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Research Article

ARTIFICIAL NEURAL NETWORK MODEL FOR PREDICTING AREA, PRODUCTION AND PRODUCTIVITY OF SAPOTA IN GUJARAT

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Abstract: Horticulture production has been increasing more than doubled in India recent days especially fruits production. Horticulture in India contributes around 33 per cent to the agriculture Gross Value Added making significant contribution to the Indian economy. Among fruits crops, sapota is producing largest quantities in Gujarat. Forecasting is one of the important aspects of all countries in the world which help to make proper plan and growth economy of the country. In this study, artificial neural network (ANN) model has used to forecast area, production and productivity of sapota in Gujarat state. Secondary data (1958-59 to 2017-18) on area, production and productivity of sapota were used. RStudio (version 3.5.2) software used to analyze the data. The forecasted study found that area, production and productivity of sapota was best explained by 4:1s:1l, 4:1s:1l and 2:2s:1l ANN architectures, with forecasted value for 2018-19, 28.48 ('000' Ha.), 320.89 ('000' MT) and 10.51 (MT/Ha.) respectively, where area, production and productivity are likely to go decrease for the next year.

Keywords: *Forecasting, Area, Production, Productivity, Sapota, Artificial neural network model*

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Introduction

Horticulture is the branch of agriculture concerned with intensively cultured plants directly used by man for food and medicinal purpose. India is the second largest country to produce vegetables and fruits next to China in the world. Currently horticulture produce in India is surpassed the food grain production. India achieved 320.48 million tonnes horticulture produce that too from much less area 25.66 million hectare. India contributes 10 per cent of the world fruit production with first rank in the production of sapota. Overall production of sapota of in India was 11,56,060 tonnes over the period 2017-18. Gujarat hold first in sapota production which achieved 3,26, 360 tonnes in 2017-18 and had 28.19 share of overall sapota production in India (National Horticulture Board, 2017-18). Statistical forecasting helps to make efficient plan and decision in future which paly cardinal role in growth of economy of our country. There are mainly two approaches in statistical forecasting *viz*., i) Extrapolation method is anticipating present series based on the behavior of past over a period. ii) Explanatory method is anticipating the future phenomenon by considering factors which influence the future phenomenon [1]. Seeing above mentioned facts, this study conducted to model and forecast area, production and productivity of sapota fruit in Gujarat state. Artificial Neural Network (ANN) model were used to analyze the data.

Review of literature

Kumari Prity *et al* (2016) [2] forecasted pigeon pea yield in Varanasi region by using statistical models. Different linear and non-linear models like multiple linear regression (MLR), autoregressive integrated moving average (ARIMA) and artificial neural network (ANN) models were used to forecasting the yield of pigeon pea in Varanasi region by using 27 years of data from 1985-86 to 2011-12. The best suited model was identified based on root mean squared error (RMSE). The study identified ANN as best model with lower RSME because ANN model forecasted yield of pigeon pea in Varanasi region during the year 2012-13 very well.

Kumari Prity *et al* (2017) [3] studied forecasting models for predicting pod damage of pigeon pea in Varanasi region. Autoregressive integrated moving average (ARIMA) and artificial neural network (ANN) with multiple linear regression models were used to predicting perc cent pod damage in pigeon pea by pod borer in Varanasi region, Uttar Pradesh by using 27 years of data (1985-86 to 2011-12). The best suited model was assessed by root mean squared error (RSME). The study found that ANN with lowest RSME as best model and ANN predicted pod damage of pigeon pea well during the year 2012-13 [4-7].

Material and Methods

Source of data

Time series secondary data on area, production and productivity of sapota were collected for the period 1958-59 to 2017-18 form National Horticultural Board (NHB).

Analytical framework

In the present study, different neural network architectures were used to compare their ability for predicting area, production and productivity of sapota in Gujarat. RStudio (version 3.5.2) software used to analyze the data.

