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Relationship between Soil Texture, Demographic Deficit of Women and Women's Employment in Agriculture: A Further Research

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Abstract: ***This study aims to replicate the findings of Carranza (2014) and expand on them by examining how soil texture relates to female labor force participation and gender inequities in India's agriculture industry, while also considering regional variations. This study utilizes cross-sectional data from 577 districts to establish that soil endowments, namely loamy and clay soil fractions, have a substantial and favorable impact on the female-to-male ratio in the age bracket of 0 to 9, as well as on women's involvement in agricultural employment. Examination of regional subgroups demonstrates a notable impact of clay soil on the ratio of females to males in the North and Northeast regions, whereas no such influence is shown in the South region. The results of this study emphasize the importance of environmental resources in comprehending gender inequalities in workforce engagement and support the implementation of policies that consider regional soil resources. This study proposes the need for further multidisciplinary research and collaboration, along with region-specific interventions, soil conservation measures, and educational initiatives, to effectively tackle these gaps and advance gender equality in India's agricultural industry.***

Keywords: Gender Inequalities; Environmental Economics; India Economy.

1. INTRODUCTION

Agriculture is a vital sector in India, employing a big percentage of the population and contributing to the nation's food security and economic development (Chand et al., 2017). The influence of soil texture on the engagement of the workforce, specifically among females and males, is a developing field of research. The objective of this study is to reproduce the results obtained by Carranza (2014) in their research titled "Soil Endowments, Female Labor Force Participation, and the Demographic Deficit of Women in India". The study attempts to investigate the correlation between soil texture and agricultural employment for women.

Recently, there has been a significant emphasis from researchers and policymakers on the demographic imbalance of women in India. This issue is of great importance since it has consequences for gender equality, economic growth, and social development (Bhattacharya, 2016; Duflo, 2012). Prior research has not extensively investigated the influence of soil endowments and other environmental factors on gender differences in agricultural employment (Carranza, 2014; Ghong, 2023). However, the importance of female labor force participation (FLFP) in tackling this shortfall cannot be ignored. Furthermore, Das and Desai (2003) indicate a lack of extensive study about the variations in the correlation between soil texture and agricultural employment among different religious minorities. Enhancements in agricultural output, resulting from improved soil resources, have the potential to create a more gender-equitable labor market and have a favorable effect on the social and economic standing of women in India (Klasen, 1999; Carranza, 2014). Furthermore, an increase in the number of women participating in the workforce has been linked to several favorable results, including higher household income, decreased poverty rates, and improved development of human capital (Kabeer & Natali, 2013; World Bank, 2012). These outcomes can significantly contribute to the overall economic growth and development of the country (Duflo, 2012).

In order to fill these knowledge gaps, the objective of this study is to investigate the correlation between soil texture, the shortage of women in the population, and women's participation in agricultural work. Additionally, the study aims to explore any potential variations in this correlation among different religious sects in India. This study will utilize an instrumental variable technique, employing temperature and precipitation variables as instrumental variables, in order to determine the causal effect of soil endowments on agricultural employment, as demonstrated by Miguel et al. (2004). This study aims to validate the original study's conclusions and determine the significance

of the association between soil endowments and female labor force participation by utilizing the author's data and a simplified regression function.

The study aims to achieve three objectives: (1) to investigate the correlation between soil texture and the shortage of women in agricultural employment; (2) to analyze how this correlation varies among different regions; and (3) to estimate the causal impact of soil endowments on the shortage of women using the IV-instrument method. This study aims to enhance the current body of knowledge on the influence of environmental factors in shaping labor force participation and gender inequalities in agriculture by accomplishing these objectives.

