative to the policy year, while controlling for region and year fixed effects using the Logit model.

The coefficient pattern, shown in Fig. 1*B*, indicates that all coefficients for the prepolicy years (years −4 and −3) were not significant, confirming the presence of parallel trends as no differential pretrends existed before the introduction of reserved seat quotas. This finding suggests that trends in the likelihood of improved water availability were similar between control and treated countries prior to the policy implementation.

To assess the robustness of our baseline result, which showed a significant impact of high quota sizes (20-30%) on improved water access in Africa, we conducted three additional tests. First, we excluded two Northern African countries, Egypt and Morocco, and focused solely on SSA countries. We present the findings in *SI Appendix*, Table S5 and Fig. S2. The results remained robust after excluding the Northern African countries, with all countries implementing reserved seat quotas showing a 5.75 pp increase in improved water access, closely aligning with the baseline analysis. Additionally, treated countries with quota sizes greater than 20% exhibited a significant increase of 13.92 pp. This confirms that the larger the quota size, the greater the impact of reserved seat quotas.

For the second robustness test, we employed an alternative measure of quota size used by Bhalotra et al. (25), which defined quota size as the proportion of seats in the lower house or unicameral legislature. We then repeated the regression model 1 outlined in the *Materials and Methods*. Consistent with our baseline findings, the results, presented in *SI Appendix*, Fig. S3 and Table S6, remained robust. Countries with reserved seat quotas and a quota size greater than 20% continued to experience a significant increase in improved water access, with the same magnitude of 12.23 pp.

Next, we examined the impact of another type of gender quota: candidate quotas. As previously discussed, candidate quotas are mandated by law to reserve a certain number of candidacies for women, but they do not guarantee parliamentary seats (23, 25). Additionally, they often fail to mitigate the strategic nomination of female candidates (29) or dismantle the barriers preventing women from playing influential political roles (30). Therefore, we hypothesized that the effects of candidate quotas on improved drinking water access in Africa would likely be smaller or even insignificant. Using a similar approach to test this, we found that, consistent with our expectations, candidate quotas did not lead to a significant improvement in drinking water availability when compared to nonadopters (*SI Appendix*, Table S7 and Fig. S4).

Finally, to further address potential confounding from broader development initiatives, we controlled for World Bank-funded water infrastructure projects and U.S. foreign aid. Specifically, we included indicators for project completion and funding amounts, as well as the annual volume of U.S. aid received by each country. The estimated effects of gender quotas on improved water access, as shown in *SI Appendix*, Tables S8 and S9, remain robust and statistically significant after including these controls, suggesting that the observed relationship is not driven by external development funding.

Heterogeneous Analyses by Household and National Characteristics. In this section, we discuss the results of our assessment of the heterogeneous effects of reserved seat policies on improved water availability, based on household and country characteristics. This assessment helped us to identify the subpopulations that benefited the most from these policies and provided evidence of key factors necessary to ensure the full effectiveness of policy implementation.

Notably, many countries worldwide experience significant disparities in access to improved water, with marked imbalances within countries, particularly among households of different socioeconomic levels, such as wealth, residence type, and education. Poorer households (31) in rural areas (32, 33) are at a much higher risk of using unimproved water, while wealthier households, who can more easily afford municipal services (15, 34), spend less time fetching water (35). Educated individuals are also more likely to recognize the health risks of unimproved drinking water and the benefits of improved water access (13, 36–38), thus enjoying better access to improved water. This pattern is observed not only in Africa (3, 13, 36) but also in other countries, such as Vietnam (34). As a result, we hypothesized that subpopulations in disadvantaged positions would benefit more from the implementation of reserved seat policies.

Our findings showed a significant increase in the probability of improved water access across all wealth levels: 16.35 pp for the poorest households, 16.86 pp for middle-income households, and 11.16 pp for richer households. However, the wealthiest households did not exhibit a significant response to the implementation of reserved seats (Fig. 2*A* and *SI Appendix*, Table S10). Additionally, rural households benefited more from gender reserved seat quotas, with a 15.11 pp increase in the likelihood of accessing improved water—significantly higher than the baseline result of 12.25 pp. In contrast, urban households did not show a significant response to the policies (Fig. 2*B* and *SI Appendix*, Table S11). These results emphasized the strong correlation between income and access to improved water, as wealthier households and regions are more likely to have better water supply.

