Factors hindering the adoption of innovations in the arid agro-ecosystems of India[†]

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This study deals with the factors hindering the adoption of innovations in the arid agro-ecosystems of India. Adoption of agricultural technologies helps increase agricultural output, which can impact poverty levels and environmental degradation. The present study was conducted in Rajasthan, India, to identify the technology adoption of agricultural households and various socio-economic and socio-personal factors affecting the same. Among several coping strategies for climate vulnerability, other than a shift towards rainfed crops, reducing the number of irrigations, deepening existing wells and advancing or delaying irrigation were common in the arid ecosystems. Some important policy measures have been drawn from this study. First, the sustainable development of groundwater resources, particularly in the low-productive eastern region, would go a long way in improving agricultural productivity in the country. Agricultural productivity can also be improved by increasing fertilizer use. Second, it proves cost-reducing technologies and creates awareness of better resource-saving options for better returns. Finally, advisory services and the availability of extension personnel are important in rural development.

Keywords: Adoption of innovations, agricultural technologies, arid agro-ecosystems, rural development.

TECHNOLOGY plays a central role in improving agricultural productivity. Adoption of agricultural technologies helps increase agricultural output, which can further impact poverty levels and environmental degradation[1]. In India, disseminating Green Revolution technologies across regions can be an example in this regard. While technological gains were concentrated in a few pockets during the initial period of introduction, wider dissemination was observed sooner across regions and crops[2]. The spillover effects in turn helped the agriculture sector attain a higher growth trajectory. The extent of technology adoption varies across regions and depends upon several factors. At the macro level, the availability and affordability of technologies[3,4], market inefficiencies[5] and risk factors[6] play a crucial role in technology adoption. At the micro level, socio-economic, institutional, and household factors can influence technology adoption[7]. In this context, an integrated study involving the linkage among technology adoption, agricultural growth and poverty with special emphasis on the socio-economic and socio-personal determinants of the above in a region-specific manner will be useful. The present study deals with the technology adoption of agricultural households and various socio-economic and socio-personal factors affecting the adoption of technology and the performance of agriculture.

Data and methodology

For this study, both primary and secondary data were collected. Primary data were collected by the survey method using a well-structured, elaborate and pre-tested schedule. The primary data related to socio-economic status, input–output information of crop production, agricultural technologies in practice and natural phenomena were collected. The period of enquiry was during the agricultural year 2017–18. The study was conducted in Rajasthan, India, based on its agro-ecosystem system. Rajasthan has an arid agro-ecosystem (pearl millet-based production system). Jodhpur district, Rajasthan, from an arid agro-ecological zone having a substantial area under the selected crop, was selected for the study. Two villages from the selected district were chosen, and a sample of 100 farmers was drawn.

Analytical techniques employed

Factors that explain vulnerability were studied using the regression approach. Vulnerability index was estimated using six different variables, viz. (1) flooding before the end of the growing or harvest season of crops, (2) drought after planting of crops, (3) prolonged rainfall/flood during the wet season, (4) prolonged drought during the dry season, (5) pests and diseases during the wet season, and (6) pests and diseases during the dry season. Equal weightage was given to all attributes, and the vulnerability index for each farmer was estimated. Using the indices as the dependent variable and

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education, size group, social group, profit, income, etc. as independent variables, the multiple regression technique was employed. Private varieties, irrigation and wide row spacing, were incorporated in the model as dummy variables.

Results and discussion

Socio-economic and personal attributes, and technology adoption

General characteristics of sample farmers: Agriculture is the main source of income in rural India, which depends on the socio-economic structure of the households. The present study is based on a sample size of 100 households. The study of these households has been done based on (a) human assets, (b) caste composition, (c) literacy status, and (d) pattern of land holdings and average number of farm equipment and livestock (Table 1).