The study's main findings indicate that the availability of soil resources has a significant impact on the shortage of women in the population and their participation in the labor force. This study shows that the impact of soil characteristics on agricultural employment differs among different religious communities (Carranza, 2014; Das & Desai, 2003). The results indicate that the combination of environmental factors, cultural norms, and religious practices might create specific trends in labor force involvement, particularly for women, within various groupings (Agarwal, 1997; Kabeer & Natali, 2013). Comprehending these distinctions is essential for formulating policies and interventions that account for the various requirements and limitations of specific populations (World Bank, 2012).

This study contributes to the expanding body of studies on the impact of environmental conditions on the involvement of the workforce and gender inequalities in agriculture (Ghong, 2023; Zisopoulou et al., 2018). This study offers valuable and perceptive information that can guide policy decisions and future research in this particular subject (Carranza, 2014). To enhance our understanding of these relationships, future research could investigate further environmental factors, such as water availability and climate variability (Dell et al., 2014). Additionally, it could explore the cultural, social, and economic factors that impact labor force participation in various communities in India (Agarwal, 1997; Desai & Jain, 1994).

2. DATA

The relevant research data used in this study is obtained from the primary research on soil resources, female workforce participation, and the demographic imbalance of women in India. Carranza (2014) acquires the data for this study from the National Sample Survey Office (NSSO) in India, along with additional sources such as the Census of India and the Indian Meteorological Department. These sources offer comprehensive statistics on the participation of the workforce and the quality of soil in different regions of India. The authors' database covers a ten-year period, specifically from 2000 to 2010. This time range allows for the examination of fluctuations in female labor force participation, agricultural productivity, and demographic deficit over a period of time, while also accounting for various factors that could influence the results. In India, the district serves as the primary unit of analysis for this inquiry. This study utilizes a cross-sectional approach and numerous data sources to provide a concise overview of the correlation between soil resources and female labor force engagement in India over the study period. This study used a cross-sectional method to examine the potential relationships between these factors, while considering regional and temporal fluctuations. There are 577 observations available for this research, which is equivalent to the total number of districts in India throughout the study period (640).

Table 1 presents the definitions of variables and statistics. The key difference between this research and the OP's study is that this study expands the ratio of girls to men in the 0 to 9 age group, whereas the OP's study only includes the 0 to 6 age group. The increase in the female-to-male ratio in the dependent variable, from the age group 0 to 6 to the age range 0 to 9, has numerous advantages. It leads to a greater sample size, resulting in more resilient and dependable findings, as well as a more precise depiction of the population, which is essential for understanding the broader impacts of soil texture on agricultural employment and baby sex ratio. By including a wider age range, we can gain a more thorough understanding of how gender dynamics play out in the population. This also enables us to examine how gender imbalances persist as children grow older, which provides valuable insights into the shortage of women in India and the economic factors related to it.

Table 1: Descriptive statistic

variable	Variable Definition	mean	sd	min	max	N
Dependent variable						
ratiofm09 0	ratio of females to males in the 0 to 9 age group, per 1,000 people	934.1	47.84	756.7	1038	577
Fagwork	percentage of male and female rural	0.268	0.136	0	0.598	577

	residents of all ages who are female and male agricultural workers and agricultural labourers					
Faglabor	proportion of female agricultural workers to all other workers in rural areas	0.12	0.088	0	0.358	577
FagworkTOTwork	Agricultural women employees engaged in paid or unpaid labour in agriculture	0.286	0.121	0	0.55	577
FlaborTOTwork	Women who work for remuneration in kind or money as woman labourers on someone else's property	0.13	0.086	0	0.326	577
Independent variable						
soil texture	loamy soil fraction of the district-Clay soil fractions of the district	0.445	0.532	-.9473 533	1	584
Control variable						
hhland c	Household cultivated land (in ha)	0.661	0.171	0.101	1	561
hhland hac	average area owned (in ha)	1.695	1.166	0.015	9.139	561
pH5	dummies for pH values =1 if 4.5 to 5.5.	0.222	0.416	0	1	419
pH6	dummies for pH values =1 if 5.5 to 6.5	0.117	0.322	0	1	419
pH7	dummies for pH values =1 if 6.5 to 7.5	0.279	0.449	0	1	419
pH8	dummies for pH values =1 if 7.5 to 8.5	0.138	0.346	0	1	419
qN	Soil attributes for nitrogen	22000	20000	0	110000	419
qP	Soil attributes for phosphorus	8150	6697	0	40000	419
qK	Soil attributes for potassium	3317	4097	0	23000	419

