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Perception of Paddy Farmers on Climate Change in Western Odisha: An ANN Model Integration

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HIGHLIGHTS

- The study focuses on the Paddy farmers' perception of climate change and its cause.
- The study supports that perception by itself does not guarantee adaptation, highlighting the need for focused capacity-building initiatives.
- Neural network architecture developed by identifying ideal hidden nodes per component, minimizing Mean Square Error (MSE), and enhancing model accuracy.

ARTICLE INFO

Keywords: Artificial neural network, Climate change, Farmers perception, Socio-economic factors, Western Odisha.

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ABSTRACT

The study, conducted during 2024-25, to examine Paddy farmers' perception of climate change in Balangir and Kalahandi districts of Western Odisha, an Artificial Neural Network (ANN) model was integrated to analyse the relationship between socio-economic factors of Paddy farmers and their perception of climate change. A total of 180 farmers were interviewed with a structured interview schedule to evaluate their perceptions of three main components, *viz.,* exposure, sensitivity, and adaptive competence. The majority of farmers strongly agreed that climate variability, including erratic rainfall, rising temperatures, and extreme weather, adversely impacts agricultural production and causes a serious threat to food security, and changes in climatic conditions lead to shifts in cropping patterns. An ANN model identified the best hidden nodes, i.e., (3,3) for both the exposure and sensitivity, and (5,3) for the adaptive competence component, achieving a minimum Mean Square Error of 7.726 for the best neural network architecture.

INTRODUCTION

Climate change encompasses long-term shifts in Earth's climate. According to World Meteorological Organisation (2024), nearly 50% possibility that average global temperature over next five years rise by more than +1.5°C between 2024-2028. Intergovernmental Panel on Climate Change (IPCC) in 2030 predicts that the 20-year average temperature rise more than 1.5°C (IPCC, 2021). Vigorous climate change has been observed throughout the first few decades of 21st century; since systematic monitoring began in 1850, 2024 has been the warmest year on record, with temperature rise of 1.60 °C (Global Climate Highlights, 2024).

The threat that climate change poses to agriculture in general and food security in particular has given the country's already pressing issues a new dimension (Ghanghas et al., 2015; Rao et al., 2016; Pathak et al., 2024; Mishra et al., 2024). India has also been recognised as one of the most vulnerable nations to climate change. (Indian Network on Climate Change Assessment, 2010). Recent research revealed that there are incidents of severe cyclonic activity, catastrophic precipitation events, droughts, heat waves, and

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temperature rise in India (Rohini et al., 2016; Sharma & Majumder, 2017; Ray et al., 2019; Pavan Kumar et al., 2023). Based on the farmers' voice study in 2024, over 75% of farmers are already affected by climate change and concerned about its effects, and 71% of them say that lower yields are a key concern (Vu et al., 2025; Sahoo et al., 2025).

Odisha is a hotspot for climatic phenomena and boasts 480 kilometres (km) of coastline that stretches from West Bengal to Andhra Pradesh. Due to its location and geophysical circumstances, Odisha is particularly affected by climate change (Meher, 2024). Poverty and present growth methods could be disrupted by climate change. Events brought on by extreme climate change might directly result in loss of life, livelihood, property, and infrastructure (Hussain et al., 2024). Kalahandi and Balangir, these two districts of KBK (Kalahandi-Balangir-Koraput) region, these are the backward districts of Western Odisha, have grown susceptible to frequent droughts and famine-like conditions, which have caused the impoverished to migrate in despair during the non-agricultural season. Majority of people in Odisha's KBK districts live Below the Poverty Line (BPL), making them one of the state's poorest areas (Panda et al., 2019). Additionally, these districts have seen more migration, diseases, and famine due to recurrence of drought and floods. However, various factors, including erratic rainfall patterns, insufficient irrigation, and rise in frequency and severity of natural disasters, are causing agricultural productivity to become increasingly unstable (Kumar & Saxena, 2024). Agriculture is most susceptible to climate change, and Paddy is most water dependent, and about 60 per cent of its land dependent on monsoon (Rao et al., 2015; Panda & Parashari, 2025). The state's food grain production depends on climatic conditions, and frequent climate variability have long-term effects on the production pattern.