On the basis of the surveyed households, it was noticed that in Rajasthan, the general caste accounted for 15% of the total households, 79 households belonged to the backward caste, and six to the scheduled caste (SC) category. Backward caste constituted a major portion of the farming population in Rajasthan, followed by SC and scheduled tribe (ST). Table 1 shows that the higher the respondents' age, the higher their experience in farming (all other factors being equal), which translates to encountering risks among older farmers than younger farmers. In Rajasthan, the majority of the respondents (49%) were aged between 36 and 50 years, and thus had more experience regarding farming practices compared to those in the up to 35 years age group (22%), who are still learning. The average family in Rajasthan had six members. From the results obtained, 27% of the farmers had secondary education, while 44% had no formal education. Only 7% were graduates and above. The average land holding size was about 4 ha, while the permanent fallow area due to extreme aridity accounted for 0.28 ha on average. The irrigated area accounted for about 30% of the total holdings in Rajasthan. The size of the land holding did not directly imply the size of farm income and/or wealth. On an average each farm family hadat least three livestock, this indicates presence of fair combination of both the crop and livestock enterprise among the farmers. Cattle rearing is considered a remunerative enterprise, which could be the possible reason for the activity by majority of farmers in Rajasthan. On average, at least one major farm equipment was observed in the study area. This reiterates the labour shortage for timely sowing and stress the role of farm mechanization in the state.

Table 1. General characteristics of sample farmers from Rajasthan, India: summary statistics

Particulars	Numbers/ percentage
Number of observations	100
Human assets	
Up to 35 years	22
36–50 years	49
51–65 years	23
Above 65 years	6
Average family size	6
Cast composition	
General	15
Backward cast	79
Scheduled cast	6
Education	
Illiterate	44
Primary	22
Secondary	27
Graduate and above	7
Land assets	
Average owned land (ha)	4.33
Average leased-in	3.20
Average permanent fallow	0.28
% Area irrigated	30.11
Average number of farm equipment	1.34
Average number of livestock	3
Income from agriculture related activity	161,974
Non-farm income	162,920
Income from salaried jobs/pension	326,859
Total expenditure on agricultural activities	128,248

Source: Field Survey, 2017.

Technologies and rate of adoption: Table 2 summarizes the various technologies and rate of adoption among sample farmers. Almost all the selected farm households adopted the improved variety of pearl millet. Out of 100 sample households surveyed, 86 farmers reported the use of optimum seed rate (Figure 1). This clearly shows that a major proportion of sample farmers are adopting weed management practices in pearl millet, which is the most important cultural practice in this crop.

Moreover, only 44 farmers used the wide row spacing technique in pearl millet. This is a dryland cereal and low-income crop. So the majority of sampled farmers did not use any micronutrients (zinc sulphate). However, Table 2 shows that 94 adopted farmers broadcasting di-ammonium phosphate and drilling of fertilizer (urea).

Factors influencing the adoption of agricultural technologies among sample farmers: Table 3 shows the various factors

Table 2. Statistics of technologies and rate of adoption in pearl millet

	Response	
Particulars	Adopters	Non-adopters
Improved variety/hybrid	99	1
Optimum seed rate	86	14
Method of sowing	31	69
Optimum dose of fertilizers	80	20
Drilling of fertilizer/broadcasting of DAP	94	6
Wide row spacing	44	56
INM (zinc sulphate)	1	99
IPM (Chlorpyrifos/parathion)	0	100
Weed management (hand-weeding)	97	3

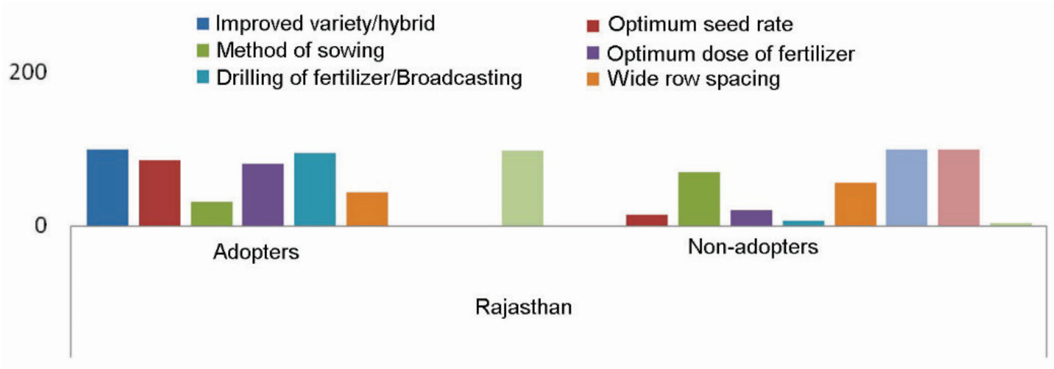

Figure 1. Technology adoption in sample districts of Rajasthan, India.

