Female Leaders and Welfare in a Water-Scarce Economy*

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Abstract

Using comprehensive groundwater data, combined with large-scale census and election records, we analyze whether and how local political leadership in India can mitigate the economic risks associated with groundwater depletion—a growing threat to freshwater availability. We find that female leaders are more effective at mitigating the adverse income effects of groundwater scarcity by reallocating resources to more labor-intensive activities. Consequently, the greater local employment opportunities improve household consumption, particularly of essential goods, and increase investment in the education of girls. This research underscores the crucial role of female leadership in devising effective risk mitigation strategies during environmental crises.

JEL Codes: H41, I38, J16, 015, Q25

Keywords: groundwater scarcity, female reservation, NREGS, employment, consumption

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1 Introduction

India is the world's largest consumer of groundwater, extracting more than the United States and China combined (World Bank, 2020, 2010). Approximately 60% of the country's irrigation and 85% of domestic water supply in rural areas come from groundwater (Saha and Ray, 2019). Such intensive use of groundwater has led to over-exploitation in many areas, with 14% of administrative areas (blocks) marked as 'over-exploited' and an additional 26% of areas categorized as 'critical' or 'semi-critical' (Central Ground Water Board, 2022). Groundwater depletion remains one of the most critical issues of our time and is becoming more pressing as the planet warms, leading to increased evaporation of surface water despite rising rainfall (Bhattarai et al., 2023).

Water scarcity has been shown to increase conflict (Unfried et al., 2022), rural poverty (Sekhri, 2014), infant mortality (Rocha and Soares, 2015), and violence against women (Sekhri and Hossain, 2023), and lead to a loss of income and wealth (Distefano and Kelly, 2017; Desbureaux and Rodella, 2019; Blakeslee et al., 2020). As groundwater becomes scarce, the burden of water collection often falls on women, which can lead to increased stress and violence against women (Sekhri, 2014), worsen public health by deteriorating water quality (Xie et al., 2023), and impose a higher social consumption cost (Sayre and Taraz, 2019). However, how these costs are effectively managed depends on who governs the local resources and provides the means to support income and consumption against the risk posed by depleting groundwater. Effective local political leadership can, therefore, be crucial in mitigating the negative economic effects of groundwater depletion.

This paper examines whether female leaders are more effective in managing local outcomes during periods of water scarcity than their male counterparts. Using household and election data from the Rural Economic and Development Survey (REDS) and groundwater data from the Central Ground Water Board (CGWB), we estimate whether households in water-scarce villages with a female leader in a reserved seat have better employment, income and consumption outcomes relative to similarly water-stressed villages with a male leader. Our identification of the causal effect of local female leadership is based on the random allocation of female reservations across Indian villages within districts, based on the 73^{rd} Constitutional Amendment in 1993 (see Chattopadhyay and Duflo (2004) and Pathak and Macours (2017)). It is worth noting that this identification strategy does not rely on how we classify villages into good and bad groundwater regions. Our baseline measure of groundwater scarcity categorizes villages into two groups: those with an average groundwater depth from the surface of less than 8 meters over the past two years (designated as good groundwater areas) and those with a depth of more than 8 meters (designated as bad groundwater areas). This choice of the 8-meter cutoff is motivated by the fact that cheaper centrifugal pumps can be used only up to a depth of 8 meters, beyond which expensive submersible pumps are required for groundwater extraction (see Sekhri (2011, 2014)). This discrete jump in the cost of groundwater extraction creates a quasi-random discontinuity in the variation of groundwater availability across villages. However, as we argue, our key identification does not rely on this quasi-random discontinuity of groundwater availability, and so we show robustness of our results using an alternative continuous measure of groundwater depth.

We first establish that poor groundwater availability is indeed associated with lower household income and expenditure. We achieve this by matching household-level income, expenditure, and other demographic data from the Consumer Pyramids Household Survey (CPHS) for more than 170,000 households with groundwater depth information from approximately 39,000 wells across the districts of residence for these households, as provided by the CGWB. We find that depleting groundwater reduces both the income and spending of households in districts with worse groundwater availability. Using the random rotation of village leadership, we then utilise cross-sectional data from the REDS (approximately 285,000 individuals from 92,000 households) and the CGWB to demonstrate that female leaders are more effective than their male counterparts in mitigating the negative economic effects of groundwater depletion. The local female leaders achieve this through expanding access to the National Rural Employment Guarantee Scheme (NREGS) for female workers by distributing more job cards and reallocating available public finances towards more labor-intensive activities like local infrastructure development through construction and manufacturing, where more male workers can find employment. This strategic reallocation of resources accelerates the pace of structural transformation away from agricultural jobs in female-led, water-stressed villages, and arguably puts the rural economy on a more sustainable path of development with reduced reliance on irrigation-driven agriculture in already water-scarce areas. The employment gains of both male and female workers translate into direct welfare improvements for households through higher income and higher expenditures, particularly on non-food items such as clothing and children's education. Related to the higher educational spending, we also find that households in female-led water-scarce villages are more likely to substitute away from government schools towards private schools, with an associated increase in school enrolment and attendance rates. While these results suggest greater human capital investments for potential future welfare gains, female-led water-stressed villages also experience a rise in unproductive expenditures, such as spending on tobacco and alcohol, likely as a consequence of higher male earnings.

This paper contributes to the nascent literature on the role of female leadership in times of crisis. A large literature has found positive effects of female political representation on education (Beaman et al., 2012; Clots-Figueras, 2011, 2012), health (Bhalotra and Clots-Figueras, 2014; Clayton and Zetterberg, 2018), infrastructure (Chattopadhyay and Duflo, 2004), economic growth (Baskaran et al., 2024), corruption (Jha and Sarangi, 2018), female entrepreneurship and employment opportunities (Ghani et al., 2014; Deininger et al., 2020), crime reporting and crimes against women (Iyer et al., 2012; Bochenkova et al., 2023) and the environment (Mavisakalyan and Tarverdi, 2019; Jagnani and Madadevan, 2024). Hessami and da Fonseca (2020) provides a comprehensive review of the literature. However, few papers have focused on the effectiveness of female leadership in response to shocks or during times of crisis. We are the first to show how female leaders manage risk induced by the groundwater crisis in the rural economy. Our paper is similar in vein to Bruce et al. (2022), who show that cities with a woman as a mayor present lower rates of death and hospitalizations from COVID-19.

This paper also relates to the literature on natural resource scarcity in developing countries and the policy responses to it, focusing particularly on groundwater depletion. As global warming worsens, the water crisis is likely to affect an increasing number of people, with the most vulnerable households being hit the hardest. With reduced agrarian income due to the water crisis that restricts irrigation, the local tax revenue might decrease, affecting future investment in development programs (Sanoh, 2015). Households and local governments might adopt strategies to cope with the water crisis, e.g., household members can migrate or try to find regular salaried jobs. However, the effectiveness of these responses also depends on how policymakers respond to the groundwater crisis. Female leaders have not only been shown to care more about climate change, but they are also more effective at managing environmental crises (Jagnani and Madadevan, 2024; McCright and Dunlap, 2011; McCright, 2010) and at delivering public services in response to crises. Our paper can be viewed as a contribution to this literature by studying whether the policy of female political reservation, as mandated by India's Constitution, is effective in coping with the risks posed by a natural crisis, namely depleting groundwater.

The paper is organized as follows. In Section 2, we provide background on the groundwater situation in India and the electoral reservation policy, and how the two can be potentially related. Section 3 then describes in detail the different data sources used and how these datasets were matched to each other. Section 4 studies the effect of depleting groundwater on the income and consumption of households, while Section 5 presents results on how the local female leadership mitigates the negative impact of poor groundwater availability. Finally, Section 6 concludes with a discussion of the policy implications and avenues for future research.

2 Background

2.1 Groundwater Availability

Groundwater refers to water that exists below the earth's surface in underground reservoirs, known as aquifers. Groundwater generally moves slowly through porous rock formations and is replenished from precipitation that filters down through the soil. Left in their natural state, aquifers can hold water for a long time, and as such have a relatively slow replenishment rate. While water in rivers is renewed every two weeks, groundwater takes anywhere from 100 to 10,000 years, depending on depth.[1] Even though precipitation is the principal determinant of groundwater recharge, short-term fluctuations in precipitation do not necessarily translate to identical fluctuations in groundwater volumes because recharge rates depend heavily on soil and vegetation types, geology and topography (Sekhri and Hossain, 2023). Aquifers also recharge at different rates, depending on the impermeability of the surface in the surrounding area.

Beyond the geographical factors, groundwater levels crucially depend on human withdrawal rates. In India, groundwater fulfils a major share of the water needs for domestic, agricultural and industrial

[1] http://www.physicalgeography.net/fundamentals/8b.html

uses, accounting for about 80% of domestic water requirement and more than 45% of the total irrigation (Kumar et al., 2005). Subsidies on electricity and irrigation further accelerated groundwater extraction for agricultural use, particularly after the Green Revolution, enabling farmers to tap aquifers on a large scale (Rodella et al., 2023), with the number of wells increasing from fewer than 1 million in the 1960s to approximately 27 million as of 2020 (Central Ground Water Board, 2020). This sudden surge in human withdrawal of groundwater resulted in India experiencing a decline in groundwater levels ranging from 1 to 8 meters below the ground surface. This drop was the most severe — between 8 and 16 meters — in the northwestern states (Sekhri, 2012; Zaveri et al., 2016; Rodell et al., 2009a). To reach these ever greater depths below the ground surface to extract the rapidly depleting groundwater, the wells need to be dug deeper, and the motorized pumps for the tube wells (which constitute about 60% of all wells in India, according to the Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, 2023) need to be more powerful. As Sekhri (2011, 2014) explains, cheaper centrifugal pumps can be used up to a depth of 8 meters, whereas more expensive submersible pumps are required for groundwater levels deeper than 8 meters.

We inform our identification strategy in this paper by combining features of the spatial distribution of groundwater and the cost of extracting groundwater. First, since groundwater aquifers are interconnected and aquifer boundaries do not align with those of political units, the groundwater management practices of any state, district, or village are likely to affect its neighbours (Rodell et al., 2009b). This necessitates the use of groundwater level data from individual wells to study the impact of depleting groundwater on the economic outcomes of households living nearest to these wells. Second, the discrete jump in the cost of installing submersible pumps instead of cheaper centrifugal pumps for groundwater levels deeper than 8 meters creates a natural quasi-random discontinuity in groundwater availability variation across regions that we exploit in our regressions.

2.2 Female Reservation in Local Political Representation

With decentralized self-governance in mind, India adopted the 73^{rd} and 74^{th} Amendments to the Constitution in December 1992, which came into effect in 1993–94. These amendments established Panchayati Raj and municipal institutions, introducing a three-tier structure of Panchayati Raj governance: Zilla Panchayat (district level), Panchayat Samiti (subdistrict level), and Gram Panchayat (village level). These amendments provide special provisions for the reservation of Gram Panchayat seats for historically marginalized groups such as women, Scheduled Castes (SCs) and Scheduled Tribes (STs). While SC/ST reservations are based on their population shares, the reservation of seats for women within each Panchayat is done in a rotational manner, essentially making it random. Article 243D(3) of the Constitution requires that at least one-third of the total number of seats in every Panchayat election be reserved for women. In practice, however, many states have gone beyond this constitutional minimum. As of 2021, 21 states (e.g., Andhra Pradesh, Bihar, Maharashtra, West Bengal) have enacted laws raising women's quotas in village Panchayats to 50%.

A large body of literature has found a positive impact of having a female leader on various outcomes. For example, female leaders have been shown to invest more in health and education (Pathak and Macours, 2017), raise aspiration (Beaman et al., 2012), invest more in water and roads (Chattopadhyay and Duflo, 2004), and improve immunization (Bhalotra and Clots-Figueras, 2014) and other local public goods (Duflo, 2005). Female leaders in village Panchayats also improve the quality and effectiveness of rural development programs, including the National Rural Employment Guarantee Scheme (NREGS) (Beaman et al., 2012; Deininger et al., 2015), and are better at providing local jobs under the NREGS as an insurance against negative shocks (Bose and Das, 2018; Deininger et al., 2020). Therefore, a natural question we investigate in this paper is whether female leaders are better than their male counterparts in mitigating the negative impact of depleting groundwater through better local governance. In particular, since the NREGS program is implemented at the local level by the village panchayat, and village council heads have discretion over what projects are undertaken and who is given work, it is interesting to study whether female leaders can allocate disproportionately more jobs in water-stressed areas.

