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ABSTRACT

Climate has got a direct impact on global food production. Soil erosion, crop disease-pest outbreaks, and other problems are caused and accentuated by rapid climate change (or other factors), necessitating more resource surveillance and management in order to develop new adaptation techniques and strategies in the face of changing climate and resources. According to the findings of this study, farmers either have no perception or are technically unaware of the need of adopting climate resilient technology to restore ecological resilience. Fifty farmers were selected for the study by snowballing techniques, systematic radom sampling being constrained by pandemic situation, from Dalilpur and Kastodanga villages in Nadia district in 2020-21 to elucidate the factors, impacts, and perceptions of farmers. A structured interview schedule has been constructed and validated used to obtain the responses. The study reveals that consumption of coal, firewood, fuelwood, organic manure production, total marketable surplus of cultivated crops, and total yield of cultivated crops were found to have a strong impact on climate resilient adaptation strategy in conservation agriculture (CA). To combat global climate change and popularize CA in order to ensure food security for a growing population, it is essential to inculcate proper cognitive acceptance of climate resilient adaptation strategy among farmers.

Keywords: Adaptation, Climate change, Climate resilience, Conservation agriculture, Ecological resilience

INTRODUCTION

Food production is the most important economic activity for humans; which will be exacerbated by anthropogenic climate change (Kumar, 2007). As a result of global warming, the Earth's climate is changing. Every decade, the temperature rises by 0.2°C, which is largely dependent on future levels of increase in fossil fuel consumption (Kumar, 2007). Crop yields are expected to fall by 4.5–9 per cent under a medium-term climate change scenario (2020–2039), depending on the extent and distribution of warming (Rao, 2014). Farm-based and smallholder livelihoods may be jeopardized as a result of such circumstances (Altieri and Nicholls, 2017; Gentle and Maraseni, 2012). This is because farm-based households may have limited livelihood options and insufficient income to invest in adaptation techniques, in addition to a lack of scientific knowledge and access to agricultural extension services (Gentle and Maraseni, 2012; Lin, 2011).

Farmers will need to switch from conventional farming practices to conservation agriculture (CA) practices and adopt climate-resilient agriculture (CRA) technologies to cope with the impact of climate change on agriculture and improve the resilience of farm-based ecosystems (Chatterjee *et al.,* 2021; Bhattacharya, 2019; Rai *et al.,* 2018). Climate Resilient Agriculture (CRA) is defined as "agriculture that reduces poverty and hunger in the face of climate change while also improving the

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resources on which future generations rely" (Cordaid, 2016). CRA practices and technologies, in general, are low-emission approaches aimed at improving food security and ecological resilience (Sain *et al.,* 2017). Drought-tolerant cultivars, crop diversification, soil management, and water harvesting are all common CRA practices (Altieri and Nicholls, 2017; Lin, 2011). This is regarded as a revolutionary approach to agricultural systems for food security in light of the changing global climate (Lipper *et al.,* 2014).

Conservation Agriculture systems, as opposed to conventional farming systems, have a better chance of adapting to climate change. According to various studies (e.g., Lal *et al.,* 2007; FAO, 2011; Kassam *et al.,* 2009), applying CA over a large area has the potential to slow/reverse the rate of emissions while increasing agricultural sinks of CO_2 and other greenhouse gases (GHG). Reduced tillage (RT) and no tillage (NT) can both help to reduce GHG emissions by lowering the oxidation of soil organic matter (SOM) into CO_2, which increases with traditional tillage practices (FAO, 2011). Furthermore, increasing long-term carbon sequestration mechanisms through permanent soil organic cover is advantageous (West and Post, 2002). Finally, crop diversity and rotation should increase the amount of organic carbon (SOC) in the soil (Gregorich *et al.,* 2001). In this context, legumes' ability to provide sufficient N can increase soil C stock, increasing atmospheric C sequestration, as well as soil N content, reducing the need for energy inputs such as fertilizer (Mrabet *et al.,* 2001; Baker *et al.,* 2007; Mrabet, 2008; López-Fando *et al.,* 2007; Akbolat *et al.,* 2009; López-Bellido *et al.,* 2010). The current study focuses on Indian farmers' adaptation strategies to climate-resilient conservation agriculture technologies. The study also attempted to comprehend the significance of climate resilient technologies in CA through farmers' perspectives, perceptions, and interpretations.