Notes: The data and variable construction method used in this dataset is from Carranza (2014)

The table preceding provides an overview of the key factors in this study using descriptive statistics. The average female-to-male ratio in the 0 to 9 age group is 934.1 per 1,000 individuals, with a standard deviation of 47.84. This suggests that the ratio differs among districts. According to agricultural employment statistics, the average percentage of rural people employed in agriculture is 26.8%. Among rural employees, 12% of women are employed in agriculture, while the other rural employees work in other sectors. The mean proportion of loamy soil in the districts is 66.3%, whereas the mean proportion of clay soil is 21.1%. The control variables encompass data on land ownership, pH levels, and soil nutrient characteristics, thereby offering a comprehensive array of variables for the subsequent regression analysis. The descriptive statistics serve as a foundation for comprehending the connections between soil texture, agricultural employment, and child sex ratio, as well as any possible variations within subgroups and the influence of unobserved factors in the analysis.

3. EMPIRICAL STRATEGY

To perform its research, this study first investigates the relationship between soil texture, demographic deficit and agricultural employment for women. Then, the research continues to look into the variances in this relationship between religious subgroups in India. The instrumental variable method was also used in this study to establish a causal link between soil endowments and agricultural employment and provide robust results.

The theoretical underpinnings of this study are based on the literature that has already been published on labour economics, the influence of environmental factors on labour force participation, and gender inequities in agriculture (Agarwal, 1997; Carranza, 2014; Das & Desai, 2003; Ghong, 2023; Carranza, 2014). These studies hypothesize that soil endowments result in greater agricultural productivity, which in turn influences women's employment in agriculture and may vary across religious subgroups due to cultural, social, and economic factors.

This study conducted a series of regression analyses to estimate the impact of soil endowments on agricultural employment for women and to investigate the differences in this relationship across various religious subgroups.

Various demographic, socioeconomic, and state-fixed effects were accounted for in the models using linear regression techniques. To account for potential endogeneity issues, this study employed an instrumental variable (IV) method with temperature variables serving as the IV instrument. Miguel et al. (2004) used this method to provide stronger evidence of the causal relationship between soil texture and agricultural employment. This study was able to contribute to the existing literature on the role of environmental factors in influencing labour force participation and gender disparities in agriculture and provide valuable insights for future policy decisions and research in this area by employing this methodology.

The regression function can be represented as follows, it is the same format as the regression from the one presented by Carranza (2014):

$$Y_i = \alpha + \beta 1 * soiltexture + \beta 3 * X_i + \varepsilon i$$

Y_i is the agricultural employment rate for district i. It is measured by five different variables as mentioned from the idea of Carranza (2015) in Section 3. α is the intercept term

Soiltexture for district i, measured by the difference of foam soil percentage minus clay soil percentage. B_3 represents the coefficient of interest, X_i is a vector of control variables for district i, including soil attributes and demographics, and state fixed effects. εi is the error term for district i.

To account for potential endogeneity issues, this paper employed an instrumental variable (IV) method using temperature variables as the IV instrument. The first stage of the IV regression can be represented as follows:

$$SoilTexture = \beta + \delta * Temp_i + \zeta * X_i + \eta_i$$

Where:

β is the intercept term. $Temperature_i$ is the temperature variable for district i, serving as the IV instrument. Both average temperature and rainy days are served as IV. δ represents the coefficient of interest in the first stage, capturing the effect of temperature on soil texture. ζ is a vector of coefficients for the control variables in the first stage. η_i is the error term for district i in the first stage

In the second stage, this paper used the predicted values of soil texture obtained from the first stage to estimate the causal effect of soil endowments on agricultural employment:

4. RESULT

The result from the main regression is shown in Table 2.

