FEED FORWARD BACK PROPAGATION NEURAL NETWORK COUPLED WITH RICE DATA SIMULATOR FOR PREDICTION OF RICE PRODUCTION IN TAMILNADU

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Abstract

This paper is the continuation of the paper published by the authors Arun Balaji and Baskaran [2]. Multiple linear regression (MLR) equations were developed between the years of rice cultivation and Feed Forward Back Propagation Neural Network (FFBPNN) method of predicted area of rice cultivation / rice production for different districts pertaining to Kuruvai, Samba and Kodai seasons in Tamilnadu. The average r^2 value in area of cultivation is 0.40 in Kuruvai season, 0.42 in Samba season and 0.46 in Kodai season, where as the r^2 value in rice production is 0.31 in Kuruvai season, 0.23 in Samba season and 0.42 in Kodai season. The Rice Data Simulator (RDS) predicted the area of rice cultivation and rice production using the MLR equations developed in this research. The range of average predicted area for Kuruvai, Samba and Kodai seasons varies from 12052.52 ha to 13595.32 ha, 48998.96 ha to 53324.54 ha and 4241.23 ha to 6449.88 ha respectively whereas the range of average predicted rice production varies from 45132.88 tonnes to 46074.48 tonnes in Kuruvai, 128619 tonnes to 139693.29 tonnes in Samba and 15446.07 to 20573.50 tonnes in Kodai seasons. The mean absolute relative error (ARE) between the FFBPNN and multiple regression methods of prediction of area of rice cultivation was found to be 15.58%, 8.04% and 26.34% for the Kuruvai, Samba and the Kodai seasons respectively. The ARE for the rice production was found to be 17%, 11.80% and 24.60% for the Kuruvai, Samba and the Kodai seasons respectively. The paired t test between the FFBPNN and MLR methods of predicted area of cultivation in Kuruvai shows that there is no significant difference between the two types of prediction for certain districts.

Keywords

Rice Data Simulator, Neural Network, Multiple linear regression, Prediction of rice production

1. INTRODUCTION

Rice is one the stable food for many Asian countries. Rice is the main food consumed in south India including the state of Tamilnadu. Rice production is a complex process involving the different types of soil, varieties of seeds, weather conditions, seasons in a year, varied land and water management practices, pest and disease management techniques, manure and fertilizer management methods, weed management and timeliness management of different unit operations like sowing the seeds, growing of rice and harvesting practices. Hence, rice production is a non

linear, parallel and interconnected process. Many mathematical and statistical methods have been developed to predict rice production based on different parameters. All these methods do not involve a non linear modeling approach. The present study is based on non linear, highly parallel and interconnected networking approach of using artificial feed forward back propagation neural network (FFBPNN) with sigmoid activation function coupled with rice data simulator. The input data like area of rice cultivation in hectare and rice production in tonnes for three seasons namely Kuruvai, Samba and Kodai for the 31 districts of Tamilnadu for five years from 2005-06 to 2008-09 were collected from the Seasons and Crop report [1] published by the Government of Tamilnadu. The authors of this paper already published [2] with more details pertaining to the prediction of rice data using FFBPNN. The published paper revealed the fact that the initial error computed for the FFBPNN output from the original input data for the entire variable like Kuruvai area and its production, Samba area and its production and the Kodai area and its production started at 0.0000548 at the first iteration and the error of all the variables became 0 at 18^{th} iteration. The error reduction pattern for the entire six variables followed the same curve linear path. This showed that the non linearity and complexity of input data were reduced and smoothened after the transformation by the sigmoid activation function multiplied by weights and subsequent updated weights. This paper is the continuation of the already published paper. The overall objective of the present study is coupling of Rice Data Simulator (RDS) with FFBPNN for simulating rice area of cultivation and rice production for the for five years of data captured, which is from 2005-06 to 2008-09. The specific objectives of this paper are:

1 To develop the multiple linear regression equations between the years and FFBPNN method of predicted area of rice cultivation / rice production
2 To predict the area of rice cultivation and rice production from the multiple regression equations developed
3 To compute the absolute relative error (ARE) between the FFBPNN method of prediction and multiple regression method of prediction and its analysis
4 To test the statistical significance using paired t-test between the FFBPNN method of prediction and multiple regression method of prediction and its analysis

2. REVIEW OF LITERATURE

According to F. A. Makinde, C. T. Ako et al [3], the Feed-Forward Back-Propagation Neural Network (FFBPNN) model was used to model the under saturated crude oil viscosity from the Niger Delta region of Nigeria. The FFBPNN is a multi- layered architecture where information flows from the input to the output through at least one hidden/middle layer. Each layer contains neurons that are connected to all neurons in the neighboring layers. The connections have numerical values (weights) associated with them which will be adjusted during the training phase. Checking the results of this model shows that the obtained results for under saturated oil viscosities in this work are in agreement with experimental data compared with the empirical correlations considered in this work. The newly developed FFBPNN model for predicting under saturated crude oil viscosity shows good results compared to the empirical correlations. The FFBPNN model achieved an average absolute relative error of 0.01998 and the relative deviation correlation coefficient of 0.999 as compared to existing empirical correlations. From the cross plots for the FFBPNN model and empirical correlations against their experimental values, the FFBPNN model data points' performance was excellent.

