Rainfall shocks and gender wage gap: Agricultural labor in India

by

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ABSTRACT

Most studies of economic crises study the impacts of recessions on urban labor markets. Very few papers consider the effect of crises in the rural areas on rural labor markets. The most common crisis in developing countries is the variability in rainfall which affects demand for agricultural labor in rural areas. Previous studies have shown that productivity shocks in agriculture like rainfall variability affect wages adversely. None of the studies however consider the heterogeneity in the impact of these shocks on agricultural wages by gender, a feature which has been well-studied for the urban labor markets for developed countries. Using National Sample survey data for India from 1993 to 2007, I create a district level panel dataset to examine how rainfall shocks, which affect demand for labor in Indian agriculture, affect wage gap in agriculture between males and females. Overall, we find that such shocks do not affect the wage gap, but low rainfall years affect the wage gap adversely in the rain-fed rice growing regions of India. This finding is consistent with greater value of female labor in rice cultivation which is also a crop highly sensitive to rainfall variability under rain-fed conditions. The paper concludes that the effect of rainfall shocks on gender wage gap in agriculture depends upon the gender roles underlying the technology of production in agriculture which varies across cropping systems.

Key words: Rainfall, Female, Labor demand, Labor supply, Wages, Rice

JEL codes: J16, J22, J23, J31, J43, O13, Q54

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1. Introduction

Labor economists have long been concerned with measurement of wage gaps across demographic groups like gender, race and ethnicity in different occupations. As noted in many countries, there is also a persistent gap in agricultural wages received by females and males in India. Agricultural wages respond to rainfall variability in India as demand for agricultural labor changes in response to rainfall since Indian agriculture is predominantly rain-fed. This can have an impact on gender wage gap in agriculture depending upon asymmetric labor demand and labor supply effects of rainfall variability on male and female labor in agriculture. Understanding this heterogeneity is important to inform the policymaking if any demographic group is hurt more than the other in times of such aggregate crisis. In this paper, we estimate the effect of rainfall shocks on gender wage gap in agriculture and also try to explore the possible mechanisms which lead to the observed results.

Most studies in wage gaps across different demographic groups are either concerned with the proportion of wage gap which can be attributed to individual observable characteristics and market institutions or trends in wage gaps over time within countries which can be explained by changing labor market conditions. Very few studies examine the cyclical nature of these wage gaps due to tightening in the labor market caused by recessionary conditions. Earlier studies by Ashenfelter (1970), Freeman (1973), O'Neill (1985) and more recently by Biddle and Hamermesh(2011) analyse the impact of aggregate changes in unemployment rates in the economy on gender gap in wages using data from United States. Freeman(1973) finds that gender wage gap increases when high unemployment rates prevail in the economy and attributed it to possibly greater vulnerability of females to layoffs due to lesser training and in general a weaker labor market for females during recessions. Biddle and Hamermesh(2011) also find that gender wage gaps are counter cyclical in nature. They attribute it to greater discrimination against females during downturns. Contrary evidence to the above is presented in Solon et al(1994) and Park and Shin(2005). Using another dataset for the United States they estimate that gender wage gaps are pro-cyclical in nature. This they argue is due to males being over represented in industries with more pro-cyclical demand. To the best of my knowledge, there is no paper which analyses the impact of adverse demand shocks in rural labor markets on gender gap in agricultural wages in a developing country context.

Agriculture plays a pivotal role in employment generation in developing countries. It continues to be the mainstay of the Indian economy in terms of its share of employment.

Though, the contribution of agriculture to Indian Gross Domestic Product is low (it now stands at approximately 15 percent according to Economic survey 2010-11) and is declining yet, 75 percent of rural workforce (Census 2001) is engaged in agriculture (rural population comprises 72 percent of total population in India) and it occupies an important place in the economic and social fabric of India. It remains the largest sector absorbing the Indian workforce. Agricultural laborers constitute 45 percent of the agricultural workforce (Census 2001). Landless households which form the lowest income quintile in India are completely dependent on agricultural wage labor for their income. They mostly work in agriculture as casual laborers since regular wage contracts in agriculture are very few (National Sample Survey 2004). In terms of gender composition, about 74 percent of female work force in India is engaged in agriculture and there is growing feminization of agricultural workforce as men are able to find alternate non-farm opportunities, however females in rural areas have not been able to gain access to non-farm jobs.

There also exists a gender gap in wages in agriculture in India. Table 1 shows the female to male wage ratios across 15 Indian states from the National Sample Survey rounds of 1993-2007. On an average, the female to male wage ratio in Indian agriculture stands at 70 percent and has not shown any changing trend over time. Mahajan and Ramaswami(2012) analyse the cross-sectional variation in agriculture wage ratios across Indian districts to find determinants which affect the spatial variation in wage ratios, particularly, the large wage gaps observed in the southern states of India. This paper focuses on over time fluctuations in gender wage gap in agriculture due to productivity shocks like rainfall variability which affect agricultural wages by affecting demand for labor in agriculture.

In the past few decades, climate change has made rainfall more variable in India leading to recurrence of drought like situations across different parts of India in different years. Each year some part of the country suffers from rainfall scarcity leading to low agricultural output and affects the livelihood of people in rural India. Such aggregate shocks are difficult to insure against using informal networks as they are correlated at community level. Of the twenty two countrywide major droughts witnessed in India in last 120 years, seven have occurred in the last 3 decades. The Indian agriculture is still predominantly rain-fed with less than 50 percent cultivable area under irrigation which makes agricultural output highly susceptible to rainfall shocks, thus affecting demand for labor and agricultural wage levels. These shocks may not have gender neutral effects on labor market outcomes, thus understanding the heterogeneous effect of such shocks by gender on labor market outcomes are of importance to formulate policies which mitigate possibly more adverse impacts on any section of the society.

There is a growing recognition that climate change can impact lives of women by affecting availability of natural resources like fuel-wood, water and forests and also because the coping mechanisms are different for men and women due to societal-constructed gender roles(WEDO(2008)). Alternative employment opportunities for women are also constrained during such distressful times either due to social norms or lack of alternative skills. Drying up of nearby water-bodies due to droughts increases the time spent by women in carrying water for household chores as this task is typically performed by women, leaving lesser time to participate in income generating activities. Climate change can also affect the livelihoods of women by changing the crop composition and technology.

In the next section we provide a literature review of studies looking into the impact of weather variability on labor market outcomes. Section 3 outlines a simple theoretical framework for the paper and section 4 discusses the data and variables constructed. In section 5 we estimate the impact of rainfall shocks on agricultural yields and in section 6 discuss the empirical strategy and the main findings. Section 7 provides a few robustness checks for the main findings and in section 8 we discuss the mechanisms which could possibly lead to the results obtained.

2. Effect of weather shocks on labor market outcomes

Weather shocks can have an impact on a variety of outcomes- education, health, time-use, income and migration. And this impact is unlikely to be gender-neutral has been well recognised in literature but is still a black-hole in terms of empirical evidence to substantiate the claims. Out of all the possible effects on women, perhaps the least researched is the impact on labor markets for men and women in the rural areas due to these variations. This can manifest itself through wages, income, time use and migration possibilities which have repercussions on labor market outcome. The literature on weather shocks and labor market outcomes can be broadly divided into two strands. One, which looks into the effect of rainfall shocks on wages and the second, which looks into the effect of such shocks on time use in different activities by agricultural households as a means to cope with the shock. There is no paper, however, which looks into the heterogeneity of these effects by gender for aggregate shocks like rainfall variability[1].

Jayachandran (2006) measures the impact of productivity shocks on district level agricultural wages for men in India and concludes that a negative productivity shock lowers the wages significantly. This effect is less pronounced in districts which are more developed in terms of access to roads and banks. Mueller and Quisumbing (2011) study the impact of 1998 Bangladesh flood on agricultural and non-agricultural wages. They find a short term reduction in wages and lesser reduction in wages for agricultural workers who were able to find non-agricultural employment. Valerie and Osgood (2009) look at not only short term effects of droughts on wages but long term effects as well. They argue that the long term effect can be due to selling of productive assets during the shock to sustain consumption and it may take a long time to replenish them. They use data on both rural and urban areas in Brazil and find that adverse rainfall shocks upto 5 years in the past can have effects on individual wages.

