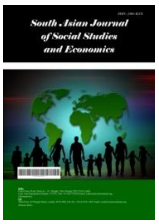

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Farm Machine and Female Labour Participation A Study of Indian Districts

Syed Noman Ahmad[1] and Mohd Murtaza[2*]

[1]Department of Economics, Aligarh Muslim University, Aligarh, India.
[2]Centre for Distance and Online Education, Aligarh Muslim University, Aligarh, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Indian labour market has been witnessing a paradoxical situation in recent years. Despite registering higher economic development the female participation in economic activities has shown deceleration. The researchers in this field have identified several determinants and explanations at aggregate level. The present study is one of the few attempts to examine the trend of female participation in agriculture at district level. Taking number of tractor in a district as a proxy for farm machination, the study confirms an inverse relationship between farm machines and female participation in agriculture. It resolves the paradox in terms of lower women participation in agriculture sector.

Keywords: Female labour; Farm mechanisation; U-Shaped Hypothesis.

1. INTRODUCTION

Women, the invisible contributors, continue to play a dominant role in agricultural and allied activities [1]. They involve in main crops production, livestock production, horticulture and various post-harvest operations. Their presence varies across space and operations [2]. Some of the farm activities require more female labour as compared to others [3]. Despite the

**Corresponding author: Email: murtazaeco.amu@gmail.com;*

predominance of female in agriculture, various studies in India conclude that women contribute to agricultural production far more than they have been acknowledged [4].

The primitive societies used very basic farm equipment in traditional agriculture which complement the whole process of agricultural production. They were invented and adopted to make the process easier. As societies moved further, the agriculture revolution of 18th century paved the ways for industrial revolution. The inventions and innovations in agriculture machines utilised the resources to the efficient level as a result agricultural productivity improved and more labour had been released for industrial jobs [5].

The cheaper food and labour were considered driving force for industrial revolution. Furthermore, the industrial revolution also created possibilities to turn the subsistence agriculture to market based agriculture in which a marketable surplus could fetch economic profit. The requirement to produce cheaper food and fiber for increasing population forced the traditional agriculture sector to adopt the modern equipment [6].

The era of farm machines started with invention of McCormick's reaper in 1831. The agriculture sector around the world witnessed substantial transformation with the help of these machines. The Mechanisation substitutes the physical works and reduce the human efforts. Now one individual could accomplish the work of several days which earlier would have done my many. The modern machine such as tractor was first introduced to agriculture during 18th century with the invention steam power. The adoption and dissemination of these inputs became common across the countries with time [5].

They also reached to developing nations like India in the mid of 20th century. Indian agriculture considered tractors' use as a visible symbol of agricultural development. In the Initial phases, they were limited to large farmers and with the passage of time also reached to small land holders with the introduction of custom and hiring based uses of farm equipment [7] Indian agriculture has climbed many ladders with these equipment and modern technologies [8].

After independence India was dependent on foreign countries not only for technology for building modern plants but also for its foodgrains requirements. The journey to achieve self-reliance started with Green Revolution. Indian agricultural sector has now been achieving new landmarks with every passing year. India's food production reached to 285.21 million tonne in 2019 from 108.4 million tonne in 1970.

The nature of agriculture is significantly different from industrial sector. The production in any manufacturing unit takes place under controlled circumstances whereas agricultural commodities being produced in open spaces facing all sorts of adverse weather events. Excess supply at harvesting, seasonality, perishable nature of the commodity, and lack of proper information create the cyclical fluctuations in the prices of agricultural commodities. Hence, they in combination can make agriculture an enterprise of uncertainties.

Male workers have been migrating from agriculture to industrial and service sectors in search of more assured and remunerative means of livelihood. Hence, the agriculture sector is left to female workers. Most of the works (planting, harvesting, threshing, weeding, winnowing) are being undertaken by female in the absence of employment opportunities in non-farm activities in rural areas. Further, the agriculture sector in modern times has witnessed increasing adoption of modern equipment. It has happened due to rise in affordability in medium and large farmers, substantial rise in wage rate and improvements in hiring based services of these inputs [9].

