Moving Women: Household Composition, Labor Demand and Crop Choice*

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Abstract

This paper estimates the effect of increases in the relative value of female labor induced by rainfall shocks on the gender composition of rural agricultural households in India. Much of the previous literature in this vein has focused exclusively on the gender composition of young children due to excess female mortality. Using a unique panel dataset from India, I focus instead on the changes in the gender composition of prime aged adults. Rice production is known to be more intensive in female labor than wheat production, and is more dependent on rainfall. I compare how rice and wheat households adjust the composition of their adult membership in response to rainfall shocks that differentially raise the relative marginal products of female labor, controlling for farm and household-level heterogeneity using fixed effects. Consistent with a model of household composition and crop choice in the presence of imperfect labor markets, I find that positive rainfall shocks are associated with an increase in the relative number of prime age females in rice households. Timing of marriage of daughter's of household heads is one of the main mechanisms adjusting the gender composition of prime aged adults in these households. I find that a one standard deviation increase in rainfall decreases the rate of marriage among young adult females in rice households by approximately 10 percent relative to wheat households. Dowries paid out by rice households also decline by a similar magnitude, indicating a rise in the value of female labor.
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1 Introduction

Most studies in economics treat household composition as exogenous, using variations in proportion of females in the household, for example, to explain variations in outcomes such as household consumption. However, a number of studies have shown that this assumption is suspect. The well know missing women studies, such as Rosenzweig and Schultz (1982) and Qian (2005), show that the gender composition of young children is responsive to changes in the relative value of female labor. In general, these studies show that increases in the relative value of female labor mitigate the gender disparities in mortality among children. Rose (1999) uses the gender composition of young children to infer the extent of gender biases in intra-household allocation in rural India. She shows that negative rain fall shocks decrease the survival probability of girls relative to boys and attributes these gender differences to the inability of households to smooth consumption. A number of authors such as Bardhan (1974) have argued that the economic value of women is driven by differences in the female intensity of agricultural production. They argue that rice farming is more intensive in female labor and thus the survival probability of girls would be higher in rice growing areas relative to wheat growing areas. Whereas these studies have mostly focused on the gender composition and mortality outcomes of young children, I focus on the responsiveness of the gender composition of adults in households to changes in the relative value of female labor in rural India. The primary mechanisms through which households can alter the gender composition of adults are marriage and migration. Households can increase the proportion of adult females by marrying their sons earlier, or by delaying the marriage of their daughters or through the migration of sons to other villages or urban areas. Since rice production is more responsive to rainfall than wheat production, rainfall shocks in rice areas will increase the demand for female labor. I exploit the difference in the responsiveness of rice production to rainfall to examine the effect of increases in the value of female labor on the probability of marriage of sons and daughters in rice and wheat growing areas. Additionally, I examine the effect of positive rainfall shocks on the migration patters of sons in rice and wheat growing areas.

There are a small number of studies that focus on the relationship between gender differences in the value of labor and gender composition of adults. Jacoby (1995) finds that the incidence of polygyny is greater when the value of female labor is higher. He argues that in the absence of labor markets for females, the institution of marriage is one of the major mechanisms through which households can augment their female labor force. Using panel data from Cote d'Ivoire, he finds the demand for wives is greater among men who own farms on which female labor is more productive. Foster and Rosenzweig (2003) show that household division is related to changing economic environments. They find that the advent of technological change brought about by the Green Revolution, educated members of the households had greater incentives to form their own households as their private gains to living in a separate household in the epoch of technical change were greater than the gains to remaining unified.

Census data from India show that the overall sex ratio, (the number of females per 1000 males), fell from 972 in 1901 to 922 in 2001. Moreover, the spatial pattern of the sex ratio shows a stark division across India, where the proportion of females is much lower in Northern India relative to the South.[1] Many observers, such as Das Gupta (1987) have attributed these salient patterns to greater cultural son preferences in the Northern states relative to the South. In her widely cited book, Miller (1981) suggests that these son preferences are derived from the practice of paying dowry to the groom's family at the time of marriage. Dyson and Moore (1983) argue that these differences are derived from differences in the kinship structure and marriage practices between the North and the South. They argue that in Southern India marriages between relatives are more likely than in Northern India, where these marriages are associated with low dowry payments. This would lead to a situation where daughters in Southern India would have closer links to their parents compared to Northern India.

However, there is a large body of literature that shows that economic forces and market incentives could explain this variation in sex ratios between Northern and Southern India. As a number of authors have observed, the are also stark differences in agricultural land use between Northern and Southern India. The staple crop in Northern India is wheat while the staple crop is rice in the South. Bardhan, in his 1974 essay, ponders whether the underlying the gender imbalances were related to the differences in the returns to male and female labor farming these crop. He states:

"Transplantation of paddy is an exclusively female job in paddy [rice] 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 tedious, often back-breaking, but delicate, operations... Could it be that in areas with paddy [rice] agriculture, the economic value of a woman is more than in other areas- so that the female child is regarded as less of a liability than in, say North-West India?" (Bardhan 1974, pg 1304)

Previous studies such as Mayer (1999), examined the cross sectional relationship between aggregate level sex ratios and the crop mix. They find that rice growing areas had greater proportions of women relative to wheat growing areas. However, due to the cross sectional nature of these studies, their findings could merely reflect an omitted factor such as culture. Qian's (2005) innovative study in China rigorously examines the relationship between crop choices and gender bias. She shows that exogenous increases in the price of tea, which she argues is a female intensive crop, increases the percentage of females in tea producing counties, whereas price increases of orchards crops, which she argues are male intensive, decrease the percentage of females in orchard counties. In a similar

[1]Figure 1 shows the 1991 district level sex ratios (ratio of women to men per 1000) in India.

manner I use panel data from rural India and exploit variations in the differences in the demand for female labor induced by rainfall shocks in rice suitable areas relative to wheat suitable areas in order to examine the effect of increases in the value of female labor on the gender composition of adult household members. It is widely accepted that rice production is more intensive in female labor relative to wheat farming. The conventional wisdom is that females have a comparative advantage in tasks such as weeding and transplanting which require great dexterity and nimbleness. Additionally, rice is a water intensive crop requiring at least 1,000 MM. of precipitation in a season.[2] Thus increased rainfall in a rice suitable area would increase the demand for female labor as the profitability of rice relative to other crops (such as wheat) would increase.

Using panel data from India, I show that positive rainfall shocks increase the demand for adult females for households in rice suitable areas relative to wheat suitable areas. I focus on marriage and migration as the predominant mechanisms through which households can change the gender composition of adults. The majority of marriages in India are characterized by patrilocal exogamy, where females move out of the natal village to co-reside with their husband's family. With imperfect labor markets, families that cultivate rice would have greater incentives to delay the marriage of their daughters in response to a rainfall shock relative to wheat growing families. I find that a one standard deviation increase in rainfall over the mean, decreases the marriage rates of females in rice growing areas by approximately 10 percent relative to households in wheat growing areas. In addition, I find that the dowry paid by households who marry of a daughter in a year with a positive rainfall shock, are also reduced by approximately 10 percent for households in rice growing areas relative to households in wheat growing areas.

In a similar manner, I also examine the effects of rainfall shocks on the migration of adult men in rice and wheat growing areas. Unlike most developing countries the migration of males in rural India is quite low. Munshi and Rosenzweig (2005) show that the out migration rates of males to be approximately 6 percent in 1999. However, Foster and Rosenzweig (2003) show that the household composition can also be affected by household division. I do not find any relationship between the probability of male out migration and rainfall shocks for landed households. I do, however, find that positive rainfall shocks in wheat growing areas reduce the probability that sons in landowning families leave their original households to start new ones

These results show that the gender composition of household responds to incentives emanating from rural labor markets. Moreover, I show that the previously highlighted results are consistent with a farm household model facing imperfect labor markets, such that the household cannot hire enough labor for its farm. The remainder of the paper is organized as follows. Section 2 describes the contextual setting and provides details about rice and wheat production. Section 3 outlines the theory of a farm household optimizing its composition and its production decisions. Section 4

[2] See Figure 2 for the optimum ecological environment for rice and other crops

provides the estimation strategy while Section 5 describes the data. Section 6 provides the results and Section 7 provides the concluding remarks.

2 Background

2.1 Rice and Wheat Production

This study is based in rural India where rice and wheat are the dominant staple crops. Data from a representative household survey of India show that 80 percent of households in this sample rural India grew at least one of these crops. As we can see in Figure 3, 60 percent of households surveyed grew rice, while approximately 45 percent grew wheat. As Bardhan (1974) noted, there are important differences in the production of rice and wheat which affect the relative returns to female agricultural labor in these crops. Thus, it is critical to understand the cultivation process of these two staples to illuminate the sources of the gender differences in the return to labor in these two crops. As Figure 5 shows there are stark differences in the gender division of labor between these two crops. While these gender divisions could simply reflect cultural norms about male and female work, there is evidence to suggest that these patterns could reflect the allocation of workers to tasks based on comparative advantage.

The majority of rice in India is grown in flooded rice paddies. Rice yields are greatly increased when rice is grown in flooded fields as the rice plant is better able to extract nutrients under this condition. However rice seeds cannot germinate under flooded conditions thus rice farmers must first grow seedlings in nurseries and then manually transplant them into the flooded field to assure increased yields. Transplanting is an extremely labor intensive task. An International Rice Research Institute (IRRI) report estimated that the transplanting required on average 77 person-days of labor per hectare. Mies (1986) argues that transplanting is the most labor intensive operation in rice cultivation. She describes transplanting as a process where women wade through muddy fields to plant each rice seedling into the field and spend a large amount of time bending down. She further reports the attitude of men towards transplanting. When asked why men do not perform transplanting, a male farmer in her study village replied that men "cannot not bend their backs the whole day, as can women. Moreover, men's work such as... ploughing, drawing water, was harder" (pg. 66). This attitude would seem to suggest that these gender divisions in labor were related to the comparative advantage of male and female labor. Bardhan (1974) noted that female labor intensity in rice was much greater than in wheat farming. Indeed, Foster and Rosenzweig (1998) using data from Philippines show that the allocation of workers by gender across various agricultural tasks was related to comparative advantage in those tasks whereby women were disproportionately represented in weeding relative to men. Men have the comparative advantage in plowing using bullocks which requires greater upper body strength to effectively plow, whereas women have the advantage in the tasks which require delicate and deft hands such as transplanting and weeding.[3] Figure 4 shows the total labor intensity of different tasks across rice and wheat, while Figure 5 shows average female labor intensity across agricultural tasks in these two crops. It is clearly evident from these figures that the major differences in the gender division of labor between rice and wheat production is in transplanting where women's sowing and transplanting labor in rice was twice that compared to wheat cultivation. Additionally, the tasks where women have a comparative advantage, namely transplanting and weeding, account for a third of the total labor percentage used in rice farming whereas these tasks only account for slightly less than a fifth of the total in wheat production.

Differences in soil and climate conditions determine the suitability of growing a certain crop in a village. Figure 2 shows the optimal ecological conditions for various crops as determined by the Food and Agricultural Organization (FAO). These optimal environmental conditions vary greatly by crop. For instance, rice cultivation requires large amounts of water, whereas wheat cultivation requires far less water and is more suited to less acidic soil and temperate conditions relative to rice. Additionally, rice can grow on a wide range of soil textures including coarse (sandy), medium (loamy) and heavy (clay) textures. Although heavy soil has the ability to retain more water, it is very difficult to plow and till this type of soil as it can become very hard during the hot pre-monsoon season. Sandy soil on the other hand does not retain water moisture well and thus requires more water to farm any crop on this type of soil, especially rice.