Next, we investigated whether there were significant differences in responses between male-led and female-led households. As shown in Fig. 2*C* and *SI Appendix*, Table S12, households led by women experienced a 14.45 pp higher likelihood of accessing improved water after the adoption of reserved seats, compared to nonadopters, while households led by men saw an increase of 10.65 pp. This finding aligns with the idea that women, particularly when they are heads of households, tend to prioritize water management issues (16). Additionally, female-led households are more likely to access improved drinking water sources (35). Consequently, after the implementation of reserved seat quotas, female-led households may better recognize the benefits and value of improved water facilities, leading to a stronger response to the policies.

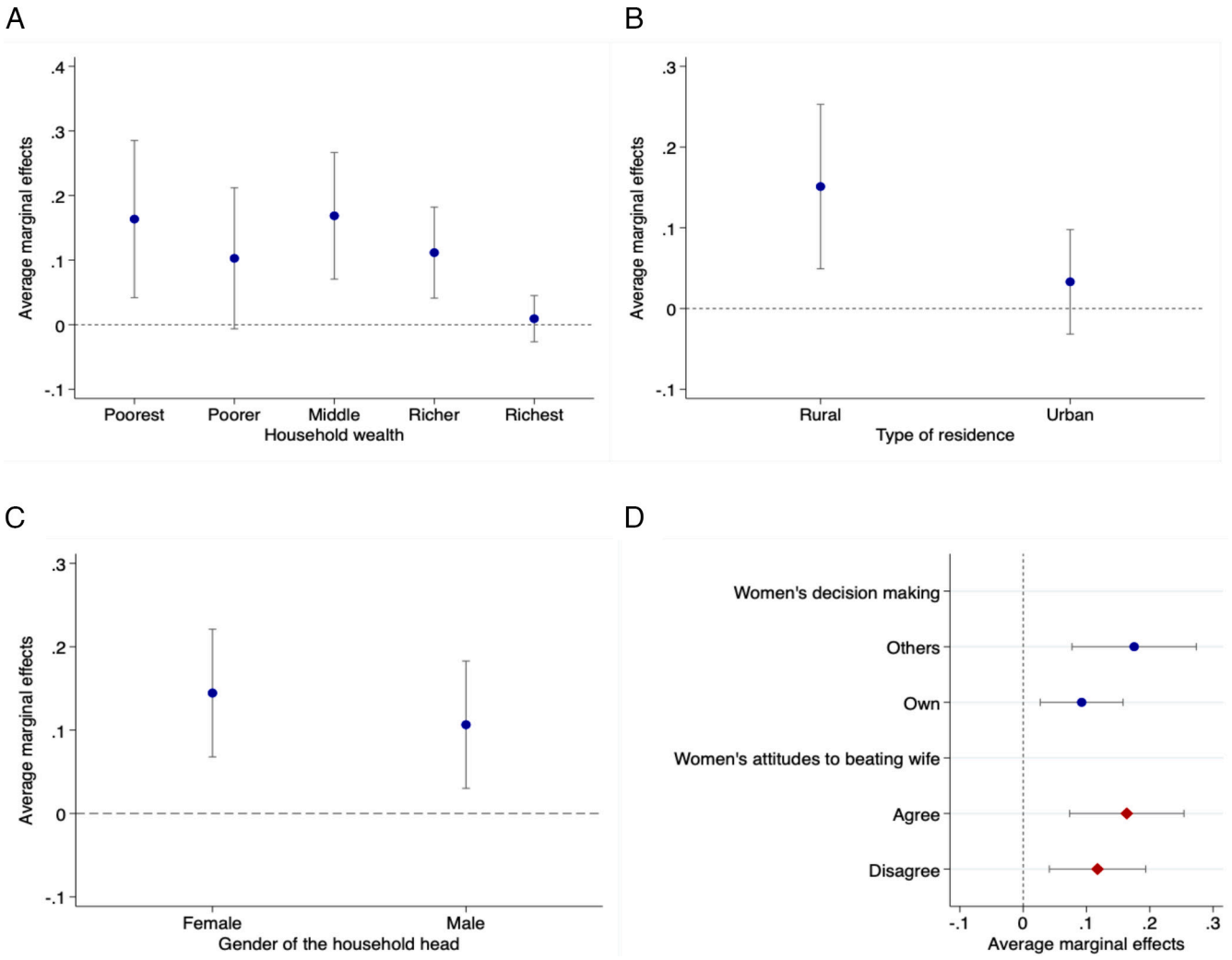

Fig. 2. Household-level heterogeneity in the impact of reserved seat quotas on improved water availability. This figure presents the average marginal effects from DID regressions on the passage of quota reforms, using subsamples categorized by: household wealth (*A*), type of residence (*B*), gender of the household head (*C*), and women's empowerment (*D*). The sample consists of nonadopters and adopters with more than 20% reserved seats. The analysis includes the same set of control variables and fixed effects as the analysis in Fig. 1, except the ones used to categorize the subsamples. The error bars represent 95% CI.

Since the implementation of gender quotas promotes women's empowerment in politics, we anticipated positive impacts at the household level. Households with lower level of women's empowerment are likely to benefit more from these policies. To measure women's empowerment, we used proxies such as decision-making processes and attitudes toward domestic violence, specifically husbands beating their wives, as indicators of a woman's status within the household. Women were considered to have higher family status and empowerment if they made decisions "themselves" or "disagreed" with the justification of husbands beating their wives. As shown in Fig. 2*D* and *SI