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Attributes of Farm Income Operating on Conservation Agriculture: The Multivariate and ANN Analytics

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ABSTRACT

Conservation agriculture (CA) is the combination of environmental management, modern and scientific agriculture, which employs farmers' ability to utilize, innovate, and adapt to changing situations, as well as their holistic acceptance of knowledge along with ensuring sustainability. Farm-level adoption of CA is related to reduced labour and agricultural inputs, more consistent yields, and increased soil nutrient exchange capacity. A good quality land yields good results to everyone, confers good health on the entire family, and causes growth of money, cattle, and grain. The present study depicts hard evidences by identifying marker variables impacting income augmentation through conservation agriculture. A score of 50 farmers has been selected from two blocks of Cooch Behar district of West Bengal, by non-probability snowballing sampling techniques with a total of eighteen independent variables along with income from major crop is used as the dependent variable through a structured interview schedule. A basket of multivariate analytical techniques has been applied along with Artificial Neural Network (ANN) as well. The results depict that a blend of diversified farming and farming experiences in CA contributed immensely to scale up income from conservation agriculture approaches.

INTRODUCTION

The good earth has her own and the sweetest music of ecological resilience and rhythm, as if, the symphonies of Beethoven or Mozart are on their best of melodies. Agriculture, once upon a time, has been the pristine child of nature with all music of traditional knowledge, praxis, and natural sciences. The explosion of population and industrialization, consumerism, and urbanization have driven us to a compulsion of making ecosystems denuded, depleted, and polluted with all kinds of disruptions inflicted into the soil, water, and biodiversity. Conservation Agriculture (CA) is a comprehensive approach to sustainable practices that include minimum to no mechanical soil disturbance, biomass mulch soil cover, and crop species diversification, as well as other associated farming practices such as integrated crop and production management (Kassam et al., 2019). Currently, CA is practiced on all continents, in a range of agro-ecosystems, and on farms of various sizes (Friedrich et al., 2012). The adoption of CA practices resulted in better economic and productive returns as compared to traditional agricultural practices along with significant environmental benefits (Tambo & Mockshell, 2018; Kiran Kumara et al., 2020).

For a few decades, maize (*Zea mays* L.) takes part of the component crop very promptly in the choice of the South Asian farmers in rice-based cropping system. In smallholder farming systems, CA-based rice-maize crop rotation is one of the feasible alternatives to improve crop and water productivity and farm revenue while also preserving natural resources (Jat et al., 2019) and also to attain high energy-use efficiency, biomass productivity, and bio-energetic based adult equivalent yield (Parihar et al., 2018a). It is an all-season growing crop and requires less amount of moisture.

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It has the potential to be a viable alternative to rice and a driver for rice-wheat system diversification. In recent years, maize production has increased in both conventional and conservation agriculture-based cereal systems in India (Das et al., 2018). A majority of the maize growing farmers are knowledgeable about sowing time, land preparation, hybrid variety, insect pest, and disease identification, water management, and harvesting stage (Parkash & Peshin, 2020). Adoption of CA practices in maize cultivation encourages higher crop production, income, and soil fertility restoration (Nyirenda & Balaka, 2021).

The approach of CA in an agrarian economy like India has to face more challenges from income insecurity for farmers rather than its ecological sustainability for the same farm units. In this context, diversification towards high-value crops has the potential to boost up the agricultural growth and well-being of the farm situations (Priscilla et al., 2021). Due to most of the farmers being small and marginal, they show more interest in cultivating more profitable crops such as maize at a lower cost than capital intensive high-value crops. The present study tried to find out the answer to the strong commitment to conservation agriculture deeply inculcated into the technology socialization behaviour attributed to operational farm incomes.

METHODOLOGY

The study was conducted in Cooch Behar district of West Bengal during 2020-21. The study sample encompassed 50 farmers selected by the snowballing sampling method (Cochran, 2007) from purposively selected two blocks namely Dinhata I and Dinhata II. A score of twenty-five respondents from each block was taken into consideration by selecting a few farmers and asking them for the farmers who performed the same cultivation practices. This type of sampling method was adopted due to the lower availability of CA practicing farmers in the COVID-19 pandemic situation. The study on farm income operating from conservation agriculture operationalized through two sets of variables (i) independent variables (x_1-x_{18}) and (ii) dependent variable (y). Change in income from major crop (y) by the farmers is collected through a pre-tested structured interview schedule and relationships among selected eighteen variables are analyzed through quantitative methods i.e. Coefficient of Correlation, Multiple Regression, Stepwise Regression, Path Analysis, and Artificial Neural Networking (ANN) with the help of IBM SPSS v20.0 and the web-based application OPSTAT (Sheoran et al., 1998).