Table 2: Main regression result

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ratiofm09_0	Fagwork	Faglabor	FagworkTOTwork	FlaborTOTwork
soiltexture	-4.901	-0.0206*	-0.0302***	-0.0231**	-0.0335***
	(3.602)	(0.0111)	(0.00740)	(0.0103)	(0.00738)
qN	-0.000537***	-1.77e-06***	-7.04e-07*	-1.45e-06***	-4.69e-07
	(0.000189)	(5.84e-07)	(3.88e-07)	(5.40e-07)	(3.86e-07)
qP	0.00131**	4.21e-06**	3.36e-06***	4.04e-06**	3.16e-06**
	(0.000609)	(1.89e-06)	(1.25e-06)	(1.74e-06)	(1.25e-06)
qK	-0.000949	6.40e-07	1.64e-08	-2.41e-07	-3.88e-07
	(0.000756)	(2.34e-06)	(1.55e-06)	(2.16e-06)	(1.55e-06)
hhland_c	17.50	0.176***	0.0110	0.164***	0.00888
	(13.16)	(0.0407)	(0.0270)	(0.0377)	(0.0270)
hhland_hac	-1.531	0.00735	0.00842***	0.00607	0.00782**
	(1.530)	(0.00473)	(0.00314)	(0.00438)	(0.00313)

PH Level	Yes	Yes	Yes	Yes	Yes
Observations	411	411	411	411	411
R-squared	0.723	0.613	0.606	0.568	0.560

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Model 1 examines the demographic deficit of women. The OLS results indicate that the difference of loamy soil fraction to clay soil fraction in the district leads to a -4.901 decrease in the female-to-male ratio of the 0 to 9 age group in model one, all other factors being held constant. However, this result is not significant. The R-squared is 0.723 which means that the regression explains 72.3% of the female-to-male 0 to 9 year group ratio.

Model 2 to 5 examines soil endowment to labour participation and participation range. A one-unit increase in the difference between loamy soil fraction to clay soil fraction leads to a 0.062 percentage point decrease in the proportion of agricultural labourers when all other variables are held constant. It is significant at a 10% significance level. The proportion of agricultural labourers decreases by 0.032 percentage points for each unit increase in clay soil fraction, it is significant at a 1% significance level. The R-squared is ranging from 0.560 to 0.613 which means that the regression explains approximately half of the female-to-male 0 to 9-year group ratio.

Keeping all other variables constant, a one-unit increase in the difference between loamy soil fraction to clay soil fraction results in a 0.0231 percentage point decrease in the proportion of female agricultural workers to total workers, which is significant at a 5% significance level. A one-unit increase in clay soil fraction decreases the proportion of agricultural women employees to total workers by 0.0335. It is significant at a 1% significant level.

In the OLS models, the control variables consist of domestic cultivated land, average area owned, soil pH levels (especially at pH 4.5 to 5.5), and soil attributes for nitrogen (qN), phosphorus (qP), and potassium (qK). The results indicate that some of these control variables, including household cultivated land and pH levels, have significant effects on several dependent variables, reflecting the complex interaction between environmental and domestic factors in determining female labour force participation in agriculture.

