



Gains from improved technology adoption in disadvantaged regions: evidences from Bundelkhand region

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ABSTRACT

The study explored the status and determinants of technology adoption in terms of shifting towards high yielding varieties, micro-irrigation and mechanisation in Bundelkhand zone. The study is based on a field survey conducted in the Jhansi district of Bundelkhand region in 2018–19. Bundelkhand is a water scarce area of the country and needs policy interventions in the form of efficient water utilization and enhanced production. The results indicate that despite least adoption of sprinkler in the region, micro-irrigation has resulted in water use conservation and improved yields in comparison to conventional irrigation method. The findings revealed that age, income from cultivation, possession of MGNREGA job card and membership of any local and village level organization had a considerable impact on the decision to adopt improved agricultural varieties and micro-irrigation implying that the security nets provided in any form motivates the households to adopt improved technology. Size of operated land, income from non-agricultural activities and possession of Kisan Credit Card are the significant factors in case of farm mechanisation.

Keywords: Bundelkhand, High-yielding varieties, Mechanisation, Micro-irrigation, Technology adoption

For an ambitious target of doubling farmers' income by 2022, it is crucial to prioritize the disadvantaged regions in India. Achieving the agricultural efficiency in these regions is crucial for achieving the pro-poor economic growth. Improvement in crop productivity remains the first and foremost source in this regard. Adoption of modern technologies can boost the agricultural productivity and farmers' incomes and promote welfare (Hailu *et al.* 2014, Duflo *et al.* 2011, Mendola 2007, Fernandez-Cornejo *et al.* 2005). Existing literature suggests that benefit commencing from advanced agricultural technologies have impacted the poor and rural disadvantaged regions directly through raising the returns of agricultural households, and obliquely, by raising wage rates of functionally landless labourers (Asfaw *et al.* 2012). However, the adoption of these technologies is not uniform across spatial domain and is a function of several socio-economic factors. Membership of a farmers' organization, distance to input and technology sources, cost of technology, yield and level of training have emerged as important factors influencing technology adoption (Awotide *et al.* 2016). Among the social factors, land size, gender,

access to technology, education etc. are known to hold importance in technological adoption. Each factor holds varying importance in different disadvantaged regions and hence is subject to detailed exploration.

Bundelkhand region has an area of 7,53,700 square kms and around 18.3 million people, 78% of whom live in rural Bundelkhand, further, more than one third of the households in the region are below the poverty line (BPL). The agriculture here is mostly rain-reliant, multifaceted, under-invested and vulnerable. Most of the region in Bundelkhand is a hard rock area with scarce groundwater reserves, inadequate infrastructure, with limited accessibility to updated technologies, markets and inputs. In this context, the study examined the status and determinants of technology adoption in one of the most vulnerable regions of India. Adoption of three major technologies i.e. high yielding variety, micro-irrigation and mechanisation in the study area have been studied.

MATERIALS AND METHODS

The study is based on primary survey conducted in the Jhansi district using multi-stage random sampling method in 2019. The survey collected the information for the agricultural year from July 2018–June 2019. Four blocks Babina, Bamaur, Moth and Mauranipur were first selected randomly from Jhansi district and two villages each from the four blocks were picked at random. Information on input

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and technology adoption used in cultivation was obtained using well-structured pre-tested questionnaire. Information was obtained via primary survey from 160 agricultural households, however, information for 127 households could finally be used for the functional analysis. The binary logistic regression model has been used so as to recognize the factors that significantly affect the choice whether or not a household would adopt certain technology. To recognize the major determinants of technology adoption in agriculture, we first computed a dichotomous variable indicating whether the household adopted any technology or not.

$$Y_i = \begin{cases} 1, & \text{for technology adoption} \\ 0, & \text{otherwise} \end{cases}$$

where, Y_i denotes the status of technology adoption (high yield variety and micro-irrigation or possessing a tractor) by households for agriculture.

On the basis of likelihood ratio Chi-square statistic, it was determined whether the predictors mentioned under different major categories: household characteristics, physical and financial, institutional and infrastructural variables were associated with the technology adoption. For analysis purpose, we used a logistic regression model.

$$\text{Logit}(P) = \ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_{pn}$$

where, P is the probability of technological adoption by households for agriculture, $1-P$ indicates the probability that household did not adopt any technology, and $P/1-P$ indicates the odds ratio of non-adoption of any technology, that is, the probability of adopting technology divided by the probability of not adopting it. X_1, X_2, \dots, X_n represent the predictor variables that affect farmers' decision of adoption of any type of technology for agriculture.

The dependent variables considered in the study included high yielding varieties, micro-irrigation and tractor possession. Around 34.12% of the sample respondents adopted the HYV varieties, 20.63% adopted the micro-irrigation, whereas 53.96% adopted the mechanisation (tractors) in crop cultivation. Due to less number of adopters, common dummy was used for HYV adopters and micro-irrigation. The detailed explanation of independent variables is given in Table 1. Explanatory variables were grouped under three categories: household characteristics, physical and financial assets and institutional and infrastructural variables. The first group of explanatory variables household characteristics included household level indicators. Figures for number of working members and age of household head are continuous variables. Table 1 reveals that average number of working members in a household was 3 whereas average age of household head was 52 years. The probability of adoption of high yield varieties (HYV), micro-irrigation and mechanisation was expected to decrease with the increase in age, as younger farmers were more likely to experiment with new technologies in comparison to old farmers. Education level of household head was included as a dummy variable and on an average 85% farmers were educated (from primary

to post-graduate) and a positive sign was hypothesized for the adoption of technology in agriculture.

