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Research Article

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Comparison of ANN and ANFIS for Projecting Changes of Maize Yield Base on Regional Weather Parameter: A Case Study of Mubi North Local Government

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Abstract Fuzzy logic system (FLS), artificial neural networks (ANNs) and Adaptive Neuro-fuzzy inference system serves as an important technique these days in modelling and system control. It is also suitable in developing predictive models in projecting maize yield due to weather parameter. The aim of this study is to compare the predictive ability of ANN model and ANFIS model in projecting maize yield base on weather parameter. The data, precipitation and temperature were collected from metrological station, department of geography, Adamawa state university, mubi and maize yield was collected from Agricultural development programme (ADP), Adamawa state for the period (2006-2015) respectively. Precipitation and temperature were used as input and maize yield as target output. The comparison between ANN and ANFIS shows that, ANN prediction ability is more accurate than ANFIS. However, the correlation coefficient of ANN was calculated as 0.0763 and -0.6657 and MAPE as 0.5% respectively lower than ANFIS.

Keywords ANN, ANFIS, Weather Parameter, Maize Yield

Introduction

Maize (zee Mays), which has its origin from Mexico is widely ground in many countries around the world today. United State is regarded as one of the major producers of maize in the world today with a total production of about 980 million metric tons. Maize serves not only as a food source for human nutrient but also as a basic nutrient of animal feed such as cow and chickens feed and raw materials manufacture by industries such as cornstarch and corn oil. Maize is grown over a wide range of climate zone, it is grown from 58N to 40S below sea level to a higher altitude than 3000M in Areas with 250mm to more than 5000m of rainfall per year [1-2] for many years. Different techniques have been employed such as regression analysis as a common modeling technique. Today, artificial neural networks (ANNs) and Adaptive Neuro-fuzzy inference system (ANFIS) are used as artificial intelligent technique in modeling because they are efficient and less time consuming with perfect accuracy compare to other models such as regression [3]. Many researchers have reported the advantages of Artificial Intelligent (AI) over statistical modeling, [4], Kaul et al [5] used ANN for predicting corn and soya beans yield. Nardelo *et al* [6] also used ANFIS for Predicting crop yield based on different energy inputs. The main objectives of this study were to, (1) To develop an ANN and ANFIS models for prediction of maize yield. (2) To ascertain the effect of precipitation and temperature on maize yield. (3) To compare ANN and ANFIS models based on the prediction accuracy of the models.

Data and Site Descriptions

Mubi north local government area is located in the North-East Geo-political zone of Nigeria. The town lies around latitude $10^{o}14'$N and longitude $13^{o}15'$E of the equator and has a wide range of farm land. The data, precipitation (mm) and temperature (^{o}C) were collected from the metrological station of the department of

Geography, Adamawa state university, mubi for the period (2006-2015) and maize yield (tons) was collected from Agricultural development programme also for the period of (2006-2015).

Methology

(i) Artificial Neural Network (ANN)

ANN is an important intelligent tool inspired by biological neurons to perform brain like task. Because of handling nonlinear computation, it is regarded as one of the effective predicting tool. Several training algorithm exist but back propagation is mostly used because of its ability to map a continues non-linear function and can accept large numbers of unknown inputs. They are basically three categories of learning in ANN. These include: supervised, unsupervised and reinforcement. In this work, supervised learning was adopted, where both the target and input data are provided. Usually, the network is trained several times based on the input data. ANN models comprised of three distinctive independent layers, which are, the input layer, the hidden layer and the output layer. Each layer communicates to other through a processing neuron in serial operation. The input values make up the neuron in the input layer, and the hidden layer process the input values with the aid of the neuron in the hidden layer in to the neuron output. The neuron in the input, hidden layer and output layer serves as the means of communication from one layer to another.ANN has demonstrate competency in handling problems in different field. For instance, used as a tool in precision farming [7], used in rice yield [8]. Figure (1) shows the ANN architectural structure for projecting maize yield.