METHODOLOGY

The study was conducted in 2024 at Balangir and Kalahandi districts of Western Odisha. These two districts are part of the KBK region, are among the poorest in the state, and the majority of the population lives below the Poverty Line (BPL). By using a simple random sampling technique, 15 villages were chosen from each district. Six farmers were selected randomly from each 30 selected villages, and a total of 180 Paddy farmers were selected as sample respondents of the study. Data was collected using a pre-tested, structured interview schedule. A total of 32 statements on farmers' perception towards climate change, out of which 26 statements were positive and 6 statements were negative (Scale developed by Govindbhai, 2023). An attempt was made to establish the machine learning approaches, *i.e.* the Artificial Neural Network (ANN) model. A computational model that draws inspiration from the architecture and operations of biological neural networks is called an artificial neural network (ANN), ANN technique is used for building such a model (Gupta & Raza, 2019). The training set is used to develop the neural network, while the testing set is used to validate the model. The model's performance was evaluated using the Mean Square Error (MSE). An input layer, one or more hidden layers, and an output layer make up this structure. Interconnected neurons with corresponding weights and biases are used to model the functional relationship between input variables and output. In the ANN model, a neuron's output y can be shown as

$$y = \gamma\left(\sum_{i=1}^{n} w_i x_i + b\right)$$

Where, x_i = Input variables, w_i = Weights assigned to every input, b = Bias term, γ = Activation function, y = Output of the neuron

RESULTS

Table 1 presents the key findings on component-wise distribution of respondents based on their perceptions of climate change. Majority of Paddy farmers strongly agreed with the following climate change statements like 89.44 per cent were strongly agreed that extreme weather condition adversely affects agricultural production followed by 86.66 per cent on temperature increase or decrease every year is cause of climate change, 83.33 per cent on increasing rainfall fluctuations and 80.55 per cent on high-intensity rainfall due to increasing global temperature. 92.77 per cent strongly agreed that climate change created a significant threat to food security followed by erratic monsoon rainfall increases crop water demand (90.55%), 86.66 per cent were believed that agricultural biodiversity is threatened by decreased rainfall and rising temperatures and 83.33 per cent were strongly agreed that climate change has resulted in the extinction of flora and fauna. Majority were strongly agreed with the statement that cropping patterns are changing due to climatic conditions (94.44%) followed by believed that extreme weather events have caused changes in crop productivity (90.55%), irrigation methods have changed due to altered rainfall and high temperatures (87.77%) and 85.55 per cent were strongly agreed that cost of cultivation has increased due to higher pest and disease control expenses.

Artificial Neural Network (ANN) model

Before applying the neural network, the dependent and independent data series were separated into training and testing sets in 75 per cent and 25 per cent, respectively. There was no such esteem observation found in the data series. Hence, all 180 data points for all variables were considered for the research. Table 2 provides all the details of the architecture and hyperparameter information of the ANN. Thirteen input variables were utilised as covariates in the analysis, and the normalised with min - max scaler technique was used to adjust the covariates. To enhance network training, scale-dependent variables and covariates were default to rescaled. Even if a testing dataset was specified, all rescaling was done using the training data. Thirteen input nodes made up the network's input layer; the number of covariates in the input layer corresponded to the number of nodes. There were thirteen nodes in two hidden layers and one output layer with a single node. The hidden layers employed a hyperbolic tangent activation function (TANH), which converted real-valued arguments into a range between -1 to 1. Since the output layer was subjected to the identity activation function, the error was the mean square error. It accepted a vector of real-valued parameters and transformed it into a vector with components falling within the range (0 to 1) and a total sum of one.