Rose(2001) and Maitra(2001) using panel data in the Indian context looks at the impact of income shocks(both idiosyncratic and aggregate shocks like rainfall) on household off-farm labor supply to cope with risk and find that farmers may use off-farm labor as a safety net in such crisis situation. Halliday (2010) is the only paper which uses self reported idiosyncratic shocks and aggregate shock of earthquakes in El Salvador to study their impact on male and female time use on own farm-agricultural field work, livestock labor, domestic labor and off-farm labor. The earthquake on the other hand increased domestic work and decreased livestock production by women. He argues that this is compatible with a theoretical framework in which household members are allocated to sectors according to their comparative advantage when it is affected by an adverse income shock. The earthquake in El Salvador increased the demand for home production and hence increased the hours spent by women in domestic work.

Adhvaryu et all(2010) quantify the impact of rainfall shocks on total manufacturing sector employment and output in India and find that there is a fall in both when rainfall shock is negative, particularly more in pro-employer states and for small factories and agro-based industries in India. The literature on the heterogeneous effect of weather shocks on labor market outcomes by gender is thus largely non-existent. This paper aims to fill this gap by

[1] Kanwar(1995) and Kochchar(1999) consider the impact on male and female off-farm hours in rural areas separately of but of household level idiosyncratic shocks only.

examining the dimension of wages and the effect of weather shocks on male and female wage gap in agriculture.

3. Theoretical framework

Before proceeding with the empirical analyses it is useful to discuss the theoretical implications of productivity shocks like ‘rainfall’ on male and female wages. In the model below we assume a competitive agricultural labor market and three factors of production – Land (L), Male labor (L_m) and Female labor (L_f) and rainfall (R). The production function is continuous and differentiable and male and female labor are imperfect substitutes in production. There exist diminishing returns to each factor and in the short run amount of land is fixed. The profit function is given by:

$$\pi = F\left(L, L_m, L_f, R\right) - \; w_m L_m - \; w_f L_f$$

In a competitive equilibrium all factors are paid their marginal products. The first order conditions for profit maximisation are:

$$w_m = F_{L_m}(L, L_m, L_f, R) \qquad (1)$$

$$w_f = F_{L_f}(L, L_m, L_f, R) \qquad (2)$$

If we assume that labor supply is exogenous and constant, then the effect of rainfall shocks on male and female wages will be:

$$\frac{dw_m}{dR} = \frac{dF_{L_m}}{dR} \qquad (3)$$

$$\frac{dw_f}{dR} = \frac{dF_{L_f}}{dR} \qquad (4)$$

The rainfall shocks in agriculture thus affect wages through their impact on marginal productivity of labor. A positive shock increases marginal productivity of both males and females and hence increases male and female wages. Thus the above expressions are unambiguously positive. The female wages will be affected more than male wages if affect of rainfall shocks on marginal productivity of females is greater than that on marginal productivity of males.

However, in general, labor supply is unlikely to be fixed and exogenous. It will respond to changes in productivity conditions in agriculture through its direct income impact on labor supply for landed households as well as role played by labor supply elasticities. Relaxing this assumption, in a general equilibrium framework, consider two types of households- landless(N) and landed(D). Landed households supply farm labor and also hire in labor on their farms, while landless households only hire out labor to landed households.

Both male and female labor are used in agricultural production and supplied by households. The two types of labor are imperfect substitutes in production but labor of each type from different households is perfectly substitutable. All households are assumed to be price takers but wage rates are determined endogenously by the market clearing equilibrium conditions.

The two types of households maximise an identical, twice differentiable utility function with respect to the consumption commodity (x), leisure of male members(l_m) and leisure of female members (l_f) subject to the budget constraint. The household maximisation problem is thus given by:

$$\text{Max } U(x^i, l_m^i, l_f^i)$$

s.t.

$$x^i + w_m l_m^i + w_f l_f^i = w_m + w_f + v \qquad \text{when } i\text{=N}$$

$$x^i + w_m l_m^i + w_f l_f^i = w_m + w_f + v + F(L, L_m, L_f, R) - w_m L_m - w_f L_f \qquad \text{when } i\text{=D}$$

$$= w_m + w_f + v + \pi$$

The first order conditions with interior solutions will be given by:

$$U_x^i = \lambda^i \qquad (5)$$

$$U_{l_m}^i = \lambda^i w_m \qquad (6)$$

$$U_{l_f}^i = \lambda^i w_f \qquad (7)$$

For the profit maximising landed households, the first order condition for maximisation will be given by (1) and (2).

In equilibrium total labor demand will be equal to total labor supply for both males and females:

$$L_m(w_m, w_f, R, L) = L_m^{S,N}(w_m, w_f) + L_m^{S,D}(w_m, w_f, R, L)$$

$$L_f(w_m, w_f, R, L) = L_f^{S,N}(w_m, w_f) + L_f^{S,D}(w_m, w_f, R, L)$$

Here, (1-$l_k^i = L_k^{S,i}$)Totally differentiating the above market equilibrium conditions and using Cramer's Rule to get expressions for $\frac{dw_m}{dR}$ and $\frac{dw_f}{dR}$, we get the following:

$$\frac{dw_m}{dR} = \frac{\varepsilon_{f,w_f}\left(L_{m,R}^{S,D} - L_{m,R}\right) - \varepsilon_{m,w_f}\left(L_{f,R}^{S,D} - L_{f,R}\right)}{\varphi} \qquad (8)$$

$$\frac{dw_f}{dR} = \frac{\varepsilon_{m,w_m}\left(L_{f,R}^{S,D} - L_{f,R}\right) - \varepsilon_{f,w_m}\left(L_{m,R}^{S,D} - L_{m,R}\right)}{\varphi} \qquad (9)$$

Where, ε_f and ε_m refer to excess demand for females and males respectively and $\varepsilon_{f,w_f}$is the differential of excess demand for females with respect to female wages. Similar interpretations hold for ε_{f,w_m}, ε_{m,w_m} and ε_{m,w_f}. $L_{m,R}^{S,D}$ and $L_{f,R}^{S,D}$ is the differential of labor supply of males and females in landed households to change in rainfall conditions. This will be negative for both males and females, as a positive productivity shock increases income and hence increases value of leisure, reducing labor supply. $L_{m,R}$ and $L_{f,R}$ have ambiguous signs if males and females are imperfect substitutes in production as they depend upon own effect and cross effect of productivity shocks. φ has to be positive for the multimarket Hicksian stability condition to hold. In general, the sufficiency conditions for $\frac{dw_m}{dR}$ and $\frac{dw_f}{dR}$ to be unambiguously positive, require male and female leisure to be substitute in household utility function, supply curve of males and females to be either upward sloping or irresponsive to wages and male and female labor demand to be positively related to rainfall shocks. However, it is not possible to arrive at relative effects of rainfall shocks on female to male wage gap since it will depend upon relative magnitudes of effect of rainfall shocks on labor demand for males and females and labor supply of males and females to agriculture.

In the Indian context it might be more difficult for females to adjust their labor supply since their access to alternative non-farm job opportunities is restricted. At the same time, females might adjust their supply by shifting their labor to home production like taking care of children and other domestic activities like fetching water and fuel-wood. Rozensweig (1978) estimates labor supply elasticities for males and females in Indian agriculture and finds female labor supply to be more elastic with respect to own and male wages at household level but both to be irresponsive to wages at aggregate level. Though, males have access to outside village labor markets as seasonal migration for employment is primarily driven by males in India, such adverse rainfall shocks also reduce demand in the non-farm employment sectors like small factories and agro-based industries(Adhvaryu et al, 2010) which form a significant component of seasonal migration. Rose(2001) and Kurosaki(2009) analyse the impact of aggregate income shocks in India on household off-farm labor supply to cope with risk. While Rose(2001) finds that households use non-farm labor supply to cope with such ex-post aggregate shocks, Kurosaki(2009) finds mixed results for the same. Goldberg(2011) in another developing country context using an experimental setting finds that male and female labors supply to agriculture is equally elastic. If male and female labor supply are equally elastic and the effect of rainfall shocks on labor supply of landed households to agriculture are gender neutral then any observed variation in female to male agriculture wages should be due to differential effect on labor demand for the two sexes.

The above neoclassical model of labor supply and demand in agriculture assumes no discrimination against females in the agricultural labor market. In Indian agricultural context, there is no evidence of wage discrimination against females as Laufer(1985) shows for the semi-arid region in India that wages paid to females are in line with the ratio of marginal productivity of male and female labor in the region. Laufer(1985) estimates generalised quadratic farm-level production functions with farm fixed effects to control for farm level fixed unobservable factors. Previous papers estimating the cyclical impact of unemployment on female-male wage gap for the US urban labor markets do not rule out discrimination as a factor affecting the wage gap.