Appendix*, Table S13, households where decisions were made by others and where women agreed with the justification for domestic violence—indicating lower level of women's empowerment—were more likely to gain improved water access compared to those with higher levels of women's empowerment. Furthermore, the response magnitudes were 17.53 pp and 16.36 pp, both higher than those of households with higher women's empowerment and the baseline result.

Household characteristics are not the only factors influencing the impact of reserved seat policies. The broader political and rule of law environment, along with the government's governance capacity, are also crucial for the effective implementation of regulations (39). To explore this, we separated observations into subgroups based on country characteristics and analyzed the heterogeneous impacts of reserved seats under varying macropolitical and social conditions.

Specifically, we found that households in countries with better control of corruption, greater political stability, and less violence or terrorism (Political Stability), as well as those with freer environments for expression and association (Voice and Accountability), were more likely to have improved water access. Additionally, countries with higher quality public and civil services (Government Effectiveness), better government capacity to formulate and implement sound policies (Regulatory Quality), and stronger societal confidence in the rule of law (Rule of Law) also experienced more positive outcomes.

These six aspects—governance ability, rule of law, political stability, and freedom—reflect the overall strength of a country's governance. The higher these factors, the more effectively regulations are executed, leading to smoother and more successful policy outcomes. This trend is shown in Fig. 3 and *SI Appendix*, Table S14.

Mechanisms Linking Reserved Seat Quotas and Access to Improved Water. The primary goal of reserved seats for women is to ensure a specific number of women hold positions in elected parliaments. The political empowerment that results from these quotas leads to changes from at least two perspectives. First, there