The predominant environmental conditions will determine the set of crops that are best suited to each region. Rice is best suited for lower soil pH areas with medium soil texture and high water availability. Furthermore, Indian agriculture is heavily dependent on the Southwest monsoon that arrives between June and August. Approximately 80 percent of India's total precipitation falls during this period. Rice farmers are heavily reliant on monsoon rains to maintain the water levels in their rice paddies.[4] Binswanger and Rosenzweig (1993) show that late arriving monsoons are just as, if not more, important than the level of monsoon rainfall in rice production. Thus farmers must try to time their rice transplanting to ensure that their transplanted seedlings are not at risk dying due to the lack of rainfall caused by late arriving monsoons. It takes about one month for rice seedlings to be ready for transplanting. As mentioned earlier rice seedlings are grown in nurseries prior to the arrival of the monsoon. Thus rainfall in the pre-monsoon season will promote the development of rice seedlings enabling farmers to increase their cultivation of rice during the

[3] Qian (2005) similarly argues that women have a comparative advantage in picking tea leaves compared to men due to the delicate nature of the task

[4] Even though approximately 50% of Indian rice is cultivated under irrigated conditions, the surface and ground-water irrigation techniques employed are still reliant on monsoon rainfall to maintain their viability.

monsoon season thereby creating a greater demand for transplanting labor. Additionally, pre-monsoon rain softens the ground making plowing, tilling, leveling and other land preparation for rice paddies much easier. After the rice is transplanted, men will irrigate and apply fertilizer or manure to the rice, while women will weed the rice manually. Upon maturation of the crop the rice will be harvested by both men and women.

Wheat is grown mostly in the winter season starting in October. Wheat grows best in areas where the soil is able to retain moisture from the monsoon season as the rainfall during the winter season is not as abundant. Although a large proportion of the area cultivated with wheat is irrigated, pre-monsoon rain and monsoon rain will increase the profitability of wheat through their effects on soil moisture and ground water levels. Wheat farmers first plow and till the ground using bullocks and will then broadcast the wheat seeds into the plowed grounds. The crop will be weeded, fertilized and irrigated up to maturity where it will be harvested. Female labor will be concentrated in weeding and harvesting of wheat. Thus relative to rice, the labor demand of females in wheat farming is much lower mainly due to the demand for transplanting labor in rice.

2.2 Marriage in India

According to Rao (1982), marriage in India is typically viewed as a strategic alliance between two families rather than a union between a couple. As a result, the majority of marriages are arranged by parents and thus children have very little input in marriage decisions especially in rural areas. As Foster and Rosenzweig (1999) show, the majority of marriages in India are characterized by patrilocal exogamy, where daughters leave their natal villages to join their husband's household, which would be located in a different village up to 100 kilometers away.[5] Rosenzweig and Stark (1989) show that families use marriage exogamy to minimize their risks. They show that farm households with more variable farm profits were more likely to marry their daughters in distant villages relative to households with less variable profits. They argue that household's enter an implicit insurance arrangement through marriage in order to mitigate their risks and smooth consumption.

The custom of dowry, where the bride's family transfers a large sum of wealth to the groom's family, is common feature of marriages in India. Although dowries have been illegal in India since the 1960's, this law is not enforced. Miller (1981) argues that the dowry system is one of the major factors in the prevalence of gender bias in India. She argues that "if one were to ask a Jat farmer of the Punjab why too many daughters are a burden, one would not be told that is because many females are needed for wheat; rather the answer undoubtedly would be that it is costly to get daughters married" (pg 133). Dowries payments can equal one year of income, sometimes more depending on the characteristics of the bride and groom. Generally, dowry increases with the age

[5] The median marriage distance was approximately 25 km in their data.

of the bride and decreases with her education. Boserup (1970) suggests that dowry is related to the value of female labor. She argues that dowries are common in areas where the plow is used, whereas bride-prices are common in areas where the hoe is used to till the ground. She concludes that these differences are driven by the value of female labor as hoe agriculture is more intensive in female labor than plow agriculture. This suggests that dowries could reflect not only the characteristics of brides and grooms but could also respond to changes in the relative productivity of female labor.

3 Theoretical Framework

In order to better understand the role of crop choices on household composition, I present a standard agricultural household model that incorporates crop choice. The essence of this model is similar to the model used by Jacoby (1995) in his study of polygyny and to the model presented in Rosenzweig and Schultz (1982).

There are two crops, rice and wheat, whose production functions are G_1 and G_2 respectively,

$$G_i = G_i(L_{i,f}, L_{i,m}; A_o, A_u, \sigma); i = 1, 2 \tag{1}$$

Each crop is produced with female and male labor comprising of both family and hired labor, a vector of fixed factors, A, consisting of observable environment characteristics such as land holdings, soil and climate (A_o), unobservables such as farm land quality and farmer ability, (A_u) and a stochastic input, rainfall (σ). Rice is more intensive in female labor compared to wheat so that

$$\frac{L_{1,f}}{L_{1;m}} > \frac{L_{2,f}}{L_{2,m}} \quad \forall \quad \frac{w_f}{w_m} \tag{2}$$

There is a function $a(A)$, that maps the vector of ecological and climatic conditions into a scalar index of rice to wheat suitability such that $\{a\epsilon\Re|0 \leq a \leq 1\}$, where $a = 1$ represents the most rice suitable environment and $a = 0$ the most wheat suitable environment. I use this index to rewrite equation (1) as:

$$G_i = G_i(L_{i,f}, L_{i,m}; a(A), A_u, \sigma); i = 1, 2 \tag{3}$$

$$\frac{\partial G_1}{\delta a} > 0; \frac{\partial G_2}{\delta a} < 0 \tag{4}$$

$$\frac{\partial^2 G_1}{\partial a\sigma} > 0 \tag{5}$$

$$\frac{\partial^2 G_1}{\partial a\sigma} > \frac{\partial^2 G_2}{\partial a\sigma} \tag{6}$$

Equation (4) shows that the rice to wheat suitability index increases the production of rice, but decreases the production of wheat. As discussed previously, rice requires much more water than wheat, therefore as condition (5) and (6) shows increases in rainfall in a rice suitable area will increase the production rice relative to wheat.

Households maximize a standard concave utility over a composite consumption good (C), and composition of the household, i.e. the number of males (M) and females (F) in the household. Household members are endowed with one unit of time and spend ϕ fraction of time working on the farm and $1-\phi$ working off the farm for an exogenously determined wage. Farm labor is comprised of both family labor ($\phi_{i,f}F$, $\phi_{i,m}M$) and hired labor ($L^h_{i,f}, L^h_{i,m}$) if it is available. Households spend earnings from the labor market and profits from their farm on consumption, where the price of the composite consumption good is normalized to one, and to finance the cost of changing their household composition where the cost of exit and entry into the household is p_m and p_f for males and females respectively.[6] The household's problem is then

$$MaxU(C, M, F) \tag{7}$$

$$st$$

$$C + p_m M + p_f F = D * [p_1 G_1(L_{1,f}, L_{1,m}; a(A), A_u, \sigma) - w_m L_{1,m} - w_f L_{1,f} + w_m(1-\phi_{1,m})M_1 + w_f(1-\phi_{1,f})F_1]$$
$$+(1-D) * [p_2 G_2(L_{2,f}, L_{2,m}; a(A), A_u, \sigma) - w_m L_{2,m} - w_f L_{2,f} + w_m(1-\phi_{2,m})M_2 + w_f(1-\phi_{2,f})F_{2.}]$$
$$L_{i,f} = L^h_{i,f} + \phi_{i,f}F \quad \text{where } i = 1, 2$$
$$L_{i,m} = L^h_{i,m} + \phi_{i,m}M \quad \text{where } i = 1, 2$$

D is an indicator function representing the household's crop choice such that $D = 1$ when rice is planted and 0 when wheat is planted.[7] The setup ignores leisure and assumes each person spends all their time working on the farm or off the farm.[8] I examine the implications of this framework under both perfect and imperfect labor markets.

Landless households will solve a similar problem except that their budget constraint will not include a farming decision. Their optimization problem can be specified as:

[6]The only avenue of households to change adult gender composition of households is through migration (including marriage migration)

[7]The assumption of discrete crop choice is for analytical convenience.

[8]Jacoby (1995) also makes a similar simplifying assumption ignoring leisure in his theoretical framework as well.

$$MaxU(C,M,F) \tag{8}$$
$$st$$
$$C + p_m M + p_f F = w_m M + w_f F$$

The role of market perfections and imperfections in agricultural household models is extensively covered in the collective article volume edited by Singh, Squire and Strauss (1986) and is further covered by Benjamin (1992) and by Rosenzweig (1980), who focuses on the differences in labor supply of landless and landed households.

3.1 The Perfect Market Case

With perfect markets family labor and hired labor are perfect substitutes and households can hire and supply as much labor as they desire. Under this scenario, the household's production decisions are separable from their consumption decisions. This separability property allows the model to be solved recursively, where we can first maximize farm profits and then maximize utility subject to the budget constraint, which includes the maximized farm profits (or profit function). In this case the household crop choice decision is based solely on the profitability of each crop rice (crop 1) and wheat (crop 2). We can specify this decision as a function of the underlying determinants of profits i.e. crop prices, wages and the environment such that:

$$\begin{aligned} D &= 1 \text{ if } \Pi_1(p_{1,}w; a(A), A_u, \sigma) \geq \Pi_2(p_{2,}w; a(A), A_2,\sigma) \\ &\quad 0 \text{ otherwise} \end{aligned} \tag{9}$$

The separability of preferences and production implies that crop choices will only depend on the differences in profits and its underlying determinants such as wages, prices, technology and environment. Equation (9) provides a very strong testable prediction about the nature of labor markets and its effects on household decision making. Under the null hypothesis of perfect markets, the separability property of household consumption and farm production decisions implies that changes to the gender composition of the household will not affect the crop allocation decision. Additionally, this property implies that conditional on profits, household farm decisions will not affect the gender composition of the household.[9]

Higher rainfall (σ) will increase the profitability of rice relative to wheat in rice growing areas. This will lead to an increase in the amount of rice cultivated in rice suitable areas relative to wheat suitable areas. Increases in rainfall will therefore generate extra farm profits and may also

[9] If a farmer were to make the same amount of money growing rice or wheat then changes in the crop choice would not affect the gender composition of households

increase the village level wages. Under the perfect market hypothesis, households employ labor on their farms to equate the marginal products of labor to wages. Since households can acquire as much labor as they require, changes in the crop choice would only affect the gender composition of households through changes in farm profits and wages. Due to the separability of production and consumption, households will maximize farm profits by equating the marginal product of farm labor to the wage. This will simplify the first order conditions from equation 7 to:

$$\frac{U_m}{U_f} = \frac{p_m - w_m}{p_f - w_f} \tag{10}$$

The above condition shows that an increase in male wages makes males "cheaper" relative to females which increases the demand for males in the household since the marginal utility of males has to fall in response to this wage change. Similarly an increase in female wages would increase the demand for females in the household. Without further assumptions on the utility function, the effect of farm profits on the demand for females and males is ambiguous. However, we can isolate the effect of farm profits on the gender composition by comparing landless and land-owning households.[10] I specify the demand for females conditional on the index of rice suitability as:

$$F = F(p, w(\sigma), \pi(\sigma); A_u, \sigma | a(A)) \tag{11}$$

As we can see crop choice does not enter this demand equation directly due to the separability property. Profits are also exogenous in this case. If village level wages and profits were a function of rainfall such that $w = w(\sigma)$, and $\pi = \pi(\sigma)$, I can specify a reduced form equation by linearizing the conditional demand for females. Denoting the index of rice suitability, $a(A)$, as $Rice\ \epsilon[0, 1]$, I define the reduced form equation for females as:

$$F = \delta_0 + \delta_1 Rice + \delta_2 p + +\delta_3 \sigma + \delta_5 Rice \times \sigma + \varepsilon \tag{12}$$

The linearized demand equation for males in the household is defined in a similar manner. Rainfall will affect the crop choice, the wages and the farm profits, thus this reduced form equation will incorporate the total effect of these factors on household composition.