2. RELEVANT STUDIES

The whole debate of women's participation started with U-shaped hypothesis [10]. According to the hypothesis, the female participation in economic activities follows a U-Shaped curve. The women work along with men in the initial phases of economic development and hence we observe higher women participation. As society attains higher economic development, the women's participation declines because they move to acquire more skills and education. The women workers reclaim to economic activities with higher education and improved skills in advanced stages of economy.

Menon [11] has also decoded factors behind the falling rate of female participation in agriculture. The documentation of the factors behind the gradual decline of female participation is the need of the hour for policy and programmes perspective. He explains the relation between

female participation and their educational level and exhibits a U-shaped relationship between female labour participation and educational level which grows positively with low and high education level and decline with a moderate level of education [10] [12] [3] [13]. The theoretical justification for a positive association between female work participation and low and high education is that the work has been divided only for the skilled and unskilled women labour. Hence, there is no scope for a female who has a moderate level of education [14].

Mechanisation is an important part of agriculture activities that enhance agricultural productivity and play a significant role to develop rural as well as the agrarian economy [15]. The purpose of mechanisation is to enhance agriculture production with the use of existing resources and also helps the labours to move from the agriculture sector to industrial and service sectors of the economy. During 1970s the demand for farm mechanisation had sharply increased due to the enhancement the agriculture production. However, research in the 1970s on women's labour force participation rates found that men tend to have more access to new technologies, which would displace women from participating in labour force in the initial stages of development (Boserup, 1970).

Laufer (1985) found that the productivity of men in India is greater than women in crop productions, and farmers distribute wages relative to their marginal productivity. If this conclusion holds with mechanisation, then as a result of men's improved productivity with mechanised tools, the comparative wage of women will further decrease because men have more access to modern machines and tools.

Other studies in this area have also supported that men have better access than women to higher-quality farm tools. For example, Babatunde et al. (2008) found that there are more resources for agricultural production in male-headed households in Nigeria. Specifically, this study concluded that the value of farm tools in male-headed households is significantly higher than in female-headed households. Similarly, Deere et al. (2010) found in Latin America that men tend to own the most valuable farm equipment and installations. The different impacts of mechanisation on men and women also change the labour distribution in households, as well as the power dynamic.

In their research paper on farm labour and input usage during 1999-2011 in India analysed the effect of increased use of farm machinery on men's and women's labour use in agriculture. When women perform tasks that require different skills, and which have limited substitutability with the tasks typically performed by men, technological change can have disproportionate gender impacts. Using the extent of loaminess of the soil, a determinant of the requirement for deep tillage, as an instrument for the adoption of tractors for tilling the land, the study found that a percentage point increase in mechanisation decreases female labour used per hectare by 0.7%. Men's labour also falls by 0.1% per hectare, but insignificantly. The study shows that an observed 32 percentage point increase in mechanisation during 1999-2011 led to more than 22% overall reduction in women's labour use in agriculture. This decline in women's labour is driven by a significant fall in labour used for weeding, an operation that follows tilling of land in the agricultural production process.

Few empirical studies confirm that the geographical differences across Indian states support the U-shaped hypothesis and with economic growth in an area the women participation rate in farm activities decline [16]. The technological changes have made a significant impact on labour absorption in the agriculture sector in India. The green revolution has intensively mechanised the agriculture sector. The mechanisation of farm activities has increased agriculture productivity but on the other hand substitution of human labour with machines especially women have got negatively impacted. The farm mechanisation is important factor which has negatively affected FLPR in India [15].

After an extensive exploration of available research on farm mechanisation and its impact on female labour participation we have come across various important findings in this area. The literature at disaggregated level is not sufficient and it has scope of further improvement. To the best of our knowledge very few attempts have been made to look at this relationship at district level. The present study is a moderate attempt to fill this gap by taking into account 176 Indian districts from 08 major states and analyse the trends and pattern of farm machines and female agricultural labour. It also examines the impact of farm machines on female labour in agriculture.