3 Data and Descriptive Statistics

This section discusses the data used in the paper. Our analyses draw on three different nationally representative data sources, which we link to inform our analyses.

3.1 Groundwater Data

Groundwater data comes from the Central Ground Water Board (CGWB), under the Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation. The CGWB maintains groundwater stations (wells) and collects seasonal information on water levels for each well.[2] In particular, data is collected during the monsoon (June to September), post-monsoon (Kharif, September to October), winter (Rabi, November to March), and pre-monsoon (Zaid, April to June) periods.[3] In total, we observe around 39,000 wells, though not all wells are measured every period or every year. Appendix Figures A.1 and A.2 show the CGWB-monitored well locations across India and the number of wells measured at least once per year by year, respectively. On average, we have 79 measurements per well, with 70% of wells having 10 or more measurements.[4]

Appendix Table A.1 lists both the number of observations as well as average annual and pre-monsoon groundwater depths by state. States with high average groundwater levels (meaning the water is closer to the surface) are predominantly found in the north-eastern and eastern parts of the

[2]For more details, see here and here

[3]There is some regional variation as to when these seasons start and end; for example, the monsoon season will start in Kerala in June and move to the north over the next month. However, conditional on the region, each season is distinct.

[4]Some wells are also measured multiple times in a season; however, this is relatively infrequent. 99.5% of wells have fewer measurements than the maximum number of possible total measurements (124 periods over 31 years).

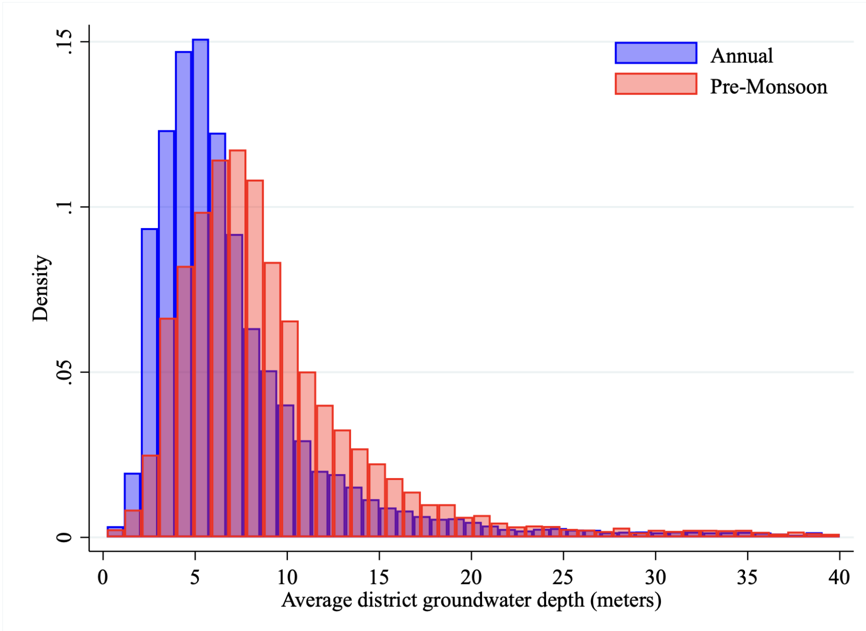

Figure 3.1: Distribution of Districts with Ground water level

country while states with low average groundwater levels are primarily located in the arid and semi-arid regions of the west and south. Assam has the highest average groundwater level at 3.13 meters, while Rajasthan has the lowest with 21.45 meters. At the same time, we also see substantial variation within states; for example, Rajasthan, Chandigarh, and Haryana show a very high degree of variation, with annual standard deviations ranging from approximately 13 to over 20 meters.

Importantly, geographic coordinates are available for each well, as well as the village and district in which the well is located. Using this information, we are able to construct local and district-level groundwater depth aggregates. Figure 3.1 plots district-level average groundwater depths for the annual and pre-monsoon periods, showing considerable variation in depth across districts. Groundwater depths are generally increasing over time, though not linearly with several peaks and troughs throughout the period for which we have available data (Figure A.3).

3.2 Consumer Pyramids Household Survey (CPHS)

Our second data source is the household-level longitudinal data from the Consumer Pyramids Household Survey (CPHS) conducted by the Centre for Monitoring Indian Economy (CMIE). We use data covering the period 2015 to 2023.[5] The panel survey started with roughly 236,000 households, and the sampled units were interviewed three times per year about their socio-economic and demographic characteristics as well as their detailed income and expenditure in each of the previous four months. We aggregate the

[5] Data collection for this survey began in 2014; however, only a limited number of households were included at this point. As such, we exclude this year from our analysis.

income and expenditure information at the yearly level.

While the CPHS does not contain local identifiers, we do have information on the household's district of residence. We therefore aggregate the groundwater data to the district level and match this with the CPHS.[6] In total, the data contains 4,344 matched district-year observations and 1,555,168 matched household-year observations. Table A.2 provides descriptive statistics for this sample. Approximately 65% of our sample is urban. Average household size is 3.9, and household heads are predominately male with an average age of 51 years. The majority of average total household income is wage income. Annual average groundwater depth is 8.4 meters, and 10.5 meters for the pre-monsoon period.

3.3 Rural Economics and Demographic Survey (REDS)

The third source of data is the 2015/16 round of the Rural Economic and Development Survey (REDS), which covers 191 villages across India.[7] The advantage of this data is that it provides detailed information at both the village and household levels, focusing on rural issues such as agriculture and employment. From the household module, which covers almost all households in a village, we are able to gather information on household member employment, member income from those employments, and education level. The survey also collect information on itemized household consumption expenditure. A separate section contains information on young (age 5–14 years old) children's education, skills such as reading and math skills, anthropometric measure and educational investment in children.

Very detailed individual-level data on the National Rural Employment Guarantee Scheme (NREGS) is also available. In particular, the survey collects information on the number of days worked in the program, income earned by each member by season, and whether the respondent received enough work in the program or wanted to work more. Besides these variables, the survey also collects information from the village head office about the type of NREGS projects that were approved. Also covered in the village module is detailed information on village structure, such as population, number of households, and a detailed section on village governance, which collected information on whether the position of village president was reserved for women.

Table A.3 in the Appendix provides descriptive statistics for this data. We focus on working-age adults, which we define as individuals between 15 and 65 inclusive. We drop the top 1% of observations in terms of total days worked to avoid issues with outliers. This leaves us with 284,898 individuals across 92,322 households. Most (87%) households are Hindu, with 28% of households identifying as belonging to Schedule Caste/Scheduled Tribe groups and 50% belonging to Other Backwards Caste groups. Households have an average of 4.6 members, and around 3 working-age adults. Half of households report owning at least some agricultural land. On average, individuals are 35 years old, 70% are

[6] We are able to match 98% of district-year observations in the CPHS to groundwater data. The districts we are unable to match are predominately in the Himalayas, where there is no groundwater data available. The remaining mismatch is due to missing groundwater data for certain years.

[7] This particular survey round is also called the Socio-Economic Profile of Rural Households in India (SEPRI). Thirteen states are covered in this survey.

married, and 64% have at least a primary education. 62% of working age adults report doing some work, either in the agriculture or non-agriculture sectors (either self-employed or as a wage worker), salary-based work or on NREGS.[8] 41% work in agriculture, 28% in non-agriculture, and 12% report working for a salary or on NREGS. Individuals report working 104 days of work per year on average, with 26 days in agriculture, 57 days in the non-agriculture sector, 16 days as a salary worker and 2 days on NREGS.

Village geographic coordinates are available for the REDS villages and we use these to match the 3 nearest wells within a 20 kilometer radius.[9] While we can match all villages to at least one well, around 15% of villages are missing any groundwater measurements either for the year 2015 or the two years before that (2013-2014). On average, groundwater depths hover around 8 meters (Table A.3).

4 Income and Consumption Effects of Depleting Groundwater

The goal of this paper is to investigate whether female political leaders at the local level are better than their male counterparts in mitigating the adverse impact of resource scarcity through policy intervention. Since we study resource scarcity in the specific context of groundwater depletion, we must establish that poor availability of groundwater is indeed associated with adverse economic conditions. In what follows, we show that depleting groundwater not only reduces the income and spending of affected households but also increases the cross-sectional dispersion of household income and consumption within the worse-affected districts.

Depleting Groundwater Reduces Consumption and Income. To document the relationship between the consumption or income of a household and the district-level average groundwater level, we estimate the following two-way fixed effects regression model using data from the CPHS:

$$Y_{idt} = \alpha + \beta GW_{dt} + \delta_d + \tau_t + \theta X_{idt} + \epsilon_{idt} \tag{4.1}$$

where Y_{idt} is the logarithm of either total or per capita consumption and income of a household living in district d in year t, GW_{dt} is the logarithm of the groundwater depth level measured in meters from the surface, δ_d denotes the district fixed effects, τ_t denotes the year fixed effects, and X_{idt} is a vector of controls that includes caste, religion and gender of the head of the household. If depleting groundwater,

[8] Individuals can work in different sectors in the same day, which would count separately as a day of work. Due to this, more than 365 days of work can be reported in total, and more than 100 days of work on NREGS can be counted. Here, non-agricultural work includes merchants/shopkeepers, hawkers/salespersons, tradespeople (carpenters, bricklayers, tailors, mechanics, electricians etc.), well diggers, and other miscellaneous labor work. Salary/regular work refers to workers on contracts with a specified number of hours, such as teachers, professional workers such as clerks or administrators, police, service workers, and drivers. Occupations can overlap between these categories depending on whether the work is stable or unstable.

[9] Our main results are also robust to using a 10km radius, though fewer villages have non-missing depth measures. Results are available upon request.

measured by a greater depth from the surface, has an adverse impact on the economic outcomes of households, we should expect the estimates of β to be negative.

Table 4.1: Income and Consumption Effects of Depleting Groundwater Levels

	Total Income		**Wage Income**		**Consumption**	
	Total	Per-capita	Total	Per-capita	Total	Per-capita
All states						
Average groundwater depth	-0.074***	-0.076***	-0.744***	-0.671***	-0.065**	-0.064**
	(0.028)	(0.027)	(0.189)	(0.166)	(0.031)	(0.031)
R^2	0.688	0.743	0.545	0.533	0.727	0.802
Dep. Mean	9.716	8.445	8.163	7.031	9.255	7.978
Observations	1377482	1377482	1377482	1377482	1223262	1223262
Excluding NE states and UT						
Average groundwater depth	-0.079***	-0.080***	-0.784***	-0.707***	-0.083***	-0.081**
	(0.029)	(0.028)	(0.202)	(0.176)	(0.032)	(0.032)
R^2	0.686	0.743	0.544	0.532	0.726	0.804
Dep. Mean	9.706	8.436	8.160	7.028	9.245	7.969
Observations	1319783	1319783	1319783	1319783	1171887	1171887

Notes: Data from CMIE and CGWB. We use the logarithmic transformation of all the outcome variables. "Total Income" includes wages, transfers, business profits, and other sources. "Wage income" is total household income earned from wages. "Consumption" includes food and non-food spending. We exclude the top 1% of households by total income in each year. "Average groundwater depth" is equal to the logarithm of the average annual groundwater depth for the previous two years, aggregated at the district level. Controls include household fixed effects, year fixed effects, religion, gender and age of household head, and household size. Standard errors clustered at district level are reported in parentheses. The top panel uses data for all states, while the bottom panel excludes the northeastern states and union territories. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results from regression (4.1) are presented in Table 4.1. Total and per capita household income from all sources are lower in districts with worse groundwater levels, with 1% greater groundwater depth translating to 7% lower household income.[10] This statistically significant negative correlation between groundwater depth and household income is present when we consider districts across all Indian states, and the correlation becomes somewhat stronger when we exclude the more sparsely populated northeastern states and union territories from our sample. The negative impact of depleting groundwater on total household income is primarily driven by the adverse impact on wage income of the households rather than non-labour income sources. The negative total income effect passes through to lower total expenditure on food and non-food items. These findings are robust to alternatively using pre-monsoon groundwater depth (Table B.2) and current-year annual groundwater depth.