3.2 The Imperfect Market Case

Ill functioning labor markets, or imperfect credit markets in a dynamic set up, are among some of the factors that would invalidate the separability of production and consumption. However,

[10] Under perfect markets land holding households and landless households will have the same first order conditions with the exception of the budget constraint. The budget constraint of landless households will not include farm profits. Therefore the only difference between the behavior of landless and landholding households will be due to the effect of farm profits.

market failures of a fixed factor of production such as land would not invalidate this property. If family labor and hired labor are not perfect substitutes due to monitoring costs for example, or if the off farm labor supply of the household is constrained then households will no longer be able to equate marginal product of labor to the wage rate.[11] Thus farm production decisions will now involve preferences.[12] Singh, Squire and Strauss (1986) introduce an off farm labor supply constraint for male and female labor. They argue that such a constraint could arise from various factors including monitoring costs, or even from cultural factors such as the restrictions placed on women in a village. If the constraint were binding then the household members would work more on their own farm than they would optimally. This would prevent the household from maximizing profits by equating marginal product of farm labor to wages. In order to clarify the exposition of my analysis, I take the extreme case of this argument and assume that labor markets do not exist. With the absence of a labor market, households have to use their own labor on their farms. This destroys the separability of consumption and production decisions resulting in production decisions that dependent on preferences.

The crop choice decision is now based on the crop that provides the greatest utility. In the presence of non separable consumption and production decisions, households would choose the crop that maximized their total utility. Defining V_1 as the indirect utility from 7 where $D = 1$ and V_2 the indirect utility where $D = 0$ we can write the crop choice decision as

$$\begin{aligned} D &= 1 \text{ if } V_1(p, w; a(A), A_u, \sigma) \geq V_2(p, w; a(A), A_u, \sigma) \\ & \quad 0 \text{ otherwise} \end{aligned} \tag{13}$$

Under imperfect markets, a rainfall shock to a household in a rice suitable area will make rice growing more attractive at the margin. Consider an all male household located in an area which is suitable for rice cultivation. A positive rainfall shock to this household would increase the returns to growing rice and would thus increase the demand for females in this household. Since rice is more intensive in female labor and the household cannot hire any female labor due to market imperfections, the household's demand for female household members will be greater due to its desire to augment its female labor force. As previously discussed, the only mechanism to adjust the adult female membership in a household is via marriage. Households can import females through marriage or they can delay the marriage of daughters in order to increase its female labor force. An increase in rainfall to a landed household would induce crop choice effects and possibly wage effects, which in turn induce farm labor demand effects and farm profit effects. An increase in rainfall to landless households would only induce wage effects on the household composition.[13] The

[11]The same would be true if the labor demand of the farm household were constrained

[12]See Chapters 1 and 2 of Singh, Squire and Strauss (1986) for an extensive discussion of separability and non-separability

[13]Although I had previously assumed the absence of labor markets, we can think of them as being sufficiently small

comparison of landless and landed households is not as useful as in the perfect market case because of the non separability of preferences and production which results in non-exogenous profits.[14]

I specify a conditional (on rice suitability) demand for females as:

$$F = F(p, w^s(\sigma), \pi^s(A_{u,}\sigma); A_u, \sigma | a(A)) \tag{14}$$

where w^s denotes the shadow wages, which depend on rainfall, while π^s denotes the shadow profits which depend on rainfall and household preferences. I can define the conditional demand for males in a similar manner. I linearize the demand for females to obtain a reduced form equation. Denoting the index of rice suitability, $a(A)$, as $Rice\ \epsilon[0, 1]$, I define the reduced form equation for females as:

$$F = \lambda_0 + \lambda_1 Rice + \lambda_2 p + \lambda_3 \sigma + \lambda_4 Rice \times \sigma + A_u + \varepsilon \tag{15}$$

I define the linearized demand equation for males in the household in a similar manner. Here an increase in rainfall results in crop choices effects, wage effects, shadow wage and shadow profit effects on the household composition.

4 Estimation Strategy

The linearized demand equation (12) and (15) and their counterparts for males, have the same specification. The only difference is in the interpretation of the effects of rainfall on household composition. Under perfect markets the effects of rainfall on the gender composition of households will be caused by profit and wage effects, whereas under imperfect markets they will be caused by farm labor demand effects in addition to profit and wage effects.

I assume that fixed cost of movement (p) for a household member is fixed over time. Additionally, I assume that the unobserved fixed factors of farm production such as farmland quality are time invariant. There are a number of issues that arise that complicate the estimation of these equations. I do not observe farm level unobservables (A_u), which could be correlated with crop choice and with the demand for females. The household stock of adults over time changes due to marriage, migration, and mortality. I treat mortality as a random occurrence in this context and focus on marriage and migration as the primary mechanism through which households willingly change the gender composition of adults. I examine the effects of rainfall shocks on the probability marriage of daughters and of sons in rice suitable areas relative to wheat suitable areas. I create

such that farm households cannot hire labor or supply it.

[14] Under separability, farm profits are exogenous to the household

a prospective panel of movement for each individual who is at risk of marriage or migration. In India, females are at risk of marriage from age 12, while 99 percent of females are married by age 30 in the sample. I thus examine the risk of marriage for each year where the females are between age 12 and age 30, while I examine the marriage of males from 15 to 40.[15] The following equation estimates the differences in the risk of marriage sons and daughters due to increases in rainfall:

$$Marry_{i,h,j,k} = \delta_0+\delta_1 Rice_{h,j}+\delta_2 Rice_{h,j}\times Rain_{j,k}+\delta_3 X_{h,j,k}+\delta_4 X_{h,j,k}\times Rain_{j,k}+\delta_5 T_k+\delta_6 Age_k+\theta_h+\epsilon_{i,h,j,k} \tag{16}$$

Where $Marry_{i,h,j,k}$ is a dichotomous variable which takes the value of 1 if child i from household h in village j marries at age k and 0 otherwise. $Rice_{h,j}$ is the rice suitability index for household h in village j. $Rain_{j,k}$ is the village level pre-monsoon rainfall occurring at age k. $X_{h,j,k}$ is a vector of controls such as land holdings, T is a vector of year dummies and Age is a vector of age dummies. θ_h is a household fixed effect that captures household level time invariant unobservables and $\epsilon_{i,h,j,k}$ is an idiosyncratic error term. The parameter of interest δ_2 provides an estimate of the effect of the value of female labor on the marriage probability.[16] Rainfall shocks are exogenous to the error term and to θ_h. However if farm level unobservables were correlated with $Rice$ then this would bias the estimates. To eliminate these biases I employ a household fixed effects regression to eliminate this time invariant heterogeneity. This prevents me from identifying the level effect of rice suitability but it does provide a consistent estimate of δ_2. Specifying Δ as the household differences operator,

I estimate the following equation:

$$\Delta Marry_{i,h,j,k} = \delta_0+\delta_2\Delta(Rice_{h,j}\times Rain_{j,k})+\delta_3\Delta X_{h,j,k}+\delta_4\Delta(X_{h,j,k}\times Rain_{j,k})+\delta_5\Delta T_k+\delta_6\Delta Age_k+\Delta\epsilon_{i,h,j,k} \tag{17}$$

The parameter of interest, δ_2, incorporates the total effect of rainfall on the marriage probabilities of sons and daughters in the household. The interpretation of δ_2 differs depending on whether the household faces perfect or imperfect labor markets. With perfect markets, the effect of a positive rainfall shock to a landed household will both raise the wage and will raise the farm profits, whereas a positive rainfall shock to a landless household will only result in a wage increase. Thus the difference in the parameters of landless and landed households will isolate the effect of farm profits on the gender composition of households. Under imperfect markets, under the assumption that the wage effects of both landless and landed are the same then, the difference between these groups will be due to farm profits and shadow wages, where the shadow wage is a function of the

[15] 99 percent of males are married by age 40

[16] Recall the marriage of sons will increase female labor while the marriage of a daughter will decrease female labor

crop choice decision.

The equations above examine the effects of rainfall on the demand for females through marriage. However, rainfall could also potentially affect the demand for males in the household. To analyze these effects, I estimate the migration risk of men in a similar fashion, examining the risk of migration for men aged 15 to 45.[17] I specify the following equation

$$\Delta Migrate_{i,h,j,k} = \beta_0 + \beta_2 \Delta(Rice_{h,j} \times Rain_{j,k}) + \beta_3 \Delta X_{h,j,k} + \beta_4 \Delta(X_{h,j,k} \times Rain_{j,k}) + \beta_5 \Delta T_k + \beta_6 \Delta Age_k + \Delta\epsilon_{i,h,j,k} \quad (18)$$

:

Where $Migrate_{i,j,k}$ is a dichotomous variable which takes the value of 1 if male i from household h in village j migrates at age k and 0 otherwise. The household fixed effect again serves to eliminate any time invariant heterogeneity.

5 Data

The data employed in this study are from the Rural Economic and Demographic Surveys (REDS) collected by the National Council of Applied Economic Research in India. The data set is nationally representative covering over 7,500 households from 250 villages in 16 states of India. Figure 6 shows the location of villages across India. The data contains very detailed information on household composition, household characteristics, individual characteristics, demographic histories and agricultural production. The data is unique in that it contains retrospective information on household composition, tracking all changes in the household composition due to events such as marriage, death, migration and fertility. Additionally, the data contains detailed farm level and village level information on cultivation patterns. These datasets are described in more detail in Foster and Rosenzweig (2003).

Using the retrospective information, I create a series of variables based on the marriages and movements of sons and daughters in the household. I use the information provided on marriage dates to create an individual panel on the timing of marriage. I create a dichotomous marriage indicator variable for each year a daughter is at risk of marriage, assuming that the risk of marriage for females begins at age 12 and ending at age 30. In a similar fashion I also examine the marriage of sons, creating a timing of marriage variable for each son at risk of marriage assuming that their risk begins at age 15 and ends at 40. The data also provide information on dowry payments. Using the Indian CPI, I compute real dowry payments in year 1999 Rupees.[18]

[17]Women only migrate through marriage in India

[18]The exchange rate in 1999 was about $1 to 45 Rupees

The movement of males is created in a similar manner. I create a movement indicator variable for each year a son is at risk of moving out of the house. The data provides information about the location of the son. I thus define migration as movements out of the house and into a different village (or urban area), while I define movements out of the household but into the same village as household division.

I create a village level time series of monthly average rainfall from 1965 to 1999 using the Indian Meteorological Department gridded data set (India Meteorological Department 2005). The data contain interpolated rainfall data for a series of 1 degree by 1 degree grids covering India. I define pre-monsoon rainfall as rainfall in the month of May, as the monsoon season starts in June and ends in September. Additionally information from the Digital Soil Map of The World, compiled by the United Nations Food and Agricultural Organization (FAO) is used to provide district level and village level information about soil properties. The map, on a scale of 1:5,000,000, contains information on soil types, including the soil pH and the soil texture of each mapping unit.

