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Socio-ecological Factors Influencing Farmers' Perceptions on Water Management under Conservation Agriculture

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ABSTRACT

Conservation agriculture (CA) is about conserving natural resources through optimum usage along with adopting proper management measures to cut down on excessive use of inputs. Minimum tillage and retention of crop residues on the field help in the conservation of soil moisture and will result in the saving of irrigation water. To inculcate the beneficial effects of CA for conserving water into the minds of the farmer, it is necessary to understand the existing perception of the farmers on water management and also the social as well as ecological factors that influence the perception build up in the farmers. The study was conducted in two districts i.e. Nadia and Hooghly of West Bengal under the new alluvial zone during the year 2018-19, depending on the agricultural intensity and propensity to arsenic contamination in the groundwater. Seventy-five respondents were identified through the snowball sampling method. The results show that variables like age of the farmer, fragmentation of land, income of the farmer per unit of land and stubble height maintained by the farmers have a strong correlation with the perception development of the farmers on water management.

INTRODUCTION

Agriculture in India is the robust consumer of available groundwater and it is close to 78 per cent (CWC, 2020). The indiscriminate depletion of groundwater will lead to a water famine by 2040 as mentioned in the sixth annual report submitted by IPCC on climate change. Sustainable use of groundwater involves has well quantified processes in its recharge and discharge. This will also lead to frequent droughts in the summer months putting the production and productivity of the major crops to an almost unanswerable question (Sundstrom & Allen, 2019). In recent years, the world has seen a serious water crisis and more droughts than ever in the century. Agriculture in India is mostly irrigated, using a thousand gallons of water every year. Unscientific irrigation practices and puddling fields lead to wastage and exploitation of groundwater (Malik, 2016). Conservation agriculture (CA), a relatively new agricultural practice, aims to conserve and make better use of natural resources by maintaining productivity as well (Chatterjee et al., 2021). It can bring about many positive benefits such as reduced soil erosion, better soil water retention and nutrient availability for crops, and increased soil organic matter accumulation (Busari et al., 2015). However, the rapid adoption of this system has outpaced the scientific understanding of the principles of CA (Chatterjee & Acharya, 2021). There is lack of information on the impact of the introduction of CA on nutrient and water use efficiency, soil organic matter dynamics, control of weeds and crop disease, and the interactions between them (Bera et al., 2022). The farmers prefer to consult the information sources of immediate availability and their concern to subject and policies (Peer et al., 2011). Research is therefore required to develop optimal CA management practices adapted to local needsand conditions. The smallholder farming households, especially in rice–wheat production

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system require adequate information, input support, awareness as well as incentives and technical knowhow for the uptake of adaptable PCAPs (Shitu et al., 2018). Natural resources like water are free goods and seem to be available in abundance (van Ginkel et al., 2018). Thus, managing such natural resources requires rigorous and focused training of the farmers so that they could develop insights on the importance of managing water in terms of enhancing productivity and restoring ecological resilience together (Saha et al., 2022). The present study elicits the marker variables making a decisive impact on water management and sustainable agriculture. Both participatory and non-participatory approaches have been followed for the alluvial zone, the agro-climatic zone that has already been depleted in favor of agricultural modernization and now is facing the reversal in the form of impoverishment, productivity decline, and biodiversity losses. The present study was undertaken to explore the key factors and issues related to farmers' perceptions of water management under conservation agriculture practices in the New Alluvial Zone (NAZ) of West Bengal. NAZ is one of the six agro-climatic zones of West Bengal with high agricultural importance for crop diversity, production, and productivity. Most of the agriculturally important districts of the state, viz., Nadia, Hooghly, East Bardhaman, Howrah, etc. comes under this agro-climatic zone. The study was intended to extract the nature of the water management behavior of alluvial farmers and to isolate the most dominant variables for a befitting policy formulation toward socializing conservation agriculture.

METHODOLOGY

This study was conducted in the purposively selected two districts, Nadia and Hoogly, from the NAZ of West Bengal. Three community development blocks viz. Balagarh block from Hooghly district and Haringhata and Chakdaha blocks from Nadia district were selected purposively. Thirteen villages, four villages from each block in Nadia district and five villages from Balagarh block in Hooghly district were selected purposively for the present study. A sample of 75 farm households with 369 family members were interviewed from the thirteen villages following a non-random snowball sampling method using personal interview schedules. Respondents were mostly farmers who followed one, two, or all of the three criteria, namely, reduced soil disturbance, permanent soil cover, or crop rotation. Since CA is a new technique in the research locations, only few farmers were practicing CA either partially or fully. Before taking up actual fieldwork, a pilot study was conducted to understand the area, its people, institution, communication, and extension system, and the knowledge, perception, and attitude of the people towards climate change and energy conservation. Data collection for the study had been completed during 2018 to 2019 which corresponds, to maximum agricultural activities. The structured interview schedule used in the present study consists of both open and closed questions consisting of two sets of variables (i) Socio-ecological variables (x_1-x_{20}) and (ii) dependent variable (y). Farmers' perception of water management(y) was measure during a pre-tested structured interview schedule, and its association with the twenty variables was examined using quantitative approaches such as coefficient of correlation, stepwise regression, and path analysis using IBM SPSS v26.0 and the web-based programme OPSTAT (Sheoran et al., 1998).