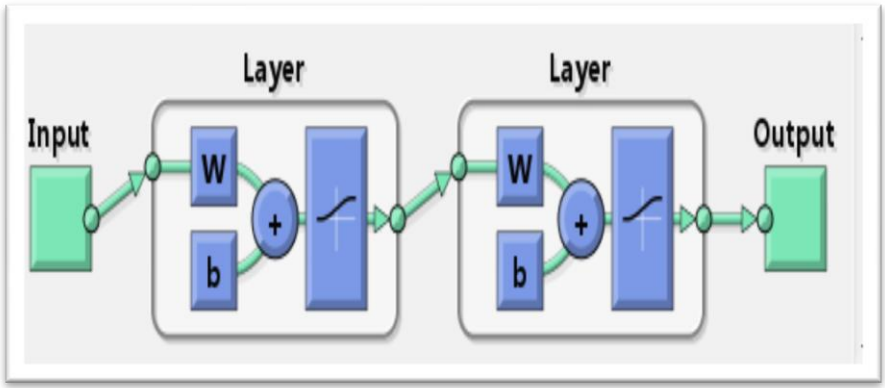

Figure 1: ANN simulated structure

(ii) Adaptive neuro-fuzzy inference system (ANFIS)

ANFIS is a combination of artificial neural network (ANN) and Fuzzy logic system (FLS) to develop a hybrid model capable of improving the performance of the two techniques mentioned above. ANFIS, because of its ability to learn, it has the ability of solving non-linear functions corresponds to the IF-THEN fuzzy logic rules, also has a tendency to solve non linear functions.

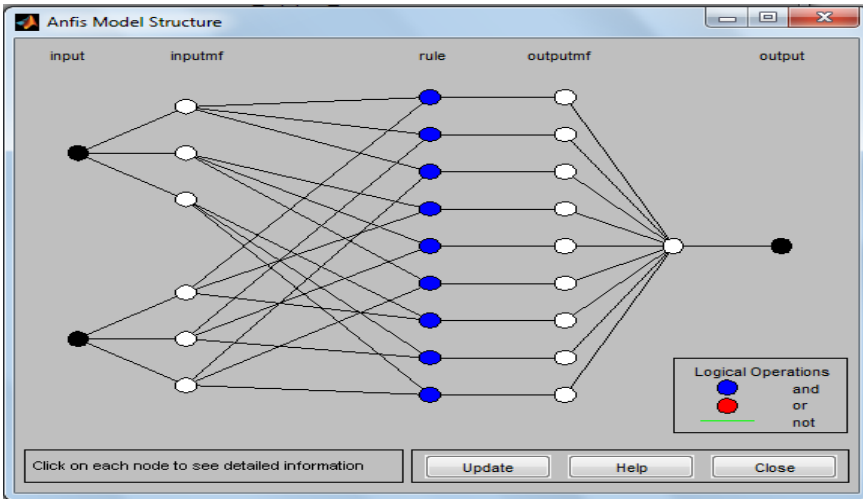

Figure 2: ANFIS simulated structure

However, this work considers only two inputs i.e. precipitation and temperature and maize yield as target output. The inputs will be multiplexed and act upon by the rules that will be developed by the ANFIS model and send it to the output as crest value. The output now becomes the forecasted maize yield. Figure (2) shows the ANFIS structure which will be used to actualized the objectives of the work.

The measure of the prediction accuracy of both ANFIS and ANN models will be determined using Absolute percentage error (APE) and Mean Absolute Percentage Error (MAPE) to evaluating the differences between the Actual and the predicted values as giving in equation (1) and (2) and The parameter relationship will be examined using correlation coefficient as given in Equation (3)

$$\text{APE} = \left|\frac{actual - forecast}{actual}\right| \times 100\% \quad (1)$$

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{actual - forecast}{actual}\right| \times 100\% \quad (2)$$

$$r = \frac{n\sum xy - \left(\sum x\right)\left(\sum y\right)}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]}} \quad (3)$$

From equation (3), n represents the number of pairs of data, y represents maize yield and x represents temperature or precipitation

Table 1: The parameter types and their values used in ANN and ANFIS models.

ANN PARAMETER TYPE	VALUES	ANFIS PARAMETER TYPE	VALUES
No. of input parameters	2	No. of input parameters	2
No. of output parameters	1	No. of output parameters	1
No. of layers	2	No. of nodes	35
No. of neuron in input layer	10	No. of linear parameters	9
Training function	TRAILM	No. of non-linear parameters	18
Network type	F-FBP	Total No. of parameters	27
No. of epoch	1000 to 2000	No. of fuzzy rules	9
Performance function	RMS	No. of epoch	2
Learning rate	0.6	No. of membership function	3
Transfer function	TANSIG	Type of membership function	Triangular
No. of neurons in output layers	1	Type of output parameter	Constant

Results and Discussion

Table (2) gives the Results from ANN and ANFIS models which access and compare the Degree of prediction accuracy of the two networks structure designed.