4. Data and Variable construction

The primary dataset used in this paper are the Employment and unemployment rounds (1993/94, 1999/00, 2004/05, 2007/08) of National Sample Surveys (NSS) in India. NSS is a cross-sectional dataset which is representative of India's population. The survey contains labor force participation and earnings details for the reference period of a week and follows a two stage sampling design. In the rural areas, the first stratum is a district. Villages are primary sampling units (PSU) and are picked randomly in the district over an entire agricultural year (July to June) over quarters to ensure equal spacing of observations over an agricultural year. The households are randomly chosen in the selected PSU's. The district level analyses includes 14 major states in the sample: Punjab, Haryana, Uttar Pradesh (includes Uttarakhand), Madhya Pradesh (includes Chattisgarh), Bihar (includes Jharkhand), Gujarat, Rajasthan, West Bengal, Maharashtra, Andhra Pradesh, Karnataka, Orissa, Tamil Nadu and Kerala. Average agricultural wage in an agricultural year is estimated by calculating average daily wage rate (7 hour work day) for all casual wage laborers in agriculture in a district weighted by sampling weights provided in the survey so that the district level average wage rate is representative of the district population. The gender gap in wages is measured by taking the differences in log of average daily wage rate received by male and female agricultural laborers. Wages are adjusted for changes in price levels over-time by using the consumer price index for agricultural laborers as the deflator.

Rainfall data used in the paper comes from the gridded dataset of the Center of Climatic Research at the University of Delaware, which includes monthly precipitation values on 0.5 degree intervals in longitude and latitude centered on 0.25 degree. This grid value is achieved by spatial interpolation using data from nearby weather stations and other sources of rainfall data[2]. District level monthly rainfall estimates were arrived at by averaging the monthly precipitation value of all the grid points lying within the geographic boundaries of a district in a year[3]. The geographic boundaries refer to the 1991 Indian census boundaries as Indian districts have been over time split into two or more districts. Districts across NSS rounds (1993, 1999, 2004, and 2007) have been merged into their parent districts according to district boundaries in the 1991 census[4]. About 75% (IMD(2006)) of the rainfall in India is received during the monsoon season from June to September[5]. The monsoon precipitation levels are very critical for agricultural yields during the agricultural year not only for the kharif crop(June to October) but also for the rabi crop(October to April) since they help recharge the aquifers and also replenish the moisture content in the soil. Methodology used for constructing rainfall shocks is similar to Jayachandran(2006). She argues that in the Indian context above normal level rainfall improves agricultural productivity while below normal level rainfall reduces it. Thus, excess rain is treated as a good shock while a shortfall is taken to be a bad shock. The “RainShock” variable equals one if the annual rainfall is above the eightieth percentile for a district, zero if it is between the eightieth and the twentieth percentile and minus one if it is below the twentieth percentile. Rainfall data from 1971-2008 is used to construct the shocks. Using this definition 67% districts experienced a drought and 49% experienced good rainfall in at least one year in the districts included in analyses. Similar to the finding of Jayachandran(2006), when coefficients for rainfall above the eightieth percentile and for rainfall below the twentieth percentile are estimated separately, I cannot reject that they have equal magnitude and this restriction helps to improve power in the regressions.

Data on area, production and yield of crops at district level is obtained from Area, Production and Yield statistics(1999-2008) published by Directorate of Economics and Statistics, Ministry of agriculture. District and time fixed effects take into account time-invariant district specific effects like culture, norms, agro-ecological conditions,

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[2] For further information on the dataset and the methodology used for interpolation please refer to the below link http://climate.geog.udel.edu/~climate/html_pages/Global2_Ts_2009/README.global_p_ts_2009.html

[3] Hilly regions of Jammu and Kashmir, Himachal Pradesh and North-East are excluded from the analyses as measurement of rainfall in hilly areas using gridded dataset induces a lot of measurement error since precipitation varies considerably by altitude.

[4] To match the districts into the parent districts two sources of information were used which track the evolution of Indian districts over time. Kumar and Somanathan (2009) document changes in district boundaries over the census years and http://www.statoids.com/yin.html which compiles changes in district boundaries from 1982 to the present.

[5] Typically, March to May are summer months and the winter spans over December to February in India: Indian Meterological Department http://www.imd.gov.in/section/nhac/dynamic/FAQ_monsoon.htm

characteristics of rural population like level of human capital and levels of development in a district and general time trends in productivity or education.

5. Rainfall variability and its effect on agricultural yield in India

Weather varies across regions in India, but broadly India experiences four seasons- winter (January to February), summer (March to May), the monsoon season (June to September) and the post-monsoon season (October to December) (Ribot et al. 1996). India has been classified into 20 Agro Ecological Regions's by National Bureau of Soil survey based on soil, physiography of the area, bioclimatic conditions and length of growing period which depends on moisture availability in soil. The nature of crops grown in an area depends on climatic and soil suitability. These regions greatly differ in their precipitation levels. It ranges from scanty to heavy in different parts of the country. The rainfall pattern thus differs spatially and temporally. Alternating sequence of multi-decadal periods of thirty years having frequent droughts and flood years are observed in the all India monsoon rainfall data. There has been no overall trend in rainfall observed in India, but the frequency and intensity of rainfall appears to be changing (IITM report (2009)). In the past few years many states in India have witnessed droughts and floods. Some major country wide drought years in India have been 1877, 1899, 1918, 1965, 1972, 1987, 2002 and 2009. Thus, the frequency of droughts seems to have been increasing over time.

Indian agriculture is subject to vagaries of nature as it is mostly rain-fed and yields are highly sensitive to rainfall conditions. The agricultural output depends on monsoon as nearly 55.7 per cent of area sown is dependent on rainfall[6]. In 1991-92 around 35% of the area under agriculture was irrigated which increased to 41% by 1999-99 and was 44% by 2007-08[7]. Thus, there has been virtually no growth in irrigated area in the past decade. Sources of irrigation like canal and groundwater also get depleted during drought years. The exogenous shock which this study focuses on is a local aggregate shock to productivity in Indian agriculture. It is captured by deviation in rainfall in a particular year from its normal value for a district. In this paper we restrict ourselves to the meteorological definition of droughts which is defined in terms of deviation from the long term normal rainfall in an area. Such rainfall shocks affect most of the households in a local area and hence are more difficult to insure against through local village insurance networks or credit. These can only be smoothed

[6] National Portal of India, website http://india.gov.in/sectors/agriculture/index.php?id=2
[7] Agricultural Statistics at a glance 2003 and 2010
http://india.gov.in/outerwin.php?id=http://agricoop.nic.in/Agristatistics.htm

by forces outside the local village. Since Indian agriculture is mostly rain-fed such shocks disrupt the labor market in the rural areas of India by lowering demand for labor during drought years and increasing it during years of good rainfall. India is particularly vulnerable to such shocks as the level of development is low in many districts and there exist a large percentage of poor households who do not have a cushion to absorb such shocks.

More than 80% of the production and area sown in India is under foodgrains. Rice and wheat are the most important foodgrains grown in India. While bajra is an important coarse cereal, gram the most important pulse grown in terms of area sown. Figure 1(a) and 1(b) plot the coefficients from regressing log of yield of rice and wheat at district level on the deciles of rainfall with the first decile as the omitted category, district fixed effects and a time trend. A concern with the rainfall shock measure constructed is that higher levels of rainfall may result in flood like situations which could destroy crops thus reducing yields. The plot of coefficients shows that this is not the case. For both rice and wheat we do not observe any dips in the ninth and the tenth deciles of rainfall which would be the case if floods were affecting these crops adversely. All the coefficients in the regression are significant at 1% level.