3. DATA AND RESEARCH METHODOLOGY

The study is based on data collected and compiled by International Crop Research Institute for Sami-Arid and Tropics (ICRISAT) under the project of Village Dynamics in South Asia (VDSA). The Agency has collected district level data on various aspects of rural economy such rural road, rural electrification, area, yield and production for 19 major crops from 19 major states. It also provides data on agriculture labour (both male and female), fertiliser consumption, number of tractor and power tiller, etc.

The data is time series starting from 1961 to 2011 with significant gap in between for several variables. We have selected 176 districts[1] spread across different states. Agricultural output per capita has been calculated by multiplying the production of 16 major crops [2] with their respective average wholesale price of 2010-11. Number of tractor in a district is taken as proxy for farm machines and number of female labour in agriculture and literacy rate for both male and female have been considered for analysis purpose. The study uses cross sectional regression using OLS for two different time period and the results have been shown in equation (i) and (ii).

Table 1 gives a brief idea about the area of study. These districts have been taken as per the boundaries of 1967. ICRISAT has combined the districts formed after 1967 to their respective parent districts.

Table 1. Details of states and districts

State	No. of Districts
Haryana	7
Punjab	11
Rajasthan	26
Uttar Pradesh	46
Gujarat	17
Madhya Pradesh	37
Andhra Pradesh	20
Tamil Nadu	12
India	176

Source: Author's Calculation based on district level data from ICRISAT, Hyderabad

The average agriculture output per capita shows improvement in all states as noticed in Fig. 1. The state of Punjab has jumped from Rs 567 in 1971 to Rs. 15452 in 2010. It has appeared to be highest growth in per capita output. There are number of favourable conditions that have pushed the Punjab and Haryana to achieve substantial growth in agricultural productivity. Assured means of irrigation, high fertility of land, higher purchasing power of the farmers in these states, and concerted efforts of state government have been vital for achieving high growth. On the other side, the state of Tamil Nadu has remained at bottom in which the average output was of Rs. 181 per capita in 1971 which rose to Rs. 2464 in 2010. The State of Uttar Pradesh is ranked 3rd in terms of Per capita agricultural output where it rose to Rs 4064 in 2010 from 178 in 1970.

Even though Rajasthan was fourth state in the bottom with average output of Rs. 245, it has emerged as third largest states of India in 2010. The performance of Rajasthan has been well ahead of Uttar Pradesh and Tamil Nadu. The credit for the success of Rajasthan goes to the policies initiatives of the state government. Average Per capita agriculture output acts as

[1] *Hissar, Gurgaon, Jind, Mahendragarh, Ambala, Karnal, Rohtak, Gurdaspur, Amritsar, Kapurthala, Jalandhar, Hoshiarpur, Roopnagar, Ludhiana, Ferozpur, Bhatinda, Sangrur, Patiala, Ajmer, Alwar, Banswara, Barmer, Bharatpur, Bhilwara, Bikaner, Bundi, Chittorgarh, Churu, Dungarpur, Ganganagar, Jaipur, Jaisalmer, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Kota, Nagaur, Pali, Sawai Madhopur, Sikar, Sirohi, Tonk, Udaipur, Saharanpur, Muzaffarnagar, Meerut, Buland Shahar, Aligarh, Mathura, Agra, Mainpuri, Etah, Bareilly, Budaun, Moradabad,, Shahjahanpur, Pilibhit, Rampur, Bijnor, Farrukhabad, Etawah, Kanpur, Fatehpur, Allahabad, Jhansi, Jalaun, Hamirpur, Banda, Varanasi, Mirzpur, Jaunpur, Ghazipur, Ballia, Gorakhpur, Deoria, Basti, Azamgarh, Lucknow, Unnao, Rae-Bareily, Sitapur, Hardoi, Kheri, Faizabad, Gonda, Bahraich, Sultanpur, Pratapgarh, Barabanki, Ahmedabad, Amreli, Banaskantha, Bharuch, Vadodara, Bhavnagar, Valsad, Jamnagar, Junagadh, Kheda, Kutch, Mehsana, Panch Mahals, Rajkot, Sabarkantha, Surat, Surendranagar, Jabalpur, Balaghat, Chhindwara, Narsinghpur, Seoni, Mandla, Sagar, Damoh, Tikamgarh, Chhatarpur, Panna, Rewa, Sidhi, Satna, Shahdol, Gwalior, Shivpuri, Guna, Datia, Morena, Bhind, Indore, Ratlam, Ujjain, Mandsaur, Dewas, Dhar, Jhabua, Khargone, Khandwa, Sehore, Raisen, Vidisha, Betul, Rajgarh, Shajapur, Hoshangabad, Srikakulam, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Nellore, Kurnool, Anantapur, Y.S.R. Kadapa, Chittoor, Hyderabad, Nizamabad, Medak, Mahabubnagar, Nalgonda, Warangal, Khammam, Karimnagar, Adilabad, Chengalpattu MGR, Cuddalore, Vellore, Salem, Coimbatore, Thiruchirapalli, Thanjavur, Madurai, Ramananthapuram, Tirunelveli, Nilgiris, Kanyakumari.*