The data does not contain retrospective farm information however, the 1999 data does contain information household farm crop choice and village level crop choice. I use the 1999 crop choice information as a measure of the index of rice to wheat suitability of households in different villages. There are a number of farmers and villages where both rice and wheat are grown. I therefore compute the rice to wheat suitability, as the area of rice cultivated out of the total land allocated to rice and wheat i.e. $\left(\frac{rice}{rice+wheat}\right)$. To account for possible measurement error, I also utilize ecological variables such as average rainfall and soil pH to instrument for the index rice suitability.

6 Results

Table 1 shows the relationship between the gender-age composition of households and the environment of the villages they are located in, using the 1999 cross-sectional data. As we can see households in villages where the environment was more suitable to rice had a greater proportion of adult women relative to men. Villages with acidic soil and high rainfall had more women relative to men aged 18 to 44 and 45 to 59.[19] Additionally, there seem to be no gender differences among the elderly household members. The lack of a relationship between gender composition and environment for elderly household members is consistent with our theory that the differences in the gender composition are driven in part by differences in labor productivity. We can also see that there does seem to be a relationship between rice suitable environments and the gender composition of children below age 17. However, the results show no significant effects of the environment on the gender composition of children aged 0-5, 6-12 and 13-17. These reduced form specifications are very suggestive of a relationship between crop choice and household composition.

[19] Recall from Figure 2 that alkaline soil is not suitable for rice growing.

6.1 Effect of rainfall on productivity

I examine the effect of pre-monsoon rainfall shocks on the village level wage rate for males and females. If positive rainfall shocks increased the productivity of female labor in rice areas relative to wheat areas, then we would expect to see an increase in female wages in rice areas relative to wheat areas. I use the 1999 cross section to evaluate the effect of rainfall shocks on the prevailing daily agricultural wages in these villages.[20] Table 2 shows the effects of pre-monsoon rainfall on wages. I find that a one standard deviation increase in pre-monsoon rainfall increases female wages by 10 Rupees in rice villages relative to wheat villages. Male wages also increase in rice villages relative to wheat villages by a similar margin. In a partial equilibrium setting, pre-monsoon rainfall would increase the demand for labor thus raising the wage rates. However, in a general equilibrium setting the increased wages would induce more workers who were are the margin of work to enter the labor market, thus dampening the effect of rainfall on wages.

Table 2 also shows the relationship between household crop revenues and rainfall. I find that a one standard deviation increase in pre-monsoon rainfall above the mean increases rice revenues by 6,000 Rupees. This is consistent with the notion that rice production is heavily dependent on rain relative to wheat production. Surprisingly, wheat revenues fall by 4,000 rupees when there is a rainfall shock. These reduced form estimates incorporate the total effect of both crop choice decisions and increased yields due to rainfall. Overall, the patterns of increase in wages and rice revenues suggest that pre-monsoon rainfall shocks to rice households will significantly affect the behavior of these households.

6.2 Marriage Timing

As discussed previously marriage is the primary mechanism through which adult females move between villages and households due to patrilocal exogamy. Marriage of females in rural India is almost universal. As Figure 7 shows over 99 percent of females are married by age 30. Thus any potential differences in the patters of marriage between rice and wheat farmers would be observed in the timing of marriage. Overall the mean age of marriage for females is approximately 18.5. The average age of marriage for females in predominantly rice villages is 19.1 compared to 18.8 for females in predominantly wheat villages.[21] In terms of males, I find that the average age of marriage for males in predominantly rice villages is 22.6 compared to 20.5. It is somewhat surprising to see that these large differences in age of marriage for males in rice villages compared to wheat villages,

[20] I define rainfall shocks as deviations from the mean scaled by the standard deviation

[21] I define a predominantly rice village as one where $\frac{Rice\ area}{(Rice\ area+wheat\ area)} \geq 0.5$ and define wheat villages conversely.

as rice households would have an incentive to marry their sons of earlier in order to augment their existing female labor supply.

I estimate equation 17 to examine the effect of rainfall on the marriage timing of girls in rice and wheat households. Table 3a shows the results of the fixed effects regression using household level rice proportions as the measure of rice suitability. Consistent with the theory that the demand for female labor is higher in rice farming relative to wheat farming these results show that a one standard deviation increase in rainfall (over the mean) decreases the probability of marriage for daughters in rice households by one percentage point relative to wheat households. Evaluated at the sample mean, this represents a 12 percent reduction in the risk of marriage per standard deviation increase in rainfall for girls in rice households. Allowing this effect to vary by age, I find that the biggest effect occurs at age 20 for daughters. Daughters from rice households who are at risk of married at age 20 are almost 4 percentage points less likely to marry when the rainfall in that year increases by one standard deviation than daughters from wheat households.

The corresponding results for sons are also shown in Table 3a. I find no significant relationship between the marriage rates of sons and rainfall in rice households or wheat households. This is a surprising result for two reasons. First, as mentioned earlier one would expect sons to marry earlier in rice households relative to wheat households. Second, one would also expect a symmetrical relationship between the marriage of males and females. If sons from rice households were marrying brides from a wheat household then we would expect to see the first relationship where these sons would marry earlier. However, if these sons were marrying brides from other rice farmers and if the correlation of rainfall was high enough between the bride's village and the groom's village then one would expect that the marriage probability for a son in a rice growing household would decrease with a positive rainfall shock. Unfortunately, I do not observe the village locations of the brides who marry the sons in the sample, nor do I observe the village location where the daughters marry. Thus for son's marriage, I would need to examine the crop choice and rainfall shock in the corresponding marriage market to correctly examine this pattern. The data show that the average marital distance for daughters is about 45 kilometers. Therefore, the current rainfall measure is a noisy measure of the marriage market rainfall conditions which affect his marriage prospects.[22] Additionally, if there were returns to specific farm experience then the value of a daughter's labor would be greater than that of a newly wed daughter in law. Under this scenario, positive rainfall shocks would provide greater incentives for fathers in rice households to delay the marriage of their daughters rather than to hasten the marriage of their sons.[23]

[22]An alternative explanation is due to the "marriage squeeze". Due to population growth younger cohorts are larger than older cohorts. Since men marry younger women there is a larger pool of women in the marriage market relative to males of marriageable age. Thus a reduction in the number of women at a point in time may have a smaller effect on the marriage outcomes of males due to the "marriage squeeze".

[23]Rosenzweig and Wolpin (1985) show that increases in the specific farm experience were related to greater profits

6.2.1 Landed versus Landless Households

The preceding results used household level crop choice as a measure of the rice suitability. This definition inherently excludes non cultivating households[24]. For the purposes of robustness, I repeat this exercise using village level rice and wheat cultivation to classify the rice suitability of each village. This allows me to compare the effect of rainfall shocks on the marriage timing of sons and daughters in landed versus landless households. For daughters in landed households I find that a one standard deviation increase in rainfall (over the mean) decreases the marriage probability for girls in rice villages by 1.25 percentage points relative to wheat villages. At the sample mean, this represents a 15.5 percent reduction in the risk of marriage for girls in landed households in rice growing villages. I do not however, observe any significant patterns from the regression results of daughters from landless households. Admittedly, landless households only represent approximately 25 percent of the sample thus the imprecise estimates could stem from the smaller sample sizes. However, the point estimates of the effect of rainfall shocks on the marriage probabilities of daughters are much smaller compared to the coefficients on landed households. For males in both landed and landless households, I do not observe any significant relationship between rainfall and the marriage probability.

The theory outlined earlier shows that the major difference in the behavior of landed versus landless households is derived from the farm profit effect. Farm profits are part of the full income constraint of landed households but do not exist for landless households. If markets were perfect, then profits are exogenous to the preferences of a farm household due to the separability condition. Thus, the differences in behavior between landed and landless households would be attributed to the extra exogenous profit earned by landed households. If the presence of a daughter was a normal good then a positive rainfall shock to a landed household would increase their profits and they would choose to keep their daughters at home longer. Landless households, on the other hand, would face the same optimization problem as landed households excluding farm profits. Thus, under prefect markets the difference in behavior between landed and landless households is entirely attributable to the effect of farm profits on behavior.

If markets were imperfect, the interpretation of these results is different due to the endogenous nature of profits. Under the simplifying assumption that labor markets do not exist, farm profits will depend on the productivity of family members on the farm and their preferences. Increased female labor productivity will increase farm profits and will also induce a substitution effect as females will be "cheaper" relative to males. Thus under imperfect market the precede results would suggest that farmers in rice villages delayed the marriage of their daughters because of increased profits and because her productivity on the family farm was higher due to rainfall shocks.

[24]Some landless households will be cultivating households due to sharecropping

6.2.2 Caste Differences

Castes play a major role in the marriage market in India. Generally, people must marry someone of the same caste, leading to a situation where there is very little inter caste intermarriage. In addition caste norms further determine the degree of female autonomy. Although high caste households tend to be richer, they place more restrictions on their women compared to low caste women. It is theoretically unclear what differences we should expect in the examination of marriage timing of high caste and low caste households. To examine this issue, I split the sample between high caste and low caste families and re-estimate the effect of rainfall shocks on the marriage timing of daughters for these two groups separately.[25] Table 3c shows the results of this exercise for daughters. Focusing on caste differences among land owning households only, we can see that the effect of rainfall on the differences in marriage timing of daughters in rice areas relative to wheat areas is similar for both castes. For low caste households, I find that a one standard deviation increase in rainfall decreases the marriage probability of a daughter in a rice area by 1.4 percentage points relative to wheat areas. For high caste households, I find that a one standard deviation increase in rainfall decreases the marriage probability of a daughter in a rice area by 1.1 percentage points relative to wheat areas. These effects are however statistically indistinguishable from each other.

6.3 Dowry

One of the salient features of the marriage system in India is the practice of dowry, where at the time of marriage the bride's family transfers a large sum of assets to the groom's family. Becker (1981) viewed dowry as the price which cleared the marriage market when grooms were scarce. Rao (1993) and Deolalikar and Rao (1995) estimate the effects of individual traits of grooms and brides on the dowry. They find that dowry was decreasing with traits such as bride's education and groom's height. If household's that cultivated rice were more likely to withdraw their daughters from the marriage market in response to a positive rainfall shock, then this could decrease the demand for husbands and thus reduce the dowry. Another possibility is that rice growing households would have greater bargaining power to demand a lower dowry payment for the marriage of their daughter in a year with a positive rainfall shock. Table 4a shows the effects of rainfall shocks on the dowries of sons and daughters. A one standard deviation increase in rainfall decreases the dowry paid by families of daughters in rice households who married in that year by 3,600 Rupees relative to wheat households. This decrease in dowry represents an 11.5 percent decrease in the dowry payment evaluated at the mean dowry level of 31,000 Rupees. I do not find any relationship between rainfall and the dowry received by sons. This is consistent with my previous findings that rainfall has no effect on the marriage timing of sons.

[25] I am using a dichotomous classification of caste here i.e. high caste and low caste.

Dowry is only observed for individuals that marry in a given year. Thus, the estimates could be biased if unobserved attributes of individuals were correlated with the dowry payments. Consider the case where selection into marriage for daughters is based on their unobserved productivity. If positive rainfall shocks induced rice households to delay the marriage of the most productive daughters, then the average labor productivity of brides in the marriage market would be lower. However, this selection process would induce a rise in the dowry payment as the groom's family would have to be compensated through dowry for marrying a less productive bride. These dowry results reinforce the marriage timing results as reduction in dowry would lead to a greater probability of marriage for daughters in rice areas relative to wheat areas. Thus the effects of rainfall shocks on the marriage probability of daughters in rice households relative to wheat households would be greater if dowries did not change.