Table 2 shows the effect of the rainfall shock variable constructed on the yields for four crops- rice, wheat, bajra and gram. For all the crops, the shock has significantly positive effect on yields. A positive shock results in approximately 8% higher yields than in normal years for rice, bajra and gram while for wheat this effect is 5.7%. The magnitude is highest for rice at 8.7%. Rice is also a very different crop in terms of the gender roles involved and cultivation practices. Soil and climate conditions in a region usually determine the nature of crops grown. Rice crop requires a lot of water and it takes 3,000–5,000 liters to produce 1 kilogram of rice, which is about 2 to 3 times more than to produce 1 kilogram of other cereals (IRRI, 2002). Rice is best grown under flooded conditions. Though rice can be grown in both dry or semi-dry conditions and wet conditions, the cultivation practices are different. In dry areas, the soil is ploughed in summer and the seed is sown by broadcasting or by sowing the seed behind the plough. In wet cultivation transplanting in puddled fields is adopted. Wetland conditions are created in semi-dry areas by impounding the rain water. Thus, areas which receive high amounts of rainfall and have tropical climate are climatically most suitable for rice cultivation. Among the Indian states in the analyses, Kerala, West Bengal, Orissa and Bihar receive the highest monsoon rainfall. Table 3 shows monsoon rainfall levels and area under rice cultivation[8] in the fourteen states of India included in the analyses. As the table shows, the states having at least fifty percent area under rice cultivation are also the states which have highest levels of rainfall in the country. These states are Kerala, located on the western coastal plain and West Bengal, Orissa and Bihar located in the Eastern Gangetic plains which receive higher amounts of rainfall(more than 1000mm during the monsoons). The climatic conditions in these states are thus highly suitable for wet cultivation of rice.

It has been documented by researchers that cultivation of rice involves greater labor-days, particularly women labor for tasks like transplanting and weeding. Wet cultivation of rice requires rice to be grown in flooded fields. Since rice seeds cannot germinate under flooded conditions they needs to be grown in nurseries and then transplanted manually in the flooded rice fields. Women are considered more efficient than males in transplanting since it requires long periods of back- bending work and delicate hands and women seem to have a comparative advantage in these skills. Bardhan(1974) noted that female labor utilisation is much more in rice growing areas and states:

"Transplantation of paddy is an exclusively female job in the paddy areas; besides, female labor plays a very important role in weeding, harvesting and threshing of paddy. By contrast, in dry cultivation and even in wheat cultivation, under irrigation, the work involves more muscle power and less of tedious, often back-breaking, but delicate, operations." Bardhan(1974, pg 1304)

Mbiti(2008) observes the above and compares intensity of tasks performed by males and females across rice and wheat and finds that women's sowing and transplanting labor in rice is twice than that in wheat cultivation. Tasks like transplanting and weeding in which females supposedly have comparative advantage account for one-third of total labor percentage used in rice farming. After transplanting of rice, men are only involved with irrigation and application of fertiliser while women undertake manual weeding operations. Harvesting of the crop is performed by both men and women. Using the above observation he finds that agricultural households in rice growing areas do not marry their daughters in good rainfall years and even if they marry them the *dowry*(payment in cash or/and kind by the bride's family to the bridegroom' s family) paid is less. He attributes this to greater relative

[8] Area, production and yield statistics (1999-2004) were used to construct the state level crop composition figures. Years 1999-2004 were used since for these years data for all states was complete.

value of female labor during good rainfall years and lower relative value of female labor during low rainfall years in regions suitable for rice cultivation. If this were indeed true then the positive effect on equilibrium wages must be greater for females in rice suitable areas during years of greater rainfall as compared to male wages in agriculture assuming that labor supply responses do not differ or at least are not able to completely offset the changing demand for female labor. To check this hypothesis I construct an index of rice suitability. If a state has at least 50% area under cultivation of rice then districts in that state are classified as rice suitable areas[9]. To check the robustness of the results I try alternative definitions of rain-fed rice suitability of a region by using district level area under rain-fed rice cultivation.

6. Estimation Strategy and Findings:

I examine the effect of rainfall shocks which affect productivity in agriculture on male and female wage gap in agriculture. Such shocks affect demand for labor in agriculture, thus affecting wages. In addition to the above I see if the impact is different across rice suitable areas relative to other areas in India. I create a district level panel dataset using the NSS rounds of 1993, 1999, 2004 and 2007. Below equation (1) estimates the effect of rainfall shock on male and female wages and equation (2) estimates the effect on gender differential in wages.

$$\ln (W_{jt}^{k}) = \beta_0 + \beta_1 (RShock)_{jt} + \beta_2 X_{jt} + \beta_3 D_j + \beta_4 T_t + \epsilon_{jt} \qquad (1)$$

$$\ln (W_{jt}^{F}) - \ln (W_{jt}^{M}) = \gamma_0 + \gamma_1 (RShock)_{jt} + \gamma_2 X_{jt} + \gamma_3 D_j + \gamma_4 T_t + \epsilon_{jt} \qquad (2)$$

Here, k=M, F indexes male and females respectively and W_{jt}^{k} is average wage in agriculture in district j at time t. '*RShock*' is the rainfall shock experienced in district 'j' at time 't'. X_{jt} are time varying district characteristics. D_j are district fixed effects which control for time invariant characteristics of the district like agro-ecological conditions, culture, norms, labor

[9] The index differs from that constructed by Mbiti(2008) who uses only area of rice and wheat. Here, rice suitability is defined by taking into account all crops grown, as $\frac{Area\ under\ rice}{Area\ under\ all\ crops}$. Since we are considering equilibrium wage effects, if only a single district is cultivating rice and others around it are not then migration of males and females into the district in response to change in relative demand can wash away the relative effect on wages. In addition, rice is either grown under rain-fed conditions with long monsoon season and on an average a higher rainfall level or under irrigated conditions. In Southern states of India and Punjab due to lower rainfall, Rice is only grown under well irrigated conditions. Around 90% of area under rice is irrigated in these states (Sen, 1985). In such areas rice cultivation may not occur due to better climate suitability but rather due to better irrigation facilities which also mitigates the effect of rainfall shocks on rice yields. Hence, we qualify a district as belonging to a rice suitable region if a larger geographical unit, in this case a state, as a whole is suitable for rice cultivation.

force characteristics and initial level of development. T_t is a vector of time dummies. The identification of the parameter of interest is thus based on over time variation in wages and rainfall in a district. The parameter of interest γ_1 gives the impact of rainfall shocks on gender wage gap. A district is taken as the unit of analyses. This is based on the assumption that districts constitute separate agriculture labor markets in India. Migration could make wages across districts to be the same, however, as argued in Mahajan and Ramaswami(2012) districts in India can be considered as distinct labor markets due to low mobility of population in India. To account for spatial correlation in rainfall, we allow for clustering of standard errors within a region-year. The district level regressions are estimated with analytical weights equal to district population since the variables are means estimated at district level and 323 districts are used in the analyses. In the below specification, we test if the effect on wage gap is different in areas suitable for rice cultivation. Here, γ'_1 gives the differential impact on gender wage gap in rice suitable areas relative to the others.

$$\ln(W_{jt}^{k}) = \beta_0 + \beta_1 (RShock)_{jt} + \beta'_1 (RShock)_{jt} * Rice_j + \beta_2 X_{jt} + \beta_3 D_j + \beta_4 T_t + \epsilon_{jt} \quad (3)$$

$$\ln(W_{jt}^{F}) - \ln(W_{jt}^{M}) = \gamma_0 + \gamma_1 (RShock)_{jt} + \gamma'_1 (RShock)_{jt} * Rice_j + \gamma_2 X_{jt} + \gamma_3 D_j + \gamma_4 T_t + \epsilon_{jt} \quad (4)$$

Table 5 gives the estimates for the impact of rainfall shocks on wages. Both male and female wages seem to be affected equally by the shocks. A one unit increase in shock increases female wages by 3.6% and male wages by 2.4%. There is no significant effect of rainfall shocks on wage gap. Table 6 shows the results for the specification with rainfall shock interacted with the rice suitability dummy. Here, we find that the gender wage gap increases during negative shocks and falls during positive shocks in rice suitable areas. A one unit increase in shock in rice suitable areas increases the wage ratio by 4.8%. This is driven by a lower impact of rainfall shocks on male wages in rice growing areas. In the last column we drop the state of Kerala from the analyses, to check if the results are driven by it since Kerala is distinct from other Indian states in terms of its level of development and also constitutes an area suitable for rice cultivation. The previous results obtained however, are robust to the exclusion of state of Kerala.