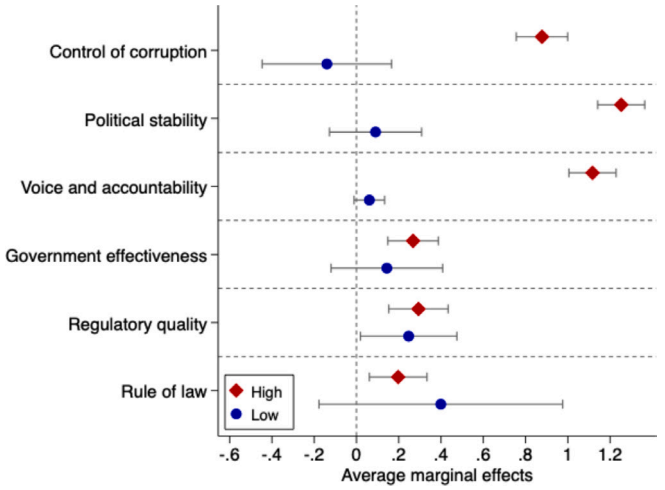

Fig. 3. Impact of reserved seat quotas by country-specific characteristics: testing the role of the macroenvironment in reform implementation. This figure presents the average marginal effects from DID regressions on the passage of quota reforms, using subsamples based on country-specific characteristics to test the importance of the macrolevel environment for the successful implementation of reforms. The analysis controls for household characteristics (such as whether the household head is female and whether the household is located in a rural area) and country-level covariates (including the logarithm of GDP per capita, democracy status, control of corruption, political stability, and voice and accountability). Additionally, region and year fixed effects are controlled. SE are clustered at the region level, and the error bars represent 95% CI.

is a direct effect: Increased representation of women in parliaments fosters greater gender equality in political participation. In this context, women in leadership positions are more likely to propose regulations or policies that prioritize women's needs. Since women and school-aged girls are often responsible for fetching and managing water within households, they experience the pressures associated with water access firsthand. Therefore, when women have a stronger political voice and influence, they are more likely to prioritize policies that improve drinking water quality.

To empirically probe the mechanisms linking gender quotas to improved water access, we conducted several empirical analyses using Afrobarometer data. First, we found that women are consistently more likely than men to identify water as the country's most pressing issue—a gap that is especially pronounced in rural areas and amounts to a 17% increase relative to men (*SI Appendix*, Tables S15–S17). Second, we show that gender quotas reduce agreement with the statement "only males make good politicians" by 4.8 pp among women—a 17.8% decline relative to the baseline rate of 27% in nonquota countries (*SI Appendix*, Table S18). Third, we find that quotas increase the likelihood that women agree their government is effectively empowering women by 11.3 pp, or roughly 19.5% relative to the 58% baseline (*SI Appendix*, Table S19). These statistically and economically meaningful results provide robust support for the proposed mechanism: that quotas elevate women's political representation, which in turn drives greater prioritization of gender-sensitive public goods like safe drinking water.

The second perspective involves broader spillover effects. The political empowerment of women can lead to increased economic opportunities and higher labor force participation for women, which in turn improves their social status and benefits society as a whole. As a result, governments are likely to place greater emphasis on advancing women's social and economic rights. Enhancing women's rights in the labor market brings increased attention to issues such as water access. Thus, greater empowerment of women can indirectly lead to improved water availability. We expect that reserved seat quotas not only enhance women's political rights but also contribute to strengthening their social and economic rights.

In Fig. 4 and *SI Appendix*, Table S20, we investigated the potential mechanisms driving the increase in improved water availability following the introduction of reserved gender quota policies, using model 3 outlined in the *Materials and Methods*. We regressed proxies for various aspects of women's rights on postreserved quota indicators. The findings indicate that, after the adoption of gender reserved seat quotas, the percentage of women in parliament increased by approximately 8.35 pp and 7.47 pp in the subsequent year, accompanied by concurrent increases in women's political and social rights. However, there was no significant improvement in women's economic rights, nor any notable effect on the Women, Business, and Law index.

These results confirm that reserved seat policies for women in parliament directly enhanced women's social status and political participation but did not significantly advance their economic standing. This suggests that the policy's impact on women's political empowerment has not yet extended into the economic and business spheres. At this stage, its influence has primarily been through promoting improved drinking water quality, driven by women's increased political power and the resulting direct policies.