Table 1. Perception of climate change

S.No.	Statements	SA	A	UD	D	SD
I.	Exposure					
1	Rainfall fluctuation is more common these days	83.33	16.66	0	0	0
2	The temperature increases or decreases every year is caused by climate change	86.66	13.33	0	0	0
3	Rainfall duration has changed as a result of more extreme weather	83.33	16.11	0.55	0	0
4	High intensity of rainfall due to the increasing global temperature	80.55	19.44	0	0	0
5	Temperature changes have little effect on agricultural production	0	0	0.55	6.66	92.77
6	Extreme weather conditions adversely affected agricultural production	89.44	10.55	0	0	0
7	Sunshine hours become hotter due to extreme heat events	75.55	24.44	0	0	0
8	More intense dry summer winds due to the very high temperature	65	35	0	0	0
9	Farming operations are impacted by the extremely cold temperatures, high winds, and dense fog	66.66	31.66	1.66	0	0
10	Heat stress is proving harmful for the crops as cause of the rise in temperature	76.66	22.22	1.11	0	0
II.	Sensitivity					
1	Climate change poses a significant threat to food security	92.77	6.11	1.11	0	0
2	Crop yield is decreased as a result of altered rainfall patterns during the monsoon season	0.55	0.55	0.55	37.22	61.11
3	There is an increase in crop water demand as a result of erratic rainfall during the monsoon season	90.55	7.22	2.22	0	0
4	Agricultural biodiversity is threatened by decreased rainfall and increased temperature	86.66	12.77	0.55	0	0
5	Extreme weather events are caused by a larger loss of soil nutrients into rivers	61.66	37.22	1.11	0	0
6	Livestock rearing has become more vulnerable due to climatic conditions like heat stress	69.44	29.44	1.11	0	0
7	Weed and insect pest incidence become more common due to changes in extreme weather	74.44	23.88	1.66	0	0
8	There is an increasing incidence of crop diseases nowadays compared to earlier times	81.66	17.22	0	1.11	0
9	The quality of crop yields has decreased as a result of variations in temperature and rainfall	0	0	1.66	29.44	68.88
10	Water shortage decreased because of variances in precipitation	1.11	0	1.11	34.44	63.33
11	Climate change has resulted in the extinction of flora and fauna	83.33	11.66	0	0	0
12	Climate change has made deforestation more severe	75.55	24.44	0	0	0
III.	Adaptive competence					
1	Changes in weather patterns make it more difficult to plant and harvest crops	0	0	0.55	18.88	80.55
2	Cropping patterns are changing because of a change in climatic conditions	94.44	4.44	0	1.11	0
3	Crop varieties are not adaptive to changing climatic conditions	0.55	0	0.55	42.77	56.11
4	The method of irrigation changed due to a change in rainfall patterns or high temperatures	87.77	11.66	0	0.55	0
5	The cost of cultivation increased due to more expenditure on the control of pests or diseases	85.55	13.88	0	0.55	0
6	Climate change has little effect on agricultural product transportation	0	0.55	0	26.66	72.22
7	Extreme weather events have caused changes in crop productivity	90.55	8.88	0	0.55	0
8	The declining groundwater table has made crop cultivation more challenging	77.77	22.22	0	0	0
9	Farmers' patterns of livelihood are shifting as a result of shifting weather patterns	70.55	29.44	0	0	0
10	Farmers' crop season and cropping techniques are changing as a result of climate change	76.66	22.77	0.55	0	0

SD-Strongly Agree, A-Agree, UD-Undecided, D-Disagree, SD-Strongly Disagree

Based on the architecture of ANN with the best hidden nodes of all components of the dependent series, the minimum Mean Square Error obtained from the testing set is represented in Table 3. The training set was used for developing a neural network, whereas the testing set was used to validate the model. The validation of the model is estimated by the Mean Square Error (MSE). It was found that the component from farmer perception on climate change, the Mean Square Error (MSE) was for exposure 2.501, for sensitivity 2.673 and adaptive competence 2,552, with a total of 7.726, provides enough evidence that the best neural architecture was developed (Figure 1).

DISCUSSION

The majority of the paddy farmers had experienced the effects of climate change, especially irregular rainfall and temperature fluctuations. However, few farmers remain unaware of adaptation measures due to limited access to information and a lack of communication with the extension agency, the findings were in line with Ansari et al., (2018) & Lahiri et al., (2024). In order to support farm-level decisions and minimize the loses in adverse climatic and weather conditions farmers' understanding about the interaction of climate and agro-ecosystem needs to be bridged through the inclusion of farmers' communication network (Ravikumar et al., 2015). Farmers recognise various climate threats; they frequently perceive their vulnerability but do not fully understand the severity of the long-term impacts of climate change, the findings derived supports from the results of Aidoo et al., (2021). Farmers were identified to have useful adaptation strategies like changes in crops, water use, and pest control, but their ability to adopt these strategies remains lower. This was due to limited availability of resources and lack of experience related to the climatic issue, the findings were partially in line up with Nduwayezu et al., (2023).