2 Rice, Wheat, Sorghum, Pearl Millet, Maize, Finger Millet, Barley, Chickpea, Pigeon-Pea, , Groundnut, Sesame, Rapeseed & Mustard, Castor, Linseed, Sugarcane and Cotton.

demand side stimulus for female agriculture labour as more labour is required for producing more output.

4. USE OF TRACTOR IN INDIAN AGRICULTURE

The tractor in agriculture purpose was first invented by Richard Trevithick in 1812. Initially they were limited to developed countries but gradually they spread to developing world also. The economic advantages of tractor are substantially higher and push the agriculture to attain more prosperity. The tractor has been used in all sort of agricultural activities ranging from land preparation, harvesting and threshing to transportation of inputs and agricultural produce to different markets.

Tractors are the widely used farm equipment in India. It has an enriched farming capacity since independence. There were several tractor companies came into being after India gained its independence. The evolution of the tractors took place due to rising demand and keen competition among tractor companies. Government of India also provided strong support to increase the production and use of this farm equipment. Initially large farmers were able to afford these farm machines but with passage of times it has reached to small land owners also.

5. FEMALE LABOUR AND TRACTOR IN AGRICULTURE

The rate of FLPR varies across states as seen in Fig. 3. In terms of use of tractor the states of Haryana and Punjab is on the top lists but interestingly they also employ least number of female workers. The state of Punjab has witnessed lowest participation of female workers whereas they occupy significant space in Rajasthan, Andhra Pradesh, Tamil Nadu and Gujarat (Fig. 3). Female labour participation is highest in the state of Rajasthan. The state of Madhya Pradesh and Andhra Pradesh and Gujarat continued to employ high proportion of female into agriculture. It might be due to their involvement in cotton, coarse cereals and oil seeds production which require more human labour. The disparities at state level clearly indicate the variations in per capita output, number of tractors and female employment in agriculture over time. By looking at average number of tractors, the state of Punjab tops the list followed by Haryana and Rajasthan. Since the state of Uttar Pradesh has largest area hence secures highest number of tractors.

In the next section we plot the number of tractors and female participation at district level. As clearly seen, an inverse relationship is clearly visible from Fig. 4. It is explained that districts with high concentration of tractor have small