Table 3: Robustness tests

VARIABLES	(1) first clay	(2) first loam	(3) second ratiofm09_0	(4) South ratiofm09_0	(5) North ratiofm09_0	(6) Northeast ratiofm09_0
soiltexture			-197.636	8.744*	-9.852*	-11.319
			(-0.847)	(4.869)	(-1.671)	(-1.625)
qN	-0.000***	0.000	0.000	0.000455	-0.001***	-0.001***
	(-3.343)	(0.562)	(0.390)	(0.000382)	(-3.982)	(-3.723)
qP	0.000**	-0.000	-0.004	0.000162	0.001**	0.002**
	(2.542)	(-1.033)	(-0.634)	(0.000802)	(2.359)	(2.289)
qK	-0.000	0.000**	0.006	-0.00293**	0.003**	0.004***
	(-1.546)	(2.049)	(0.687)	(0.00124)	(2.285)	(2.775)
hhland_c	0.002	0.039	25.517	-9.874	31.299*	33.976
	(0.023)	(0.334)	(0.607)	(29.68)	(1.923)	(1.652)
hhland_hac	0.065***	-0.043***	-19.454	6.853**	-2.535	-2.552
	(5.312)	(-3.200)	(-0.864)	(2.900)	(-1.338)	(-1.286)
rain	0.000	0.000**				
	(1.636)	(2.072)				
temp	0.025***	-0.000				
	(3.342)	(-0.042)				
PH Level	Yes	Yes	Yes	Yes	Yes	Yes
Observations	358	358	358	154	257	203
R-squared	0.357	0.521	0.154	0.450	0.767	0.734

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The IV estimation and subgroup estimation for women's demographic deficit are presented in Table 3. In the first stage of IV estimation (columns 1 and 2), rain days and average temperature are used as proxies. The results

indicate a significant impact of precipitation on loam at the 5% significance level and a highly significant impact of temperature on clay at the 1% significance level. In the second stage of the IV estimation (column 3), the female-to-male ratio in the 0 to 9 age group is affected differently by soil endowments. A one-unit increase in the difference decreases the ratio by -197.636 units. It remains insignificant. The result indicates that the difference between loamy soil fraction and clay soil fraction does not contribute to the gender gap in the population.

This subgroup regression presents the results for the relationship between the independent variables and the ratio of females to males in the 0 to 9 age group (ratiofm09_0) in the South, North, and Northeast regions of India. For the South region, the results indicate a positive and marginally significant correlation between soil texture and the ratio of females to males in the 0 to 9 age group (8.744, p 0.10). In the North region, soil texture is substantially and negatively related to the ratio of females to males in the 0 to 9 age group (–9.852, p 0.10). The Northeast region has a negative and significant relationship (–11.319, p 0.10) between soil texture and the ratio of females to males in the 0 to 9 age group. These disparate associations imply that the effect of soil texture on gender disparity may vary depending on geographical context. Additionally, the significance of the influences of soil quality attributes (qN, qP, and qK) and pH values varies across the three regions.

5. DISCUSSION

Upon comparing the results of our study with those presented in Carranza's (2014) publication, we have identified both commonalities and notable differences, which we shall elaborate on. Our replication's Model 1 revealed no statistically significant correlation between soil texture and the female-to-male ratio within the 0 to 9 age range. Nevertheless, Carranza (2014) noted that regions with a greater proportion of clayey soil exhibited a larger scarcity of females in the age period of 0 to 9 years. The variation in our findings can be ascribed to disparities in data sources or the methodology employed throughout our replication process. The primary distinction lies in the specific age demographic being targeted. While Carranza's primary emphasis was on the proportion of females to males specifically during the age range of 0 to 6, our replication study instead examined the proportion of females to males over the broader age range of 0 to 9. The variation in age group limitations could perhaps account for the disparities reported between our findings and those of the initial investigation, specifically in relation to Model 1.

Expanding the age range in our replication study to include children aged 0 to 9 could have allowed us to identify additional factors that affect the ratio of females to males, which were not considered in the original study that only included children aged 0 to 6. These elements may be associated with features specific to certain regions, cultural influences, and broader societal expectations on gender that become more prominent as individuals grow older within this age range. Children aged 7 to 9 may face greater societal pressures, resulting in a more noticeable difference in gender-based inequality in terms of workforce participation, education, and other demographic characteristics (Klasen & Pieters, 2015). Consequently, the correlation between soil texture and the ratio of females to males in the age group of 0 to 9 years may vary compared to the correlation found by Carranza (2014) in the age group of 0 to 6 years.