Artificial neural network (ANN)

ANNs are nonlinear data-driven models capable to perform modeling without a prior knowledge about the relationships between input and output variables. Its generalizing ability, after learning the data presented to structure, can often correctly infer the unseen part of a population even if the sample data contain noisy information. Time series can be modelled with the structure of a neural network by the use of time delay, which can be implemented at the input layer of the neural network. Such an ANN is termed as Time Delay Neural Network [8-15].
The structure of the neural network consists of: 1. Input Layer, 2. Hidden Layer
3. Output Layer

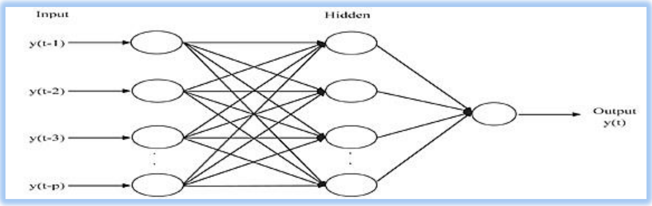

Fig-1 Time-Delay Neural Network (TDNN) with one hidden layer

The general expression for the final output value yt+1 in a multilayer feed forward time delay neural network is given by equation:

$$y_{t+1}=g\left[\sum_{j=1}^{q}\alpha_j f\left(\sum_{i=0}^{p}\beta_{ij}y_{t-i}\right)\right]$$

Where,

f and g denote the activation function at the hidden and output layers, respectively.

p is the number of input nodes (tapped delay),

q is the number of hidden nodes,

β_{ij} is the weight attached to the connection from the i^{th} input node to the j^{th} node of hidden layer,

α_j is the weight attached to the connection from the j^{th} hidden node to the output node,

y_{t-i} is the i^{th} input (lag) of the series.

The main task of activation function is to map the outlying values of the obtained neural input back to a bounded interval such as [0,1] or [-1,1].

Research Results

Area, production and productivity of sapota were analyzed through this study by using different neural network architecture.

Forecasting of area for Sapota

[Fig-2] illustrates chart series of area dataset for Sapota from 1991-92 to 2017-18.

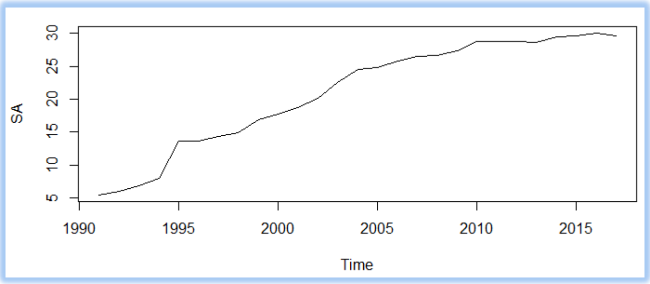

Fig-2 Area (In ' 000 Hectare) under Sapota in Gujarat

Also, the characteristics (basic statistics) of the data set used were presented in the [Table-1].

Table-1 *Summary statistics of Sapota area time series*

No. of observations	27
Minimum	5.5
Maximum	30.01
Mean	21.05
Median	24.59
Standard Deviation	8.2
Sem	1.58
Skewness	-0.57
Kurtosis	-1.13

Various architectures of neural network were tried considering the availability of data. Further, the model performance in training set and testing data set is given in [Table-2].

Based on the lowest training RMSE, ANN model 4:1S:1l is selected. It is also assessed based on its hold out sampling (testing set) forecasting performance and is having least testing RMSE, out of all five neural network architecture. Therefore, neural network architectures 4:1s:1l was used to forecast area of sapota in Gujarat.