Jayachandran(2006) finds that effect of rainfall shocks on wages is lower in more developed areas. To control for level of development of a district we use percentage literate population in a district and interact it with rainfall shock. Generally non-farm sector enterprises locate in areas with better infrastructure and education levels. Level of education might be a proxy for better access to other job opportunities leading to low dependence on agriculture for livelihoods. Also, technological advancement in agriculture may be greater in areas with more educated workforce. Thus, in districts having more literate population agricultural wages will be better protected against rainfall variations. Also, irrigation potential of a district may lead to differential effect of rainfall shocks on wages. To the extent that well irrigated areas suffer lower demand shocks the wages in irrigated areas will be more insulated against rainfall variations. But cultivation of more risky crops in well-irrigated areas, lesser adjustment in labor supply in well irrigated areas as population will be predominantly dependant on agriculture or downward rigidity in real wages in low irrigation areas as these areas also have low real agricultural wages which are closer to subsistence level can make local agricultural wages less responsive to rainfall shocks in low irrigated areas. Table 7 shows the results conditional on the above indicators of development. Both male and female wages are less responsive to rainfall shocks in areas of more literate population since the interaction term is negative but there is no impact on gender wage gap. On the other hand, both male and female wages are more responsive to rainfall shocks in better irrigated areas since the interaction term is significantly positive. Thus, wages fall less in response to negative rainfall shocks in less irrigated areas. The addition of the above controls does not change the effect of rainfall shocks in rice growing areas on the gender wage gap as the coefficient is still positively significant and one unit increase in shock increases the wage ratio by 5%. The specification with district controls is used as the baseline and we add further controls to check the robustness of the above results.

A host of other development indicators like accessibility of villages in a district by bus, road, rail, closeness of villages to a town and banking activity in a district, are used by Jayachandran(2006). Level of per capita expenditure as an indicator of poverty and percentage landless households in a district are also used as indicators of subsistence level in a district. We examine the robustness of the above results to inclusion of these indicators as well. Table 8(a) shows the results for indicators of accessibility like bus, road, rail, and Table 8(b) shows the results for mean distance to town and banking activity with the last column incorporating all the indicators. Controlling for these indicators of development only make our results stronger that in rice suitable areas the fall in female wages is more than male wages in bad rainfall years. In the results we obtain, none of the indicators of accessibility or their interaction with the rainfall shock have a significant effect on either absolute wages or female to male wage ratio. In Table 8(c) I control for other indicators of povety like percentage landless households and monthly per capita consumption of households in a district in 1993 along with the previous indicators. As observed before, these indicators do not affect the main result.

7. Robustness checks:

To further check the robustness of the results obtained in the previous section, I use district level area under rain-fed rice percent instead of a dummy for rice growing states to check if the results are indeed driven by rice suitability and rice suitability is not capturing any other factor common to the rice growing states. Rice can be grown under both rain-fed and irrigated conditions and it is crucial to make this distinction since the rain-fed areas are more likely to suffer yield shocks in rice which affect demand for labor. Percent area under un-irrigated rice cultivation in a district is calculated by multiplying the district level percentage area under rice cultivation with percentage rice area un-irrigated in the state to which the district belongs to[10]. Table 9 shows the results with this alternative definition of rice suitability. The results support the previous findings and a positive shock decreases wage gap while a negative shock increases the wage gap as the percentage under un-irrigated rice cultivation in a district increases. This is driven by lower effect on male wages in rain-fed rice cultivating regions. The above result is not affected when district level development indicators in Table 8(a), 8(b) and 8(c) are also controlled for.

As a second robustness check I conduct the analyses at the individual level. The district level estimates do not take into account the difference in labor force characteristics for males and females in agriculture. To the extent that difference in characteristics are constant over time within a district, district fixed effects take into account the effect of these differential characteristics which are not changing over time, on male-female wage gap. To see if our results are robust to inclusion of individual characteristics I estimate the following equation. The differential impact of rainfall shocks on gender wage gap here is given by α_3. A significantly positive value of $\alpha_3$indicates that gender differential in wages is lower in years of good rainfall and greater in years of low rainfall.

$$\ln(W_{ijt}) = \alpha_0 + \alpha_1 RShock_{jt} + \alpha_2 Female_i + \alpha_3 RShock_{jt} * Female_i + \alpha_4 C_{ijt} + \alpha_5 D_j + \alpha_6 T_t + \varepsilon_{ijt}$$

[10] The district level crop-wise irrigated area is not reported for all states and hence to overcome this data constraint I use state level crop wise irrigated area(1999-2004) which is available for all states from Directorate of Economics and Statistics, Ministry of Agriculture, India.

Here, 'i' refers to an individual in district 'j' at time 't'. C_{ijt} are individual characteristics, D_j are district, T_t are time fixed effects. To check for the effect of rice suitability of an area, in the below specification I interact the rice suitability of a district with the interaction of female dummy and rainfall shock. α'_3 gives the differential impact of rainfall shock on gender differential in wages in rice suitable areas. A significantly positive value of α'_3indicates that gender differential in wages is lower in years of good rainfall and greater in years of low rainfall in rice suitable areas. X_{jt} includes district characteristics like percent literate population and percent area irrigated in a district which were controlled for in the baseline district level regressions.

$$\begin{aligned}\ln\left(W_{ijt}\right) = {} & \alpha_0 + \alpha_1 RShock_{jt} + \alpha_2 Female_i + \alpha_3 RShock_{jt} * Female_i + \alpha'_3 RShock_{jt} * Female_i \\ & * Rice_j + \alpha_4 RShock_{jt} * Rice_j + \alpha_5 Female_i * Rice_j + \alpha''_3 RShock_{jt} * Female_i \\ & * X_{jt} + \alpha_6 RShock_{jt} * X_{jt} + \alpha_7 Female_i * X_{jt} + \alpha_8 C_{ijt} + \alpha_9 D_j + \alpha_{10} T_t + \varepsilon_{ijt}\end{aligned}$$

Table 10 shows the individual level results. Females earn on an average 26% less than males in agriculture. Wages increase with positive rainfall shocks and there is no differential impact on male and female wages at the overall level ($\alpha_3$is insignificant) in column (1). Column (2) includes the interaction of the rice suitability dummy with rainfall shock and female dummy. A one unit increase in rainfall shock in rice suitable areas increases female wages relative to male wages by 3.4%. Thus, the result obtained at district level though lower in magnitude at individual level is still maintained. The individual results show that in rice growing states the gender differential in wages is 15% lower than other areas which is in line with the finding of Mahajan and Ramaswami(2012) that in rice growing areas demand for female labor is more in agriculture which results in lower wage gap in rice growing areas. The proportion of literates in a district has a significantly positive effect on wages and its interaction with the rainfall shock has a significant negative effect, which is again in accordance with the district level results. The interaction of proportion area under irrigation with rainfall shock has a significantly positive effect on wages which also confirms the district level results that wages are more variable to shocks in better irrigated areas.

Column (3) in Table 10 shows the individual regressions with the alternative definition of rain-fed rice cultivation in a district. It shows the results when percentage area under rain-fed rice cultivation for all districts is used as the definition. The previous findings continue to hold. In general the wage gap between males and female is lesser in rice growing regions but it exacerbates during negative rainfall shocks and decreases during positive rainfall shocks.

8. Possible mechanisms:

As discussed in the theoretical section there can be both demand side and supply side phenomenon which can result in differential effect of rainfall shocks on male and female wages. Which side of the labor market is driving the above findings is of interest to understand the gender dynamics in the agricultural labor market. The documented anecdotal evidence on rice cultivation and women suggests that demand for females is more in rice growing areas in years of good rainfall since females are in greater demand in rice cultivation due to their comparative advantage in tasks like transplanting and weeding. But could it also be that in these rice growing areas females are not able to adjust their labor supply in bad rainfall years as compared to men which results in larger wage gap. Thus, to control for possible supply side effects we control for district level labor supply of males and females in the specification in Table 11. The main results are not affected by including labor supply as a control. The coefficient of labor supply ratio of female to males is negative as expected, indicating that wage ratio falls as labor supply ratio of females to males increases. In column (1) rice suitability is defined by a dummy variable and in columns (2) and (3) district level rice percentage under rain-fed conditions is used to define rice growing areas. In column (3) we include the level of female and male labor supply instead of their ratio but find similar results. However, labor supply can be endogenous to wages and hence the results obtained from this specification will be biased if labor supply is not instrumented. We cannot think of a suitable instrument for labor supply changes over time, thus this is the best that can be done given that one cannot get a suitable instrument.