Table 2: Results of Actual and predicted maize yield of ANN and ANFIS

S/N	Rain fall (mm)	Temp. (ºC)	Maize yield (tones)	ANN Forecasted	ANFIS Forecasted	ANN APE (%)	ANFIS APE (%)
1	12.27	24.7	57.5	5750.37	57.6	0.37	0.17
2	11.99	24.3	58.7	5819.48	59.1	0.52	0.68
3	12.07	24.1	62.0	6199.68	61.3	0.32	1.13
4	12.81	22.9	69.0	6891.47	66.8	8.53	3.19
5	12.93	22.4	69.1	6894.56	68.8	15.44	0.43
6	11.04	22.6	61.5	6150.67	62.2	0.67	1.14
7	19.23	22.3	62.5	6249.55	62.5	0.45	0.00
8	09.27	22.9	63.7	6369.75	63.6	0.25	0.16
9	12.94	23.2	64.2	6709.48	65.9	289.48	2.65
10	14.32	22.1	64.0	6400.17	64.5	0.17	0.78
					MAPE	0.5%	1.0%

The MAPE of ANN and ANFIS was determined as 0.5% and 1.0% using equation (2) and model efficiency was validated as 99.5% and 99.0% respectively. The coefficient of correlation between maize yield and rainfall, maize yield and temperature are obtained as 0.0763 and -0.6657 respectively. Maize yield does not completely depend on rainfall. While as temperature increases maize yield decreases. The Comparison graphs between the two Networks models are shown in figure 3,4 and 5 respectively.