[10] In Table 4.1 we exclude the top 1% of households based on total income. Table B.1 includes these households and finds similar results.

Depleting Groundwater Increases Economic Inequality. Next, we document the positive correlation between depleting groundwater and increasing inequality by estimating the following regression specification:

$$\ln(\sigma_{dt}) = \alpha + \beta\, GW_{dt} + \delta_s + \tau_t + \chi_{st} + \epsilon_{dt} \tag{4.2}$$

where $\ln(\sigma_{dt})$ is the logarithm of the standard deviation of either consumption or income across households within a district d in year t, GW_{dt} has the same interpretation as in regression (4.1), δ_s denotes the state fixed effects where the districts are located, τ_t denotes the year fixed effects, and χ_{st} denotes the state×year fixed effects. A positive β in this context implies that groundwater depletion is associated with greater dispersion in household economic outcomes within the affected districts. Additionally, we also run a modified version of regression (4.2) where we replace the GW_{dt} variable with the standard deviation of the groundwater depth across the different wells located within the district d in year t. In this alternative version, the β coefficient captures the impact of spatial dispersion in groundwater availability on the cross-sectional inequality in household economic outcomes.

Table 4.2: Impact of Level and Dispersion of Groundwater Availability on Economic Inequality

	Std. Dev. of Total Income		**Std. Dev. of Consumption**	
	Total	Per capita	Total	Per capita
Panel A: Impact of Depleting Groundwater Level				
Average groundwater depth	0.077*	0.067	0.072*	0.080**
	(0.042)	(0.043)	(0.039)	(0.034)
R-squared	0.405	0.355	0.402	0.354
Dependent Variable Mean	9.153	7.937	8.020	6.987
Number of Observations	4261	4261	3771	3771
Panel B: Impact of Dispersion in Groundwater Level				
Std. dev. of groundwater depth	0.101***	0.097***	0.114***	0.106***
	(0.030)	(0.031)	(0.028)	(0.024)
R-squared	0.409	0.360	0.408	0.363
Dependent Variable Mean	9.150	7.935	8.016	6.985
Number of Observations	4232	4232	3744	3744

Note: Data from CMIE and CGWB database. Outcome variables are district-level standard deviations of total household income and expenditure in logged form. "Total Income" includes wages, transfers, business profits, and other sources. and transfers, and other other components. "Consumption" includes food and non-food spending. "Average groundwater depth" in Panel A is the average district groundwater depth for the previous two years. "Std. dev. groundwater depth" in Panel B is the average district standard deviation in groundwater depth for the previous two years. Groundwater variables are logged. State, year and state by year fixed effects are included. Standard errors clustered at the district level are reported in parentheses. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

In Panel A of Table 4.2, we show that worse groundwater availability translates into higher cross-sectional dispersion in total income and consumption among households within districts. Although the standard deviation of per capita household income is not significantly correlated with groundwater depth, the general finding of a positive correlation between bad groundwater and high inequality is clear from Panel A. Furthermore, in Panel B of Table 4.2, we show that higher dispersion in groundwater levels across different wells within a district is also positively correlated with higher cross-sectional inequality in household income and consumption.[11]

Taken together, the evidence in Tables 4.1 and 4.2 suggests that not only does depleting groundwater reduce the level of income and consumption for affected households, but it also increases economic inequality across households in adversely affected areas.

5 Groundwater and Female Leadership

A small but emerging body of literature suggests that female leaders are more effective during times of crisis. For instance, female leaders had lower COVID-19 mortality rates in the early stages of the pandemic, partly driven by more proactive and inclusive responses to the crisis (Bruce et al., 2022; Garikipati and Kambhampati, 2021). Female leaders are more likely to prioritize social protection programs, especially those benefiting women and children. In hard times, such programs play a more protective role, insuring household consumption against income risk. Improvements in the effective delivery of such programs not only affect immediate consumption, but are also likely to improve the human capital of the next generation (Bhalotra et al., 2018). We test this hypothesis in this paper using the random rotation of female leadership that happened to be in water-stressed Indian villages.

5.1 Empirical Strategy

Our goal is to estimate the impact of female reservation on the economic outcomes of households in water-stressed villages. We view the historical level of groundwater as a state of the world and not as an exogenous shock for the local village economy. The efficacy of the village leadership determines how well households can cope with water scarcity. In particular, we want to know whether female village leaders are better at providing households with the means to insure against the negative economic impact of water scarcity compared to their male counterparts. To this end, our regression specification for household i in village v in district d generally follows the form:

$$y_{ivd} = \alpha + \beta GW_{vd} + \lambda F_{vd} + \gamma GW_{vd} \times F_{vd} + \delta_d + \theta X_i + \varepsilon_{ivd} \tag{5.1}$$

where y_{ivd} denotes household-level outcomes like employment, income and expenditure, GW_v is an indicator variable measuring groundwater scarcity, which is equal to one if the nearest well to a village

[11] Tables B.4 and B.5 in the Appendix provide results with pre-monsoon and annual data, respectively. We find similar results.

has average groundwater level of 8 meters or more for the previous two years (2013-2014), F_{vd} is an indicator equal to one if the post of the village president is reserved for a female candidate at the time of the survey, δ_d denotes district-level fixed effects, and X_i is a vector of additional control variables like age, education, marital status, caste group, religion, and household size. We are interested in the coefficient γ of the interaction between a village having bad groundwater and being reserved for female leadership. We cluster all standard errors at the village level.

Our identifying assumption is that, conditional on district-level fixed effects δ_d, the allocation of female leadership across Indian villages is random. Following the 73^{rd} Constitutional Amendment passed in 1993, a fixed proportion of leadership positions at the village level must be reserved for underrepresented groups, namely, SC/STs and women. While the allocation of caste-based reservations is often based on population shares of these disadvantaged castes, female reservation is effectively random (Chattopadhyay and Duflo, 2004; Pathak and Macours, 2017). Appendix Table C.1 corroborates no difference in observable characteristics between villages with and without female leadership reservation once we control for district fixed effects. Since the quasi-random treatment is female reservation, our identification strategy does not require that the variation in groundwater levels within districts is random across villages.

5.2 Employment Effects

We begin by documenting the impact of female leadership on different types of employment in water-scarce villages for working-age household members. Our employment outcomes are days of work over the previous 12 months.

Table 5.1 shows the effect on non-NREGS employment, split by agricultural and non-agricultural work, separately for male and female working-age household members. We find that among the bad groundwater areas, female-led villages generate significantly more non-NREGS employment for male workers outside agriculture. This finding of higher non-NREGS employment in female-led villages with groundwater scarcity is significant because non-NREGS employment captures the general level of local economic activity, which goes beyond the immediate impact that political leaders can have through better implementation of NREGS. Higher non-NREGS employment can be brought about either through higher NREGS activity that creates positive general equilibrium spillovers to other sectors of the local economy (Muralidharan et al., 2023), or through direct increases in public and/or private sector employment that may occur due to adopting more labour-intensive production practices, or the local political leadership being able to attract state and national level public investment into the village. Below, we investigate these channels.

First, we consider the possibility that female leaders in bad groundwater areas are raising non-NREGS employment outside agriculture directly, and not through positive spillovers from more NREGS work allocation. This raises the question of what tools are available to a local leader to influence employment outside of NREGS. One potential channel is to use village expenditures to create additional

Table 5.1: Employment Effects of Female Reservation in Water Scarce Villages by Type of Non-NREGS Employment

	All		Female		Male	
	(1)	(2)	(3)	(4)	(5)	(6)
	Agri.	Non-Agri.	Agri.	Non-Agri.	Agri.	Non-Agri.
GW > 8m	6.054	-17.995***	2.322	-0.715	9.066*	-33.992***
	(3.726)	(5.364)	(3.052)	(2.158)	(4.974)	(9.934)
Reserved	0.772	-3.535	0.243	1.719	1.096	-9.063
	(2.217)	(3.958)	(2.400)	(2.080)	(3.474)	(6.178)
GW > 8m x Reserved	-7.449	11.687**	-1.296	-2.356	-12.039	28.055***
	(5.047)	(5.689)	(4.368)	(2.751)	(7.395)	(10.214)
R^2	0.184	0.079	0.210	0.035	0.236	0.211
Dependent Variable Mean	109.574	109.582	21.385	16.614	31.495	141.609
Observations	221135	221080	107339	107333	113796	113747

Notes: Data from SEPRI 2015-16 and CGWB database. Outcome variables are individual days worked for individuals between 15 and 65 years. OLS regression is used for estimation. "Agri" refers to the numbmer of days worked in either self-employed or casual agricultural labor. "Non-Agri" refers to days worked as in a self-employed business or as non-agricultural casual labor (excluding NREGS) or as a salaried employee. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. "Female" is an indicator variable equal to on if the individual is a woman. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

employment opportunities. Villages typically operate on several sources of revenue: state and central government transfers, local-level taxes (e.g., land taxes), and fees (e.g., water and electricity fees, and user charges for hospitals and schools). This revenue is then spent on a range of services, such as local infrastructure (e.g., drinking water, roads, and sanitation facilities) and benefits or schemes, such as Below Poverty Line (BPL) cards and NREGS. There are several ways in which village operations can create employment opportunities — the collection and management of the taxes and fees requires workers, new infrastructure projects need construction workers, and the expansion of services such as schools, healthcare or transportation needs workers to deliver these services. Female leaders could be better at raising revenues, which are then invested into the local economy, generating more jobs, or they may be better at utilizing the available resources to create additional employment opportunities.

Table 5.2: Panchayat and Private Employment Effects of Female Reservation in Water Scarce Villages Using Average GW

	Public Finance		**Panchayat Employment**		
	Revenue	Expenditure	Federal/State & Local Taxes	Local Infrastructure	Local Facilities Schemes
	(1)	(2)	(3)	(4)	(5)
Panel A					
GW > 8m	-0.110	-0.338	219.322	-8.313*	-75.631*
	(0.230)	(0.206)	(159.828)	(4.671)	(41.497)
Reserved	-0.009	0.118	-52.003	-10.962**	-80.631*
	(0.140)	(0.225)	(42.283)	(5.415)	(41.497)
GW > 8m x Reserved	-0.277	0.064	-93.579	16.670**	79.460*
	(0.264)	(0.289)	(131.199)	(6.638)	(40.562)
R^2	0.314	0.311	0.835	0.571	0.510
Dependent Variable Mean	11.129	10.678	193.641	49.961	38.439
Observations	1585	724	1302	304	139

	Local Firm Employment				
	Trading	Construction/ Repair/Maintenance	Food Production	Manufacturing	Other Service
	(6)	(7)	(8)	(9)	(10)
Panel B					
GW > 8m	1.681	-14.082*	-7.903**	-68.857*	22.001*
	(11.716)	(7.397)	(3.672)	(40.716)	(13.045)
Reserved	0.704	-16.029	-0.926	-38.638	44.533*
	(1.787)	(11.512)	(1.488)	(44.774)	(24.680)
GW > 8m x Reserved	-3.535	27.126*	20.310***	106.638*	-55.388*
	(26.761)	(14.669)	(7.072)	(60.491)	(29.199)
R^2	0.366	0.110	0.401	0.483	0.129
Dependent Variable Mean	11.200	11.781	33.232	56.691	17.437
Observations	175	352	228	81	485

Note: Data from SEPRI 2015-16 and CGWB database. OLS is used for estimation. Outcome variables in Panel A are total Panchayat revenues (column (1)), total Panchayat expenditures (column (2)), and number of workers employed from each category (columns (3)-(5)). Revenues and expenditures are in log(x+1) form. The unit of observation is village-source, where we observe up to 50 sources of revenues or expenditures per village. We aggregate information on revenue, expenditure, and employment for the past two years. Outcome variables in Panel B are total workers employed for private firms falling within the main activity categories listed as column headers. The unit of observation here is village-firm type, where we observe up to 31 different firm types per village. OLS regression used for estimation. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in the local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. District fixed effects included. Standard errors are clustered at the village level. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Using information from the past two years on the amount spent and the number of people employed across 50 different sources of revenues and expenditure categories in village operations, we study whether female leaders in villages with poor groundwater are raising more revenues, spending more, or reallocating resources towards more labour-intensive activities.[12] Table 5.2 provides the results. Overall revenues and expenditures are not significantly higher in bad groundwater villages with a female leader (see columns (1) and (2)), but we do find significant Panchayat employment effects, with female leaders generating more employment in local infrastructure and local facilities and schemes (see columns (4) and (5)). This suggests that rather than being better at raising revenues or increasing local government spending, female leaders in areas with poor groundwater are more effective at generating local employment through a reallocation of economic activities towards more labour-intensive sectors, such as infrastructure development and service delivery by the Panchayat.