6.3.1 Landed versus Landless Households

I repeat the dowry analysis using village level crop choice as my measure of rice to wheat suitability in table 4b. Using this measure I find that for girls in land owning households in rice villages, a one standard deviation increase in rainfall decreases the dowry paid by households in rice villages by approximately 3,100 Rupees relative to households in wheat villages. Evaluated at the sample mean, land owning households in rice villages pay 10 percent less dowry for a one standard deviation increase in pre-monsoon rainfall when their daughters marry in that year. I do not however find a differential effect of rainfall shocks on the dowry of daughters in landless households in rice villages relative to wheat villages. These differences suggest that in the presence of positive rainfall shocks, landed rice households are willing to postpone the marriage of their daughters and pay higher dowries later.

6.3.2 Caste Differences

Historically the practice of dowry was concentrated among high caste families but gradually diffused to all strata of Indian society. Table 4c shows the differences in the effect of rainfall shocks on the dowry payments made by low caste and high caste households in rice areas relative to wheat areas. Previous analysis showed that there was very little difference in the marriage timing of sons and daughters in low caste and high caste households in response to rainfall shocks. I do, however find large caste differences in response of dowry payments of daughters to rainfall shocks in rice areas relative to wheat areas. For low caste households, I find that a one standard deviation increase in rainfall above the mean in a rice growing area will decrease dowry payments by 4,200 Rupees, relative to wheat areas. However, I do not find any effect of rainfall on the dowry of daughters in high caste families. This is consistent with the notion that the labor supply of high caste women is more restricted than low caste women. If high caste women did not perform farm work, then rainfall would have little effect on their productivity. However, this theory would not explain the findings regarding the marriage timing of daughters from high caste households. If it was acceptable for high caste daughters to work in their father's fields but not acceptable for them to work in their husband's fields then fathers in rice areas would have an incentive to delay the marriage of their daughter's in response to a rainfall shock. However, since daughters from high caste households would not be working on their husband's fields, the fluctuations in the value of female labor due to rainfall shocks would not be capitalized in the dowry. Banerjee (1998), describes a previous ethnographic survey from Madhya Pradesh which suggested that women were able to work on their father's fields but not on their husband's fields. Although she does not elaborate on any caste differences, there are numerous studies, such as Miller (1981) that argue that the labor force participation of low caste women is higher than high caste women.

6.4 Movement of Males

There are two primary mechanisms through which men can move out of the house. Men can move through migration, either to urban areas or to other villages, or as Foster and Rosenzweig (2003) show, men can also leave the household through household division. The REDS data reports movements of individuals into and out of the household and also reports their location. I define migration as movement of males out of the household to a different village or urban setting. While, I define household division as men who moved out of the house but stayed in the village. I examine the effect of rainfall shocks on the risk of these movements for individual males who are at risk of moving. Overall about 7 percent of males over 15 migrated out of their natal villages, while 22 percent of males over 15 moved out to form other households within their natal village.

I estimate the effect of rainfall shocks on the risk of movement for sons between ages 15 and 50 living in rice households relative to those living in wheat households in Tables 5a and 5b. Examining cultivating households only, I find that a one standard deviation increase in rainfall decreases the probability of males moving out of the house by almost quarter of a percentage point. I do not find any differences in movement probability between rice and wheat growing households under this specification. Examining migration and household division separately, I find that there is no relationship between the risk of migration of males and rainfall shocks for these households. However, relative to wheat households I find that a one standard deviation increase in rainfall increases the probability on household division by a quarter of a percentage point for rice households. Evaluated at the sample mean, a one standard deviation increase in rainfall increases the probability of the division of rice households by 25 percent relative to wheat households.

6.4.1 Landed versus Landless Households

I repeat the analysis using village level crop choice as the measure of rice to wheat suitability and stratify the sample by land ownership in Tables 5b and 5c. The results for Land owning households are very similar to those described above. I do not find any relationship between rainfall shocks and migration but I do find that positive rainfall shocks to land owning households in rice villages will increase the probability of household division by a similar margin as described above.

There is however, a striking difference in the patterns of male movements between landless and land owning households. Relative to landless households in wheat villages, I find that a one standard deviation increase in rainfall decreases the probability of migration for sons in landless households in rice villages also by two-thirds of a percentage point. Additionally in terms of household division I find that a one standard deviation increase in rainfall decreases the probability of household division for landless households in rice suitable villages by half a percentage point. At the sample mean, this represents a 50 percent reduction in the probability of household division for households in rice villages relative to wheat villages per standard deviation increase in rainfall.

For land owning and cultivating households the results suggest that men in wheat areas are more likely to stay in their father's household relative to rice areas. This is consistent with the view that male labor is more valuable in wheat farming than in rice farming. If positive pre-monsoon rainfall shocks increase the profitability of wheat, then the demand for male labor will be greater for wheat growing suitable relative to rice suitable households.[26]

6.5 Robustness

The prior results use the rice and wheat crop mix in 1999 as the measure of rice suitability in each year from 1965 to 1999. This is a noisy measure of the underlying rice suitability of an area and will induce measurement error in the estimates. This is a serious problem, as measurement error in the rice to wheat proportion would cause the results to be attenuated towards 0. Additionally, the measures of rice suitability could have been contaminated by transitory shocks in 1999. I use the permanent ecological and soil conditions present at each village to predict the village level crop choice for households in each village. I use this predicted measure of rice suitability at the village level and replicate the main findings.

Table 6 shows the first stage from this regression where the dependent variable is the rice to wheat proportion of cultivating households. As we can see the environmental conditions clearly affect the choice of crops grown by households in different villages. The major constraint in growing rice is the availability of water. As we can see from Table 6, households located in areas with high

[26] I would expect the effect of rainfall to be higher in rice. Nevertheless, I would expect this correlation to be positive

average rainfall cultivated a larger proportion of rice relative to wheat. As expected, soil pH is a major determinant of crop choice. As the Soil pH rises the yield of rice declines thus alkaline soil would not be suitable for rice cultivation. Since both rice and wheat prefer loamy soil and sandy soil is not beneficial for growing either crop, the soil textures do not seem to affect the cultivation decisions between rice and wheat.[27] The joint F statistic of these variables is 24. This is very high and is significant beyond the 99 percent level. This suggests that the soil and environmental variables are powerful predictors of crop choice.

I use the predicted rice to wheat proportion as the measure of village level crop choice and repeat the previous analysis on the marriage timing of sons and daughters and the movement of sons. I use a standard bootstrapping procedure to correct the standard errors of this manual two step estimation procedure. I find similar results for the timing of marriage for women in Table 7. As before I find no relationship between rainfall shocks and the probability of marriage for girls in landless households. However for girls in land owning households, I find that a one standard deviation increase in rainfall decreases the probability of marriage by one percentage point in rice villages relative to wheat villages. The coefficients of this exercise are very close to the ones found using the rice to wheat proportion in 1999. Table 8a and 8b show the results of the effects of rainfall shocks on the probability of male movement. I also find similar results here.

7 Conclusions

In her seminal book, Ester Boserup (1970) observes that in regions where the plough was used along with a draught animal to till the ground, such as in India, the value of female labor is diminished when compared with agricultural systems where the hoe is used. Boserup's insights motivated a growing body of research that examines the relationship between agricultural production technologies and gender disparities in outcomes of adults and children. In this paper I show that, the production processes embodied in the crop choice available to agrarian households also has a substantial impact on the relative status of adult females.

Due to the differences in the relative value of female labor in rice cultivation compared to wheat cultivation, positive rainfall shocks decrease the marriage probability of girls in villages relative to wheat villages. In addition, I find that daughters from rice households pay a smaller dowry when they marry in a year with a positive rainfall shock. This suggests that families in rice villages are willing to delay the marriage of their daughter in order to accrue the benefits of her labor for at least another year. I find that these differences are driven by land-holding households who would have greater incentives to delay the marriage of their daughters relative to landless households.

Additionally, I find that positive rainfall shocks increase the likelihood that sons in landholding

[27] FAO research suggests that in fact rice could be grown in sandy soil, but farmers would require even more water to successfully cultivate it. Cultivating wheat would be more difficult on sandy soil than rice

rice households split from their natal households. This is consistent with increasing demand for male labor in wheat households relative to rice households. Interestingly, landless households have the reverse relationship, where positive rainfall shocks decrease the likelihood that sons in rice households split from their natal households relative to wheat households. I also find that landless sons in rice households are less likely to migrate than sons in wheat households in the event of a positive rainfall shock.

There has been a large effort on the part of donors, NGOs and other international developmental organizations to institute policies and programs that increase the status of women in these societies in order to alleviate gender inequalities. A number of authors such as Miller (1981) argued that the observed patterns of gender inequities were driven by the custom of dowry and not by differences in the value of female labor. I show that in spite of a reduction in dowry during years with positive rainfall shocks, families were willing to delay the marriage of their daughters and probably face higher dowry costs in the future in order to benefit from their daughters' labor. This shows that in fact the value of a woman's labor does play a significant role in determining her outcomes in the household and in the marriage market.

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Table 1: The Relationship between Crop Choice and Household Composition

Gender- Age Household Composition

	Age 0 to 5	Age 6 to 12	Age 13 to 17	Age 0 to 17	Age 18 to 44	Age 45 to 59	Age over 60	Total Female Proportion
Average Rainfall	0.0110	0.0037	-0.0069	0.0081	0.0078	0.0192	0.0095	0.0086
(mm)	(0.0076)	(0.0056)	(0.0057)	(0.0038)**	(0.0032)**	(0.0056)***	(0.0062)	(0.0020)***
Alkaline Soil	0.0088	-0.0387	-0.0219	-0.0264	-0.0157	-0.0140	0.0376	-0.0107
	(0.0167)	(0.0152)**	(0.0194)	(0.0098)***	(0.0065)**	(0.0163)	(0.0195)*	(0.0049)**
Constant	0.4277	0.4705	0.4960	0.4067	0.4821	0.4354	0.4071	0.4575
	(0.0233)***	(0.0197)***	(0.0230)***	(0.0127)***	(0.0093)***	(0.0203)***	(0.0235)***	(0.0066)***
N	2,969	3,516	2,663	5,447	6,249	3,424	2,447	6,839

Notes:
Dependent variable are the number of females in age category/ total family size
Total Female Proportion is the total number of females/total family size
Rice to Wheat Proportion is the rice area/ (rice area+wheat area)
Standard Errors Clustered at the Village Level reported in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2:The Effect of Rainfall Shocks on Village Level Wage Rates

Panel A:The Effect of Rainfall Shocks on Village Level Wage Rates

	Male Daily wage (Rs)	Female Daily wage (Rs)
Village Rice wheat Proportion	3.29	-0.34
	(3.34)	(2.67)
Village Rice wheat Proportion x Premonsoon Rain	11.76	10.23
	(5.08)	(4.07)
Premonsoon rain	-13.5	-11.6
	(4.56)	(3.66)
N	210	210

Notes: Village level average daily wages for men and women
Mean wages: Male 42, Female 26

Panel B:The Effect of Rainfall Shocks on Crop Revenues

	Rice Revenues (Rs)	Wheat revenues (Rs)
Premonsoon Rainfall shock	6137.351	-4039.513
	(1919.71)***	(970.56)***
Constant	3812.499	9396.307
	(2212.37)*	(1724.248)***
N	4332	4332

Notes:
Rice and Wheat Revenues measured in Rupees
Additional controls for land holdings, average and sd rainfall
Standard Errors Clustered at the Village Level in Parenthesis