Table-2 *Forecasting performance of ANN model for Sapota area time series Model ParametersRMSE*

Model	Parameters	RMSE	
		Training	Testing
2-1S-1L	5	20.583	1.101
3-1S-1L	6	19.244	0.997
4-1S-1L	7	16.255	0.495
2-2S-1L	9	20.549	0.937
3-2S-1L	11	19.19	0.9

[Table-3] reflects that the estimates of all weights associated with nodes of different layer. Input layer lag1, lag2, lag3 and lag4 are denoted by I1, I2, I3 & I4, Hidden layer node1 is denoted by H1 and output node is denoted by O, where biases of two nodes are given by the notation HB1 & OB. The forecasted value of Sapota area in Gujarat for the year 2018-19 by 4:1s:1l neural network architecture was obtained as 28.48 ('000' Hectares) with confidence interval 27.46to 29.47.

Table-3 *ANN model parameter Sapota area time series*

Weights between nodes		Biases	
I1:H1	0.437	Hidden node	
I2:H1	1.208	H_{B1}	-0.815
I3:H1	-0.07	Output node	
I4:H1	0.121	O_B	2.073
H1:O	1.108		
Forecasting (2018-19)		C.I.	
28.48		27.46	29.47

Forecasting of production for Sapota

[Fig-3] illustrates chart series of production dataset for Sapota from 1991-92 to 2017-18. Also, the characteristics (basic statistics) of the data set used were presented in [Table-4].

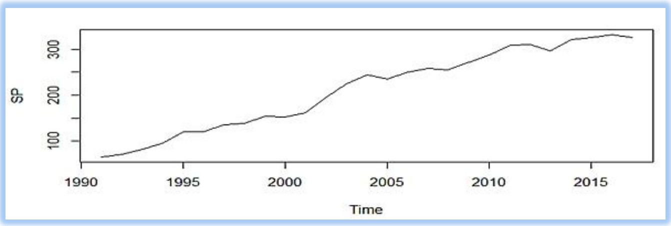

Fig-3 Production (In '000 MT) of Sapota in Gujarat

Table-4 *Summary statistics of Sapota production time series*

No. of observations	27
Minimum	66
Maximum	331.54
Mean	212.76
Median	235.68
Standard Deviation	88.56
Sem	17.04
Skewness	-0.19
Kurtosis	-1.48

Various architectures of neural network were tried considering the availability of data. Further, the model performance in training set and testing data set is given in [Table-5].

Table-5 *Forecasting performance of ANN model for Sapota production time series Model ParametersRMSE*

Model	Parameters	RMSE	
		Training	Testing
2-1S-1L	5	231.520	10.691
3-1S-1L	6	225.537	10.851
4-1S-1L	7	214.565	10.416
2-2S-1L	9	229.931	8.759
3-2S-1L	11	220.220	7.776

Based on the lowest training RMSE, two ANN models 4:1S:1l & 3:2S:1l are selected. It is also assessed based on its hold out sampling (testing set) forecasting performance but due to overestimation case 4:1S:1l is preferred over 3:2S:1l. Therefore, neural network architectures 4:1s:1l was used to forecast production of sapota in Gujarat.

[Table-6] reflects that the estimates of all weights associated with nodes of different layer. Input layer lag1, lag2, lag3 and lag4 are denoted by I1, I2, I3 & I4, Hidden layer node1 is denoted by H1 and output node is denoted by O, where biases of two nodes are given by the notation HB1 & OB. The forecasted value of sapota production in Gujarat for the year 2018-19 by 4:1s:1l neural network architecture was obtained as 320.89('000' MT) with confidence interval 294.09 to 344.43.

Table-6 *ANN model parameter Sapota production time series*

Weights between nodes		Biases	
I1:H1	0.200	Hidden node	
I2:H1	0.771	H_{B1}	-2.529
I3:H1	-0.083	Output node	
I4:H1	-0.193	O_B	5.095
H1:O	0.329		
Forecasting (2018-19)		C.I.	
320.89		294.09	344.43

Forecasting of productivity for sapota

[Fig-4] illustrates chart series of productivity dataset for sapota from 1991-92 to 2017-18. Also, the characteristics (basic statistics) of the data set used were presented in [Table-7].