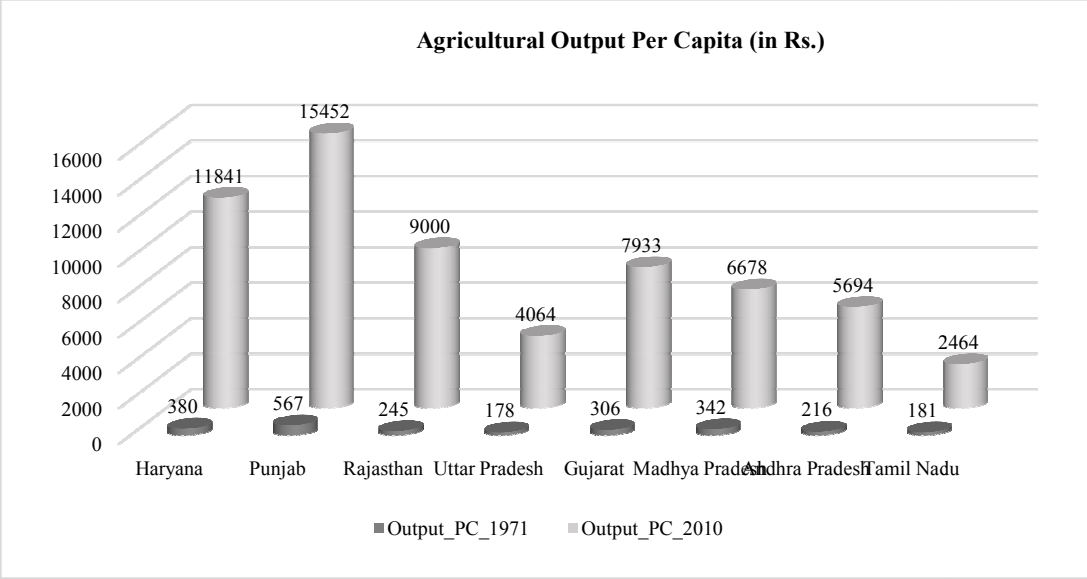

Fig. 1. Agricultural Output Per Capita (in Rs)
Source: Author's Calculation based on district level data from ICRISAT, Hyderabad.

presence of female labour and vice-versa. The districts having higher number of tractor tend to employ lesser number of female labours in the year 1971 as well as in 2010. These figures confirm the inverse relationship between farm machines and female labour in agriculture both in 1970 as well as in 2010.

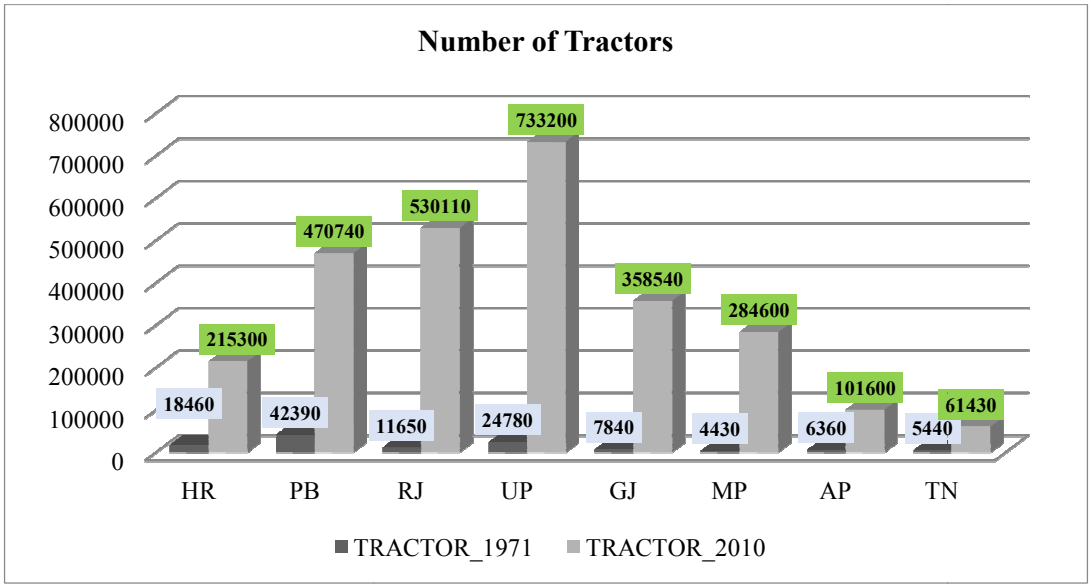

Fig. 2. Number of tractor

Source: Author's Calculation based on district level data from ICRISAT, Hyderabad.