Table 2. Neural Network Information Summary

Layers	Covariates	1	Age
A. Input Layer		2	Gender
		3	Education
		4	Household Size
		5	Land Holding
		6	Framing Experience
		7	Credit access
		8	Framer Association Membership
		9	Extension agency contact
		10	Training Attended
		11	Mass Media Exposure
		12	Risk Experience
		13	Knowledge of Crop Insurance
	Number of Units	13	
	Rescaling Method for Covariates	Normalised (With min–max scaler)	
B. Hidden Layers	Number of Hidden Layers	2	
	Number of Units in Hidden Layers 1 and 2	3,3 Exposure	
		3,3 Sensitivity	
		5,3 Adaptive competence	
	Activation Function	Hyperbolic tangent	
C. Out Layers	Dependent Variables	1	Farmers' Perception on Climate Change (Exposure, Sensitivity, Adaptive Competence)
	Number of Units	1	
	Rescaling Method for Scale Dependents	Normalised (With min–max sealer)	
	Error Function	Mean Square Error (MSE)	

Table 3. Error Summary of Testing

Component	Mean Squares Error (MSE)
Exposure	2.501
Sensitivity	2.673
Adaptive competence	2.552
Total	7.726

Agencies and stakeholders assisting farmers in scaling up the adoption of climate smart agricultural practices, like precision conservation agriculture, should develop a shared understanding and strategy for promoting these cutting-edge technologies within farming communities (Shitu & Nain, 2024). By applying the best number of units in the hidden layer 1 and 2, *i.e.* (3,3) for both the exposure and sensitivity component and (5,3) for the adaptive competence component, to get the minimum Mean Square Error obtained from the testing data set and to validate the developed neural network architecture.

CONCLUSION

The study underlines that perception alone cannot drive adaptation; therefore, capacity-building initiatives are crucial to motivate farmers to solve their problems. Creating localized climate advisory services, promoting community-based extension services can be more resilient for sustainable farming community. Following improved agricultural methods, expanding credit access and knowledge on crop insurance, ensuring frequent extension services,

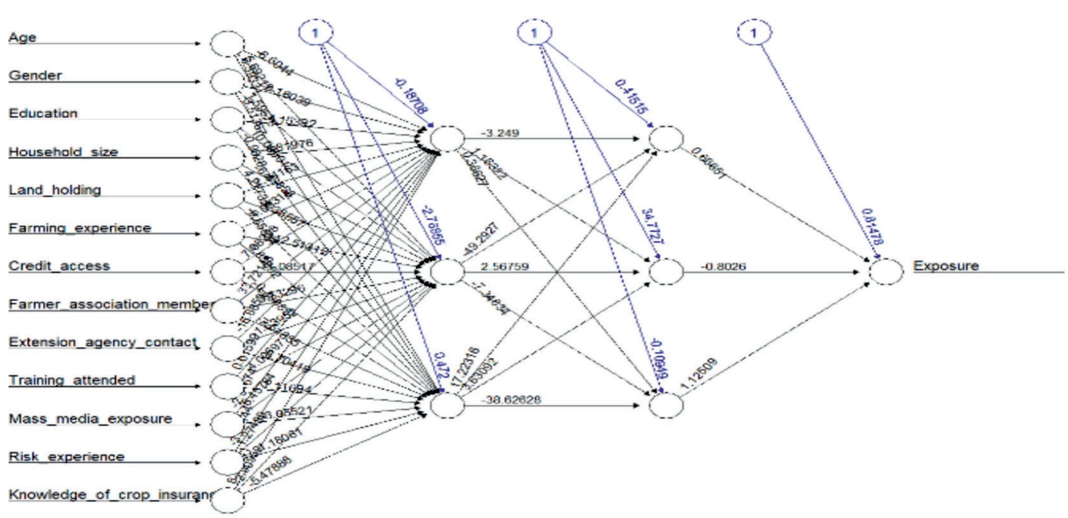

Figure 1a. Developed neural network architecture for farmers' perception of climate change based on the Exposure component