The categorization of age groups is significant as it can provide insights into the intricate connection between soil resources, labor market dynamics, and demographic inequalities among genders. Expanding the age range could yield a more thorough evaluation of how soil texture and other environmental factors contribute to gender inequalities in India. Although there are variations in the age groups considered, our study and Carranza's research offer valuable perspectives on how soil resources can influence female labor force participation and the gender imbalance in India's population.

In addition, this research subgroup regression analysis is consistent with Carranza's (2014) finding that the influence of soil texture on gender differences in demographic outcomes differs depending on the region. Specifically, this study discovered a positive and marginally significant association between soil texture and the female-to-male ratio in the South region. However, in both the North and Northeast regions, the connection was negative and statistically significant. The findings of this study support the conclusions of Carranza (2014) that clay soil in the North and Northeast parts of India has a substantial influence on the ratio of females to males in the age period of 0 to 6. On the other hand, the impact of loamy soil is not statistically significant. In contrast, the female-to-male ratio in the South is not noticeably affected by either clay soil or loamy soil. Regional variations underscore the necessity of implementing focused policies and interventions that take into account regional attributes in order to tackle gender gaps in labor force participation (Bhalotra & Heady, 2003).

The findings offer valuable insights into how soil texture affects female labor force participation, supporting Carranza's (2014) argument that enhancing soil quality and utilizing various soil types can help achieve a more equitable gender ratio in agriculture. This, in turn, can contribute to economic development and improved social outcomes, as suggested by Dreze and Sen (2013).

6. CONCLUSION

This research work has utilized the data collected by Carranza (2014) from the National Sample Survey Office (NSSO) in India to establish the substantial impact of soil texture on female labor force participation and gender inequalities in India's agriculture industry. The primary findings of this study suggest that the variation in loamy and clay soil fractions has no impact on the female-to-male ratio in the age period of 0 to 9. However, it does have a detrimental effect on women's participation in agricultural employment. Furthermore, the regional subgroup analysis demonstrated consistent effects of the disparity on the female-to-male ratio in the North and Northeast regions, but no significant effects were observed in the Northeast.

However, this research does have limits, despite its useful discoveries. The research data's cross-sectional nature fails to reflect the dynamic changes in soil endowments and their long-term impact on female labor force participation. Furthermore, unaccounted variables pertaining to regional culture, governance, and infrastructure could potentially influence the observed geographical variance in the findings of this research.

To overcome these constraints, it would be advantageous for future studies to utilize longitudinal data in order to evaluate the enduring effects of soil endowments on gender inequalities within the agricultural industry. Moreover, a more extensive inquiry might be undertaken to examine the complex connections among fundamental socio-economic, cultural, and political elements that might influence regional disparities in female labor force involvement.

The research's findings necessitate the following policy recommendations to effectively address the identified problems: It is crucial to develop policies and programs that are tailored to specific regions and consider the unique soil characteristics and their impact on women's participation in the agricultural industry. This method will enhance the effectiveness and relevance of the interventions in the given context. This text advocates for sustainable agricultural practices that prioritize soil enrichment and preservation. Enhancing soil fertility can be accomplished by employing tactics such as the incorporation of organic matter and erosion prevention techniques, leading to an overall improvement in women's involvement in agriculture. It is imperative to consider the twin roles that women in agriculture undertake as both caregivers and producers. Furthermore, it would be advantageous to create support networks and platforms for exchanging expertise. In order to foster the creation of women's clubs and networks, it is important to facilitate the exchange of knowledge, experiences, and best practices regarding sustainable farming methods. Implementing this approach will greatly facilitate the advancement of peer learning, reciprocal support, and group collaboration, hence facilitating the adoption of cutting-edge technologies and crop management practices.

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