Next, we examine reallocation of employment within the private sector, which is largely outside the direct political control of the village leader but can still be influenced through local policies. For example, while infrastructure development by the Panchayat can generate public employment, it can also create jobs in the private construction sector, to which the development work is outsourced. Organizing private firms by their main activity, we find that sectors like construction, food production, and manufacturing experience large increases in employment, while service sector roles such as tailors, barbers, potters, and washermen see a relative decline in female-led water-scarce villages (see Panel B of Table 5.2).

One important implication of the above results for non-NREGS employment is that in water-scarce villages, female leaders facilitate the process of structural transformation away from agriculture and towards sectors such as manufacturing and construction at a relatively greater speed than their male counterparts. Comparing the estimates in the third row of columns (1) and (2) of Table 5.1, we find that overall employment is higher in the non-agricultural sector, which comes at the cost of lower agricultural employment (albeit the decrease in agricultural employment is not statistically significant). This facilitation of structural transformation could be a reasoned choice by the local political leadership in areas with poor groundwater availability, as the scarcity of freshwater for irrigation could make dependence on agriculture for livelihood unsustainable in the long run for those regions. Alternatively, it could be an attempt by female leaders to reverse the decline of male employment in the non-agricultural sector in groundwater-scarce regions (see the estimates in the first row of columns (5) and (6) of Table 5.1), without attention to the long-run implications for structural transformation.

While non-NREGS employment opportunities are created mostly for male workers in sectors like construction, local infrastructure and manufacturing, Table 5.3 shows that additional NREGS jobs in female-led water-scarce villages are mostly allocated to women. Digging into the mechanisms, column (1) of Table 5.4 shows that the increase in female NREGS work is driven by registering more women for a job card, that is, increasing the pool of workers eligible for NREGS. We do not see any effect on unemployment insurance (column (2)), which individuals in NREGS become eligible for at the pre-

[12] Since we are interested in employment, we exclude expenditures on benefits or schemes, which have no direct employment effects.

Table 5.3: Employment Effects of Female Reservation in Water Scarce Villages

	Female		Male	
	Non-NREGS	NREGS	Non-NREGS	NREGS
	(1)	(2)	(3)	(4)
GW > 8m	1.590	-3.691*	-25.318***	-3.566
	(3.760)	(1.902)	(7.215)	(2.755)
Reserved	1.960	0.405	-8.016*	1.170
	(3.575)	(0.804)	(4.268)	(1.039)
GW > 8m x Reserved	-3.620	5.778***	16.803***	4.827
	(5.931)	(1.438)	(6.088)	(3.351)
R^2	0.100	0.359	0.252	0.129
Dependent Variable Mean	37.988	9.157	172.976	6.246
Observations	107368	26908	113840	28311

Notes: Data from SEPRI 2015-16 and CGWB database. Outcome variables are individual days worked for individuals between 15 and 65 years. OLS regression is used for estimation. "Non-NREGS" refers to the numbmer of days worked in either self-employed or casual agricultural labor, self-employed business or non-agricultural casual labor (excluding NREGS) or as a salaried employee. "NREGS" is the number of days worked on NREGS conditional on having a NREGS job card. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. "Female" is an indicator variable equal to on if the individual is a woman. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

vailing wage rate if they do not receive the employment promised under NREGS within 15 days of application. This is likely because women are significantly more likely to report receiving enough work from the program (see column (3)). Previous research (see, for example, Dutta et al. (2014) and Liu et al. (2020)) has shown that despite being legally guaranteed, NREGS employment opportunities are often demand-constrained, that is, households frequently want more work than they are offered, and this unmet demand, due to reasons ranging from administrative delays to local capture, translates into job-rationing. Our finding suggests that female leaders are better than their male counterparts in water-stressed villages at relaxing these demand constraints on NREGS employment, particularly for female workers. These patterns also hold for male workers, albeit with somewhat smaller and statistically insignificant effects.

Taken together, the overall employment results in Tables 5.1 through 5.4 indicate that female-led governance is not only more effective at NREGS program implementation, particularly for expanding access for female workers, but also better at reallocating available resources towards more labor-intensive activities such as construction and manufacturing, where male workers can be employed both by private

Table 5.4: Effects of Female Reservations on NREGS Employment in Water Scarce Villages

	Registered job card (1)	Received unemp. allowance (2)	Received enough work (3)	Average wage rate (4)
	Panel A: Female			
GW > 8m	-0.023	0.020***	0.049	-0.061**
	(0.031)	(0.007)	(0.147)	(0.025)
Reserved	-0.036***	-0.013**	-0.005	-0.049
	(0.012)	(0.005)	(0.066)	(0.052)
GW > 8m x Reserved	0.059***	0.012	0.198**	0.054
	(0.022)	(0.007)	(0.086)	(0.053)
Observations	97051	54672	12038	6099
R^2	0.290	0.040	0.279	0.453
Dep. Mean	0.145	0.014	0.257	4.792
	Panel B: Male			
GW > 8m	-0.010	0.020***	0.036	-0.035
	(0.039)	(0.006)	(0.128)	(0.031)
Reserved	-0.032**	-0.010*	0.058	-0.068
	(0.013)	(0.005)	(0.064)	(0.063)
GW > 8m x Reserved	0.013	0.008	0.103	0.067
	(0.025)	(0.010)	(0.116)	(0.064)
Observations	101368	57958	12397	5682
R^2	0.282	0.041	0.205	0.506
Dep. Mean	0.159	0.013	0.230	4.941

Notes: Data from SEPRI 2015-16 and GW database. Adults 15 to 65 years included. With the exception of Column (4), all variables are binary, equal to one if yes. Column (1) is equal to one if the respondent has a NREGS job card or name registered on another job card. Column (2) is equal to one if the respondent reports receiving any unemployment allowance under NREGS. Column (3) is conditional on working on NREGS and is equal to one if the respondent reports receiving as much work as he/she wanted. Column (4) is log total daily average wage over the past 12 months for those who worked on NREGS. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. OLS estimation used. Standard errors are clustered at the village level. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

firms as well as by the local Panchayat.

Table 5.5: Effects of Female Reservations on Income and Consumption in Water Scarce Villages (OLS)

	Total Wage Income		**Consumption**	
	Total	Per-capita	Total	Per-capita
	(1)	(2)	(3)	(4)
GW > 8m	-0.312**	-0.305**	-0.018	-0.018
	(0.148)	(0.141)	(0.037)	(0.037)
Reserved	-0.091	-0.097	0.013	0.013
	(0.091)	(0.086)	(0.025)	(0.025)
GW > 8m x Reserved	0.269**	0.279**	0.092**	0.092**
	(0.124)	(0.119)	(0.040)	(0.040)
Observations	71569	71569	71553	71553
R^2	0.229	0.113	0.523	0.480
Dep. Mean	10.659	9.307	11.092	9.707

Notes: Data from SEPRI 2015-16 and the CGWB database. Outcome variables are at the household level. Income variables are log(x+1), consumption variables are log(x). Total wage income is the sum of all individual wage income components. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include caste group, religion, and district fixed effects. OLS estimation used. Standard errors are clustered at the village level. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.3 Income and Consumption Effects

The better employment prospects in female-led water-stressed villages translate to higher household earnings and spending in those regions. Using matched SEPRI and CGWB data, Table 5.5 shows the effect of female reservation at the local Panchayat leadership level on household income and spending in water-scarce villages. The first row confirms the results in Section 4, which used CPHS data to show that depleting groundwater has a negative impact on household income and consumption. Nevertheless, the statistically significant and positive coefficients of the interaction term between poor groundwater availability and female reservation in the third row show that a female leader counteracts the negative impact of groundwater scarcity.[13]

Appendix Tables C.8 and C.9 study the impact of female reservation on individual income components, separated by gender, using alternative empirical specifications to deal with the large number of zeros in the dependent variable of each income component. While Table C.8 uses the $\ln(1 + x)$ transfor-

[13]While Table 5.5 uses the 8-meter depth cutoff to define poor groundwater availability, Appendix Table C.7 provides analogous results using average groundwater depth. Both income and consumption coefficients are smaller in magnitude, and only the consumption coefficients remain significant at the 10% level.

mation of the income components, Table C.9 uses a Tobit specification with the nominal rupee values of the income components. Aligned with our results on employment in Table 5.3, both specifications show that women in female-reserved villages have significantly higher income from NREGS work, while men have significantly higher income earned outside the agricultural sector, compared to male-led villages with groundwater scarcity. Both Tables C.8 and C.9 use the 8-meter depth cutoff to define groundwater scarcity, but an alternative continuous measure of groundwater depth in Appendix Table C.10 also corroborate the findings.

Turning to the components of expenditure, we find interesting effects of female reservation on spending allocations (see Table 5.6). The effect of reservation on total food spending is muted (column (1)). The fact that spending on food items like cereals, pulses, dairy products, vegetables, and fruits remains unchanged (see columns (2) through (4) of Table 5.6) is unsurprising, given the essential nature of these items.The fact that spending on food items like cereals, pulses, dairy products, vegetables, and fruits remains unchanged (see columns (2) through (4) of Table 5.6) is unsurprising, given the essential nature of these items. However, we do find a weakly significant increase in spending on intoxicants like alcohol and tobacco (column (5)). Since these intoxicants are more likely to be consumed by male members of the household (see Subramanian and Deaton (1991)), the increased spending on such items may reflect the improved bargaining power of men because of the relative increase in male income compared to female income (see Appendix Tables C.8 through C.10). Nevertheless, the evidence for this changing intra-household bargaining power is mixed. First, in Appendix Table C.11, where we use a continuous measure of groundwater depth instead of the 8-meter cutoff as in Table 5.6, we do not find a statistically significant increase in alcohol and tobacco expenses. Second, we find that the overall increase in household expenditure found in Table 5.5 is predominantly driven by spending on non-food items, and in particular, on clothing and education of children (see columns (6) through (10) of Table 5.6 - both of which are arguably correlated with a higher bargaining power of women in the household. Therefore, the overall evidence on the effect of female reservation in water-scarce villages on intra-household bargaining is inconclusive.