Discussion

We investigated the impact of women's political empowerment, driven by the introduction of reserved seat policies, on households' access to improved drinking water in Africa—where access to improved water sources remains a major challenge. In many African countries, water-fetching tasks are primarily performed by women and young girls, highlighting gender inequality in household water management. Following the adoption of reserved seat quotas, women's political power significantly increases through greater representation in parliament, leading to policies and infrastructure improvements that better support women's rights, including enhanced access to improved drinking water. This is because women, more than men, understand the challenges of

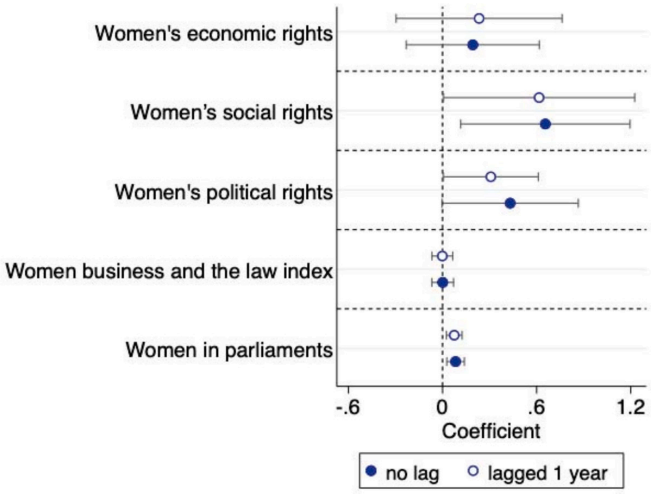

Fig. 4. Mechanisms linking reserved seats and improved water access: women's participation in political, social, and economic fields. This figure explores the mechanisms through which reserved seats impact improved water access, focusing on adopters with more than 20% reserved seats. We regressed different dependent variables measuring women's equality in political, social, and economic participation on the passage of quota reforms using DID analysis. The regressions control for the logarithm of GDP per capita, democracy status, control of corruption, political stability, and voice and accountability. Additionally, country and year fixed effects are controlled. SE are clustered at the country level, and the error bars represent 95% CI.

fetching water, a conclusion supported by our study's outcomes. Using household-level data from the DHS across Africa between 1996 and 2020, we found that reserved seat legislation not only increased the percentage of women in parliament but also improved women's political rights, resulting in a 4.71 pp average increase in access to improved water. This effect was even more pronounced in countries with quota sizes over 20%, where access improved by 12.25 pp. Our findings offer valuable insights for policymakers and contribute to the literature in the following ways.

First, existing literature has explored various strategies for improving household access to basic water resources. From the water demand perspective, income is a critical factor. Increasing national and household income through globalization (40), financial development (41), financial inclusion (42), poverty reduction (43), and foreign aid (12, 44) can all help reduce the reliance on unimproved water sources. On the water supply side, the root cause of the water crisis is often not absolute scarcity or a lack of technological solutions, but poor governance (5, 45). Governance shapes the entire water system, determining who receives water and sanitation services, when, how, and why. This is achieved through policies, institutions, rules, processes, and practices that articulate interests, make decisions, regulate behavior, and exercise power (46). Corruption in the water sector can undermine efforts to improve water quality (47, 48), making the prevention of corruption and improvement of governance essential. Stronger accountability (46) and increased transparency lead to better governance and institutional environments, which, in turn, improve access to safe drinking water (49, 50). In our study, we contribute further evidence that increasing women's representation in parliaments through gender quotas—particularly reserved seats—serves as a political tool to enhance household access to drinking water in Africa. Such an effect is particularly pronounced when the quota size reaches 20%.

Second, empirical evidence from Zambia (15), Ghana (33, 35), Liberia (32), Nigeria (37), and Eswatini (38) highlights unequal access to improved drinking water among subpopulations with different socioeconomic backgrounds. Poorer, rural, and less educated households are at greater risk of using unsafe drinking water compared to those at higher socioeconomic levels (3, 32, 51). Therefore, policies aiming at improving water access should particularly benefit these disadvantaged groups to promote equality in public services. In our research, we found that households with lower wealth, located in rural areas, and with lower levels of women's empowerment and education showed a significantly higher response to reserved seat policies. This suggests that women's political empowerment, driven by reserved seat quotas, helps narrow the socioeconomic gaps in access to safe drinking water.