Table 3. Factors influencing the adoption of agricultural technologies among sample farmers

	Response		
Factors	Agree	Disagree	Undecided
Education level	97	0	3
Cost of technology	97	0	3
Availability of agri-insurance and credit facilities	96	0	4
Availability of inputs	90	1	9
Training of farmers on agricultural technology	79	3	18
Awareness of farmers	65	8	27
Availability of extension officers	13	71	16
Infrastructure (roads, warehouse, cold storage)	18	75	7
Males and females adopt technology equally	10	78	12

which influence the adoption of agricultural technologies. Nearly 97% of respondents from Rajasthan indicated that the cost of technology was a strong factor affecting the adoption of any technology. Majority of respondents (96%) were of the opinion that the availability of tools and equipment was also a significant factor affecting the adoption of a technology. Ninety per cent of the respondents mentioned that the availability of inputs determines whether a technology will be adopted or not, while only 4% of the respondents were undecided. On the exposure of sample farmers to training as a determinant of technology adoption, 79% of the respondents agreed, 3% disagreed, and 18% were undecided (Figure 2).

Adaptation measures: Farmers who observed climate variability over 10 years were asked to describe the adaptation measures undertaken in response to climate change. The results demonstrated that farm households applied a wide range of adaptation measures in response to climate change (Table 4). In Jodhpur district, Rajasthan, a large number of farmers used both modern and traditional farming technologies. Crop choice was dependent upon many factors in the selected district. Availability of water (rainfall) was the most important factor for selecting a particular crop in the state.

The wide row spacing in pearl millet is a popular technology being adopted by farmers in the study region (Table 5). The system allows for better crop establishment and nutrient mobilization, thus providing better yield and returns. The factors associated with adoption were studied using the logistic regression approach, where adoption and non-adoption behaviour have been depicted by binary choices. The results reveal that age and extent of vulnerability perceived by the farmers are the two significant factors explaining adoption behaviour. The other factors indicated in Table 5 have expected to bear considerable influence over adoption however they have limited impact thereby indicating that adoption decision are common among young farmer than rest.

The positive association between irrigation coverage and agricultural productivity reveals good scope to increase agricultural productivity by improving irrigation coverage. Among alternative irrigation sources, groundwater has emerged as a predominant source due to better reliability and higher efficiency. A strong relationship between agricultural productivity and groundwater development is reflected through the positive and significant correlation coefficient of 0.435. It is to be noted that there exists wide variation in groundwater development across different regions in India. The overexploitation of groundwater resources in the northwestern part of the country coexists with its under-utilization in the eastern part. The sustainable development of groundwater resources, particularly in the low-productive eastern region, would go a long way in improving agricultural