MATERIALS AND METHODS

During the years 2020-21, the research was undertaken in Nadia district of West Bengal. The research employed both purposeful and basic random sampling procedures (Ray and Mondal, 2014). A total of fifty farmers were chosen from Kastodanga and Dalilpur villages in the Haringhata block of the aforementioned district. Because the area was under high-intensity agriculture, rice and vegetable-based farming, declining productivity, livestock count, and organic carbon, the district, block, and villages were purposefully chosen for the study. The COVID-19 situation, socio-political context, and level of farmer responsiveness all influenced the number of respondent selection constraints. Despite the fact that the study is focused on the Nadia district, the findings are said to be applicable to a wide range of adjacent places with similar climate and socio-economic conditions. The study used two sets of variables to examine farmers' perceptions and interpretations of climate resilient technology in conservation agriculture (i) independent factors (X_1-X_{23}) and (ii) dependent variables (y). The perceptions of farmers of the study area regarding climate resilient adaptation strategy (y) in conservation agriculture is collected by scoring different measures to cope up with the changing climate and environment.

RESULTS AND DISCUSSION

Table 1 presents the coefficient of correlation and multiple regression between climate resilient adaptation strategy (y) and 23 independent variables (X_1-X_{23}). The variable consumption of coal, firewood, fuel wood (kg/year) (X_{22}) has recorded significant but positive correlation. The relation depicts that in an attempt to make our farming ecological resilient and productive, we have to be sensitive and careful about energy management which again is missing badly in our farming. We are mostly concerned about application of fertilizer, drenching of irrigation water, indiscriminate application of pesticides and sometimes unaudited mechanization as well. We mostly remain callous and careless about the energy aspect of the farm. Our farms are biologically productive and energy wise prodigal that is why the variable consumption of coal, firewood, fuelwood, which in turn indicates the energy behavior which has got tremendous effect on climate resilient agriculture. If we want to make our farm climate resilient, eco-friendly and ecologically productive, then we have to rationalize the consumption of energy. Sometimes whole of a night, the farm remains under operating pump-set and the farmer remains careless about the energy loses contributing climate change and global warming. The variable production of organic manure (kg/year) (X_{23}) has recorded significant and negative correlation with the dependent variable, climate resilient adaptation strategy

Table 1: Coefficient of Correlation and Multiple Regression Analysis of Climate resilient adaptation strategy (y) vs. selected causal variables (X_1-X_{23})

Independent Variables	'r' Value	Unstandardized coefficients		Standardized coefficients	t-value
		Reg. Coef. B	S.E. B	Beta	
Age (X_1)	-0.137	-0.043	0.026	-0.573	-1.666
Education (X_2)	-0.181	0.288	0.140	0.647	2.050
Functional education (X_3)	0.153	-0.459	0.212	**-0.996**	-2.162
Family size (X_4)	-0.171	-0.145	0.153	-0.265	-0.950
Size of land holding (X_5)	-0.083	-0.123	0.113	-0.300	-1.095
Number of land fragments (X_6)	0.167	-0.003	0.012	-0.092	-0.214
Average size of land fragment (X_7)	-0.253	-0.004	0.002	**-1.277**	-2.319
Mean distance between two land fragments (X_8)	-0.246	0.057	0.039	0.607	1.456
Size of homestead land (X_9)	-0.189	-0.136	0.206	-0.277	-0.661
Number of crops cultivated (X_{10})	0.101	-4.475	0.000	-0.499	-1.176
Total yield of crops cultivated (X_{11})	0.074	1.159	0.000	0.020	0.062
Total marketed surplus of crops cultivated (X_{12})	0.090	3.238	0.000	0.264	1.052
Total input cost (X_{13})	0.027	-9.666	0.000	-0.330	-0.912
On farm income (X_{14})	-0.019	7.064	0.000	0.038	0.124
Family expenditure (X_{15})	-0.205	-6.755	0.000	-0.365	-1.340
Annual savings (X_{16})	0.148	0.166	0.111	0.772	1.494
Land under irrigation (X_{17})	0.031	0.003	0.004	0.258	0.689
Cropping intensity (X_{18})	-0.064	-0.001	0.001	-0.462	-1.387
Total hours of irrigation (X_{19})	-0.151	0.104	0.116	0.283	0.892
Livestock count (X_{20})	-0.250	0.005	0.009	0.204	0.563
Communication variable (X_{21})	0.004	0.001	0.000	0.649	2.823
Consumption of coal, firewood, fuelwood (X_{22})	**0.387***	-0.001	0.000	**-1.270**	-3.059
Production of organic manure (X_{23})	**-0.359***	-0.043	0.026	-0.573	-1.666

**Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level; R square: 84.00%; The standard error of the estimate: 0.699