Table 3A : Effects of Rainfall shocks on Marriage Probability in Rice Vs Wheat Households
Cultivating Households Only:
Household Level Rice Suitability Measure

Dependent variable: Whether an Individual marries at a certain age

	Females	Males
Premonsoon rain	0.0080	-0.0006
	(0.0037)**	(0.0022)
Rice Suitability X Premonsoon rain	-0.0100	-0.0041
	(0.0042)**	(0.0026)
Constant	0.1250	0.2090
	(0.035)**	(0.0210)
N	42,843	69,141
Groups	2,823	3,303

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1) Land X rain, Land X rain(t-1)
This sample only includes cultivating households
Rice suitability is the 1999 rice to wheat cultivation proportion defined as rice /(rice+wheat) at the household level

Table 3B : Effects of Rainfall shocks on Marriage Probability in Rice Vs Wheat Households
Comparison of Landed and Landless Households
Village Level Rice Suitability Measure

	Dependent variable: Whether an Individual marries at a certain age					
		Females			Males	
	Full Sample	Landed	Landless	Full Sample	Landed	Landless
Premonsoon rain	0.0077	0.0090	-0.0024	-0.0010	-0.0015	0.0000
	(0.0025)***	(0.0027)***	(0.0059)	(0.0016)	(0.0017)	(0.0034)
Rice Suitability X Premonsoon rain	-0.0103	-0.0125	-0.0006	-0.0009	0.0000	-0.0045
	(0.0030)***	(0.0033)***	(0.0076)	(0.0019)	(0.0021)	(0.0045)
Constant	0.1305	0.1341	0.1594	0.2099	0.2254	0.1462
	(0.0263)***	(0.0285)***	(0.0634)**	(0.0156)***	(0.0172)***	(0.0354)***
N	51,800	42,843	8,957	85,161	69,141	16,020
Group	3,546	2,823	723	4,197	3,303	894

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1)

Rice Suitability is the 1999 rice to wheat cultivation proportion defined as rice /(rice+wheat) at the village level

Table 3C : Effects of Rainfall shocks on Marriage Probability in Rice Vs Wheat Households
Comparison of Castes
Village Level Rice Suitability Measure

	Dependent variable: Whether an Individual marries at a certain age Landed Household Only			
	Females		Males	
	Low Caste	High Caste	Low Caste	High Caste
Premonsoon rain	0.0116	0.0062	-0.0015	-0.0020
	(0.0036)***	-(0.0042)	-(0.0022)	-(0.0027)
Rice Suitability X Premonsoon rain	-0.0139	-0.0115	0.0000	0.0003
	(0.0043)***	(0.0054)**	-(0.0027)	-(0.0035)
Constant	0.1122	0.1094	0.1911	0.3013
	(0.0360)***	(0.0458)**	(0.0214)***	(0.0274)***
N	27,323	15,520	44,863	24,278
Group	1,818	1,005	2,128	1,175

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1)

Rice suitability is the 1999 rice to wheat cultivation proportion defined as rice /(rice+wheat) at the village level

Table 4A: Household Fixed Effects Estimates of the Effects of Rainfall on Dowry Payments
Cultivating Households Only:
Household Level Rice Suitability Measure

	Dowry Paid	Dowry Received
	Females	Males
Premonsoon rain	2189.75	800.34
	(1685.08)	(995.37)
Rice Suitability X Premonsoon rain	-3592.06	-3594.89
	(1974.87)*	(5346.70)
Constant	17544.02	55137.27
	(23113.00)	(40756.00)
N	3,667	3,635
Groups	1,934	1,948

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1) Land X rain, Land X rain(t-1)

Dowry payments are adjusted to 1999 Rupees
This sample only includes cultivating households
Rice Suitability is the 1999 Rice to wheat cultivation proportion defined as rice /(rice +wheat) at the Household level

Table 4b: Household Fixed Effects Estimates of the Effects of Rainfall on Dowry Payments
Comparision of Landed and Landless Households
Village Level Rice Suitability Measure

	Dowry Paid			Dowry Received		
	Females			Males		
	Full Sample	Landed	Landless	Full Sample	Landed	Landless
Premonsoon rain	-358.66	333.86	-6399.42	-4360.283	-5511.48	1757.52
	(1210.22)	(1216.66)	(3912.38)	(3590.53)	(4201.40)	(1984.75)
Rice Suitability X Premonsoon rain	-2071.64	-3065.92	4272.59	2260.14	2932.65	-2437.81
	(1602.79)	(1657.65)*	(5647.95)	(4654.17)	(5619.42)	(2882.66)
Constant	32178.89	19587.57	-2057.96	-10707.7	63824.37	112959.1
	(17191.66)	(17628.64)	(7025.64)	(36805.13)	(38595.42)	(25514.44)
N	4,375	3,667	708	4,463	3,635	828
	2,346	1,934	412	2,394	1,948	446

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1) Dowry payments are adjusted to 1999 Rupees

Rice suitability is the 1999 rice to wheat cultivation proportion defined as rice /(rice+wheat) at the village level

Table 4C: Household Fixed Effects Estimates of the Effects of Rainfall on Dowry Payments
Comparision of Castes
Village Level Rice Suitability Measure

	Dowry Paid	
	Land owning Females	
	Low Caste	High Caste
Premonsoon rain	881.74	-116.23
	(1797.07)	(1584.27)
Rice Suitability X Premonsoon rain	-4228.57	67.74
	(2,259.22)*	(2510.24)
Constant	20536.79	9547.67
	(34962.97)	(32233.78)
N	2,284	1,383
	1,237	697

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain
Dowry payments are adjusted to 1999 Rupees
Rice suitabiltiy is the 1999 rice to wheat cultivation proportion defined as rice /(rice+wheat) at the village level

Table 5A: Household Fixed Effects Estimates of the Probability of Male Movement
Cultivating Households Only
Household Level Rice Suitability Measure

Dependent Variable:	Son Moves out of Household	Son Migrates to other Location	Son Splits from Household
Premonsoon rain	-0.0021	0.0011	-0.0032
	(0.0010)**	(0.0007)	(0.0007)***
Rice Suitability X	0.0011	-0.0014	0.0025
Premonsoon rain	(0.0013)	(0.0009)	(0.0010)**
Years of Schooling	0.0002	0.0006	-0.0004
	(0.0002)	(0.0001)***	(0.0002)***
Constant	0.0116	-0.0048	0.0164
	(0.0179)	(0.0124)	(0.0131)
Observations	59646	59646	59646
N of Households	2182	2182	2182
R-squared	0.02	0.01	0.01

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1) and Years of schooling

This sample only includes cultivating households
Rice Suitability is the 1999 Rice to wheat cultivation proportion defined as rice /(rice +wheat) at the Household level

Table 5B: Household Fixed Effects Estimates of the Probability of Male Movement
Comparision of Landed and Landless Households
Village Level Rice Suitability Measure

	Son Moves out of Household	Son Moves out of Household	Son Moves out of Household
	Full Sample	Landless	Land Owning
Premonsoon rain (t)	-0.0012	0.0087	-0.0025
	(0.0009)	(0.0024)***	(0.0010)***
Rice Suitability X Premonsoon rain (t)	-0.0002	-0.0116	0.0019
	(0.0011)	(0.0033)***	(0.0012)
Years of Schooling	0.0002	-0.0005	0.0002
	(0.0002)	(0.0006)	(0.0002)
Constant	0.0276	0.0105	0.0327
	(0.0161)*	(0.0541)	(0.0166)**
Observations	96,192	16,321	79,871
N of households	3,706	748	2,958
R-squared	0.02	0.04	0.02

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1) and Years of schooling
Rice Suitability is the 1999 Rice to wheat cultivation proportion defined as rice/(rice+wheat) at the village level

Table 5C: Household Fixed Effects Estimates of the Probability of Male Movement
Examination of Different Location of movement
Comparision of Landed and Landless Households
Village Level Rice Suitability Measure

	Son Moves out of Household to other village to other Location	Son Moves out of Household to other village to other Location	Son Moves out of Household to other village to other Location	Son Moves out of Household and stays in the same village	Son Moves out of Household and stays in the same village	Son Moves out of Household and stays in the same village
	Full Sample	Landless	Land Owning	Full Sample	Landless	Land Owning
Premonsoon rain	0.001	0.0063	0.0003	-0.0021	0.0024	-0.0028
	(0.0007)	(0.0016)***	(0.0007)	(0.0007)***	(0.0018)	(0.0007)***
Rice Suitability X Premonsoon rain	-0.0011	-0.0063	-0.0002	0.001	-0.0053	0.0021
	(0.0008)	(0.0022)***	(0.0009)	(0.0008)	(0.0025)**	(0.0009)**
Years of Schooling	0.0006	0.0004	0.0006	-0.0004	-0.0009	-0.0004
	(0.0001)***	(0.0004)	(0.0001)***	(0.0001)***	(0.0004)**	(0.0001)***
Constant	0.0062	0.026	0.0071	0.0214	-0.0155	0.0255
	(0.0113)	(0.0367)	(0.0119)	(0.0116)*	(0.0406)	(0.0118)**
Observations	96192	16321	79871	96192	16321	79871
N of households	3706	748	2958	3706	748	2958
R-squared	0.01	0.02	0.01	0.01	0.02	0.01

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1)

Rice Suitability is the 1999 Rice to wheat cultivation proportion defined as rice/(rice+wheat) at the village level

Table 6: First Stage Regression
Determinants of Rice Growing in 1999

	Rice to Wheat Proportion
Alkaline soil	-0.12
	(0.0560)
Loamy soil %	0.00095
	(0.0009)
Sandy soil %	0.00061
	(0.0014)
Average rain (mm)	0.2
	(0.0380)
N	3345
Joint F Statistic	24.86

Notes:
Clustered Standard Errors in Parenthesis
Rice to Wheat Proportion is defined for each household as rice area planted / (rice area + wheat area planted)
Loamy soil is the proportion of Loamy soil found in the soil unit that the village lies within
Sandy soil is the proportion of sandy soil present in the soil unit that the village lies within
Alkaline soil is 1 If the average soil Ph is above 7

Table 7 : Effects of Rainfall shocks on Marriage Probability in Rice Vs Wheat Households
Comparison of Landed and Landless Households
Rice Suitability meausure: Predicted Rice to Wheat ratio

	Dependent variable: Whether an Individual marries at a certain age			
	Females		Males	
	Landed	Landless	Landed	Landless
Premonsoon rain	0.0082	0.0189	0.0007	-0.0014
	(0.0032)***	(0.0100)*	-(0.0021)	-(0.0058)
Rice Suitability X Premonsoon rain	-0.0106	-0.0362	-0.0033	-0.0034
	(0.0042)**	(0.0158)**	-(0.0028)	-(0.0100)
Constant	0.1810	0.1271	0.2290	0.1531
	(0.0414)***	(0.0613)**	(0.0223)***	(0.0489)***
N	46,147	9,214	73,983	16,777
Group	3,067	745	3,574	931

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1). Bootstrapped Standard Errors reported in parenthesis. Rice Suitability is the 1999 Predicted Rice to wheat cultivation proportion defined as rice/(rice+wheat) at the village level

Table 8A: Household Fixed Effects Estimates of the Probability of Male Movement
Comparision of Landed and Landless Households
Rice Suitability meausure: Predicted Rice to Wheat ratio