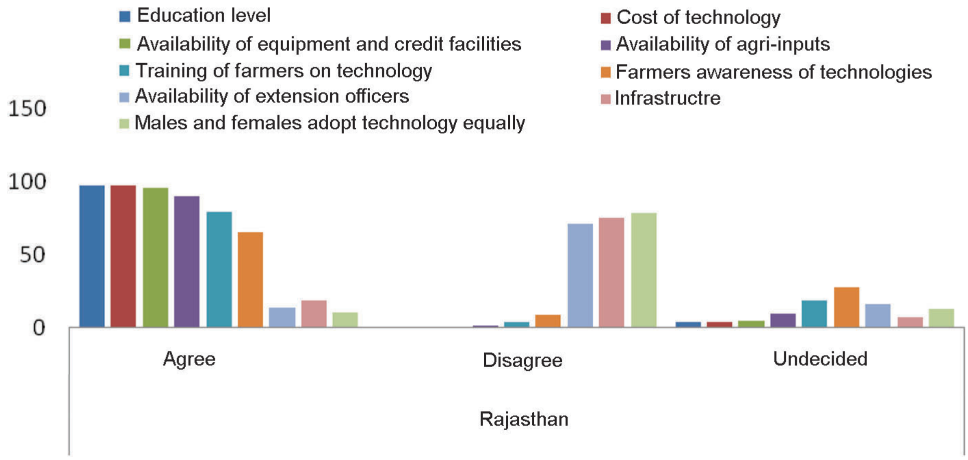

Figure 2. Factors influencing technology adoption.

Table 4. Adaptation measures among sample farmers

Adoption strategies		Value
Farming of land	Using traditional methods	23
	Modern technology	21
	Both	56
	Total	100
Influences the choice of crops grown	Changing climate	17
	Economic conditions	2
	Type of soil	0
	Water	44
	Market	37
	Total	100
Grow different types of crops	Yes	22
	No	78
	Total	100

Table 5. Determinants of wide row technology adoption in pearl millet

Explanatory variables	Coefficient	Standard error	$P > z$
Size group			
Medium	0.41	0.59	0.48
Large	0.44	0.58	0.45
Education			
Primary	–0.82	0.59	0.17
Secondary	–0.29	0.60	0.63
Social group	–0.27	0.69	0.70
Age	–0.06	0.02	0.01
Household size	0.06	0.13	0.62
Income (Rs/person/month)	0.00	0.00	0.11
Vulnerability index	–2.36	1.37	0.08
Constant	5.11	2.11	0.02

productivity in India. Agricultural productivity can also be improved by increasing fertilizer use.

Information access: In agriculture, the source of information varies with activity. In order to assess the most widely used sources of information, a source-wise rank list was prepared. In this list, information sources included group electronic/print media, ICT, personal sources and institutional sources (Table 6). Institutional source topped the list to provide agriculture-related and credit-related information among the farmers. Informal institutional source occupies the second position, while for marketing-related information, electronic/print media occupied the first position in Rajasthan. The table also revealed that ICT have very little attention,

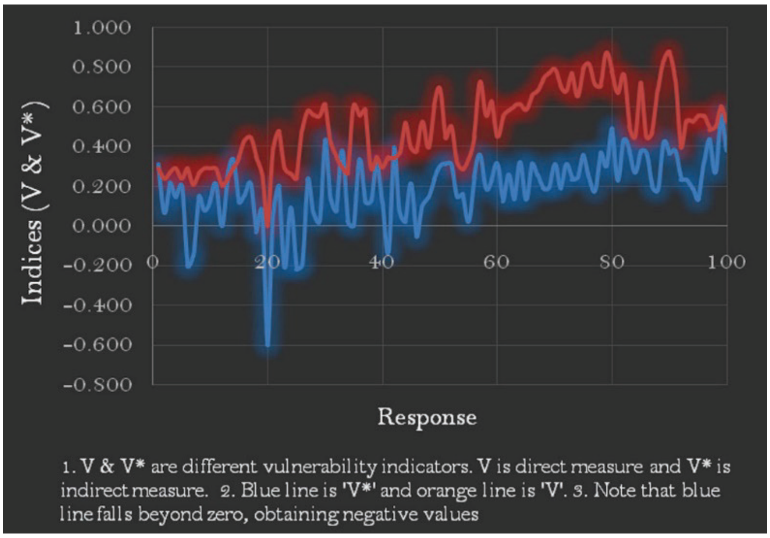

Figure 3. Performance of vulnerability measures.