(y). This relation is obvious because production of organic manure has been so important in replacing chemical fertilizer, regaining ecological resilience and re-engineering the production process perfectly tuned to ecological functions. When production process goes in compliance with ecological principle and prerequisite, the whole of the production system is certain to go climate resilient. Beta coefficient of the causal variable average size of land fragment (X_7) is negative but significant implies that the average size of land fragment has contributed substantially on climate resilient adaptation strategy. The more is the number of land fragment, the higher would be the energy loses that is how with the number of fragments the whole of the farm operations will turn energy prodigal and cost intensive. Whereas beta coefficient of the causal variable consumption of coal, firewood, fuelwood (X_{22}) is negative but significant which implies that the energy consumption behavior and pattern of the respondent has got substantive effect on the climate resilient character of his farm. A person who is energy prodigal at his family level, is expected to go energy extravagant at his farm also. Beta coefficient of the causal variable functional education (X_3) is also negative but significant. It implies that functional education helps to build up consciousness about ecological behavior of farm, its impact on global warming and climate change through different training and sensitization programmes attained by the respondents has been instrumental in farming state or perception on ecological inputs on agriculture and its management. The R square value stands at 84.00 per cent can be inferred that combination of 23 causal variables has explained 84.00 per cent of variance in the consequent variable climate resilient adaptation strategy. A similar study also revealed that the most stable yield and the highest yields were obtained when socio-ecological variables were handled over recurring crop cycles by integrating biennial fallow, gravity flow irrigation, and manure application (Altaweel, 2008).

Table 2 presents the stepwise regression analysis which elicits that four causal variables, consumption of coal, firewood, fuelwood (kg/year) (X_{22}), production of organic manure (kg/year) (X_{23}), total marketed surplus of crops cultivated (kg) (X_{12}), total yield of crops cultivated (kg) (X_{11}), have come out with stronger determining character on the consequent variable, climate resilient adaptation strategy (y). These four causal variables together have contributed 53.30 per cent of the variance in the consequent variable climate resilient adaptation strategy. The rest (23-4) i.e. 19 causal variables have contributed only (84.00-53.30) per cent i.e., 30.70 per cent variance. The fact has elicited from this hard evidence speaks that variable consumption of coal, firewood, fuelwood (X_{22}) has come out as an important determinant for characterizing the climate resilient adaptation strategy. The energy consumption behavior and pattern of the respondent has got substantive effect on the climate resilient character of his farm. A person who uses a lot of energy in his family is expected to use a lot of energy on his farm as well. The production of organic manure (X_{23}) has emerged as a key determinant in defining climate resilient adaptation strategy. Organic manure production has been crucial in substituting synthetic fertilizers, restoring ecological resilience, and re-engineering a production process that is precisely matched to ecological functions. When the production process follows ecological principles and requirements, the entire production system is certain to be climate resilient. Total marketed surplus of crops (X_{12}) cultivated has come out as an important determinant for characterizing the climate resilient adaptation strategy. It elicits that whenever the farm keeps generating higher marketed surplus with an increasing trend which implies the farm well-being through sustainable management including ecological issues and inputs. A climate resilient farm means its production pattern will be steady, consistent and upward and that is how higher marketed surplus has been a strong determinant to decide on the climate resilient level and nature of the farm. Total yield of crops cultivated (X_{11}) has come out as an important determinant for characterizing the climate resilient adaptation strategy. It implies that a climate resilient farm means a farm with higher ecological resilience and function. Whenever application of organic manure, mixing of crop residue, appropriate water and nutrient management, the yield will be positively and effectively impacted. A similar study also revealed that the farmers' traditional knowledge is vital for the sustainable agricultural development of the country (Lenka and Satpathy, 2020).

Table 3 presents the path analysis wherein the total effect of exogenous variable on consequent variable has been decomposed into direct, indirect and residual effect. The causal variable average size of land has exerted the highest direct effect on climate resilient adaptation strategy and the beta value indicates that the more is the number of fragmentation, the less it will be climate resilient. The increasing scale of

Table 2: Stepwise Regression Analysis: Climate resilient adaptation strategy (y) Vs. 23 Causal Variables (X_1-X_{23})

Independent Variables	Unstandardized coefficients		Standardized coefficients	t value
	Reg. Coef. B	S.E. B	Beta	
Consumption of coal, firewood, fuelwood (kg/year) (X_{22})	0.000	0.000	0.441	3.163
Production of organic manure (kg/year) (X_{23})	0.000	0.000	-0.556	-3.857
Total marketed surplus of crops cultivated (kg) (X_{12})	2.574E-05	0.000	0.438	3.036
Total yield of crops cultivated (kg) (X_{11})	-2.765E-05	0.000	-0.308	-2.147

R square: 53.30%; The standard error of the estimate: 0.632

Table 3: Path Analysis: Decomposition of Total Effect into Direct, Indirect and Residual Effect: Climate resilient adaptation strategy (y)