Third, as we previously discussed, the success of a policy depends heavily on the overall institutional environment, particularly in the water sector, which involves multiple departments and procedures in the supply process. A better institutional environment ensures that gender quota policies are more effective by preventing corruption (21, 22). To explore this, we conducted a subsample analysis to test the heterogeneous impacts of reserved seat quota policies under varying levels of institutional quality. Our findings revealed that improved water availability increased significantly in countries with stronger corruption control, higher political stability and absence of violence, greater freedom of expression and voice for citizens, higher government effectiveness, better regulatory quality, and stronger rule of law. These results highlight the critical role that the institutional environment plays in the successful implementation of political policies.

An important limitation of our study lies in our inability to directly observe or measure the internal parliamentary dynamics that underpin the observed outcomes. While our analysis convincingly demonstrates a statistical association between the implementation of gender quotas above the 20% threshold and improved access to drinking water, the specific mechanisms through which increased female representation leads to tangible policy outcomes remain unclear.

This challenge is compounded by the complex and context-dependent nature of parliamentary coalition-building and advocacy. The political processes through which women legislators influence policy—such as agenda-setting, advocacy, coalition formation, or leveraging committee roles—are difficult to empirically trace given the available data. Future research should aim to investigate these intermediary political processes more systematically, using qualitative or mixed-method approaches, including case studies and analyses of parliamentary proceedings. Such work could significantly deepen our understanding of how and why gender quotas translate into improved policy outcomes when representation crosses critical thresholds.

Materials and Methods

We analyzed changes in improved water availability in African countries in relation to the abrupt implementation of gender quota legislation between 1989 to 2020, a period during which nine African countries introduced reserved seat quotas for women in parliaments.

Data.

Improved water availability. We generated a household-level dataset for Africa from the DHS. Since the 1980s, the DHS has been conducted every five years in low- and middle-income countries. These nationally representative, repeated cross-sectional surveys collect data on household-, women-, and men-level demographic and reproductive characteristics, as well as health behaviors. Administered by local implementing agencies, the DHS selects a random sample of households and gathers a wide range of information at the household level, including interactions between family members.

We first gathered household-level data on drinking water sources from the Household Recode (HR) module. By combining the World Health Organization's standards (52) with the categories presented in the DHS dataset, we classified piped water, tube wells or boreholes, protected wells/springs, rainwater, tanker trucks, carts with small tanks, and bottled water as improved water sources. In contrast, unprotected wells/springs, rivers, dams, lakes, ponds, streams, and canals were categorized as unimproved sources. Using this classification, we created a dummy variable to indicate whether a household consumes improved water.

We constructed key control and explanatory variables using data from multiple DHS modules. From the Household (HR) module, we created indicators for female-headed and rural households, and incorporated the DHS wealth index–a composite measure of economic status based on household assets and amenities (53), derived using principal components analysis. To capture women's empowerment, we merged the HR module with the Birth Record (BR) module using unique household identifiers. We then classified households based on women's participation in decision-making and their attitudes toward wife-beating, designating households as having women decision-makers or as rejecting wife-beating if the majority of married women reported autonomy in key decisions or disagreed with common justifications for domestic violence.

Gender quota data. We gathered information on African countries' adoption of gender quota legislation, including the year of adoption, the type of quota (either reserved seats or legislated candidate quotas, with both considered as treated countries), and the share of seats reserved for women (referred to as quota size, calculated by dividing the number of reserved seats by the total seats in the unicameral or bicameral legislature) from Bhalotra et al. (25). The data up to 2005 were sourced from Dahlerup (54) and were updated to 2015 using the Global Database of Quotas for Women. This database is developed and maintained by the International Institute for Democracy and Electoral Assistance (IDEA), the

Inter-Parliamentary Union, and Stockholm University. Information on candidate list quotas was also obtained from this database.

Additional country-level data. We gathered a rich array of country-level data for each nation and year within the study period, including GDP per capita (PPP-adjusted, expressed in 2017 international dollars), the share of women in parliament, the Women, Business, and the Law (WBL) index, and six worldwide governance indicators. In addition, we retrieved details on whether a country operates under a democratic system, as well as three indexes capturing the intricate landscape of women's political, social, and economic rights. These indexes, like reflections of societal shifts, were sourced from Bhalotra et al. (25), built upon the foundation of data from Cingranelli et al. (55).