To further explore the possible mechanisms we also look at the effect of rainfall shocks on crop yields as area under rain-fed rice cultivation increases. Table 12 shows the results for four major crops. The estimates show that as area under rain-fed rice cultivation increases, the yield of rice is affected more by rainfall shocks. However, for the other crops the yield is affected less in rain-fed rice cultivating regions. This result could be due to higher absolute level of rainfall in rain-fed rice growing areas as compared to the other areas (which makes these regions suitable for cultivation of transplanted paddy), so even if rainfall is below the twentieth percentile the yield of crops like wheat, gram and bajra is affected less. These crops require less water than rice and hence can be grown even in drought like conditions in the rain-fed rice cultivating regions. Also, these crops require less female labor in comparison to rice, thus lesser reduction in yield of these crops would lead to a greater fall in demand for female labor as compared to male labor. Pandey et al(2007) document in their report the coping strategies of rice growing farmers in regions of eastern India during years of low rainfall. They find that 10% farmers in Jharkhand and 20% in Orissa report change in crop establishment of rice from transplanting to broadcasting. The technique of broadcasting absorbs lesser female labor as compared to the technique of transplanting which can only be conducted in flooded fields (Sen, 1985). Around 50% of farmers reported changes in cropping pattern altogether in bad rainfall years with either an early sowing of the next season crop or replanting with a different crop other than rice. Usually in rice growing areas, the rice-wheat or rice-pulse cultivation pattern is followed and hence wheat, pulse or cash crops like vegetables are usually grown to compensate for the loss of the rice crop. The remaining farmers resorted to migration to distant cities in search of work. The above findings and documented evidence suggests that in rice growing areas in good rainfall years rice is transplanted as compared to low rainfall years in which other crops are used to substitute for rice and the technique of broadcasting is used in rice cultivation which reduces the marginal product of female labor more than it reduces the marginal product of male labor. Thus, the observed variation in wage gap in rice suitable areas could be a result of relatively greater fall in marginal product of female labor as compared to male labor due to asymmetric demand effect.

Another test to distinguish between the labor demand and labor supply effects could be to check the effect of rainfall shocks on quantity of male and female labor employed. Given positive sloping labor supply curves, if greater fall in women's wage relative to men is due to differential fall in demand then female hours of work should be impacted more relative to men in rice growing regions. On the other hand, if differences in labor supply elasticity are driving the results then women's hours of work should be affected less relative to men in rice growing regions. To check this hypothesis, we estimate the below equations:

$$L_{jt}^{M} = \alpha_0 + \beta_1 (RShock)_{jt} + \alpha_1 (RShock)_{jt} * Rice_j + \alpha_2 D_j + \alpha_3 T_t + \epsilon_{jt}$$
$$L_{jt}^{F} = \alpha'_0 + \beta'_1 (RShock)_{jt} + \alpha'_1 (RShock)_{jt} * Rice_j + \alpha'_2 D_j + \alpha'_3 T_t + \epsilon_{jt}$$
$$L_{jt}^{F} - L_{jt}^{M} = \gamma_0 + \gamma_1 (RShock)_{jt} + \gamma'_1 (RShock)_{jt} * Rice_j + \gamma_2 D_j + \gamma_3 T_t + \epsilon_{jt}$$

Here L is defined as the number of days worked in agriculture per person per week in age 15-60 in rural areas of district 'j' at time 't'. If the relative demand effects in rice growing areas are at work then the sign of γ'_1 should be positive.

Another check for the mechanism could be differential variation in unemployment rates for males and females. To check the hypotheses if unemployment rates among males and females are differentially affected in rice growing areas as compared to non-rice growing areas, we estimate the below equation:

$$U_{jt}^F - U_{jt}^M = \gamma_0 + \gamma_1(RShock)_{jt} + \gamma'_1(RShock)_{jt} * Rice_j + \gamma_2 D_j + \gamma_3 T_t + \epsilon_{jt}$$

Here U is defined as the number of days unemployed per person per week in age 15-60 in rural areas of district 'j' at time 't'. If the relative demand effects in rice growing areas are at work then the sign of γ'_1 in the above equation should be negative.

Table 13 shows the results for days worked in cultivation and unemployed. Rainfall shock and days worked in agriculture are positively associated as expected, though not significant. In rice growing areas the effect of rainfall shocks on male hours worked is less and significantly negative. The relative effect on female to male hours is positive and significant in both panel A and B. This evidence is suggestive of demand side effects in rice growing regions. The last column in Table 13 shows the results for estimation with unemployment days. As the results show, women in rice growing areas suffer a larger increase in unemployment relative to men when rainfall is low. Again, this evidence is also suggestive of demand side effects resulting in larger gender wage gap in rice growing areas in years of low rainfall.

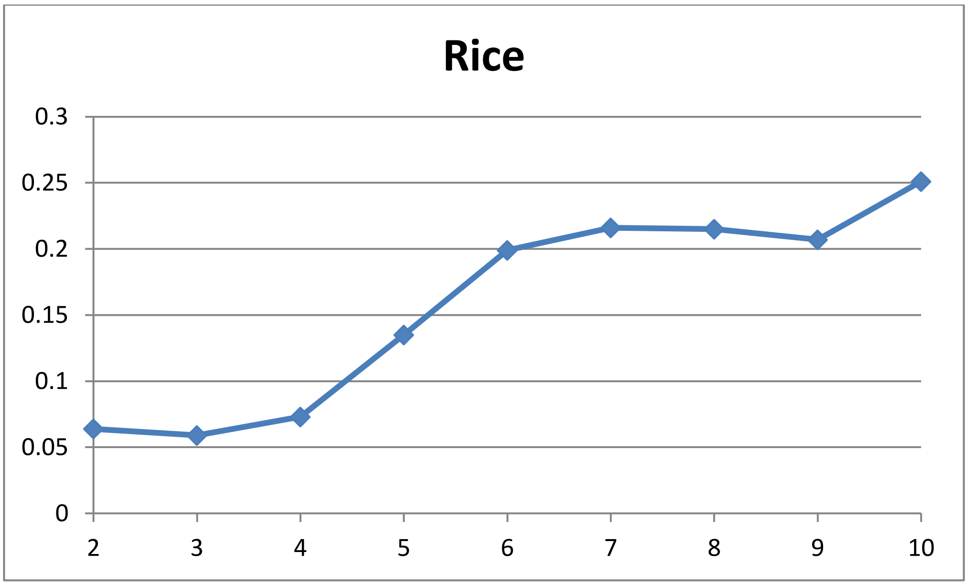
10. Conclusion

In this paper we examine if the shocks to agricultural productivity like rainfall variability over the years affect the wages received by men and women differently. Overall we do not find any effect of such shocks on gender wage gap. However, in rain-fed rice growing regions of India females suffer a greater loss in their wages as compared to men, thus increasing the gender wage gap during low rainfall years. We try to find the mechanism through which the differential effect on wages may occur. The results indicate that the differential variation in wages to such shocks can be due to underlying differential effect on gender demand as a result of production technology in agriculture. Greater demand for women in cultivation of crops which are severely affected by rainfall variability can make them more vulnerable to labor market losses during low rainfall years.

Table 1. Female to male wage ratio for manual laborers in agriculture

State	1993	1999	2004	2007
Andhra Pradesh	72%	67%	65%	70%
Bihar	87%	88%	87%	89%
Gujarat	98%	89%	90%	99%
Haryana	85%	90%	84%	83%
Karnataka	73%	68%	69%	70%
Kerala	70%	63%	59%	63%
Madhya Pradesh	83%	85%	83%	86%
Maharashtra	63%	65%	63%	68%
Orissa	73%	79%	72%	77%
Punjab	99%	94%	83%	88%
Rajasthan	75%	80%	81%	89%
Tamil Nadu	57%	58%	54%	52%
Uttar Pradesh	75%	78%	83%	84%
West Bengal	88%	89%	88%	94%
All India	72%	72%	70%	74%