Independent Variables	TE	DE	IE	HIE
Age (X_1)	-0.137	-0.573	0.436	-0.671(x_{17})
Education (X_2)	-0.181	0.647	-0.828	0.457(x_{17})
Functional education (X_3)	0.153	-0.996	1.149	0.843(x_{17})
Family size (X_4)	-0.171	-0.265	0.094	0.956(x_{17})
Size of land holding (X_5)	-0.083	-0.299	0.216	0.036(x_{17})
Number of land fragments (X_6)	0.167	-0.092	0.259	0.113(x_{17})
Average size of land fragment (X_7)	-0.253	**-1.275**	1.022	0.682(x_{17})
Mean distance between two land fragments (X_8)	-0.246	0.607	-0.853	0.404(x_{17})
Size of homestead land (X_9)	-0.189	-0.277	0.088	0.237(x_{17})
Number of crops cultivated (X_{10})	0.101	-0.499	0.600	0.204(x_{17})
Total yield of crops cultivated (X_{11})	0.074	0.020	0.054	-0.993(x_{17})
Total marketed surplus of crops cultivated (X_{12})	0.090	0.264	-0.174	-0.249(x_{17})
Total input cost (X_{13})	0.027	-0.330	0.357	0.273(x_9)
On farm income (X_{14})	-0.019	0.038	-0.057	0.184(x_{17})
Family expenditure (X_{15})	-0.205	-0.365	0.160	0.918(x_{17})
Annual savings (X_{16})	0.148	0.772	-0.624	0.368(x_{17})
Land under irrigation (X_{17})	0.031	0.258	-0.227	-0.306(x_5)
Cropping intensity (X_{18})	-0.064	-0.461	0.397	-0.622(x_{17})
Total hours of irrigation (X_{19})	-0.151	0.283	-0.434	0.692(x_{17})
Livestock count (X_{20})	-0.250	0.204	-0.454	-0.193(x_{17})
Communication variable (X_{21})	0.004	0.649	-0.645	0.494(x_{17})
Consumption of coal, firewood, fuelwood (X_{22})	0.387	-1.270	**1.657**	-0.259(x_{17})
Production of organic manure (X_{23})	-0.359	-0.571	0.212	-0.509(x_{17})

TE- Total effect; DE- Direct effect; IE – Indirect effect, HIE- Highest Indirect Effect; Residual effect:0.157

fragmentation of small and marginal holding of India with special reference to West Bengal condition indicates that the higher fragmentation has added energy prodigal of the holding. As has already been discussed the faster and intense fragmentation of marginal holding is making the entire farm operation not only energy and cost intensive but also economically non-remunerative. The causal variable consumption of coal, firewood, fuelwood has exerted the highest indirect effect on climate resilient adaptation strategy. It justifies that the basic proposition that farmers' energy consumption behavior has also been reflected in the resilient character of his farm under ownership and operation. It has been found that the exogenous variable land under irrigation has appeared as many as 21 out of 23 times in exerting the highest effect on the consequent variable climate resilient adaptation strategy, it means that in an irrigated agro-based ecosystem, the energy and input management system is quite sensitive, and we must be cautious because several irrigation requires a lot of energy. When there is more energy, fertilizer application will increase. Then again, it has energy equivalent, and when intensive agriculture is practiced in an irrigated agro-based ecosystem, the total number of workers employed is higher, implying that it has energy equivalent. As a result, it has a huge associating effect, or the ability to impact the characteristics of other variables. For e.g., now the groundwater quality of Punjab and Haryana agriculture was highly intensive and mostly irrigated agro-ecosystem has been there and the entire ecological resilience of Punjab and Haryana agriculture has been seriously depleted and disrupted. The so called green revolution which took place during 1970s, nevertheless it was so sparkling for the phenomenal achievement and at the same time we remain ignorant about how to protect, defend and regenerate our ecological resilience. The residual value is 0.157 it infers that a little over 15.7 per cent cannot be explain with this combination of 23 variables. It has been supported by the R square value 84.00 per cent as well. Similar study also revealed that the achievement motivation of the farmers plays a crucial role in practicing organic farming (Bhattacharjee *et al.,* 2021).

CONCLUSION

The study concluded that the energy consumption behavior and pattern of the respondent has got substantive effect on the climate resilient character of his farm. A person who uses a lot of energy in his family is expected to use a lot of energy on his farm as well. The production of organic manure (X_{23}) has emerged as a key determinant in defining climate resilient adaptation strategy. The study also envisaged that consumption of coal, firewood, fuelwood, production of organic manure, total marketed surplus of crops cultivated and total yield of crops cultivated are treated as marker variables which have got tremendous impact on climate resilient adaptation strategy in conservation agriculture. The stronger path coefficient between consumption of coal, firewood, fuelwood and climate resilient adaptation strategy is self-explanatory. The study also reveals the dominance of non-cognitive adoption of climate resilient adaptation strategy in conservation agriculture in Indian farming, indicating that it is high time to turn each of these non-cognitive adoptions into logical, assertive, and conscious ecological tradeoffs between farm, resource ecosystems, and global climate change to enhance food security for a rising population.

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