	Son Moves out of Household	Son Moves out of Household	Son Moves out of Household
	Full Sample	Landless	Land Owning
Premonsoon rain (t)	0.0008	0.0032	0.0006
	(0.0019)	(0.0042)	(0.0015)
Rice Suitability X Premonsoon rain (t)	-0.0023	-0.0028	-0.0022
	(0.0026)	(0.0083)	(0.0022)
Years of Schooling	0.0001	-0.0008	0.0003
	(0.0002)	(0.0005)	(0.0002)
Constant	0.0411	0.0096	0.0421
	(0.0219)*	(0.0416)	(0.0268)
Observations	102269	17012	85257
N of households	3969	778	3191

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1) and Years of schooling
Bootstrapped Standard Errors reported in parenthesis
Rice Suitability is the 1999 Predicted Rice to wheat cultivation proportion defined as rice/(rice+wheat) at the village level

Table 8B: Household Fixed Effects Estimates of the Probability of Male Movement
Examination of Different Location of movement
Comparision of Landed and Landless Households
Rice Suitability meausure: Predicted Rice to Wheat ratio

	Son Moves out of Household to other village to other Location	Son Moves out of Household to other village to other Location	Son Moves out of Household to other village to other Location	Son Moves out of Household and stays in the same village	Son Moves out of Household and stays in the same village	Son Moves out of Household and stays in the same village
	Full Sample	Landless	Land Owning	Full Sample	Landless	Land Owning
Premonsoon rain	0.0009	0.0071	0.0005	-0.0002	-0.0039	0.0001
	(0.0011)	(0.0025)***	(0.0013)	(0.0011)	(0.0042)	(0.0010)
Rice Suitability X Premonsoon rain	-0.0012	-0.0083	-0.0006	-0.0012	0.0056	-0.0016
	(0.0017)	(0.0040)**	(0.0020)	(0.0014)	(0.0082)	(0.0013)
Years of Schooling	0.0006	0.0004	0.0007	-0.0005	-0.0012	-0.0004
	(0.0001)***	(0.0004)	(0.0002)***	(0.0001)***	(0.0005)**	(0.0002)**
Constant	0.0203	0.0249	0.0172	0.0208	-0.0154	0.0248
	(0.0183)	(0.0281)	-0.0206	(0.0102)**	(0.0282)	(0.0147)*
Observations	102269	17012	85257	102269	17012	85257
N of households	3969	778	3191	3969	778	3191

Notes: Household Fixed Effects Specification. Additional Controls include, Age dummies, Year of Marriage dummies, premonsoon rain (t-1), rice x premonsoon rain (t-1), Land X rain, Land X rain(t-1)

Bootstrapped Standard Errors reported in parenthesis
Rice Suitability is the 1999 Predicted Rice to wheat cultivation proportion defined as rice/(rice+wheat) at the village level

Figure 1: Sex Ratio (Females per 1000 Males) Across India

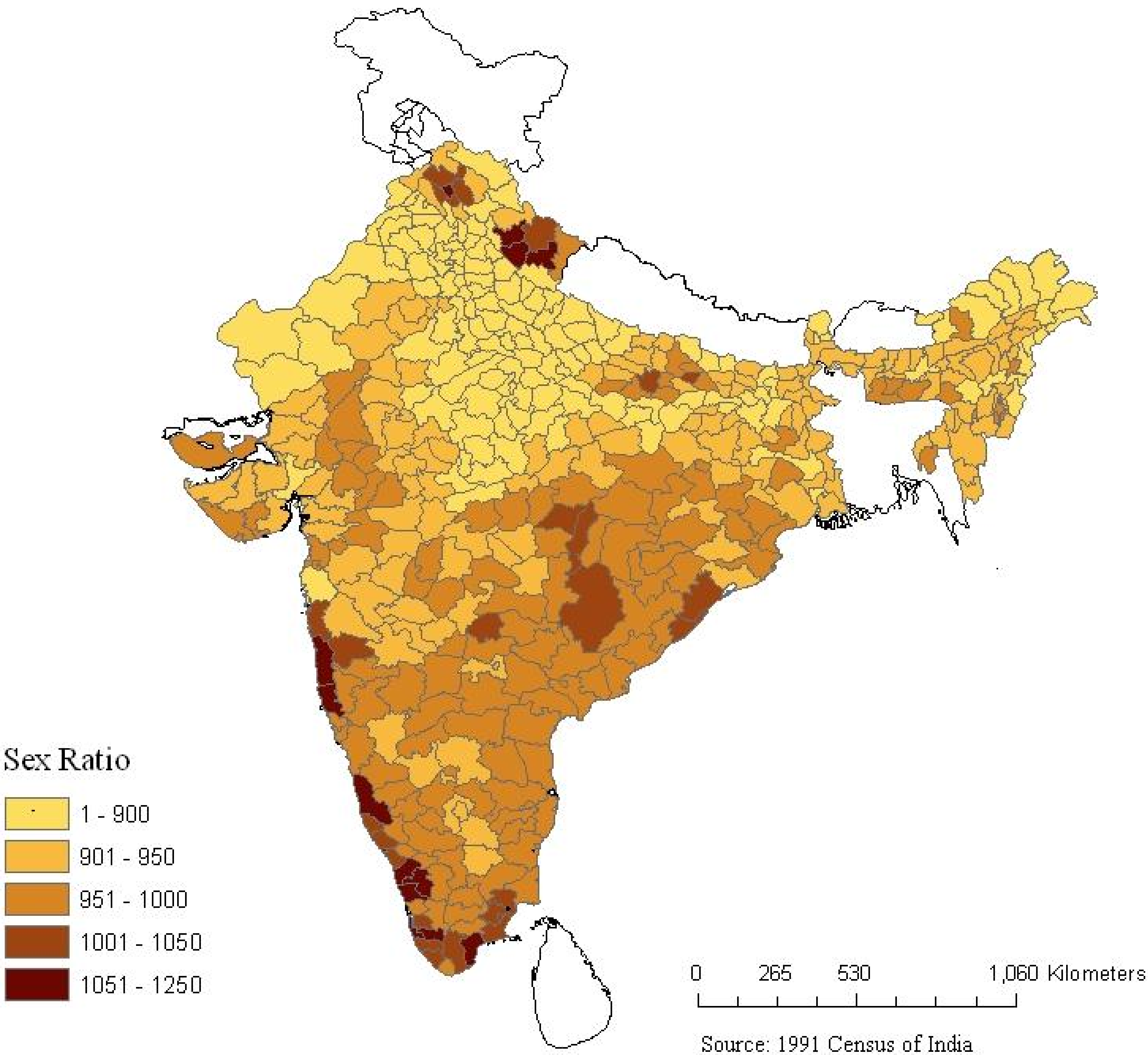
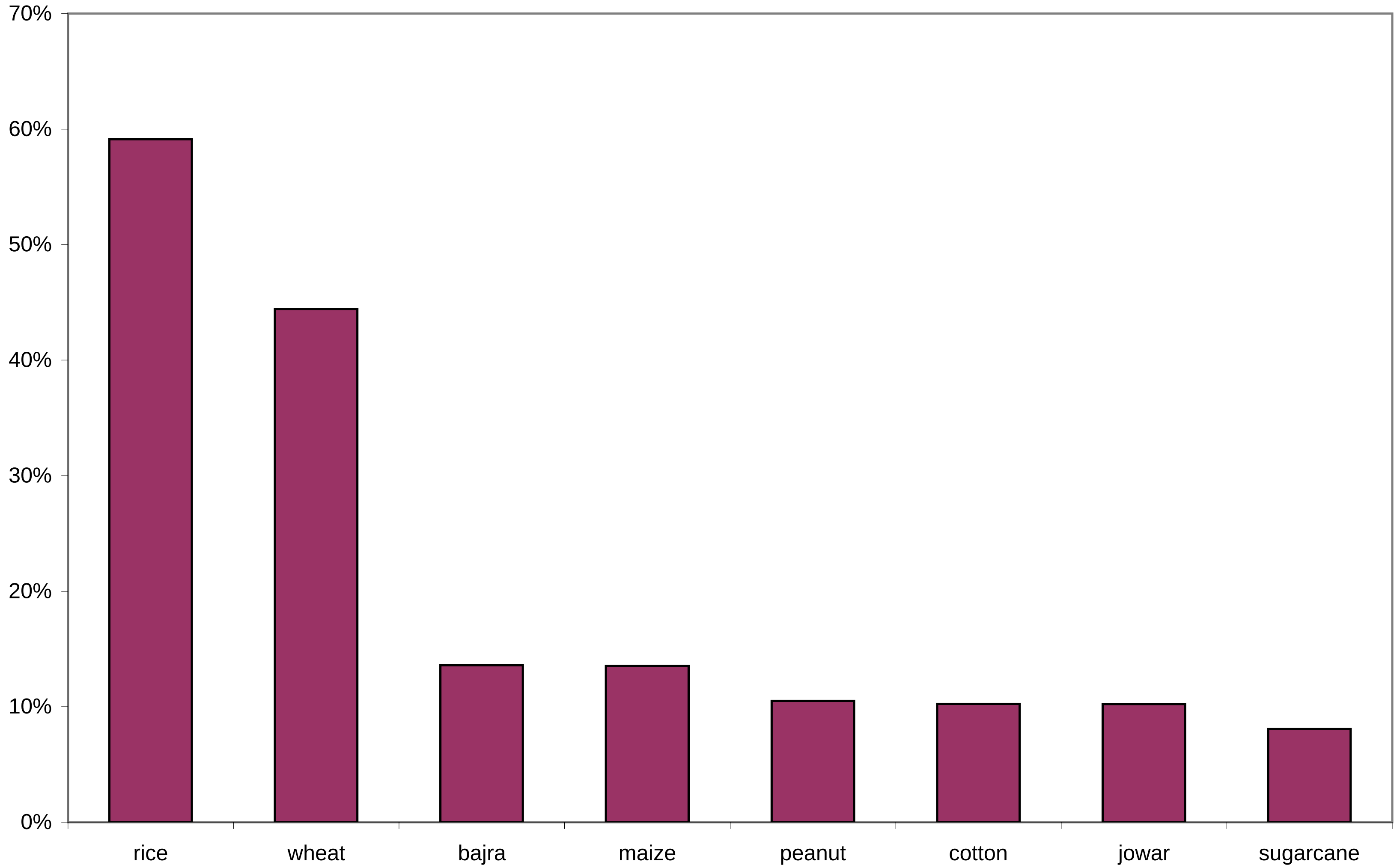


Figure 2: Optimal Environmental Conditions for Cultivating Selected Crops

Crop	Optimal Soil temp ('C)	Optimal Soil Ph	Optimal Precipitation	Critical salinity threshold (ds per m)
Wheat	20	5.5-7.0	250-1750	6
Rice	25-30	5.0-5.5	>1000	3
Corn	25-30	5.0-5.5	600-900	2
Sorghum	NA	5.5-6.0	>300	4.8
Soybean	30	5.5-6.0	330-800	5
Bean	28	5.5-6.0	NA	1
Peanut	24-33	5.0-5.5	500-600	3.2
Sugarcane	25-30	5.8-7.2	NA	1.7
Cotton	28-30	NA	NA	7.7
Source: FAO Ecoport, Fageria et al (1991)				