Variables which are quantified changes were calculated by the following formula:

Change in income from major crop (y) = (Farm income at present - Farm income at 10 years back) / (Farm income at 10 years back) × 100

Change in number of irrigation (x_{12}) = (No. of irrigation at present - No. of irrigation 10 years back) / (No. of irrigation 10 years back) × 100

Change in number of tillage operations (x_{14}) = (No. of tillage at present - No. of tillage 10 years back) / (No. of tillage 10 years back) × 100

Change in number of CA crops (x_{15}) = (No. of crops under CA at present - No. of crops under CA 10 years back) / (No. of crops under CA 10 years back) × 100

Change in labour requirement (x_{17}) = (No. of labour required at present - No. of labour required 10 years back) / (No. of labour required 10 years back) × 100

Change in level of inputs used (x_{18}) = (No. of inputs used at present - No. of inputs used 10 years back) / (No. of inputs used 10 years back) × 100

RESULTS AND DISCUSSION

Relation between farmers' income and selected variables

Table 1 presents the coefficient of correlation and multiple regression between income from CA crop and selected eighteen independent variables. It depicts that two variables, farming experience of CA (x_4) and change in number of CA crops (x_{15}) have recorded a significant correlation at 5 per cent level of significance

Table 1. Coefficient of Correlation and Multiple Regression Analysis of change in income from major crop vs. selected causal variables (x_1-x_{18})

Independent Variables	r Value	Unstandardized Coefficients		Standardized Coefficients	t value
		Reg. Coeff. B	S.E. B	Beta	
Age (x_1)	-0.126	-0.005	0.008	-0.105	-0.573
Family size (x_2)	0.001	0.019	0.074	0.052	0.257
Education (x_3)	0.020	0.013	0.036	0.060	0.346
Farming experience of CA (x_4)	**0.342***	0.146	0.071	0.372	2.070
Size of homestead land (x_5)	-0.008	-0.011	0.057	-0.075	-0.191
Size of cropland (x_6)	0.038	0.014	0.041	0.093	0.335
Land under zero tillage(x_7)	0.009	-0.025	0.072	-0.077	-0.340
Number of livestock (x_8)	0.278	0.057	0.059	0.169	0.969
Average volume of cow dung produced(x_9)	-0.082	-0.014	0.017	-0.177	-0.827
Volume of manure applied in farm land (x_{10})	0.243	0.057	0.036	0.272	1.585
Land under vegetables cultivation (x_{11})	0.184	0.017	0.087	0.045	0.199
Change in number of irrigation (x_{12})	-0.003	0.074	0.474	0.028	0.156
Cropping intensity (x_{13})	-0.058	-0.001	0.002	-0.102	-0.388
Change in number of tillage operation (x_{14})	-0.231	0.092	0.334	0.052	0.275
Change in number of CA crops (x_{15})	**-0.299***	-0.079	0.057	-0.274	-1.381
Energy consumption (x_{16})	0.145	0.001	0.003	0.087	0.442
Change in labour requirement (x_{17})	0.122	0.011	0.417	0.005	0.027
Change in level of inputs used (x_{18})	0.129	0.094	0.400	0.038	0.235

*Correlation is significant at the 0.05 level; R square: 37.50%; The standard error of the estimate: 0.542

with the dependent variable, change in income from major crop. It has been found that with the progress in conservation agriculture in area and intensity, the income from maize has been substantially improved along with the inclusion of more numbers of crops in CA practices can equally contribute to the farm income from other crops as well. A similar study also revealed that crop diversification is also had a positive and significant association with family size, distance to the market, economic motivation, risk orientation, innovativeness, and scientific orientation which can be used as an approach to increase farmers' income as well as agricultural sustainability (Ghouse & Hassan, 2020). The CA farms having more years of experience have got a substantive impact on change in income. That is how the farmers in North Bengal, following CA enterprises, are more interested in maize. Nevertheless, there has been a steady and performing market link between the maize growers and the Farmers Producers Organization (FPO). That is how the farmers are getting a steady income from maize for ten years. The R square value being 37.50 per cent, it can be inferred that these eighteen causal variables together had contributed to 37.50 per cent variance in the consequent variable, change in income from major crop.