Figure 1. Effect of Rainfall deciles on yield variability



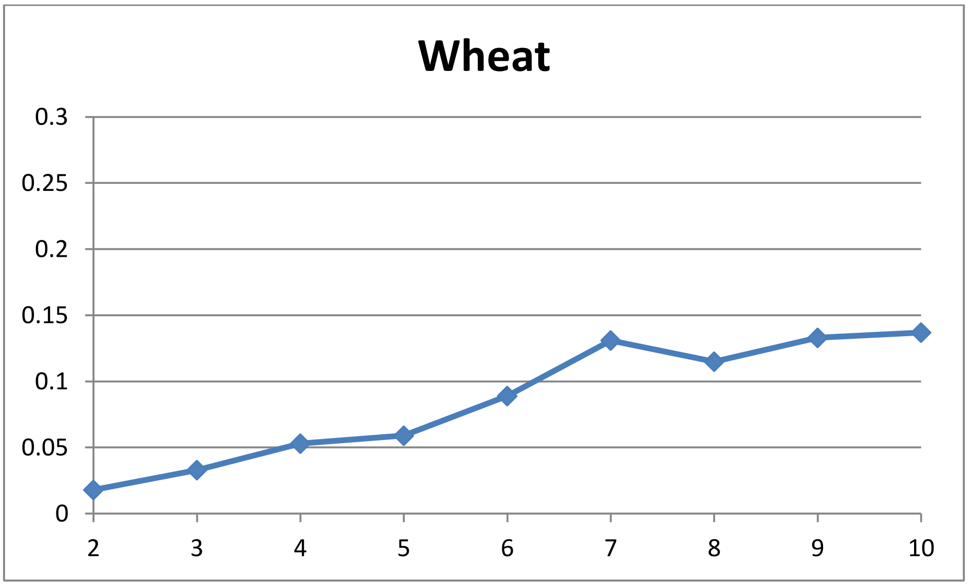


Table 2. Effect of rainfall shock on yield of major crops

	Rice	Wheat	Bajra	Gram
Rainfall shock	0.087***	0.057***	0.080***	0.083***
	(0.009)	(0.007)	(0.014)	(0.009)
Constant	0.519***	0.656***	-0.217***	-0.288***
	(0.014)	(0.011)	(0.023)	(0.015)
District fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes
Observations	4,112	3,548	2,628	3,560

Notes: The dependent variable is the log of yield of a crop in a district according to 2001 census district boundaries for the 14 major states in the analyses.

Table 3. Cropping pattern and rainfall

State	Lon term average Monsoon rainfall (mm)	Area under rice cultivation
Kerala	1,902.69	95%
West Bengal	1,426.71	74%
Orissa	1,144.99	80%
Bihar	1,011.28	55%
Madhya Pradesh	979.59	24%
Maharashtra	900.43	8%
Uttar Pradesh	863.33	26%
Karnataka	850.24	13%
Gujarat	703.17	7%
Tamil Nadu	633.60	39%
Andhra Pradesh	613.68	30%
Punjab	510.39	39%
Haryana	457.95	19%
Rajasthan	386.28	1%

Table 4. Variable definitions and Summary statistics

Variable	Definition	Mean	Standard deviation
Male wage	Real average wage of male casual laborers in cultivation aged 15-60	10.21	8.55
Female wage	Real average wage of female casual laborers in cultivation aged 15-60	8.02	4.48
Literate	Percentage literate population	0.51	0.13
Bus	Percentage villages connected by bus	0.41	0.33
Irrigation	Percentage area irrigated in a district	0.35	0.27
Road	Percentage villages connected by paved roads	0.51	0.29
Rail	Percentage villages connected by rail	0.02	0.02
Bank	Percentage villages having a commercial bank branch	0.09	0.12
Town	Mean distance from Town (km)	21.34	11.48
Landless	Percentage landless households	0.13	0.12
Per capita expenditure	Mean monthly per capita expenditure of a household in 1993	292.75	67.69
Labor supply males	Average days worked in a reference week in cultivation by a male aged 15-60	3.39	1.08
Labor supply females	Average days worked in a reference week in cultivation by a female aged 15-60	1.50	1.12
Unemployment Males	Average days spent unemployed in a reference week by males aged 15-60	0.27	0.21
Unemployment Females	Average days spent unemployed in a reference week by females aged 15-60	0.11	0.15

Table 5. Impact of rainfall shocks on wages and gender differential in wages

	Female wage	Male wage	Wage ratio
RainShock	0.036**	0.024*	0.012
	(0.014)	(0.014)	(0.013)
Constant	1.259***	1.492***	-0.233***
	(0.017)	(0.017)	(0.014)
Observations	1,216	1,216	1,216
R-squared	0.874	0.903	0.493
District and Year Fixed effects	Yes	Yes	Yes

Notes: Log of wages and log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 6. Differential impact of rainfall shocks on gender differential in wages in rain-fed rice growing areas

	Female wage	Male wage	Wage ratio	Wage ratio
RainShock	0.037***	0.039**	-0.001	-0.002
	(0.014)	(0.015)	(0.014)	(0.014)
RainShock*Rice	-0.005	-0.053*	0.048*	0.046*
	(0.032)	(0.032)	(0.025)	(0.025)
Constant	1.259***	1.490***	-0.231***	-0.225***
	(0.017)	(0.017)	(0.014)	(0.014)
Observations	1,216	1,216	1,216	1,171
R-squared	0.874	0.903	0.495	0.501
District and Year Fixed effects	Yes	Yes	Yes	Yes

Notes: Log of wages and log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 7. Differential impact of rainfall shocks on gender differential in wages in rain-fed rice growing areas conditional on district controls

	Female wage	Male wage	Wage Ratio
RainShock	0.153***	0.101*	0.051
	(0.056)	(0.055)	(0.052)
RainShock*Rice	-0.005	-0.057*	0.052**
	(0.029)	(0.029)	(0.025)
Literate	0.127	0.042	0.085
	(0.177)	(0.144)	(0.173)
Literate*RainShock	-0.287***	-0.200**	-0.087
	(0.103)	(0.099)	(0.092)
Irrigation	0.034	0.008	0.026
	(0.058)	(0.061)	(0.045)
Irrigation*RainShock	0.108*	0.129**	-0.022
	(0.058)	(0.057)	(0.056)
Constant	1.207***	1.476***	-0.269***
	(0.079)	(0.064)	(0.072)
Observations	1,216	1,216	1,216
R-squared	0.876	0.905	0.496
District and Year Fixed effects	Yes	Yes	Yes

Notes: Log of wages and log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 8(a). Differential impact of rainfall shocks on gender differential in wages in rain-fed rice growing areas conditional on other development indicators

	Wage Ratio	Wage Ratio	Wage Ratio
Indicator	Bus	Road	Rail
RainShock	0.054	0.057	0.048
	(0.052)	(0.051)	(0.052)
RainShock*Rice	0.059**	0.063**	0.052**
	(0.027)	(0.027)	(0.025)
Literate	0.088	0.097	0.083
	(0.174)	(0.173)	(0.174)
Literate*RainShock	-0.124	-0.132	-0.076
	(0.097)	(0.100)	(0.091)
Irrigation	0.031	-0.016	0.023
	(0.046)	(0.058)	(0.046)
Irrigation*RainShock	-0.029	-0.041	-0.019
	(0.054)	(0.055)	(0.057)
Indicator	-0.079	0.084	0.319
	(0.108)	(0.075)	(0.675)
Indicator*RainShock	0.034	0.040	-0.241
	(0.040)	(0.047)	(0.700)
Constant	-0.241***	-0.296***	-0.273***
	(0.087)	(0.077)	(0.073)
Observations	1,216	1,216	1,216
R-squared	0.496	0.497	0.496
District and Year Fixed effects	Yes	Yes	Yes

Notes: Log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 8(b). Differential impact of rainfall shocks on gender differential in wages in rain-fed rice growing areas conditional on other development indicators

	Wage Ratio	Wage Ratio	Wage Ratio
Indicator	Bank	Town	All
RainShock	0.052	0.067	0.077
	(0.052)	(0.064)	(0.063)
RainShock*Rice	0.052**	0.053**	0.076***
	(0.025)	(0.024)	(0.028)
Literate	0.085	0.085	0.099
	(0.173)	(0.173)	(0.175)
Literate*RainShock	-0.090	-0.089	-0.142
	(0.091)	(0.093)	(0.102)
Irrigation	0.026	0.025	-0.014
	(0.045)	(0.046)	(0.059)
Irrigation*RainShock	-0.021	-0.029	-0.049
	(0.056)	(0.059)	(0.062)
Indicator			
Indicator*RainShock	0.007	-0.001	
	(0.103)	(0.001)	
Constant	-0.269***	-0.269***	-0.260***
	(0.072)	(0.072)	(0.090)
Observations	1,216	1,216	1,216
R-squared	0.496	0.496	0.498
District and Year Fixed effects	Yes	Yes	Yes

Notes: Log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 8(c). Differential impact of rainfall shocks on gender differential in wages in rain-fed rice growing areas conditional on other development indicators