Among the non-food items, the increased spending on education is particularly noteworthy because of its long-term implications for the human capital formation of children in water-scarce villages. We utilise information on child education outcomes from the SEPRI dataset to examine the implications of higher education spending more closely. Specifically, we regress child-level school expenditures and measures of enrollment, attendance, and school choice for children aged between 5 and 16 years on the interaction between poor groundwater availability and local female reservation, along with other controls. Table 5.7 presents these results on the effect of female reservation in water-scarce villages on human capital formation. We find significant effects of higher enrollment and attendance rates, as well as evidence of households substituting away from government schools and toward the relatively higher-quality private schools. This spending on education benefits both younger and older children, with some suggestive evidence that parents are making larger investments earlier on in the educational

Table 5.6: Effects of Female Reservations on Consumption Components in Water Scarce Villages

	Total food expenditure (1)	Cereals & pulses (2)	Milk, meat & eggs (3)	Vegetables & fruits (4)	Alcohol & tobacco (5)
GW > 8m	-0.005	0.019	0.023	-0.028	-0.148**
	(0.032)	(0.046)	(0.062)	(0.050)	(0.073)
Reserved	-0.011	0.035	-0.015	-0.036	-0.177
	(0.027)	(0.032)	(0.039)	(0.049)	(0.118)
GW > 8m x Reserved	0.052	0.063	0.009	0.061	0.243*
	(0.048)	(0.045)	(0.094)	(0.100)	(0.146)
R^2	0.458	0.534	0.498	0.510	0.291
Dep. Mean	10.478	9.310	9.184	8.765	7.086
Observations	71550	71519	68289	71421	36271
	Total non-food expenditure (6)	Jewelry & ornaments (7)	Clothing & footwear (8)	Education expenditure (9)	Medical expenditure (10)
GW > 8m	-0.039	0.062	-0.226***	-0.350***	-0.034
	(0.066)	(0.128)	(0.075)	(0.119)	(0.076)
Reserved	0.038	-0.066	-0.000	-0.121**	0.074
	(0.040)	(0.125)	(0.048)	(0.058)	(0.060)
GW > 8m x Reserved	0.161**	0.051	0.345***	0.376***	0.129
	(0.077)	(0.155)	(0.111)	(0.105)	(0.095)
R^2	0.412	0.171	0.412	0.140	0.249
Dep. Mean	10.201	7.748	8.219	7.797	7.792
Observations	71542	36343	70652	36453	62363

Notes: Data from SEPRI 2015-16 and GW database. Outcomes are measured at the household level and are in the form log(x+1). OLS regression used. Columns (2)-(5) are components of "Total food" expenditure. Columns (7)-(10) are components of "Total non-food" expenditure. All food expenditure includes both purchased and home-produced items. Expenditure is for the past 365 days. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

process. In Appendix Table C.12, where we use a continuous groundwater depth measure instead of the 8-meter cutoff as in Table 5.7, we do not find statistically significant increases in enrollment and attendance rates but the statistical significance of the other effects, namely, switching away from gov-

Table 5.7: Effects of Female Reservations on Child Education in Water Scarce Villages

			School		Education Expenditure		
	Enrolled	Attendance	Govt.	Private	All children	Age 5–10	Age 11–16
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GW > 8m	-0.011	-0.689***	0.133***	-0.123***	-0.249*	-0.397**	-0.143
	(0.025)	(0.155)	(0.043)	(0.042)	(0.129)	(0.167)	(0.106)
Reserved	-0.006	-0.286	0.097*	-0.093*	-0.174***	-0.236***	-0.142**
	(0.015)	(0.303)	(0.050)	(0.049)	(0.057)	(0.064)	(0.062)
GW > 8m x Reserved	0.044**	0.607*	-0.180**	0.164**	0.421***	0.544***	0.351***
	(0.020)	(0.361)	(0.072)	(0.071)	(0.129)	(0.149)	(0.128)
R^2	0.172	0.128	0.172	0.189	0.315	0.238	0.246
Dependent Variable Mean	0.802	20.962	0.765	0.217	6.793	2080.793	3523.632
Observations	76074	44658	44664	44664	55663	23796	31867

Notes: Data from SEPRI 2015-16 and GW database. Children ages 5 to 16 (inclusive) included. OLS estimation used. Column (1) is equal to one if a child is reported as being currently enrolled. Column (2) is the number of days in the past month the child attended school. "Government school" is equal to one if a child is currently enrolled in a government school. "Private school" is equal to one if a child is currently enrolled in a private, government aided, or convent school. School expenditures refers to the total amount spent on schooling expenditures for the child and are in log(x) form. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include age, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

ernment and toward private schools, and education expenditure increasing for both younger and older children, continue to hold.

Our results on the effects of local female leadership are consistent with earlier findings that female politicians are more likely to focus on issues directly affecting women and girls, including health, education, and access to infrastructure (Chattopadhyay and Duflo, 2004; Beaman et al., 2012). While existing research has shown that female leaders invest more in public goods and are responsive to women's preferences, our findings suggest that female leadership can be especially effective in managing risk from water distress, as well as in managing the environment itself.

6 Conclusion

This research has provided evidence that female political leadership plays an effective role in mitigating the adverse economic consequences of environmental crises. Focusing on the context of severe groundwater depletion in India, our findings demonstrate that local female leaders are uniquely positioned to protect their communities from resource scarcity. While poor groundwater availability is associated with significant reductions in household income and consumption, female leaders can counteract these negative effects. Our results suggest that the mitigation strategies used by female leaders include expanding access to the NREGS, particularly for female workers, and resource reallocation towards more labor-intensive activities like local infrastructure development through construction and manufacturing, where more male workers can find employment. This strategic resource reallocation facilitates a structural transformation in the water-stressed rural economy, shifting its dependence away from agriculture.

The improvements in employment opportunities translate directly into tangible welfare gains for households. In water-scarce villages with female leadership, we found a statistically significant increase in total household income and consumption. A deeper dive into the composition of household spending revealed that this rise in expenditure is primarily driven by non-food items, with a particularly notable increase in spending on children's education. This observation is further supported by our findings of higher school enrollment and attendance rates, as well as a significant shift from government to private schools. This suggests that female leaders not only help households cope with immediate shocks but also foster long-term human capital formation, which is essential for future resilience and prosperity.

Our paper contributes to a growing body of literature highlighting the substantive and positive impact of female political representation, particularly in challenging environments. The findings from this study underscore the critical importance of policies like the 73^{rd} Constitutional Amendment, which, beyond simply providing a voice for women in local governance, allows female leaders to bring a distinct and effective approach to crisis management, prioritizing social protection and long-term investment in human capital. Further research could explore the specific mechanisms through which local female leaders achieve these outcomes, for example, by examining differences in community engagement or negotiation with higher-level government bodies. Future work might also investigate whether these leadership effects persist over time and whether they extend to other types of environmental and economic shocks.

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Appendix

There are three appendices, A through C corresponding to Sections 3 through 5, respectively in the main paper.

A Appendix to Section 3

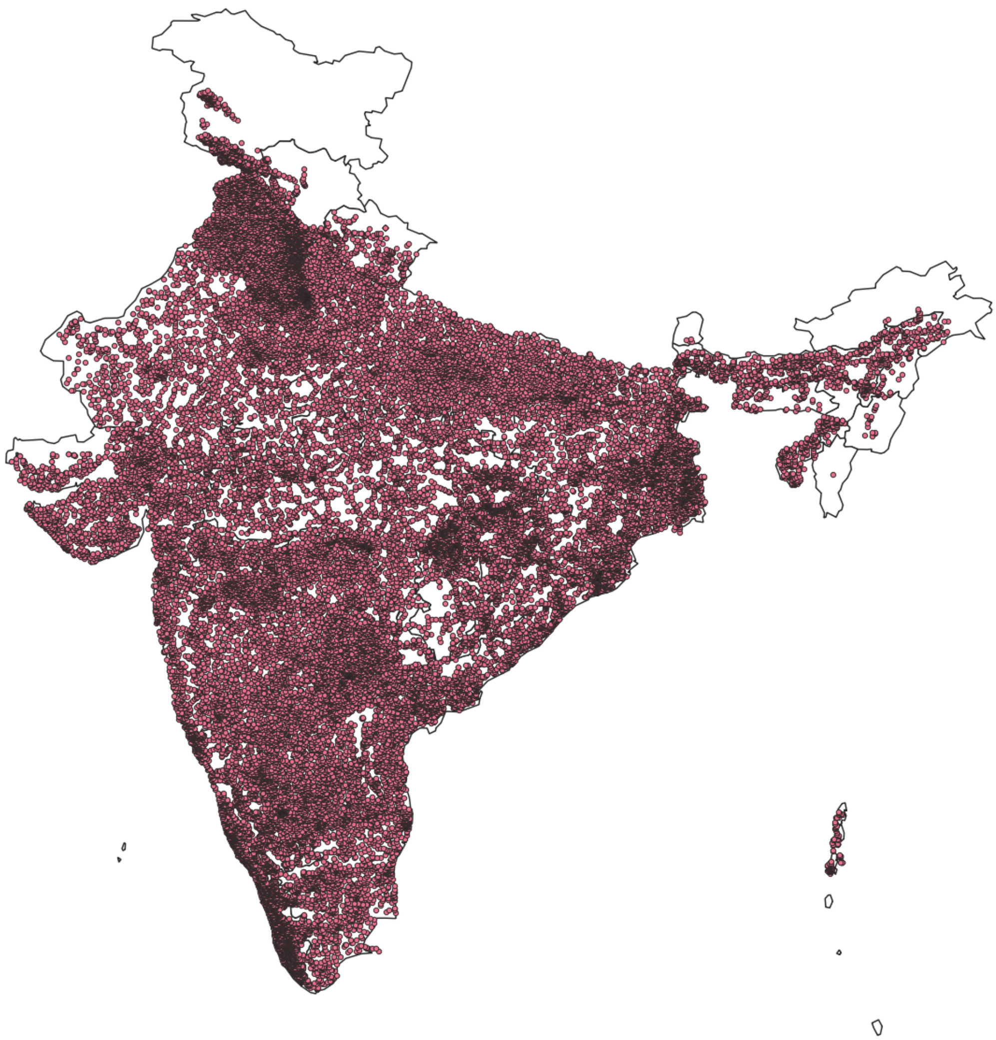

Figure A.1: Monitored Wells Across India

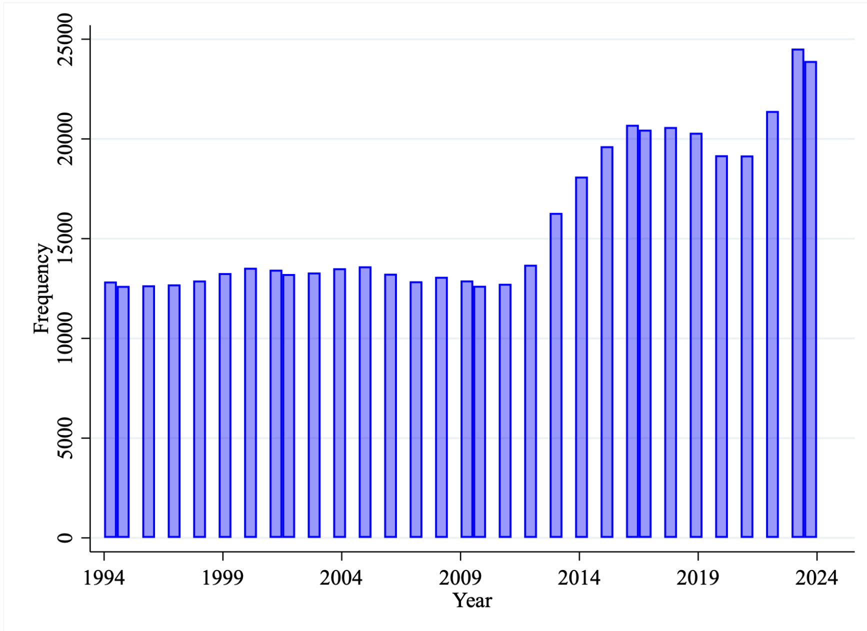

Figure A.2: Number of Depth Observations By Year

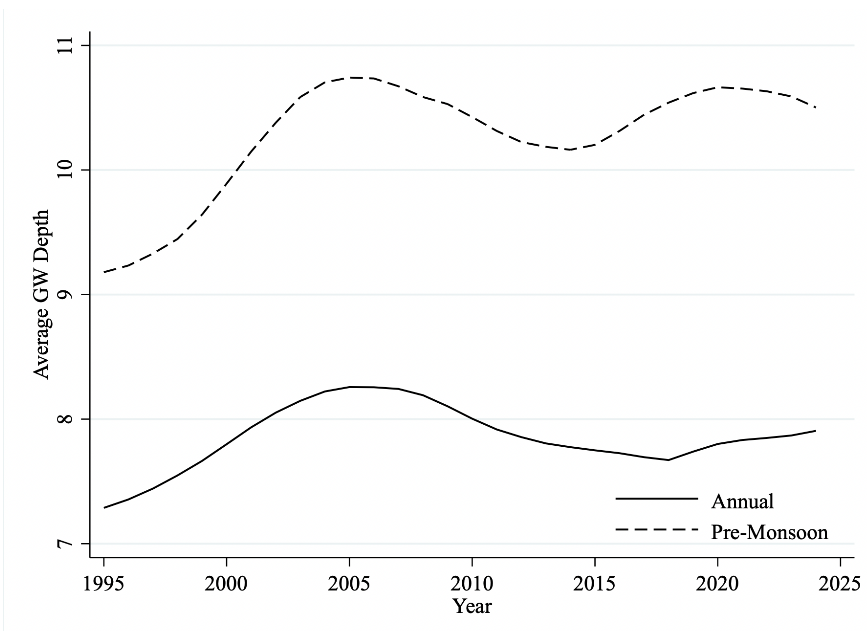

Figure A.3: Average Groundwater Levels Over Time

Table A.1: Descriptive Statistics for Annual and Pre-Monsoon Groundwater Depth by State