RESULTS AND DISCUSSION

Relation between farmers' perception on water management and selected socio-ecological variables

The perception of farmers' on water management in CA has empirically been tested by developing a set of stimuli statements, which have subsequently been elucidated by experts in the relevant domain. This has been done as to calibrate the farmers' cognitive and functional competency in water management so that the prime objectives of CA can well be socialized among the farmers. Here the perception has been estimated through a set of socio-ecological characters.

Table 1 presents the coefficient of correlation between farmers' perception of water management (y) and socio-ecological variables (x_1-x_{20}) considered as dependent and independent variables, respectively. It is discernable from the table that the variables, age of the respondent, and stubble height retention have recorded positive and significant correlations, whereas the number of fragments and income per unit of land has recorded negative but significant correlation with the dependent variable under discussion.

The results suggest that the higher the age of the farmers; the better has been the water management. This is because aged farmers are more experienced in water requirements and water stress conditions and how to overcome that strategically through managing the resources. The negative correlation with income per unit of land reveals that the farmers' perception of water management has failed to make any positive contribution to the income of the farmers in the alluvial zone. A similar study shows that socio-economic, institutional, psychological, and biophysical aspects influenced

Table 1. Correlation coefficient of farmers' perception of water management (y) and selected socio-ecological variables (x_1-x_{20})

Independent Variables	'r' Value
Age (x_1)	0.448**
Education (x_2)	0.192
Family size (x_3)	-0.171
Farm size (x_4)	0.153
Cropping intensity (x_5)	-0.088
No. of fragments (x_6)	-0.426**
Annual income (x_7)	0.044
Income per capita (x_8)	0.143
Income per unit of land (x_9)	-0.434**
Annual expenditure (x_{10})	-0.062
Stubble height (x_{11})	0.480**
Volume of residue (x_{12})	0.140
Scientific orientation (x_{13})	0.014
Innovativeness (x_{14})	0.104
Extension agency contact (x_{15})	0.150
Information seeking behavior (x_{16})	0.157
Residue management score (x_{17})	-0.055
Perception on natural resource degradation (x_{18})	0.083
No. of livestock (x_{19})	0.140
Mass media utilization (x_{20})	-0.030

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level farmers' willingness to invest in soil and water conservation technologies (Moges & Taye, 2017). Water conservation and crop management proficiency may be increased through training and farmer-to-farmer contact, which implies that conservation knowledge gaps may be resolved, and adoption does not appear to be an enormous challenge (Dalton et al., 2014). While the fragmentation hinders the adoption of efficient water management since it makes farms more cost-prodigal (Breen et al., 2018). Since the area enjoys a rainfall regime ranging from 1700 to 1900 mm per year, farmers do not pay additional attention to water management on their farms. This offers a challenge for the socialization of CA in terms of water management wherein the farmers are already blessed with the bounty of water, both in terms of groundwater regime and total annual precipitation.

Predicting relative contribution of selected socio-ecological variables on farmers' perception of water management

CA technologies ensure advantages to minimize agricultural costs, conserve water and nutrients, enhance yields, diversification of crops, improve resource efficiency, and help the environment although, there are many barriers to CA technology adoption (Bhan & Behera, 2014). Table 2 presents the path analysis of the dependent variable, farmers' perception of water management (y), wherein the total effect (coefficient of correlation) has been decomposed into direct, indirect, and residual effects. It has been recorded that the variable stubble height retention has exerted the highest direct effect on farmers' perception of water management (y). It implies that for the alluvial agroecosystem, water management perception has got a collateral impact exerted by stubble height retention. This is because stubbles help to conserve soil moisture by covering the ground surface and reducing evaporation loss. This curbs down the water requirement of the next crop, especially during the sowing time. Thus, stubble height retained in the field by the farmers has direct implications on their water management strategies. Farmers' irrigation methods differ due to the uneven availability of canal and tube well water, which may affect salt and water balances in the fields (Kazmi et al., 2012). The highest indirect effect has been exerted by exogenous variable income per capita.

This is extremely important that income has been a strong determinant in deciding the extent of water management by the farmers. The research continuously points out that without consideration of the economy of CA, the ecology of CA cannot be addressed. The variable income per unit of land has routed the highest indirect effect in as many as eight variables to ultimately characterize and scale up the level of water management. A parallel study also reveals that, despite the farmers' positive perceptions of inadequate irrigation water management practices as the prime reasons for increasing water shortages, low crop yields, productivity reduction, and negative environmental consequences, their overall adaptation measures were insufficient (Yohannes et al., 2017). Farmers are limited in their capacity to manage irrigation water effectively due to a lack of technical expertise, a weak enforcement capability of the Water Users Association (WUA), and insufficient irrigation infrastructure (Yami, 2013). The consequent study also reveals that the greatest strategy to boost rural farmers' water productivity and livelihood preservation is to employ integrated rainwater harvesting from agricultural lands and then put it to numerous uses in their crops (Kumar et al., 2021) as well as understanding farmer socio-personal characteristics and production environment in which the farmer operates, are the prerequisite for the dissemination of any soil and water conservation technologies at the farm level for greater acceptance (Arya et al., 2019). The residual effect being 0.428 means 42.8 per cent of the variance could not be explained by the present set of socio-ecological variables (exogenous variables).