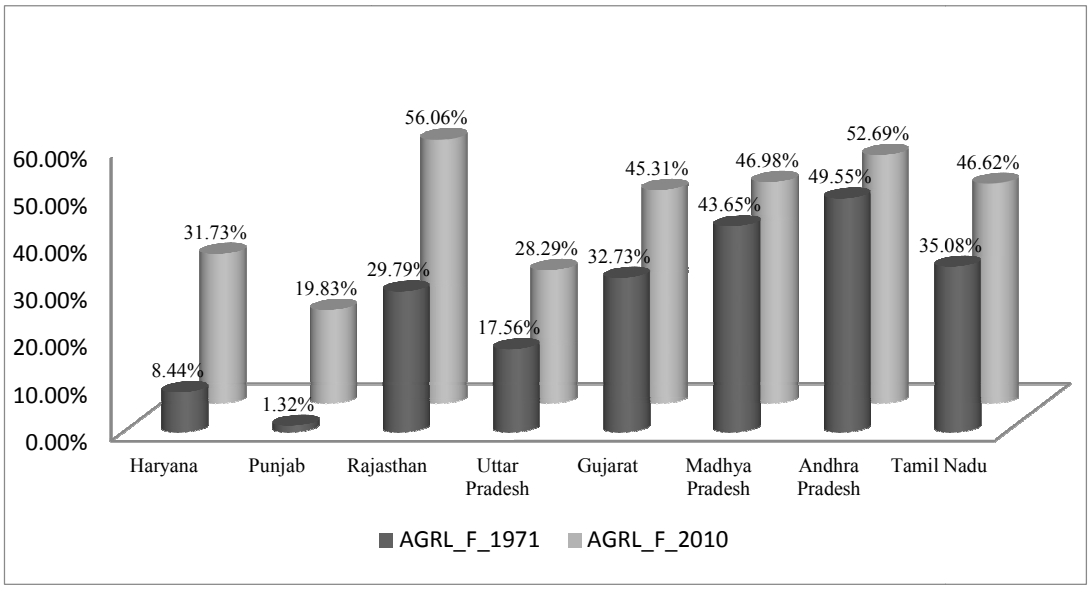

Fig. 3. Female Agriculture Labour (%)

Source: Author's Calculation based on district level data from ICRISAT, Hyderabad.