	Annual			**Pre-Monsoon**		
	Obs.	Mean	S.D.	Obs.	Mean	S.D.
Andhra Pradesh	25239	6.71	7.69	21270	8.11	8.19
Assam	9869	3.13	2.52	7058	3.81	2.58
Bihar	15398	4.13	2.16	11874	5.49	2.46
Chandigarh	331	17.93	16.87	312	20.39	16.94
Chhattisgarh	23351	5.33	3.73	17714	7.65	4.47
Delhi	3714	13.47	13.60	3354	14.18	14.01
Goa	2326	5.89	4.32	2053	6.72	4.52
Gujarat	29892	12.01	15.96	25727	14.58	17.15
Haryana	18724	14.68	13.87	16710	15.03	13.76
Himachal Pradesh	2793	7.53	8.16	2410	8.58	8.49
Jammu & Kashmir	5943	5.31	6.74	5280	6.25	6.94
Jharkhand	8083	5.26	2.54	5936	7.49	2.98
Karnataka	40265	8.06	8.05	33225	9.48	8.55
Kerala	30367	6.13	4.62	25859	7.13	4.94
Madhya Pradesh	38506	8.26	7.09	34944	10.84	7.47
Maharashtra	48290	6.46	5.44	39951	8.70	6.03
Meghalaya	1335	3.36	4.63	1034	4.16	5.17
Odisha	36522	3.75	2.19	32701	5.41	2.71
Puducherry	204	7.02	7.10	182	7.84	7.53
Punjab	15639	14.13	10.36	13492	14.30	10.10
Rajasthan	33347	21.45	20.48	28744	22.49	19.86
Tamil Nadu	16018	7.94	8.53	13217	8.86	9.30
Telangana	18349	9.68	8.26	16581	11.01	8.58
Tripura	1730	4.06	3.86	1332	4.95	4.25
Uttar Pradesh	34657	6.44	5.22	28851	7.46	5.03
Uttarakhand	2867	13.29	15.56	2688	14.92	16.30
West Bengal	29370	6.13	5.10	23154	7.66	5.26
Total	493129	8.44	10.26	415653	10.05	10.51

Notes: Data from CGWB. Obs. is the number of wells observed at any time between 1994 and 2024. Annual groundwater is the average of the four measured groundwater depths (winter, pre-monsoon, monsoon, post-monsoon). Pre-monsoon groundwater is measured between April and June. Groundwater depths are in meters.

Table A.2: Descriptive Statistics for CPHS Data

	Obs.	Mean	S.D.	Min	Max
Panel A: Household					
Urban	1555168	0.65	0.48	0.00	1.00
Hindu	1555168	0.87	0.33	0.00	1.00
Muslim	1555168	0.21	0.41	0.00	1.00
Female head	1555168	0.20	0.40	0.00	1.00
Age of head	1430491	50.75	11.36	0.00	100.00
Household size	1450678	3.89	1.53	1.00	16.00
Total income	1450678	21289.45	16908.44	0.00	1140000.00
Wage income	1450678	14917.42	14312.08	0.00	1103333.33
Total expenditure	1288527	11781.24	9281.98	237.50	6519251.00
Panel B: District					
Average total income	4290	19891.57	9364.87	4886.18	100475.41
SD total income	4289	11185.92	7118.11	960.49	69237.43
Average wage income	4290	13376.07	5862.91	0.00	58048.39
SD wage income	4289	10414.95	5550.63	0.00	56303.40
Average total expenditure	3795	11271.69	3927.58	3440.86	32580.57
SD total expenditure	3794	3740.42	5197.82	294.72	220737.22
Panel C: District Groundwater					
Annual GW depth	4332	8.36	8.08	0.65	76.34
Pre-monsoon GW depth	4035	10.54	8.86	0.73	99.19
2-year annual GW depth	4329	8.30	7.81	0.75	67.74
2-year pre-monsoon GW depth	4251	10.36	8.44	0.85	80.73

Notes: Data from CPHS 2015-2023. Household weights applied in Panel A. Income and expenditure variables are annual and in rupees. “2-year” refers to the average groundwater depth for the previous two years, not including the current year. Annual groundwater is the average of all measurements available for the calendar year.

Table A.3: Descriptive Statistics for Individuals and Households from REDS/SEPRI Data

	Obs.	Mean	S.D.	Min	Max
Household:					
Hindu	92322	0.87	0.33	0	1
Muslim	92322	0.10	0.30	0	1
Caste SC/ST	92321	0.28	0.45	0	1
Caste OBC	92321	0.50	0.50	0	1
Household size	92330	4.61	2.44	1	26
Number of working age males	92330	1.61	1.08	0	13
Number of working age females	92330	1.53	0.92	0	10
Household owns any land	86326	0.53	0.50	0	1
Individual:					
Age	284915	35.29	14.50	15	65
Female	284915	0.50	0.50	0	1
Married	283907	0.69	0.46	0	1
At least primary education	283561	0.64	0.48	0	1
Any days worked:					
Any days of work	284915	0.62	0.49	0	1
Agriculture	284915	0.41	0.49	0	1
Non-agriculture	284915	0.28	0.45	0	1
Salary/regular work	284915	0.06	0.24	0	1
NREGS	284915	0.06	0.23	0	1
Number of days worked:					
Total days	284915	103.77	120.13	0	372
Agriculture	284915	26.36	45.90	0	372
Non-agriculture	284915	57.37	100.87	0	370
Salary/regular work	284856	17.96	71.69	0	370
NREGS	284743	2.09	12.13	0	365
Village groundwater:					
Average distance to wells	191	6.50	3.16	0	20
2-year average GW depth	160	7.82	8.01	1	52
5-year average GW depth	170	8.33	8.07	1	48
2-year average GW > 8m	160	0.29	0.45	0	1
5-year average GW > 8m	170	0.31	0.46	0	1

Notes: Data from SEPRI 2015-16. The top 1% of observations in terms of "All employment" have been dropped due to outliers but results are robust to their inclusion. "Working age" refers to individuals between 15 and 65 years of age. Employment days are for the past 12 months. "Any days of work" is equal to 1 if an individual reported working in either agriculture, non-agriculture, salary or NREGS. "Agriculture" refers to total days in agriculture as self-employed or wage labor. "Non-agriculture" refers to total days in non-agriculture as self-employed business or wage labor. An employment day is counted as equal to 1 if any work in that sector was undertaken, and an individual can therefore report multiple employment days if more than one job was undertaken on the same day. All groundwater variables are the average outcomes of the three nearest wells within a 20km radius of the center of the village. "Distance" is in kilometers. "2-year average" is the average groundwater measured in 2013-2014. "5-year average" is the average groundwater measured in 2010-2014.

B Appendix to Section 4

Table B.1: Income and Consumption Effects of Depleting Groundwater Levels Including Top 1% of Households

	Total Income		Wage Income		Consumption	
	Total	Per-capita	Total	Per-capita	Total	Per-capita
All states						
Average groundwater depth	-0.066**	-0.068**	-0.789***	-0.711***	-0.057*	-0.056*
	(0.032)	(0.031)	(0.195)	(0.171)	(0.032)	(0.032)
R^2	0.708	0.750	0.543	0.531	0.739	0.803
Dep. Mean	9.749	8.475	8.167	7.035	9.273	7.991
Observations	1405859	1405859	1405859	1405859	1248487	1248487
Excluding NE states and UT						
Average groundwater depth	-0.071**	-0.073**	-0.833***	-0.750***	-0.076**	-0.074**
	(0.033)	(0.033)	(0.208)	(0.182)	(0.033)	(0.033)
R^2	0.703	0.748	0.543	0.531	0.736	0.804
Dep. Mean	9.736	8.464	8.159	7.028	9.261	7.981
Observations	1344317	1344317	1344317	1344317	1193733	1193733

Notes: Data from CMIE and CGWB. All outcome variables y are transformed to $ln(1+y)$. "Total Income" includes wages, transfers, business profits, and other sources. "Wage income" is total household income earned from wages. "Consumption" includes food and non-food spending. "Average groundwater depth" is equal to the average annual groundwater depth for the previous two years, aggregated at the district level. Controls include household fixed effects, year fixed effects, religion, gender and age of household head, and household size. Standard errors clustered at district level are reported in parentheses. The top panel uses data for all states, while the bottom panel excludes the northeastern states and union territories. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table B.2: Income and Consumption Effects of Depleting Groundwater Levels Using Pre-Monsoon Average Depths

	Total Income		**Wage Income**		**Consumption**	
	Total	Per-capita	Total	Per-capita	Total	Per-capita
All states						
Pre-monsoon groundwater depth	-0.049**	-0.045**	-0.480***	-0.437***	-0.050*	-0.042
	(0.019)	(0.019)	(0.146)	(0.128)	(0.027)	(0.027)
R^2	0.690	0.744	0.543	0.531	0.729	0.802
Dep. Mean	9.714	8.440	8.156	7.022	9.253	7.971
Observations	1350078	1350078	1350078	1350078	1196485	1196485
Excluding NE states and UT						
Pre-monsoon groundwater depth	-0.052**	-0.049**	-0.517***	-0.470***	-0.070**	-0.061**
	(0.020)	(0.020)	(0.158)	(0.139)	(0.027)	(0.027)
R^2	0.688	0.744	0.543	0.531	0.729	0.804
Dep. Mean	9.704	8.431	8.153	7.019	9.243	7.962
Observations	1293004	1293004	1293004	1293004	1145768	1145768

Notes: Data from CMIE and CGWB. All outcome variables y are transformed to $ln(1+y)$. "Total Income" includes wages, transfers, business profits, and other sources. "Wage income" is total household income earned from wages. "Consumption" includes food and non-food spending. We exclude the top 1% of households by total income in each year. "Pre-monsoon groundwater depth" is equal to the average pre-monsoon groundwater depth for the previous two years, aggregated at the district level. Controls include household fixed effects, year fixed effects, religion, gender and age of household head, and household size. Standard errors clustered at district level are reported in parentheses. The top panel uses data for all states, while the bottom panel excludes the northeastern states and union territories. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.3: Income and Consumption Effects of Depleting Groundwater Levels Using Yearly Groundwater Depth

	Total Income		**Wage Income**		**Consumption**	
	Total	Per-capita	Total	Per-capita	Total	Per-capita
All states						
Annual groundwater depth	-0.049**	-0.045**	-0.480***	-0.437***	-0.050*	-0.042
	(0.019)	(0.019)	(0.146)	(0.128)	(0.027)	(0.027)
R^2	0.690	0.744	0.543	0.531	0.729	0.802
Dep. Mean	9.714	8.440	8.156	7.022	9.253	7.971
Observations	1350078	1350078	1350078	1350078	1196485	1196485
Excluding NE states and UT						
Annual groundwater depth	-0.052**	-0.049**	-0.517***	-0.470***	-0.070**	-0.061**
	(0.020)	(0.020)	(0.158)	(0.139)	(0.027)	(0.027)
R^2	0.688	0.744	0.543	0.531	0.729	0.804
Dep. Mean	9.704	8.431	8.153	7.019	9.243	7.962
Observations	1293004	1293004	1293004	1293004	1145768	1145768