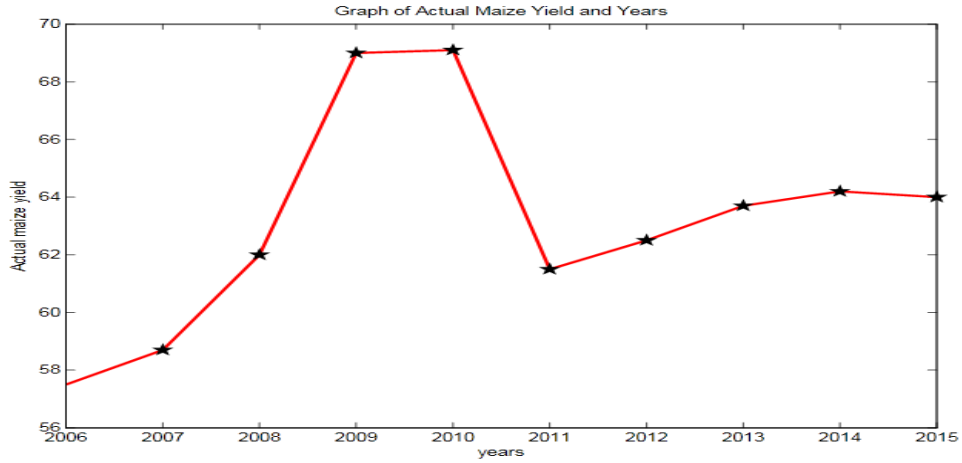

Figure 3: Actual maize yield against Years

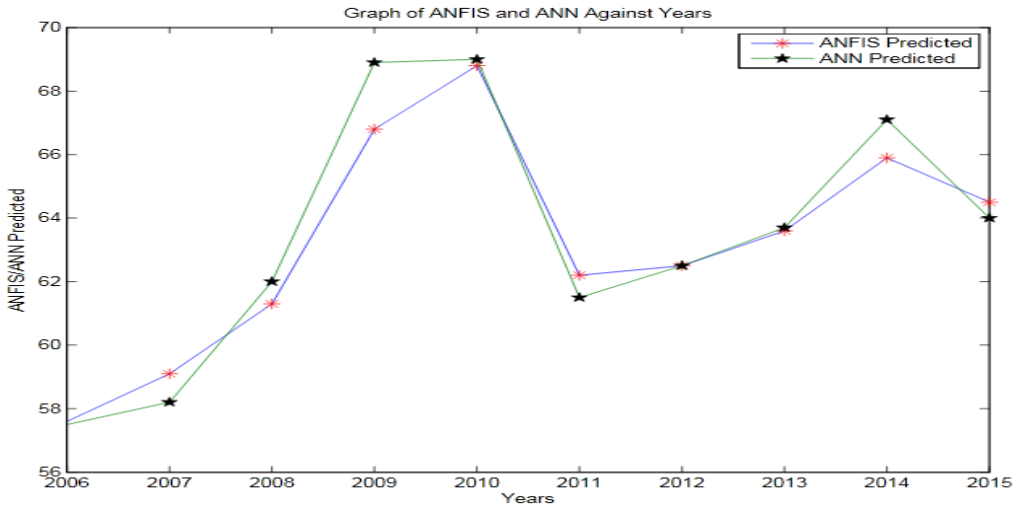

Figure 4: ANFIS / ANN Predicted maize yield against Years

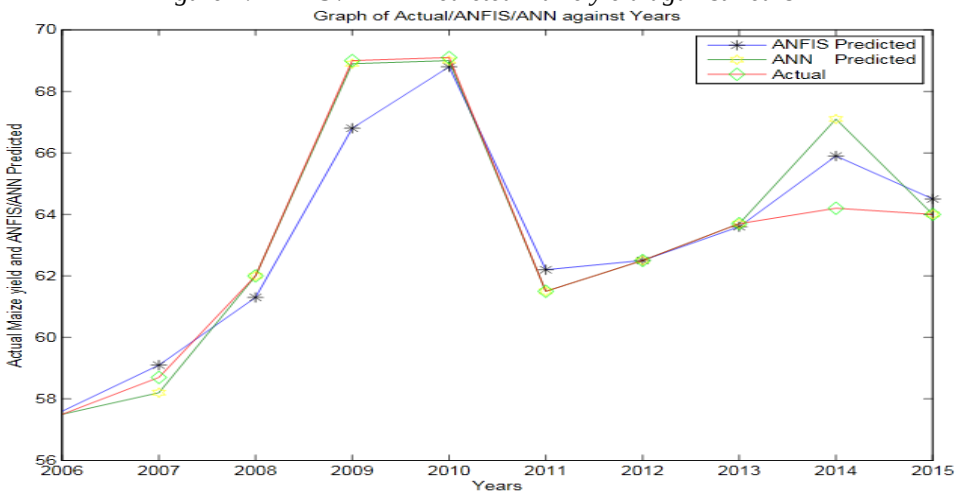

Figure 5: Actual, ANN/ANFIS against Years

From physical view of the comparison graph, ANN model gives a higher degree of projecting maize yield than the ANFIS model. Hence, the graph suggests that, ANN model is superior over ANFIS model.

Conclusion

In this paper, the two predictive models were compared, i.e. Artificial Neural Networks (ANNs) and Adaptive Neuro-Fuzzy Inference System (ANFIS) for projecting changes of maize yield base on regional weather parameter in Mubi North Local Government area of Adamawa State. The results of the comparison shows that, the artificial neural network model gives higher coefficient correlation of 0.0763 and -0.6657 and lower Mean Absolute percentage error (MAPE) of 0.5% than the Adaptive Neuro-Fuzzy Inference System (ANFIS). ANN model efficiency was validated as 99.5% higher than ANFIS. Hence, the result of this study shows that ANN method is best fit for projecting changes of maize yield base on regional weather parameter in comparison to ANFIS.

References

[1]. Shaw, R. H. 1988. Climate requirement. In: Sprague G.F., Dudly J.W eds. Corn and Corn 638 Improvement, 3rd ed Madism, WI:ASA 609.

[2]. Dowswell, C. R., Paliwal, R.L. and Cantrell, R.P. 1996. Maize in the Third World. Westview Press, Boulder, USA.

[3]. Pahlavan, R., Omid, M., and Akram, A. 2012. Energy input-output analysis and application of artificial neural networks for predicting greenhouse basil production. Energy, 37, 171-176.

[4]. Razi, M. A. and Athappilly, K. 2005. A Comparative Predictive Analysis of Neural Networks (NNs), Nonlinear Regression and Classification and Regression Tree (CART) Models. *Expert Syst. Appl.*, 29: 65-74.

[5]. Kaul, M., Hill, R. L. and Walthall, C. 2005. Artificial Neural Networks for Corn and Soybean Yield Prediction. *Agr. Syst.*, 85: 1-18.

[6]. Naderloo, L., Alimardani, R., Omid, M., Sarmadian, F., Javadikia, P., Torabi, M. Y. and Alimardani, F. 2012. Application of ANFIS to Predict Crop Yield Based on Different Energy Inputs. *Measurement*, 45: 1406-1413.

[7]. Irmak A., Jones J. W., Batchelor W. D., S., Irmak K. J. and Boote J. O. Paz. "Artificial neural network model as a data analysis tool in precision farming". *American Society of Agricultural and Biological Engineers*. 49(6): 2027-2037

[8]. Sanjib Kumar Hota. 2014. "Artificial neural network and Efficiency estimation in rice yield" *International Journal of Innovative Research in science, engineering and technology*. 3(7): 2319-8753