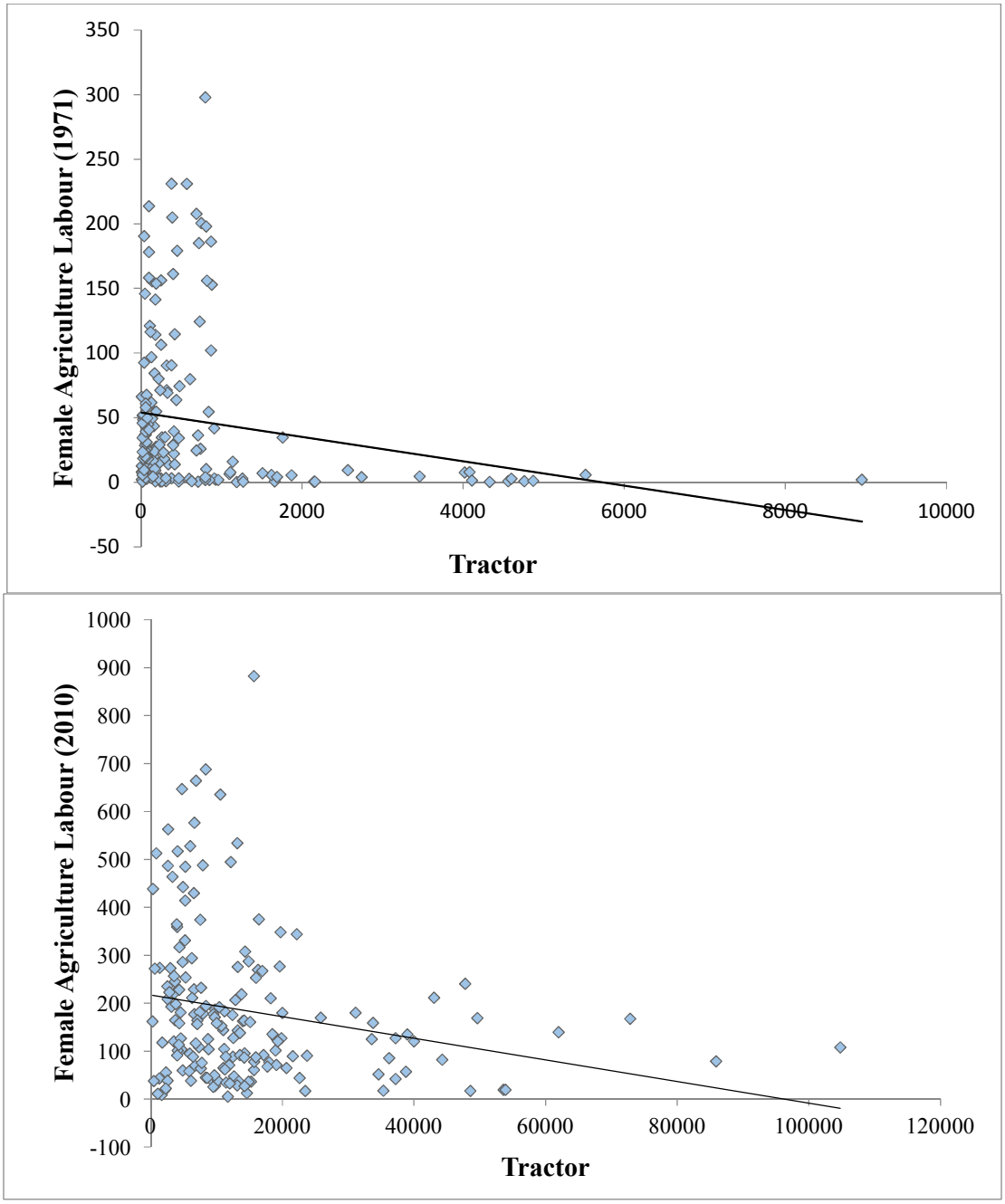

Fig. 4. Relationship between Female Agriculture Labour and Tractor
Source: Author's Calculation based on district level data from ICRISAT, Hyderabad.

6. RESULTS AND DISCUSSION

The results in this section have been obtained based on cross sectional regression analysis. The first regression equation has been estimated for 1971. In the following regression the number of female agriculture labour in a district (Labour) is considered as dependent variable which is regressed on agricultural output (Output), number of literate females in a district (LitF) and number of tractor in a district. The numbers in parentheses are t-value of individual coefficient. The agricultural output and female literacy both

have positive effects on female agriculture labour participation rate.

$$\text{Labour}_{1971} = 19840.31 + 9.14\ \text{Output}_{1971} + 0.31\ \text{LitF}_{1971} - 15.28\ \text{Tractor}_{1971} \ldots\ldots\ldots\ldots\ldots\ldots \text{ i}$$

$$(2.09)\ (0.30)\ (9.64)\ (-4.21)$$

$$\boldsymbol{R^2} = 0.39$$

A change in agricultural output by Rs 1000 required 9.14 unit of labour. The positive effect of literacy can be explained with its coefficient. An increase of number of literate female by 100 leads to improve the female participation by 31 units. On the contrary, increase the number of tractor by one unit would reduce the female labour by 15.28 units. The similar results have been found in (Pingali, Bigot, & Binswanger, 1987). They reviewed 24 studies and found that 20 out of 24 studies reported more reduction in labour use in farms depends on tractors as compared animal draft farms.