Notes: Data from CMIE and CGWB. All outcome variables y are transformed to $ln(1+y)$. "Total Income" includes wages, transfers, business profits, and other sources. "Wage income" is total household income earned from wages. "Consumption" includes food and non-food spending. We exclude the top 1% of households by total income in each year. "Annual groundwater depth" is equal to the yearly average groundwater depth for the survey year, aggregated at the district level. Controls include household fixed effects, year fixed effects, religion, gender and age of household head, and household size. Standard errors clustered at district level are reported in parentheses. The top panel uses data for all states, while the bottom panel excludes the northeastern states and union territories. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.4: Impact of Level and Dispersion of Pre-monsoon Groundwater Availability on Economic Inequality

	Std. Dev. of Total Income		**Std. Dev. of Consumption**	
	Total	Per-capita	Total	Per-capita
Panel A: Impact of Depleting Groundwater Level				
Pre-monsoon groundwater depth	0.073*	0.060	0.075*	0.076**
	(0.041)	(0.044)	(0.039)	(0.035)
R^2	0.400	0.350	0.396	0.353
Dep. Mean	9.154	7.935	8.019	6.985
Observations	4185	4185	3697	3697
Panel B: Impact of Dispersion in Groundwater Level				
Std. Dev. pre-monsoon groundwater depth	0.087***	0.087***	0.093***	0.089***
	(0.029)	(0.031)	(0.028)	(0.024)
R^2	0.401	0.354	0.398	0.358
Dep. Mean	9.152	7.933	8.014	6.981
Observations	4134	4134	3648	3648

Notes: Data from CMIE and CGWB database. Outcome variables are district-level standard deviations of total household income and expenditure in log form. "Total Income" includes wages, transfers, business profits, and other sources. and transfers, and other other components. "Consumption" includes food and non-food spending. "Pre-monsoon groundwater depth" in Panel A is the average district pre-monsoon groundwater depth for the survey year. "Std. dev. pre-monsoon groundwater depth" in Panel B is the average district standard deviation in pre-monsoon groundwater depth for the survey year. Groundwater variables are logged. State, year and state by year fixed effects are included. Standard errors clustered at the district level are reported in parentheses. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table B.5: Impact of Level and Dispersion of Yearly Groundwater Availability on Economic Inequality

	Std. Dev. of Total Income		**Std. Dev. of Consumption**	
	Total	Per-capita	Total	Per-capita
Panel A: Impact of Depleting Groundwater Level				
Annual groundwater depth	0.070*	0.064	0.067*	0.073**
	(0.039)	(0.042)	(0.036)	(0.032)
R^2	0.408	0.355	0.394	0.354
Dep. Mean	9.157	7.937	8.027	6.991
Observations	3970	3970	3482	3482
Panel B: Impact of Dispersion in Groundwater Level				
Std. dev. annual groundwater depth	0.083***	0.088***	0.101***	0.098***
	(0.027)	(0.030)	(0.026)	(0.023)
R^2	0.409	0.360	0.399	0.363
Dep. Mean	9.156	7.935	8.025	6.989
Observations	3921	3921	3437	3437

Notes: Data from CMIE and CGWB database. Outcome variables are district-level standard deviations of total household income and expenditure in log form. "Total Income" includes wages, transfers, business profits, and other sources. and transfers, and other other components. "Consumption" includes food and non-food spending. "Annual groundwater depth" in Panel A is the average district groundwater depth for the survey year. "Std. dev. annual groundwater depth" in Panel B is the average district standard deviation in groundwater depth for the survey year. Groundwater variables are logged. State, year and state by year fixed effects are included. Standard errors clustered at the district level are reported in parentheses. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

C Appendix to Section 5

Table C.1: Female Reservations and Village Characteristics

	(1)	(2)	(3)
Population	0.059	0.026	-0.030
	(0.058)	(0.070)	(0.135)
Distance to district HQ	-0.000	-0.000	0.003
	(0.001)	(0.001)	(0.003)
Distance to tehsil HQ	0.004	0.005	0.002
	(0.005)	(0.005)	(0.010)
Distance to block HQ	0.004	0.009	-0.003
	(0.006)	(0.006)	(0.010)
Distance to nearest town	0.000	-0.003	0.005
	(0.004)	(0.004)	(0.008)
Distance to nearest secondary school	0.040***	0.026**	0.024
	(0.009)	(0.013)	(0.024)
Distance to nearest hospital	-0.006	-0.008*	-0.009
	(0.004)	(0.005)	(0.007)
Total land cultivated	-0.030	-0.039	0.027
	(0.040)	(0.047)	(0.081)
Share Hindu	-0.438*	-0.365	0.302
	(0.246)	(0.280)	(0.924)
Share Muslim	-0.704**	-0.751**	0.212
	(0.322)	(0.379)	(1.114)
Share SC/ST	0.007	-0.087	0.290
	(0.228)	(0.246)	(0.569)
Share OBC	0.039	0.053	-0.027
	(0.192)	(0.212)	(0.450)
Constant	0.374	0.642	-0.165
	(0.501)	(0.578)	(1.818)
Observations	161	150	111
R^2	0.127	0.217	0.506
State FE	No	Yes	No
District FE	No	No	Yes

Notes: Data from SEPRI 2015-16. All columns present results for those villages which have their Panchayat president post reserved for female candidates in the current period. Population and total land cultivated are logged. Shares are calculated as the proportion of households identifying as belonging to that group in the village. Distance is in kms. Standard errors are clustered at the village level. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.2: Employment Effects of Female Reservation in Water Scarce Villages Among Those Working

	All	**Female**		**Male**	
		Non-NREGS	NREGS	Non-NREGS	NREGS
	(1)	(2)	(3)	(4)	(5)
GW > 8m	-26.604***	-6.035	-6.928	-28.828***	-9.799
	(8.957)	(5.580)	(5.850)	(8.425)	(9.886)
Reserved	-9.857*	3.231	2.697	-13.385***	4.354**
	(5.898)	(4.540)	(2.284)	(4.858)	(1.872)
GW > 8m x Reserved	19.231	-3.902	12.183***	25.036***	0.517
	(12.515)	(9.172)	(3.799)	(8.515)	(2.481)
R^2	0.115	0.176	0.342	0.165	0.122
Dep. Mean	175.804	88.501	38.986	220.802	29.257
Observations	137874	46086	6320	89182	6044

Notes: Data from SEPRI 2015-16 and CGWB database. Outcome variables are individual days worked for individuals between 15 and 65 years. Only those that worked a positive number of days are included. OLS regression is used for estimation. "All" is the sum of columns (2)-(5). "Non-NREGS" refers to the numbmer of days worked in either self-employed or casual agricultural labor, self-employed business or non-agricultural casual labor (excluding NREGS) or as a salaried employee. "NREGS" is the number of days worked on NREGS conditional on having a NREGS job card. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. "Female" is an indicator variable equal to on if the individual is a woman. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.3: Employment Effects of Female Reservation in Water Scarce Villages with Log Days Worked

	All	**Female**		**Male**	
		Non-NREGS	NREGS	Non-NREGS	NREGS
	(1)	(2)	(3)	(4)	(5)
GW > 8m	-0.169***	-0.033	-0.339	-0.154***	-0.215
	(0.064)	(0.080)	(0.209)	(0.053)	(0.256)
Reserved	-0.068	0.011	0.053	-0.082**	0.144
	(0.054)	(0.055)	(0.077)	(0.034)	(0.100)
GW > 8m x Reserved	0.095	-0.097	0.362***	0.136**	0.072
	(0.097)	(0.090)	(0.087)	(0.058)	(0.160)
R^2	0.098	0.205	0.359	0.131	0.197
Dependent Variable Mean	4.797	4.038	3.377	5.194	3.096
Observations	137874	46086	6320	89182	6044

Notes: Data from SEPRI 2015-16 and CGWB database. Outcome variables are individual days worked for individuals between 15 and 65 years. Outcomes are logged. OLS regression is used for estimation. "All" is the sum of columns (2)-(5). "Non-NREGS" refers to the numbmer of days worked in either self-employed or casual agricultural labor, self-employed business or non-agricultural casual labor (excluding NREGS) or as a salaried employee. "NREGS" is the number of days worked on NREGS conditional on having a NREGS job card. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. "Female" is an indicator variable equal to on if the individual is a woman. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.4: Employment Effects of Female Reservation in Water Scarce Villages with Average Groundwater

	All	**Female**		**Male**	
		Non-NREGS	NREGS	Non-NREGS	NREGS
	(1)	(2)	(3)	(4)	(5)
Average GW	-0.589***	-0.416	-0.385***	-0.552*	-0.477**
	(0.117)	(0.301)	(0.103)	(0.291)	(0.224)
Reserved	-2.945	4.664	0.008	-10.102**	0.562
	(3.098)	(3.431)	(0.921)	(4.193)	(1.271)
Average GW x Reserved	0.145	-0.362**	0.280***	0.646***	0.270
	(0.098)	(0.170)	(0.067)	(0.185)	(0.165)
R^2	0.102	0.101	0.359	0.252	0.130
Dep. Mean	109.572	37.988	9.157	172.976	6.246
Observations	221213	107368	26908	113840	28311

Notes: Data from SEPRI 2015-16 and CGWB database. Outcome variables are individual days worked for individuals between 15 and 65 years. OLS regression is used for estimation. "All" is the sum of columns (2)-(5). "Non-NREGS" refers to the numbmer of days worked in either self-employed or casual agricultural labor, self-employed business or non-agricultural casual labor (excluding NREGS) or as a salaried employee. "NREGS" is the number of days worked on NREGS conditional on having a NREGS job card. "Average GW" is equal to log average groundwater depth in the local area over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. "Female" is an indicator variable equal to on if the individual is a woman. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table C.5: Panchayat and Private Employment Effects of Female Reservation in Water Scarce Villages Using Tobit and Poisson Regression (Tobit)

	Public Finance		**Panchayat Employment**		
	Revenue	Expenditure	Federal/State & Local Taxes	Local Infrastructure	Local Facilities Schemes
	(1)	(2)	(3)	(4)	(5)
Panel A					
GW > 8m	-24890.942	-21183.478	-0.362	-0.253*	-0.053
	(33300.222)	(21303.064)	(0.311)	(0.144)	(0.249)
Reserved	-24320.461	-2387.991	-0.276	-0.203***	-0.864***
	(14777.263)	(39330.422)	(0.215)	(0.060)	(0.249)
GW > 8m x Reserved	36194.541	6568.278	0.740**	0.548***	0.374
	(33527.111)	(40792.611)	(0.374)	(0.120)	(0.291)
Observations	1585	426	1122	304	139

	Local Firm Employment				
	Trading	Construction & Repair/Maintenance	Other Service	Food Production	Manufacturing
	(6)	(7)	(8)	(9)	(10)
Panel B					
GW > 8m	0.099	-1.013**	1.278***	-0.392	-0.536
	(0.357)	(0.426)	(0.490)	(0.245)	(0.482)
Reserved	0.092	-1.051**	1.634***	-0.017	-1.926**
	(0.129)	(0.502)	(0.426)	(0.169)	(0.945)
GW > 8m x Reserved	-0.184	1.653***	-2.009***	1.156***	2.167**
	(0.706)	(0.635)	(0.655)	(0.344)	(0.946)
Observations	175	352	485	228	81

Note: Data from SEPRI 2015-16 and CGWB database. Outcome variables in Panel A are total Panchayat revenues (column (1)), total Panchayat expenditures (column (2)), and number of workers employed from each category (columns (3)-(6)). The unit of observation is village-source, where we observe up to 50 sources of revenues or expenditures per village. We aggregate information on revenue, expenditure, and employment for the past two years. Outcome variables in Panel B are total workers employed for private firms falling within the main activity categories listed as column headers. The unit of observation here is village-firm type, where we observe up to 31 different firm types per village. Columns (1) and (2) use a Tobit specification; all remaining columns use a Poisson specification. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in the local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. District fixed effects included. Standard errors are clustered at the village level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table C.6: Panchayat and Private Employment Effects of Female Reservation in Water Scarce Villages Using Average GW