Predicting farmers' income from selected variables

Farming experience of CA (x_4) and change in number of CA crops (x_{15}) including maize have been retained at the last stage of stepwise regression analysis (Table 2), which has already been justified by the above interpretation. So, it can be considered the most important determinant in the income from the major crop in CA. It is also observable that from the last ten years the area under maize is increasing like anything. The reason being, good market price, operating support from FPOs, huge biomasses are produced which can add value to the soil health, as the source of fodder to the livestock, low water consumption. A related study also says that Crop rotations under a CA-based system are one strategy to increase crop productivity, water productivity, and farm revenue while reducing the risk of excessive temperature and moisture stress and preserving natural resources (Parihar et al., 2018b).

Table 3 presents the path analysis and, it has decomposed the total effect (r value) into direct (beta value), indirect and residual effects. The highest direct effect has been exerted by years in CA. More numbers in years, better will be the experience and market network. That is coming in favour of the farmers helping them access better income from maize. Interestingly, the highest indirect effect has been routed through the variable change in the numbers of tillage. The residual effect being 62.50 per cent, it can be inferred that even with the combination of thee 18 exogenous variables, 62.50 per cent variance embedded in change in income from major crop could not be explained.

Artificial neural network analysis

Artificial Neural Network Analysis (ANN) depicts (Figure 1) three layers viz. Input layer, hidden layer and an output layer with two biases. The interaction network shows that cropping intensity (x_{13}), change in number of tillage operation (x_{14}), change in number of CA crops (x_{15}) have exerted (as depicted by the blue and bolder line) substantive and dominant effect output variable change in income from major crop (y). ANN helps to understand that family size (x_2), farming experience of ca (x_4), size of homestead land (x_5) got precise and decisive effect (as depicted by blue and bold lines), passing through respective hidden layers, have substantially impacted change

Table 2. Stepwise Regression Analysis: Change in income from major crop vs. selected causal variables (x_1-x_{18})

Independent variables	Unstandardized coefficients		Standardized coefficients	t value
	Reg. Coeff. B	S.E. B	Beta	
Farming experience of CA (x_4)	0.145	0.051	0.369	2.864
Change in number of CA crops (x_{15})	-0.095	0.037	-0.329	-2.555

R square: 22.50%; The standard error of the estimate: 0.491

Table 3. Path Analysis: Decomposition of Total Effect into Direct, Indirect and Residual Effect: Change in income from major crop (y)

Independent variables	TE	DE	IE	HIE
Age (x_1)	-0.126	-0.105	-0.021	-0.048(x_4)
Family size (x_2)	0.001	0.052	-0.051	-0.055(x_{15})
Education (x_3)	0.020	0.059	-0.039	0.031(x_1)
Farming Experience of CA (x_4)	0.342	0.372	-0.030	-0.032(x_9)
Size of homestead land (x_5)	-0.008	-0.073	0.065	0.121(x_4)
Size of cropland (x_6)	0.038	0.092	-0.054	-0.069(x_9)
Land under zero tillage(x_7)	0.009	-0.078	0.087	0.117(x_4)
Number of livestock (x_8)	0.278	0.169	0.109	0.075(x_{15})
Average volume of cow dung produced (x_9)	-0.082	-0.177	0.095	0.067(x_4)
Volume of manure applied in farm land (x_{10})	0.243	0.272	-0.029	-0.030(x_9)
Land under vegetables cultivation (x_{11})	0.184	0.045	0.139	0.118(x_4)
Change in number of irrigation (x_{12})	-0.003	0.027	-0.030	-0.057(x_{10})
Cropping intensity (x_{13})	-0.058	-0.103	0.045	-0.033(x_5)
Change in number of tillage operation (x_{14})	-0.231	0.052	-0.283	-0.105(x_{10})
Change in number of CA crops (x_{15})	-0.299	-0.274	-0.025	-0.047(x_8)
Energy consumption (x_{16})	0.145	0.087	0.058	-0.060(x_{10})
Change in labour requirement (x_{17})	0.122	0.006	0.116	0.152(x_{15})
Change in level of inputs used (x_{18})	0.129	0.038	0.091	0.042(x_9)

TE= Total effect; DE = Direct effect; IE = Indirect effect; HIE = Highest Indirect effect; Residual effect: 0.625