Table 6. Ranking of existing sources of information among sample farmers

Source	Electronic/print media	ICT	Personal source	Institutional source
Agriculture-related information	–	3 (10)	2 (32)	1 (58)
Credit	2 (22)	3 (16)	1 (62)	–
Marketing price	2 (22)	1 (60)	3 (18)	–

Table 7. Determinants of vulnerability

Explanatory variables	Coefficient	Standard error	$p > \|t\|$
Education			
Primary	0.012	0.047	0.806
Above primary	–0.046	0.040	0.248
Size group			
Medium	0.045	0.043	0.294
Large	0.645	0.044	0.143
Social group (SC/ST)	–0.031	0.049	0.523
Profit (Rs/ha)	–0.001	0.000	0.005
Income (Rs/person/month)	0.001	0.000	0.028
Farm income (% to total)	0.003	0.001	0.000
Private seed (dummy)	–0.069	0.042	0.110
Irrigation (dummy)	0.058	0.044	0.185
Wide row spacing (dummy)	–0.024	0.035	0.488
Constant	0.274	0.099	0.007
R^2	0.340		
Adjacent R^2	0.250		

in both the state farmers and used as a thin source of information.

Table 7 shows that the variables considered in the linear model explain 34% variability in the dependent variable. The regression coefficient of profit, per capita income per month and share of farm income in total shows a statistically significant impact on the vulnerability index (Figure 3). The coefficient of profit shows a negative sign as the income of farmers increases, their ability to alleviate climatic risk improves, and they are in a better condition to deal with any climatic vulnerability. In the study area, farmers primarily depend on agricultural activities as the farm income share is substantially large in their total income. The result shows a positive relation between per capita income and farm income with the vulnerability index, as the income of farmers mainly comes from agriculture, which is highly dependent on the climatic conditions of the study area, which comes under rainfed agriculture. So, climatic conditions and its extent of uncertainty will drive the income of the farmers. Under favourable climatic conditions, farmers will earn better income and vice-versa. Dummy variable for private variety and wide row spacing were considered in the model and they affect negatively on dependent variable, but they are insignificant. This may be due to crop varieties and their package of practices providing better mitigating factors to help farmers fight against climatic uncertainty.

Conclusion

The present study shows the primary survey results that indicate notable variations in arid ecosystems. Cost-reducing technologies and creating awareness of better resource-saving options could help in this aspect. Arid ecosystems indicate the need for higher credit, provided mostly by commercial banks, among other sources. The amount of credit received seems to be correlated with input intensity in cultivation. While poor net returns from cultivation affect the repayment of loans. Credit policies that help in a specific context might help ensure better returns.

The adoption of improved practices was crop dependent however their extent of adoption was fairly high in the study area. Other than the use of integrated nutrient management (INM) and integrated pest management (IPM), the technology adoption and better management practice are high across the farmers. Appropriate information dissemination and in-field demos on INM and IPM practices could encourage the adoption of technology. The adoption of agricultural technologies was relatively high in Rajasthan. Among other factors, major constraints perceived in adoption include less awareness on fertility-restoring, conservation and yield-raising technologies. Advisory services and availability of extension personnel are the other major constraints reported, followed by poor infrastructure and a gender gap in awareness. Among several coping strategies for climate vulnerability, other than a shift towards rainfed crops, reducing the number of irrigations, deepening existing wells and advancing or delaying in arid ecosystems. But consequent credit requirements and provisions for risk mitigations could help the farmers for better adoption of technology.

1. Meinzen-Dick, R., Raju, K. V. and Gulati, A., What affects organization and collective action for managing resources? Evidence from canal irrigation systems in India. *World Dev.*, 2002, **30**(4), 649–666.
2. Dasgupta, B., India's green revolution. *Econ. Polit. Wkly*, 1977, **12**, 241–260.
3. Carletto, C., Savastano, S. and Zezza, A., Fact or artifact: the impact of measurement errors on the farm size–productivity relationship. *J. Dev. Econ.*, 2013, **103**, 254–261.
4. Foster, A. D. and Rosenzweig, M. R., Microeconomics of technology adoption. *Annu. Rev. Econ.*, 2010, **2**(1), 395–424.
5. Jack, B. K., Market inefficiencies and the adoption of agricultural technologies in developing countries, 2013; https://escholarship.org/content/qt6m25r19c/qt6m25r19c.pdf
6. Reardon, T., Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Dev.*, 1997, **25**(5), 735–747.
7. Mwangi, M. and Kariuki, S., Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *J. Econ. Sustain. Dev.*, 2015, **6**(5), 208–216.

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