	Public Finance		Panchayat Employment		
	Revenue	Expenditure	Taxes & Fees	Local Infrastructure	Local Facilities Schemes
	(1)	(2)	(3)	(4)	(5)
Panel A					
Average	180.526	-2906.431*	-1.332	-0.209	3.213
	(1066.764)	(1551.040)	(0.914)	(0.292)	(4.220)
Reserved	-27364.195	-3378.530	-28.699	-10.259*	-83.067*
	(17387.630)	(44697.382)	(25.024)	(5.744)	(41.595)
Average GW x Reserved	1508.834	690.589	0.947	0.424*	0.592
	(1159.357)	(1749.508)	(0.807)	(0.245)	(1.437)
R^2	0.219	0.301	0.861	0.570	0.503
Observations	1584	419	1121	298	127

	Local Firm Employment				
	Trading	Construction & Maintenance	Other Service	Food Production	Manufacturing
	(6)	(7)	(8)	(9)	(10)
Panel B					
Average GW	1.581	-0.026	1.206***	0.074	0.291
	(0.963)	(0.271)	(0.442)	(0.214)	(3.854)
Reserved	2.490	-14.639	30.421	-3.947**	-49.364
	(6.407)	(11.502)	(20.541)	(1.501)	(42.380)
Average GW x Reserved	0.021	0.778	-0.480	1.054***	3.828***
	(0.776)	(0.538)	(0.487)	(0.148)	(0.950)
R^2	0.464	0.107	0.124	0.401	0.485
Observations	175	352	485	228	81

Note: Data from SEPRI 2015-16 and CGWB database. Outcome variables in Panel A are total Panchayat revenues (column (1)), total Panchayat expenditures (column (2)), and number of workers employed from each category (columns (3)-(5)). The unit of observation is village-source, where we observe up to 50 sources of revenues or expenditures per village. We aggregate information on revenue, expenditure, and employment for the past two years. Outcome variables in Panel B are total workers employed for private firms falling within the main activity categories listed as column headers. The unit of observation here is village-firm type, where we observe up to 31 different firm types per village. OLS regression used for estimation. "Average GW" is equal to log average groundwater depth in the local area over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. District fixed effects included. Standard errors are clustered at the village level. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table C.7: Effects of Female Reservations on Income and Consumption in Water Scarce Villages (Average GW)

	Total Wage Income		**Consumption**	
	Total	Per-capita	Total	Per-capita
	(1)	(2)	(3)	(4)
Average GW	-0.212***	-0.197***	0.034	0.034
	(0.078)	(0.074)	(0.024)	(0.024)
Reserved	-0.008	-0.033	-0.032	-0.032
	(0.170)	(0.162)	(0.046)	(0.046)
Average GW x Reserved	0.023	0.034	0.038*	0.038*
	(0.065)	(0.062)	(0.022)	(0.022)
Observations	71569	71569	71553	71553
R^2	0.229	0.113	0.523	0.480
Dep. Mean	10.659	9.307	11.092	9.707

Notes: Data from SEPRI 2015-16 and CGWB database. Outcome variables are at the household level. Income variables are log(x+1), consumption variables are log(x). Total wage income is the sum of all individual wage income components. "Average GW" is equal to log average groundwater depth in the local area over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include caste group, religion, and district fixed effects. OLS estimation used. Standard errors are clustered at the village level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table C.8: Effects of Female Reservations on Income Components in Water Scarce Villages

	Total Income (1)	Agriculture Income (2)	Non-Agriculture Income (3)	NREGS (Job Card) (4)
	Panel A: Female Income			
GW > 8m	0.509	0.575	0.197*	-0.736
	(0.390)	(0.386)	(0.114)	(0.529)
Reserved	0.182	0.188	0.118	0.112
	(0.230)	(0.264)	(0.116)	(0.233)
GW > 8m x Reserved	-0.342	-0.438	-0.266	0.904**
	(0.578)	(0.585)	(0.164)	(0.384)
R^2	0.214	0.246	0.043	0.349
Observations	107372	107339	108140	25951
	Panel B: Male Income			
GW > 8m	-0.350**	0.956**	-0.882***	-0.797
	(0.139)	(0.405)	(0.326)	(0.841)
Reserved	0.014	0.341	-0.266	0.164
	(0.082)	(0.330)	(0.213)	(0.279)
GW > 8m x Reserved	0.079	-1.026	0.685*	1.056
	(0.136)	(0.665)	(0.351)	(0.875)
R^2	0.329	0.236	0.198	0.268
Observations	113841	113796	114567	27282

Notes: Data from SEPRI 2015-16 and CGWB database. OLS regression used for estimation. Outcomes refer to individual income and are log(x+1). "Total Income" is the sum of columns (2)-(5). "Agriculture" refers to income received from wages in the agriculture sector. "Non-Agriculture" refers to wages received from non-agricultural casual labor (excluding NREGS) and income from work as a salaried employee. These variables do not include income from self-employed work. "NREGS" is income received from NREGS-based employment, conditional on having a job card. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table C.9: Effects of Female Reservations on Income Components in Water Scarce Villages Using Tobit Regression

	Total Income (1)	Agriculture Income (2)	Non-Agriculture Income (3)	NREGS (Job Card) (4)
	Panel A: Female Income			
GW > 8m	123.784	523.151	-275.529	-605.242*
	(944.558)	(497.867)	(751.211)	(321.783)
Reserved	184.294	-22.308	272.786	31.820
	(851.809)	(382.091)	(606.242)	(153.336)
GW > 8m x Reserved	-544.898	-135.804	-720.254	801.727***
	(1265.221)	(717.773)	(742.881)	(224.762)
Observations	107372	107339	107334	25951
	Panel B: Male Income			
GW > 8m	-13739.552***	1880.286**	-15467.155***	-713.742
	(4398.345)	(814.970)	(4803.121)	(556.784)
Reserved	-6732.278***	458.136	-7148.622***	67.785
	(1612.829)	(806.833)	(1927.420)	(134.097)
GW > 8m x Reserved	11318.009***	-2228.191	13178.821***	833.172
	(3383.852)	(1410.362)	(4070.141)	(591.923)
Observations	113841	113796	113747	27282

Notes: Data from SEPRI 2015-16 and CGWB database. Tobit regression used for estimation. Outcomes refer to individual income. "Total Income" is the sum of columns (2)-(5). "Agriculture" refers to income received from wages in the agriculture sector. "Non-Agriculture" refers to wages received from non-agricultural casual labor (excluding NREGS) and income from work as a salaried employee. These variables do not include income from self-employed work. "NREGS" is income received from NREGS-based employment, conditional on having a job card. "GW > 8m" is an indicator variable, which is equal to one if the average groundwater level in local area was 8 meters or more deep from the surface over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.10: Effects of Female Reservations on Income Components in Water Scarce Villages Using Average Groundwater Levels

	Total Income (1)	Agriculture Income (2)	Non-Agriculture Income (3)	NREGS (Job Card) (4)
		Panel A: Female Income		
Average GW	-0.040	-0.038	-0.007	-0.092***
	(0.037)	(0.037)	(0.008)	(0.029)
Reserved	0.492**	0.497*	0.116	0.033
	(0.248)	(0.279)	(0.119)	(0.261)
Average GW x Reserved	-0.037**	-0.040**	-0.009	0.047**
	(0.018)	(0.020)	(0.006)	(0.018)
R^2	0.217	0.248	0.043	0.349
Observations	107372	107339	107334	25951
		Panel B: Male Income		
Average GW	-0.021***	-0.044	-0.014	-0.113**
	(0.004)	(0.037)	(0.017)	(0.054)
Reserved	-0.007	0.514	-0.316	0.072
	(0.076)	(0.340)	(0.211)	(0.327)
Average GW x Reserved	0.002	-0.049**	0.024**	0.056
	(0.003)	(0.020)	(0.009)	(0.041)
R^2	0.329	0.239	0.197	0.270
Observations	113841	113796	113747	27282

Notes: Data from SEPRI 2015-16 and CGWB database. OLS regression used for estimation. Outcomes refer to individual income and are log(x+1). "Total Income" is the sum of columns (2)-(5). "Agriculture" refers to income received from wages in the agriculture sector. "Non-Agriculture" refers to wages received from non-agricultural casual labor (excluding NREGS) and income from work as a salaried employee. These variables do not include income from self-employed work. "NREGS" is income received from NREGS-based employment, conditional on having a job card. "Average GW" is equal to log average groundwater depth in the local area over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include age, marital status, education, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table C.11: Effects of Female Reservations on Consumption Components in Water Scarce Villages Using Average Groundwater

	Total food expenditure (1)	Cereals & pulses (2)	Milk, meat & eggs (3)	Vegetables & fruits (4)	Alcohol & tobacco (5)
Average GW	0.026	0.044*	0.042	0.023	0.008
	(0.019)	(0.023)	(0.033)	(0.036)	(0.049)
Reserved	-0.025	0.019	-0.033	-0.095	-0.303
	(0.054)	(0.068)	(0.076)	(0.082)	(0.249)
Average GW x Reserved	0.016	0.018	0.008	0.039	0.108
	(0.026)	(0.029)	(0.041)	(0.042)	(0.097)
R^2	0.458	0.534	0.499	0.510	0.290
Dep. Mean	10.478	9.310	9.184	8.765	7.086
Observations	71550	71519	68289	71421	36271
	Total non-food expenditure (6)	**Jewelry & ornaments (7)**	**Clothing & footwear (8)**	**Education expenditure (9)**	**Medical expenditure (10)**
Average GW	0.048	0.081	-0.012	-0.090	0.056
	(0.041)	(0.074)	(0.040)	(0.077)	(0.047)
Reserved	-0.045	-0.161	-0.157	-0.325***	0.014
	(0.078)	(0.255)	(0.112)	(0.123)	(0.110)
Average GW x Reserved	0.069*	0.051	0.143**	0.174***	0.052
	(0.040)	(0.093)	(0.063)	(0.065)	(0.050)
R^2	0.411	0.171	0.410	0.140	0.249
Dep. Mean	10.201	7.748	8.219	7.797	7.792
Observations	71542	36343	70652	36453	62363

Notes: Data from SEPRI 2015-16 and GW database. Outcomes are measured at the household level and are in the form log(x+1). OLS regression used. Columns (2)-(5) are components of "Total food" expenditure. Columns (7)-(10) are components of "Total non-food" expenditure. All food expenditure includes both purchased and home-produced items. Expenditure is for the past 365 days. "Average GW" is equal to log average groundwater depth in the local area over the previous two years (2013-2014)."Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table C.12: Effects of Female Reservations on Child Education in Water Scarce Villages Using Average Groundwater

			School		Education Expenditure		
	Enrolled	Attendance	Govt.	Private	All children	Age 5–10	Age 11–16
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average GW	-0.021	-0.216**	0.069**	-0.066**	-0.073	-0.154	-0.015
	(0.018)	(0.094)	(0.032)	(0.031)	(0.082)	(0.101)	(0.071)
Reserved	-0.015	-0.568	0.203*	-0.194*	-0.439***	-0.573***	-0.360**
	(0.025)	(0.574)	(0.107)	(0.107)	(0.151)	(0.184)	(0.146)
Average GW x Reserved	0.014	0.257	-0.089*	0.084*	0.211***	0.273***	0.172**
	(0.010)	(0.208)	(0.047)	(0.047)	(0.079)	(0.096)	(0.074)
Observations	76074	44658	44664	44664	55663	23796	31867
R^2	0.172	0.127	0.172	0.189	0.314	0.239	0.246
Dep. Mean	0.802	20.962	0.765	0.217	6.793	6.333	7.136

Notes: Data from SEPRI 2015-16 and GW database. Children ages 5 to 16 (inclusive) included. OLS used for estimation. Column (1) is equal to one if a child is reported as being currently enrolled. Column (2) is the number of days in the past month the child attended school. "Government school" is equal to one if a child is currently enrolled in a government school. "Private school" is equal to one if a child is currently enrolled in a private, government aided, or convent school. School expenditures refers to the total amount spent on schooling expenditures for the child. "Average GW" is equal to log average groundwater depth in the local area over the previous two years (2013-2014). "Reserved" is an indicator variable, which is equal to one if the village has a female reservation for village president in the current electoral period. Additional control variables include age, caste group, religion, household size and district fixed effects. Standard errors are clustered at the village level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.