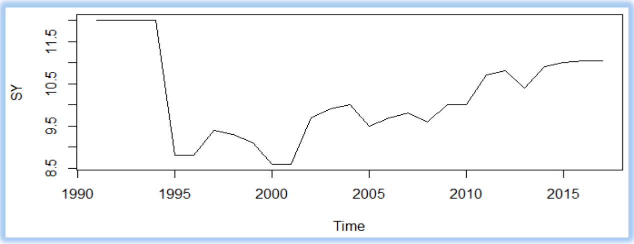

Fig-4 Productivity (In MT/Ha.) of sapota in Gujarat

Table-7 Summary statistics of Sapota productivity time series

No. of observations	27
Minimum	8.6
Maximum	12
Mean	10.17
Median	10
Standard Deviation	1.07
Sem	0.21
Skewness	0.33
Kurtosis	-1.03

Various architectures of neural network were tried considering the availability of data. Further, the model performance in training set and testing data set is given in [Table-8].

Table-8 Forecasting performance of ANN model for Sapota productivity time series

Model	Parameters	RMSE	
		Training	Testing
2-1S-1L	5	0.0999	0.673
3-1S-1L	6	0.568	0.622
4-1S-1L	7	1.866	0.485
2-2S-1L	9	0.0956	0.625
3-2S-1L	11	0.572	0.566

Based on the lowest training RMSE, two ANN models 2:1S:1l &2:2S:1l are selected. It is also assessed based on its hold out sampling (testing set) forecasting performance, where 2:2S:1l is having lowest testing RMSE. Therefore, neural network architectures 2:2s:1l was used to forecast productivity of sapota in Gujarat. [Table-9] reflects that the estimates of all weights associated with nodes of different layer. Input layer lag1 and lag2 are denoted by I1 & I2, Hidden layer node1 & node 2 are denoted by H1 & H2 and output node is denoted by O, where biases of three nodes are given by the notation HB1 HB2 & OB. The forecasted value of Sapota productivity in Gujarat for the year 2018-19 by 2:2s:1l neural network architecture was obtained as 10.51 (MT/ha) with confidence interval 7.77 to 12.81.

Table-9 *ANN model parameter Sapota productivity time series*

Weights between nodes		Biases	
I1:H1	-2.261	Hidden node	
I2:H1	-1.470	H_{B1}	0.870
I1:H2	-0.225	H_{B2}	-7.505
I2:H2	-10.641	Output node	
H1:O	-4.681	O_B	2.628
H1:O	-5.510		
Forecasting (2018-19)		C.I.	
10.51		7.77	12.81

[Table-10] illustrates Area, production and productivity of sapota was best explained by 4:1s:1l, 4:1s:1l &2:2s:1l ANN architectures, with forecasted value for 2018-19, 28.48 ('000' Ha.), 320.89 ('000' MT) &10.51 (MT/Ha.) respectively, where area, production & productivity are likely to go decrease for the next year.

Table-10 *Performance of different models for sapota*

Model for crops		Area (In '000' Ha.)	Production (In '000 MT)	Productivity (MT/Ha.)
Sapota	Model	4:1s:1l	4:1s:1l	2:2s:1l
	RMSE	16.25	214.56	0.09
	Forecast	28.48 (29.55)	320.89(326.36)	10.51 (11.04)
	C.I.	27.46 to 29.47	294.09 to344.43	7.77 to 12.81

Conclusion

Based on this work, one can conclude that artificial neural network models performed well than classical time series models. Hybrid time series models is better compared to single models to forecast the area, production and productivity of sapota in Gujarat was the finding of this study. Among the hybrid model, ANN was superior compare to all other models. The hybrid approach can be further extended using some other machine learning techniques for varying auto regressive and moving average so that practical validity of the model can be well established. This hybrid approach will be applied to study of other data agricultural and horticultural crops.

Application of research

Forecasting area, production and productivity of sapota in Gujarat b using artificial neural network model.

Research Category: Agricultural Statistic

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Study area / Sample Collection: National Horticultural Board

Cultivar / Variety / Breed name: Sapota

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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