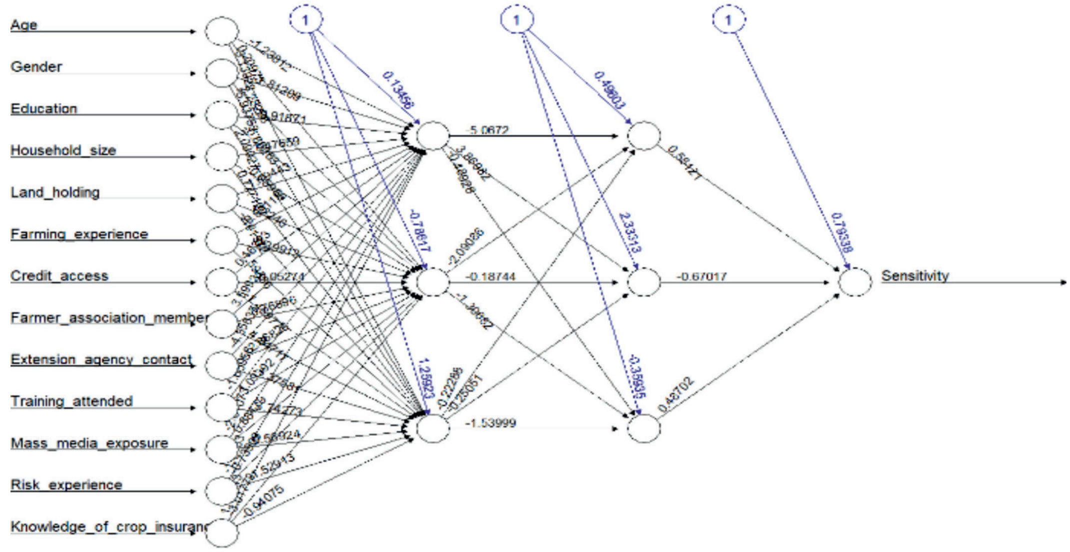

Figure 1b. Developed neural network architecture for farmers' perception on climate change based on the Sensitivity component

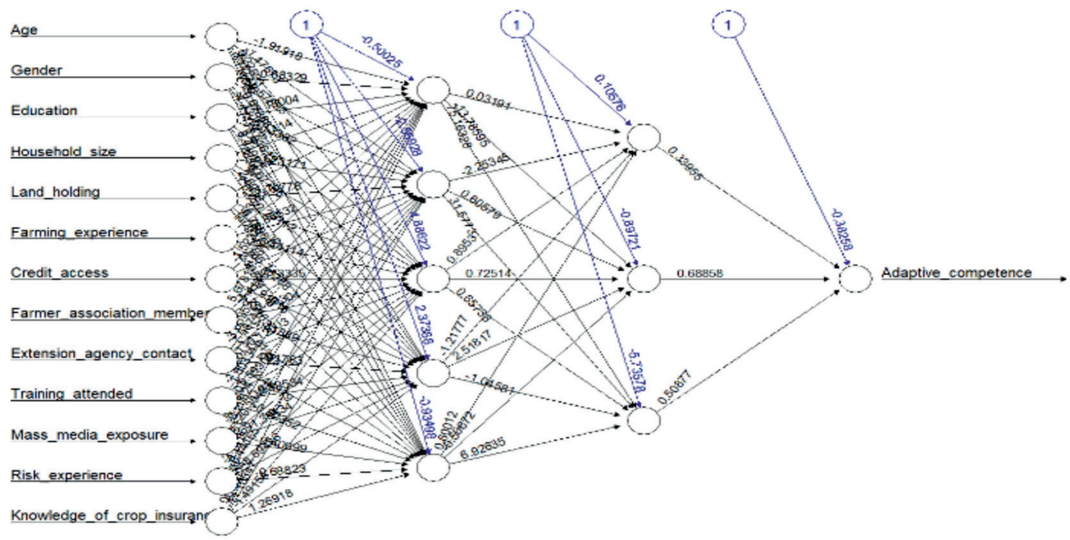

Figure 1c. Developed neural network architecture for farmers' perception on climate change based on the Adaptive competence component

and creating awareness on climate literacy among farmers are very essential approaches in the context of climate change. Predictive tools like Artificial Neural Networks (ANN) could effectively guide policymakers for sustainable agriculture. By addressing these key areas, policymakers can better assist vulnerable agricultural communities in Western Odisha in reducing climate risks and guaranteeing food security by tackling these issues.

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