Figure 3: Percentage of Household Cultivating Selected Crops



Source: Rural Economic Demographic Survey 1999

Figure 4: Percentage of Total Labor Allocated Across Tasks in Rice vs Wheat

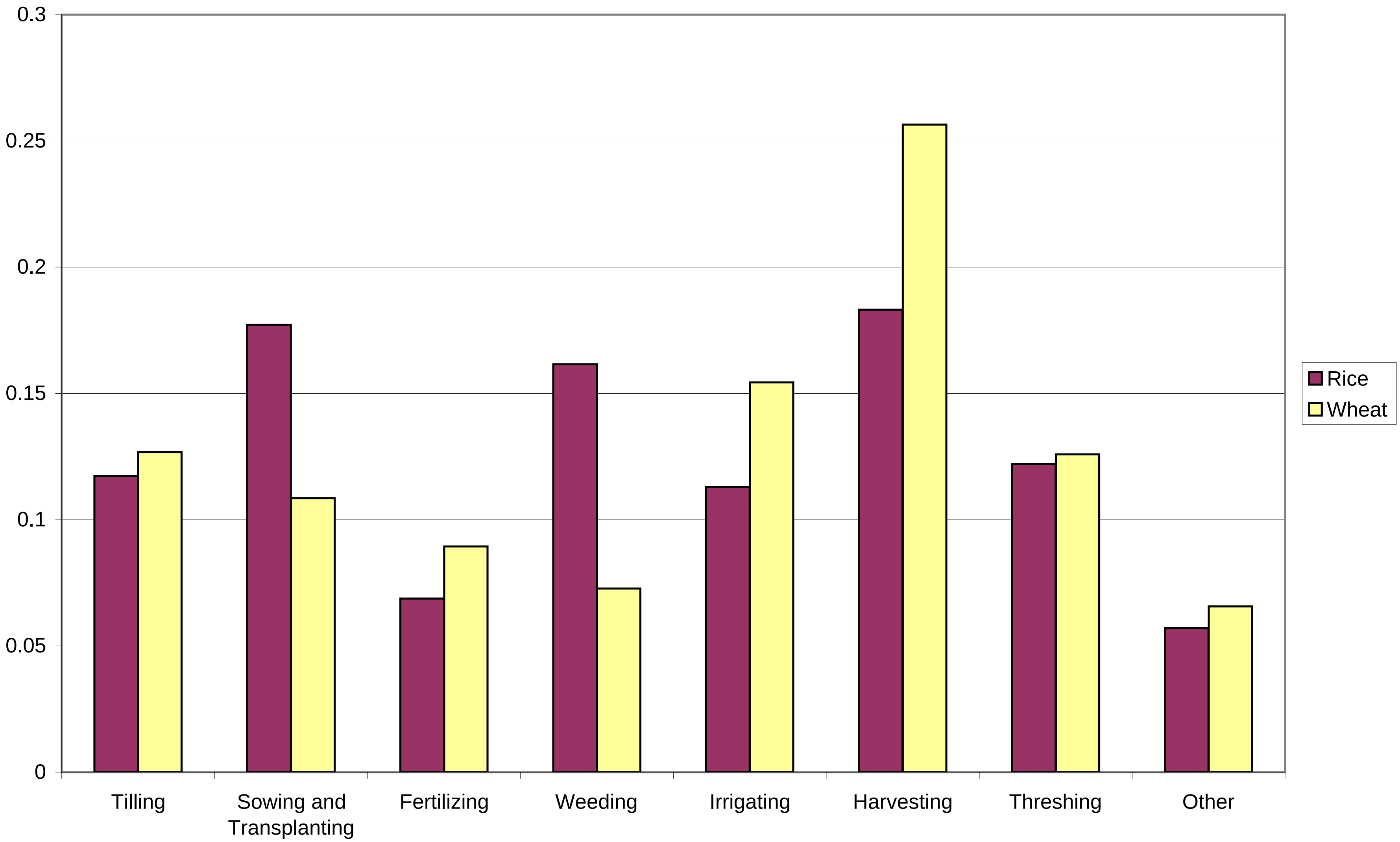
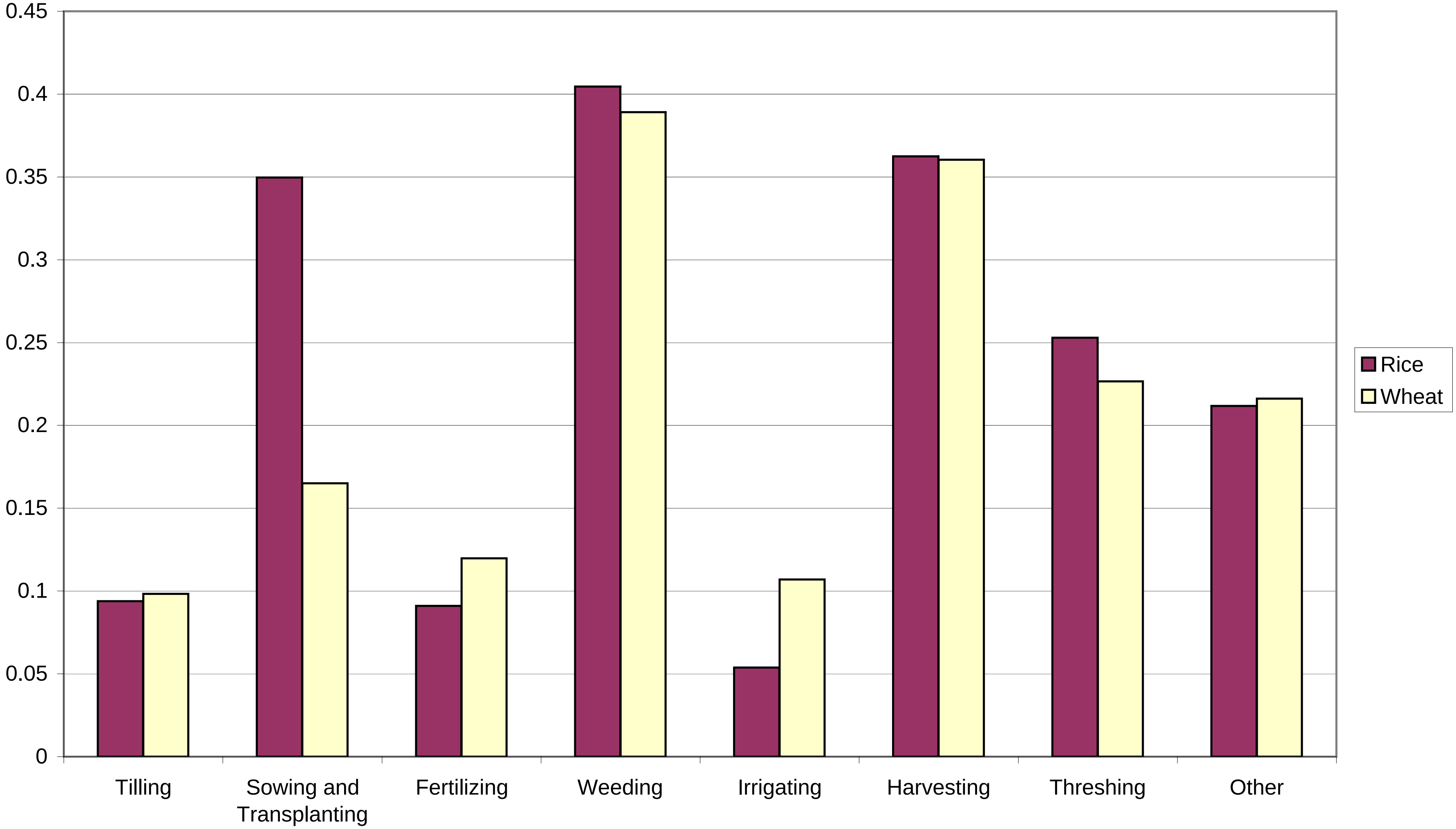


Figure 5: Percentage of Female Labor used in Each Task in Rice Vs Wheat Production



Source: REDS 1999 Survey

Figure 6: Location of 1999 REDS Sample Villages

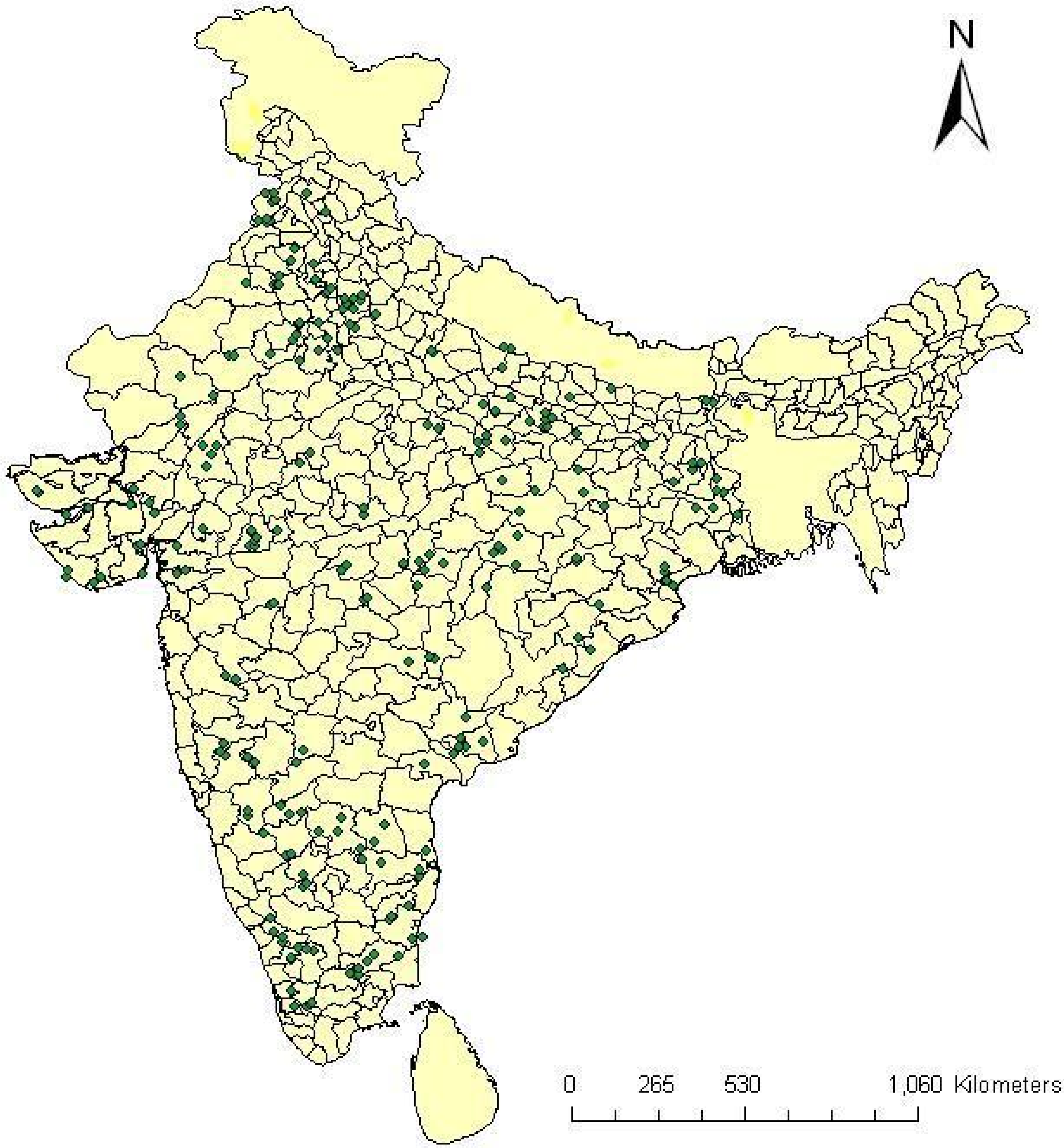


Figure 7: Distribution of Age at Marriage for Males and Females