Table 3 shows that variables, stubble height retention (x_{11}), age of the respondent (x_1), number of fragments (x_6), and income per unit of land (x_9) have been retained at the last step. The R square value is 51.80 per cent that reveals that these four variables together explain 51.8 per cent of the variance embedded in the

Table 2. Path analysis of farmers' perception on water management (y) vs. socio-ecological variables

Variables	TE	DE	IE	HIE
Age (x_1)	0.448	0.268	0.180	0.087(x_6)
Education (x_2)	0.192	0.002	0.190	0.050(x_9)
Family size (x_3)	-0.171	-0.117	-0.054	-0.088(x_6)
Farm size (x_4)	0.153	0.071	0.082	0.101(x_9)
Cropping intensity (x_5)	-0.088	0.005	-0.093	-0.066(x_9)
No. of fragments (x_6)	-0.426	-0.312	-0.114	-0.075(x_1)
Annual income (x_7)	0.044	0.023	0.021	-0.065(x_8)
Income per capita (x_8)	0.143	-0.115	0.258	0.076(x_{10})
Income per unit of land (x_9)	-0.434	-0.269	-0.165	-0.105(x_{11})
Annual expenditure (x_{10})	-0.062	0.131	-0.193	-0.070(x_3)
Stubble height (x_{11})	0.480	0.319	0.161	0.089(x_9)
Volume of residue (x_{12})	0.140	0.023	0.117	0.073(x_9)
Scientific orientation (x_{13})	0.014	-0.151	0.165	0.066(x_9)
Innovativeness (x_{14})	0.104	-0.011	0.115	0.033(x_{11})
Extension agency contact (x_{15})	0.150	0.111	0.039	0.025(x_9)
Information seeking behavior (x_{16})	0.157	0.093	0.064	0.092(x_9)
Residue management score (x_{17})	-0.055	0.010	-0.065	-0.097(x_{11})
Perception on natural resource degradation (x_{18})	0.083	-0.041	0.124	0.041(x_{19})
No. of livestock (x_{19})	0.140	0.114	0.026	0.034(x_{11})
Mass media utilization (x_{20})	-0.030	0.047	-0.077	-0.056(x_6)

TE = Total Effect, DE = Direct Effect, IE = Indirect Effect, HIE = Highest Indirect Effect, Residual effect: 0.428

Table 3. Stepwise regression analysis of farmers' perception of water management (y) and selected socio-ecological variables (x_1 – x_{20})

Variables	Reg. coeff. B	S.E. B	Beta	t value
Stubble height (x_{11})	0.451	0.143	0.286	3.155
Age of the respondents (x_1)	0.067	0.022	0.273	3.072
No. of fragments (x_6)	-0.186	0.055	-0.302	-3.368
Income per unit of land (x_9)	0.000	0.000	-0.300	-3.298

R square = 51.80 per cent, Std. error of the estimate = 2.175

farmers' perception of water management. Stubble height is an important part of conserving soil moisture. When the optimum amount of stubble is retained, it helps a farm to save on their water requirement; more during the sowing season. Aged farmers with a better experience in managing water stress conditions. Fragmentation of holding has got a deleterious impact on the energy and cost management of a farm (Friedrich et al., 2012). With more fragmented land, the drudge of management will automatically increase, turning the farm energy and cost prodigal. This is the reason fragmentation as a functional variable is so important to predicting water management. A similar study also reveals that farmers' conservation decisions and the extent to which they adopt better water conservation technology are favourably and significantly influenced by the educational level of the household head, extension contact, and the slope of the land, distance from home, livestock holding, and farmland productivity (Nurie et al., 2013). The results rightly direct the attention of the conservationists in agriculture to the need for upscaling return, that too into a happy return, through pursuing efficient and cost-effective water management. Thus, in designing and implementing CA technologies, it is critical to have a deeper grasp of the restrictions that affect farmers' perceptions. A greater understanding of the effects of CA advantages requires frequent communication between farmers and extension professionals, as well as ongoing agricultural training (Andersson & D'Souza, 2014).

CONCLUSION

Getting off to a start in this empirical research and passing through a series of analytical discourses, it has rightly been detected that the variables stubble height, age of the respondents, number of fragments, and income per unit of land have contributed substantially to the perception building of farmers on water management in CA. This indicates that unabated fragmentations of smallholdings have substantially damaged the conservation dimension of water management, albeit stubble height has to contribute to the restoration of ecological resilience as well. A collateral prospect of environmental economics, ecological resilience, and perceptual growth of operating farmers in making conservation agriculture a success was revealed. In addition, access to water, water sharing, water auditing, and monitoring may go further to characterize the dictum and direction of CA and it is simply because water is the prime for any kind of production or existence of life.

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