All the variables under category of physical and financial assets are of continuous nature. The average size of operated land holding was 10 acres (1 Acre= 0.40469 ha). Annual gross income was ₹2.74 lakhs per household that included contribution from various sources. Merely cultivation contributed 89% share of total income, regular salary earnings comprised 11% and rest came from livestock and non-agricultural activities. Other important factors in determining technology adoption include *kisan* credit card (KCC) synonymous to compulsory insurance, membership of any local and village level organization, MGNREGA card targets to augment livelihood security by offering minimum 100 days of wage assignment in a financial year to adult members in rural household ready to do unskilled manual work. These variables were taken as dummy in regression equations. About 33 and 82% farmers possess MGNREGA card and ration card, respectively. On an average, 68% farmers had access to short term loan with 1.5 thousand average outstanding amount per household. Membership of an organization enables farmers to access inputs and information about new technology easily with an affordable price. Only 17% farmers were found to be members of any association under the sample survey.

RESULTS AND DISCUSSION

Technology plays an important role in terms of improved crop yield and farmers' income (Chandran and Surendran 2016, Brookes and Barfoot 2018). Access to information and credit positively influenced the adoption of hybrid wheat varieties in Maharashtra (Matuschke *et al.* 2007). Similarly, across the developing countries, different researchers have recognized diverse range of factors affecting the technological adoption in agriculture. In this study, farm households shifted to a number of improved crop varieties during the last five years for improvement in crop productivity (Supplementary Table 1). A number of crops were grown in the selected region, wheat and pulses occupied major share in the cropping pattern of farm households. In some pockets of the selected region, the farmers had shifted towards basmati rice when more irrigation facilities and infrastructure was created. Though paddy was grown in very small area in the region, Pusa Basmati 1121 known for its fine grain qualities provided excellent results both in terms of productivity gains and fetching premium price in the market. Pulses occupied important place in the region and held significance due to sustainability concerns. Continued emphasis on technological improvements in this area would be crucial for development of pulses sector in the region.

Researchers suggest that drip irrigation system increased yields up to 40–130% while ensuring water efficiency up to 65% (Cetin and Uygan 2008, Al-Omran *et al.* 2005, El-Hendawy *et al.* 2008, Payero *et al.* 2008). Despite being a water scarce region, the adoption of micro-irrigation was very less in the study region. Adoption of sprinkler irrigation led to better yield and water use efficiency in contrast to

Table 1 Description, units, and statistics for variables used in the study

Variable	Type	Definition	Mean	Standard deviation
<i>Household characteristics</i>				
Age	Continuous	Age of head (in years)	51.57	12.05
Education	Dummy	Education of head (1-literate, 0-otherwise)	0.85	0.36
Household size	Continuous	Number of household members	7.52	3.99
Working member	Continuous	Number of members working in household	2.63	1.64
<i>Physical and financial Assets</i>				
Operated land	Continuous	Land used for agriculture (in acres)	9.78	12.31
Herd size	Continuous	Number of animals	2.41	3.17
Cultivation income	Continuous	Annual gross income from cultivation (₹ in lakhs)	2.44	3.07
Livestock income	Continuous	Annual gross income from livestock (₹ in lakhs)	0.05	0.13
Income from regular salary earning	Continuous	Annual gross income from regular salary (₹ in lakhs)	0.31	0.50
Income from non-agricultural activities	Continuous	Annual gross non-agricultural income (₹ in lakhs)	0.12	0.46
<i>Institutional and infrastructural variables</i>				
Kisan Credit Card (KCC)	Dummy	Possession of KCC for short term loan (1=yes, 0=otherwise)	0.68	0.47
Outstanding amount	Continuous	Loan amount (Thousand ₹)	1.50	2.02
Membership	Dummy	Membership of any organization (1=yes, 0=otherwise)	0.17	0.38
MGNREGA	Dummy	Card Possession (1=yes, 0=otherwise)	0.33	0.47
Ration card	Dummy	Card Possession (1=yes, 0=otherwise)	0.82	0.39

traditional irrigation method as evidenced through the study. The yield obtained from sprinkler system was as high as 40% in groundnut in comparison to conventional irrigation (Supplementary Table 2). In vegetables and pulses also, the yield was upto 10% higher in sprinkler irrigation. Wheat demonstrated an improved yield of 15% under micro-irrigation. The water use efficiency coefficients for micro-irrigation over the flood irrigation method had been drawn from Narayanmoorthy (2009). Under micro-irrigation water use efficiency was enhanced by 55–65%. Crop wise water consumption was calculated across various crops both in flood irrigation and micro-irrigation in the selected region and the same had been used for calculating the water use efficiency.