	(1)	(2)
	Wage Ratio	Wage Ratio
Indicator	Landless	Per capita expenditure
RainShock	0.082	0.066
	(0.063)	(0.076)
RainShock*Rice	0.074***	0.078***
	(0.028)	(0.029)
Literate	0.088	0.101
	(0.176)	(0.174)
Literate*RainShock	-0.136	-0.146
	(0.104)	(0.109)
Irrigation	-0.014	-0.012
	(0.059)	(0.060)
Irrigation*RainShock	-0.046	-0.051
	(0.061)	(0.062)
Indicator	-0.047	
	(0.094)	
Indicator*RainShock	-0.082	0.000
	(0.099)	(0.000)
Constant	-0.247***	-0.261***
	(0.091)	(0.089)
Observations	1,216	1,216
R-squared	0.498	0.498
District and Year Fixed effects	Yes	Yes

Notes: Log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 9. Differential impact of rainfall shocks on gender differential in wages with alternative rain-fed rice cultivation definitions

	Female wage	Male wage	Wage Ratio
RainShock	0.152***	0.099*	0.053
	(0.057)	(0.054)	(0.052)
RainShock*Rice	-0.064	-0.169**	0.104*
	(0.067)	(0.065)	(0.056)
Literate	0.139	0.063	0.075
	(0.177)	(0.143)	(0.173)
Literate*RainShock	-0.267**	-0.161	-0.107
	(0.109)	(0.099)	(0.094)
Irrigation	0.033	0.006	0.026
	(0.058)	(0.061)	(0.046)
Irrigation*RainShock	0.101*	0.102*	-0.001
	(0.061)	(0.058)	(0.056)
Constant	1.202***	1.467***	-0.265***
	(0.079)	(0.064)	(0.072)
Observations	1,216	1,216	1,216
R-squared	0.877	0.905	0.495
District and Year Fixed effects	Yes	Yes	Yes

Notes: Log of wages and log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively.

Table 10. Impact of rainfall shocks on wages using individual level data

	(1)	(2)	(3)
	Wage	Wage	Wage
RainShock	0.034***	0.170***	0.170***
	(0.004)	(0.019)	(0.019)
Female	-0.268***	-0.226***	-0.235***
	(0.004)	(0.014)	(0.014)
Female*RainShock	0.002	0.046	0.034
	(0.006)	(0.028)	(0.029)
Female*Rice		0.151***	0.447***
		(0.009)	(0.019)
RainShock*Rice		-0.034***	-0.093***
		(0.009)	(0.021)
Female*RainShock*Rice		0.034**	0.068**
		(0.015)	(0.033)
Literate		0.203***	0.236***
		(0.043)	(0.043)
Literate*RainShock		-0.381***	-0.361***
		(0.033)	(0.034)
Female*Literate		-0.156***	-0.228***
		(0.026)	(0.026)
Female*Literate*RainShock		-0.002	-0.008
		(0.050)	(0.052)
Irrigation		-0.015	-0.033**
		(0.016)	(0.016)
Irrigation*RainShock		0.213***	0.192***
		(0.016)	(0.017)
Female*Irrigation		0.018	0.070***
		(0.016)	(0.016)
Female*Irrigation*RainShock		-0.140***	-0.110***
		(0.025)	(0.025)
Constant	1.164***	1.099***	1.085***
	(0.016)	(0.024)	(0.024)
Observations	84,793	84,793	84,793
R-squared	0.619	0.624	0.625
District controls	No	Yes	Yes
District and Year Fixed effects	Yes	Yes	Yes

Notes: Log of wage is the dependant variable. The regressions are weighted using the sampling weights in National sample survey. Robust standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively. Individual controls include age, age square, education and task dummies. In column (2) rice is defined as a dummy for states having at least 50 percent area under rice cultivation. In column (3) rice is defined as district level area under rice cultivation under rain-fed conditions.

Table 11. Differential impact of rainfall shocks on gender differential in wages in rice suitable areas conditional on labor supply

	(1)	(2)	(3)	(4)
	Wage Ratio	Wage Ratio	Wage Ratio	Wage Ratio
RainShock	0.052	0.052	0.054	0.054
	(0.053)	(0.052)	(0.052)	(0.052)
RainShock*Rice	0.052**	0.053**	0.105*	0.107*
	(0.025)	(0.025)	(0.056)	(0.056)
Literate	0.069	0.068	0.060	0.058
	(0.174)	(0.174)	(0.174)	(0.174)
Literate*RainShock	-0.089	-0.087	-0.109	-0.107
	(0.093)	(0.092)	(0.094)	(0.094)
Irrigation	0.026	0.026	0.027	0.027
	(0.046)	(0.046)	(0.046)	(0.046)
Irrigation*RainShock	-0.020	-0.022	0.001	-0.001
	(0.056)	(0.055)	(0.056)	(0.055)
Labor supply ratio	-0.051		-0.049	
	(0.043)		(0.044)	
Labor supply females		-0.014		-0.014
		(0.014)		(0.014)
Labor supply males		0.006		0.005
		(0.014)		(0.014)
Constant	-0.239***	-0.260***	-0.237***	-0.255***
	(0.078)	(0.089)	(0.079)	(0.089)
Observations	1,216	1,216	1,216	1,216
R-squared	0.496	0.496	0.496	0.496
District and Year Fixed effects	Yes	Yes	Yes	Yes

Notes: Log of wages and log of female to male wage ratio is the dependant variable. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively. In columns (1) and (2) rice is defined as a dummy for states having at least 50 percent area under rice cultivation. In columns (3) and (4) rice is defined as district level area under rice cultivation under rain-fed conditions.

Table 12. Effect of rainfall shocks on yield of crops

	Rice	Wheat	Bajra	Gram	Rice	Wheat	Bajra	Gram
RainShock	0.056***	0.071***	0.117***	0.095***	0.163***	0.128***	0.270***	0.158***
	(0.011)	(0.008)	(0.016)	(0.011)	(0.019)	(0.014)	(0.027)	(0.018)
Rice*RainShock	0.188***	-0.089***	-0.546***	-0.086*	0.087**	-0.141***	-0.592***	-0.131***
	(0.042)	(0.032)	(0.107)	(0.046)	(0.044)	(0.034)	(0.106)	(0.047)
Irrigation*Rainshock					-0.204***	-0.111***	-0.319***	-0.131***
					(0.030)	(0.022)	(0.045)	(0.030)
Constant	0.515***	0.658***	-0.207***	-0.285***	0.518***	0.660***	-0.204***	-0.283***
	(0.014)	(0.011)	(0.023)	(0.015)	(0.014)	(0.011)	(0.023)	(0.015)
Observations	4,110	3,548	2,628	3,560	4,110	3,548	2,628	3,560
R-squared	0.810	0.879	0.713	0.654	0.812	0.880	0.719	0.656
District and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the log of yield of a crop in a district according to 2001 census district boundaries for the 14 major states in the analyses. Standard errors are in parenthesis; ***, ** and * indicate significance at the 1, 5 and 10% levels respectively. Rice is defined as district level area under rice cultivation under rain-fed conditions.

Table 13. Impact of rainfall shocks on days worked in agriculture and unemployment days per person per week

Panel A				
	Female Days	Male Days	Relative Female days	Relative Female unemp days
RainShock	0.056	0.028	0.028	0.021**
	(0.047)	(0.063)	(0.053)	(0.009)
RainShock*Rice	-0.020	-0.150*	0.130*	-0.040*
	(0.055)	(0.082)	(0.073)	(0.021)
Constant	1.591***	3.581***	-1.990***	-0.128***
	(0.046)	(0.064)	(0.047)	(0.008)
Observations	1,216	1,216	1,216	1,216
R-squared	0.824	0.744	0.820	0.586
District and Year Fixed effects	Yes	Yes	Yes	Yes

Panel B				
	Female Days	Male Days	Relative Female days	Relative Female unemp days
RainShock	0.047	0.044	0.003	0.028***
	(0.049)	(0.062)	(0.053)	(0.009)
RainShock*Rice	0.027	-0.388**	0.415**	-0.119**
	(0.143)	(0.190)	(0.181)	(0.054)
Constant	1.592***	3.583***	-1.991***	-0.127***
	(0.046)	(0.062)	(0.045)	(0.008)
Observations	1,216	1,216	1,216	1,216
R-squared	0.824	0.744	0.820	0.588
District and Year Fixed effects	Yes	Yes	Yes	Yes

Notes: In Panel A, rice is a dummy variable for major rice growing states whereas in Panel B district level rice percentage under rain-fed conditions is used. The unit of analyses is a district and analytical weights equal to district rural population are used. Robust clustered standard errors are in parenthesis; ***, ** , * and # indicate significance at the 1, 5, 10 and 15% levels respectively.

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