We included all surveys conducted in Africa from 1990 onward, merged variables from multiple sources, and excluded observations with missing values for key variables used in the primary analysis. The final sample comprises 965,482 observations covering the period from 1996 to 2020. Detailed definitions of the variables are provided in *SI Appendix*, Table S1, while summary statistics are presented in *SI Appendix*, Table S2, Panel *A*.

Empirical Strategy.

Baseline staggered DID. We first employed a DID approach to identify the causal impact of reserved seat implementation on civilians' access to improved water in African countries using a logit estimator. This approach involved comparing changes in water access between adopters and nonadopters before and after the implementation of the legislation, using a generalized staggered DID model.

$$ln\left(\frac{P_{ijt}}{1-P_{ijt}}\right)=\alpha_0+\alpha_1 Quota\ reserved_{ijt}+\beta Controls_{ijt} + region_j+year_t+\varepsilon_{ijt}, \quad [2]$$

where P_{ijt} is the probability that members of household i residing in region j in year t have access to improved or safe water sources. Our primary explanatory variable is $Quotareserved_{ijt}$ which equals 1 if region j adopted a reserved quota in year t, and 0 otherwise. The coefficient of interest α_1 captures the association between the implementation of reserved seats legislation and the logistic transformation of the probability of household with access to safe or improved water sources. To better understand the treatment effect magnitudes, we calculated the average marginal effects as well.

We included household- and country-level control variables ($Controls_{ijt}$) in model 1 to account for potential confounding factors that could influence the relationship between policy implementation and access to safe water. At the household level, we included two covariates: whether the head of the household is female (*Female head*) and whether the household is located in a rural area (*Rural*). At the country level, the control variables include the logarithm of GDP per capita (*lnGDP*), an indicator for whether the country is democratic (*Democracy*), and three indexes measuring institutional quality: control of corruption, political stability, and voice and accountability.

Additionally, we included country-region fixed effects ($region_j$) to account for region-specific, time-invariant factors such as natural endowments and cultural influences, as well as year fixed effects ($year_t$) to control for macroeconomic time shocks. We clustered the SE at the region level to allow for arbitrary correlations among the residuals within the same region. ε_{ijt} represents the residual term.

To better understand the impact of quota size on the effects of reserved seats, we divided the treated countries into three categories based on the intensity of the legislation: less than 10% (two countries), between 10 and 20% (one country), and more than 20% (six countries). We then ran the regression for each group following model 1. Given the significant response of improved water availability in the "more than 20%" group, we focused our subsequent analyses on this group of treated countries and the control group. As a result, the sample size for this analysis was reduced to 883,271 observations. Summary statistics are provided in *SI Appendix*, Table S2, Panel B, and the regression results are shown in *SI Appendix*, Table S4.

Mechanism test. Finally, we sought to understand the mechanism by which reserved seats for women in parliament influence household-level access to improved water from a country-level perspective. To explore this, we employed a regression model to examine the impact of reserved seats on enhancing women's rights and social standing, particularly in terms of their political power and participation in the labor force.

$$Women's\ right_{ct}=\alpha_0+\alpha_1 Quota\ reserved_{ct}+\beta Controls_{ct} + country_c+year_t+\varepsilon_{ct}. \quad [3]$$

Here, c and t represent country and year, respectively. $Women'sright_{ct}$ measures women's rights and social status, including the share of women in parliament, the Women, Business, and the Law (WBL) index, and indices for women's political, social, and economic rights. Country-level controls include the logarithm of GDP per capita (*lnGDP*), an indicator for whether the country is democratic (*Democracy*) country or not, and three indices measuring institutional quality: control of corruption, political stability, and voice and accountability. Country ($country_c$) and year ($year_t$) fixed effects are included to account for time-invariant country characteristics and macrolevel time trends. ε_{ct} represents the residual term.

Data, Materials, and Software Availability. Anonymized Analytical data have been deposited in OSF (https://doi.org/10.17605/OSF.IO/GQ3SU) (56).

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