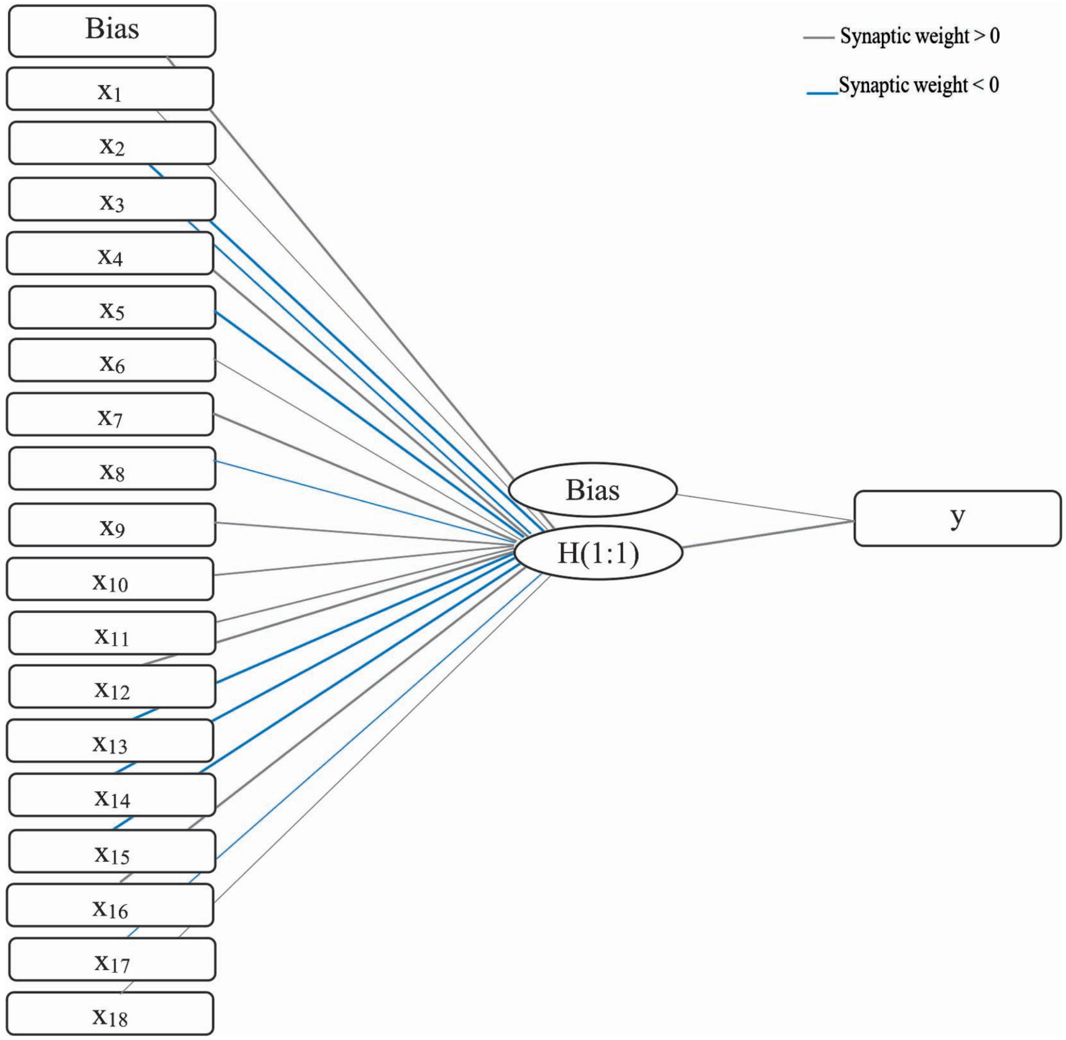

Figure 1. Artificial Neural Network for depicting the dominant impact of input variable on change in income from major crop

in income from major crop (y). The inclusion of vegetable crops in conservation agriculture and effective socialization of input use has generated a conjunctive impact on the income augmentation for small and marginal farmers of North Bengal. It can be concluded that the type, number, cost and rationalization of input are exerting the highest effect on yield. Land under vegetables, which has been instrumental in socialization and entrepreneurial socialization of CA. Because vegetables help earn a better income and it needs less water to retain groundwater level. It aims to enhance the interconnection between individual smallholder production systems and integrates production areas, forests, and ecological corridors, supporting agro-ecosystems (Folke, 2006).

CONCLUSION

The dialectics of sustainable agriculture are embedded with the classical conflicts between ecology and economy. In an attempt to augment farmers' income, we have disrupted ecological resilience; on the other hand, it's really difficult to balance ecological resilience with seamless increment in farmers' income and livelihood. The present study, conducted in a very promising agro-ecological zone for conservation agriculture, the Dooars region of North Bengal, elicits the fact that conservation agriculture without income upscaling for farmers can go futile. It further shows that a blend of crop diversification along with vegetable enterprises, exposure to experiential learning have substantially impacted entrepreneurial success from conservation agriculture. To save the planet and civilization, we have to go for conservation agriculture, albeit, the economic security needs to be blended with the restoration of ecological resilience.

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