These results of 1971 maintained the relationship among variables even in 2010. Equation ii, though, represents the similar results for 2010, the intensity of tractor to affect the female participation is seen lower.

$$Labour_{2010} = 100292.5 + 0.12\ Output_{2010} + 0.14 LitF_{2010} - 2.93\ Tractor_{2010} \ldots\ldots\ldots\ldots\ldots\ldots \text{ ii}$$

$$(3.42)\ (0.04)\ (6.89)\ (-3.83)$$

$$\boldsymbol{R^2} = 0.29$$

It can be interpreted that a rise of tractor by one unit leads to a decline of 3 units of female labour. The regression results on these two different time points clarify that female literacy has positive effects on female participation though its intensity declines overtime. On the other hand, the negative relationship between female participation and agriculture machines has been clarified from the results. The regression results of 2010 also indicate that agriculture output, being a demand side factor, is seen less effective in order to increase the female participation. The R-squared of less than 40 percent claims that there are other more influential factors affecting female labour participation.

7. CONCLUSIONS

Both demand and supply side factors influence FLPR in any sector. Indian agriculture has witnessed men migration to other sectors in early phases of economic reforms. Rising population and demand for food and fiber work as demand side factors whereas farm mechanisation, education, security risks and household income are supply side factors. The results of this paper reveal that female literacy and per capita output exert positive effects on FLPR but farm mechanisation leave a negative effect on female labour.

Introducing modern machines and equipment to agriculture has improved the outcomes in positive direction. Per hectare output has increased many folds. The state of Haryana and Punjab utilized the highest number of tractors. But gradually it has reached to small farmers of relatively poor states due prevalence of custom and hiring based agricultural equipment. The use of tractor in agriculture has substitute the female agriculture labour in both the years of analysis. Taking tractor as a proxy for farm machine the study has analysed this relationship at district level. The main findings are as follows-

1. The survey of available research in this area clarifies that female's enrolment for higher education exhibits a U-shape relationship. The FLPR remains high at low as well as at high level of education but declines at moderate level of education. It has also been noticed that women carry out a lot of unpaid works at home regardless they being working in formal or informal sector. According to the studies, they perform these in-house duties because no one else wants to do it. It appears to be a substantial reason for their preference to leave the jobs once the household income rises.
2. Patriarchal social norms, religious views and customs hinder the movement and freedom to work for females. Generally, it has been noticed that women from upper castes and classes do not want their women to work in low paid and menial jobs. That is why majority of female workers in agriculture and other low grade jobs are from schedule caste and other backward caste. Females from middle class also face a lot hindrance while doing their works outside their house.
3. Transportation facilities include safe and quick commutation through roads and railways. The FLPR in economic activities can see a positive spike if efficient transportation facilities are placed.

Analogously, security risks also play important role in female participation. The incidents of rape and molestation give negative signals to the female labour force and discourage their participation rate.

4. Lastly, farm mechanisation also has substantial impacts on FLPR. Introduction and spread of farm machines across the regions and into the various agricultural operations substitute the human and draught animal power. Since modern technologies are gender biased. Most of the machines are operated by males due to various reasons and thus have more negative effects on FLPR in agriculture.
5. A formal regression analysis gives a clear idea that FLPR and farm machines are negatively related across Indian districts. The districts with more number of tractors employ lesser female labour in agricultural operations and vice-versa. It is observed in this chapter; per capita agricultural output and female literacy leave positive effects on FLPR among Indian districts.

Having analysed the above mentioned determinants of female participation we can put forward some of the suggestions and recommendations to improve the female participation in economic activities. Security risks such as rape, sexual harassment and molestation can be dealt with stringent laws. Speedy trials should be put in place to discourage such activities. These initiatives discourage the incidents of violence against women and give positive signals to female participation. Providing efficient transportation facilities such connecting roads and arrangements of trains and buses also improve the female participation rate.

Other important bottlenecks for female participation are social customs & norms which do not allow free movements and choice of employment. These societal hindrances are handled with counseling of male members of the society. Lack of skills among women is also responsible factor for low participation and proper training is required for its improvement. Lastly, women centric technologies shall be improved to retain them into farm activities.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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