As far as the adoption of high yielding varieties for cultivation was concerned, the age of the household head was found to be negatively associated with it (Table 2). This indicates that an aged and experienced farmer was less probable to embrace latest technology. The results indicate that owning a job card was positive and significant for adopting the improved varieties. The results also indicate positive and significant effect of household income from cultivation on adoption of improved crop varieties. Although the unit change for adoption of new varieties for unit change in income from cultivation was very less, but farm income

positively affected the farmers' decision of adopting new or superior varieties. On the other hand, gross income from regular salary earnings was also significant but had a negative impact on technology adoption. Outstanding loan amount showed affirmative and significant influence for the adoption of HYVs in agriculture. The impact of ration card on adoption of advanced varieties in agriculture was positive and significant. Results further indicate that households participating in community organizations and trainings were aware of new and improved methods or technologies. This helped in enhanced earnings and had positive and significant impact on the technology adoption.

The land, non-agricultural income and credit (holding of KCC) primarily determine whether the farm households would possess a tractor (farm mechanisation) or not. Size of operated land is an important driver of farm mechanisation. KCC emerged as an important determinant of farm mechanisation in the region. Though KCC is a type of crop loan offered by the banks, however, the loan could be used for a number of other purposes not just limiting to meeting the requirements of working capital. Non-agricultural income was positively and significantly linked with the adoption of farm mechanisation suggesting that an increase in income from non-agricultural sources would boost the amount of money available with the farm households to

Table 2 Determinants of adoption of improved agricultural varieties, micro-irrigation and farm mechanisation

Variable	Improved agricultural varieties and micro-irrigation		Farm Mechanisation	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Age	-0.062**(0.012)	-0.012	0.027 (0.362)	0.002
Education	0.942(0.297)	0.151	0.179 (0.860)	0.012
Household size	0.018(0.838)	0.003	0.106 (0.378)	0.007
Working members	-0.096 (0.677)	-0.018	-0.177 (0.471)	-0.011
Ration card	1.347*(0.063)	0.204	-1.334 (0.135)	-0.061
Operated land	-0.078 (0.103)	-0.015	0.535*** (0.001)	0.034
Cultivation income	0.000**(0.029)	0.000	0.000 (0.318)	0.000
Livestock income	0.000(0.626)	0.000	0.000 (0.712)	0.000
Non-agricultural Income	0.000(0.228)	0.000	0.000 **(0.022)	0.000
Regular salary earning	0.000**(0.055)	0.000	0.000 (0.133)	0.000
MGNREGA	3.237*** (0.006)	0.647	-0.600 (0.548)	-0.042
Herd size	0.058 (0.011)	0.011	-0.019 (0.925)	-0.001
Kissan credit card	0.041 (0.947)	0.008	1.867** (0.032)	0.168
Outstanding amount	0.000**(0.037)	0.000	0.000 (0.459)	0.000
Membership	1.124*(0.075)	0.245	0.131 (0.878)	0.008
Constant	-0.808 (0.594)		-6.456 (0.002)	
LR chi ² (15)	43.91		96.98	
Pseudo R ²	0.272		0.558	
Observations	126		126	

Note: *, **, *** and represents 10%, 5% and 1% level of significance, respectively. Figures in parentheses indicate the standard errors.

invest in farm machinery.

The study scrutinized the significance and determinants of technology adoption in dry regions of Bundelkhand. We studied three technologies, viz. high yielding variety, micro-irrigation and mechanisation. The study establishes that socio-economic factors have important bearing on the technology adoption in a region. Interestingly, those farmers who shifted to improved crop varieties during the last five years reported significant improvement in crop productivity. Adoption of sprinkler irrigation led to enhanced yield and water use efficiency in comparison to conventional irrigation method of canal, well and tanks. Water use efficiency under micro-irrigation enhanced by 55–65%.

As far as socio-economic characteristics were concerned, age of the household head emerged to have negative association with the adoption of high yielding varieties for cultivation. This indicates the bending and favouritism of relatively young generation towards new technologies. Additionally, owning a job card was positive and highly significant in adoption of advanced varieties. This could be viewed in light of additional source of income and affordability to cost of technology adoption. A job card ensures additional income to farmers, which in turn ensures the additional cost of technology adoption can be met by farmers in the field. Confirming to this, the study established affirmative and significant effect of household income from

cultivation on adoption of improved crop varieties. On the other hand, gross income from regular salary earnings was also significant but had a negative impact on technology adoption. Credit (outstanding loan amount) created an affirmative and important influence on the adoption of HYVs in agriculture. Participation in community organizations and trainings enhanced earnings of households significantly. KCC emerged as an important determinant of farm mechanisation in the region besides land and income from non-agricultural occupations. Regarding the adoption of farm mechanisation, non-agricultural income was positively and significantly linked, revealing that increase in income from non-agricultural sources would increase the amount of money available with the farm households to invest in farm machinery. There should be quick spread of seeds of new, high yielding, stress tolerant and climate resilient varieties to the farmers. Productivity enhancement needs to be coupled with efficient and effective market linkage along with risk mitigation. Effective extension systems hold the key to success in terms of disseminating advanced technological information.

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