Khashei-Siuki et al [4] studied the prediction of dry land wheat yield based on the daily available weather data and yearly agricultural data with several nonlinear modeling techniques for an arid and semi-arid climate. Two models were used to predict the wheat yield. They were Adaptive

Neuro-Fuzzy Inference Systems (ANFIS) model and Artificial Neural Network with Multi-Layered Preceptron (MLP) model. The study used seven meteorological variables namely precipitations, humidity, evapotranspiration, net radiation, maximum and minimum temperature, and dew temperature for the estimation of dry land wheat yield. ANFIS method provided a general framework for the combination of ANN and fuzzy systems capabilities. The performance of ANFIS model was more pronounced than MLP in testing period. It was concluded that ANFIS model has the ability for precise estimation of dry land wheat yield, while MLP being the most suitable model for this study area. It was reported that there is a lack of comparative studies of different models. Their study used different expert nonlinear models to predict dry land wheat yield. It was reported that MLP and ANFIS techniques could be used in many fields including scheduling, politics, design, and various other analyses. These models can also be integrated into modules for application in general economic models.

Sanjay R. Bhatikar et al [5] reported the challenging problem of modeling of the Energy Storage System (ESS) of a Hybrid Electric Vehicle (HEV).The problem is not amenable to physical modeling without simplifying assumptions that compromise the accuracy of such models. It was reported that the application of an artificial neural network (ANN) was used to model the ESS. The model maps the system's state-of-charge (SOC) and the vehicle's power requirement to the bus voltage and current. It revealed that ANN models can accurately capture the complex, non-linear correlations accurately. It was reported that smart select is a technique used for designing ANN training data. The underlying philosophy of Smart Select is to design the training data set such that it is uniformly distributed over the entire range of an appropriate ANN output variable, which is typically the variable that is most difficult to model. It was found that the training data that were uniformly distributed over the current range. It was reported that smart-select is economical in comparison with conventional techniques for selection of training data. The study reported that an artificial neural network model was developed with 2 inputs, 3 hidden neurons and 2 outputs utilizing only 1583 of the available 32,254 points. When validated on the remaining points, its predictive accuracy, measured by R-squared error, was 0.9978. Also, it was reported that there was an integration of the ANN model of the ESS into the MATLAB-SIMULINK environment of NREL's vehicle simulation software, ADVISOR. This yields a simpler implementation of the ESS module in ADVISOR and does away with certain tenuous assumptions in the original implementation. The report showed that there was dramatic reduction in the size of the training data set by the application of the model modifier approach developed by the research group at the University of Colorado at Boulder.

Using ANNs and Fuzzy Logic, Mayilvaganan, and Naidu [6] have tried to predict ground water level and they have concluded that ANN performs better than Fuzzy Logic.

It has been also proved by the contribution of Karmakar et al., [7] that Back Propagation Network forecast are more efficient technique over the statistical model for forecasting long-range monsoon rainfall over the high resolution geographical region such as district or sub-division level. He has successfully obtained global minima up to the level of 10^{-04} during the training period. And also has obtained more than 80% accuracy in prediction during the independent period.

3. METHODOLOGY

3.1 Prediction of rice data using Feed Forward Back Propagation Neural Network

As reported by Arun Balaji and Baskar [2], a computer program in C++ was developed to read the training data for the FFBPNN. The five years mean area of cultivation and five year mean rice production for the all the districts cultivating rice in Kuruvai, Samba and Kodai seasons of the year 2005 to 2009 was taken as training data. The training data contains the six data items like area and production of rice for three seasons for each district. The FFBPNN system consists of two neurons per season. The first neuron is made of area of rice cultivation in a season and the second neuron is made up of rice production in the same season. Hence, there are two neurons per season. Tamilnadu is producing rice in three seasons. This leads to a total of six neurons. The Feed Forward Back Propagation Neural Network (FFBPNN) to predict rice area of cultivation and rice production is shown in Figure 1 in appendix 1. Readers of this paper are requested to go through the first paper published by the same authors Arun Balaji and Baskaran [2] for more details.

3.2 Rice Data Simulator (RDS)

RDS is software created in C++ for the simulation of rice data. RDS used the input data either area of rice cultivation in hectare or rice production in tonnes for different districts of Tamilnadu cultivating rice in Kuruvai, Samba and Kodai seasons for the five years 2005 to 2009. RDS was developed based on the multiple linear regression (MLR) analysis of the set of data pertaining to year of rice cultivation (x variable) and either area of rice cultivation or rice production predicted from FFBPNN (y variable). The predicted rice data from the FFBPNN for either area of rice cultivation or rice production will be the input into RDS system.. The following is the steps involve in the prediction of rice data using RDS.

3.2.1 Fitting the multiple linear regression (MLR) equations between years and the area of rice cultivation for three seasons

The years of rice cultivation from 2005 to 2009 is taken as independent variable x. The number of observation is N, which is 5 in the present case. The y1, y2 and y3 vectors are the area of rice cultivation in hectare for Kuruvai, Samba and Kodai seasons respectively for a district. Thus RDS provide three sets of multiple regression equations for the area data. Fitting regression equation between independent variable x and dependent variable y will give the equation of the form y = a + bx. The a1, a2 and a3 are the constants and b1, b2 and b3 are regression coefficients computed based on the theory of fitting regression equation. The values of r_1^2, r_2^2 and r_3^2 are coefficient of correlation computed to understand the type of fitting. The various generic formulae used to fit the regression equation between x and y is given below:

Sum of Product of X and Y = SPXY = $\sum XY - \frac{\sum X \sum Y}{N}$

Sum of square of X = SSX = $\sum X^2 - \frac{(\sum X)^2}{N}$

Sum of square of Y = SSY = $\sum Y^2 - \frac{(\sum Y)^2}{N}$

b= $\frac{SPXY}{SSX}$, $\bar{x} = \frac{\sum x}{N}$, $\bar{y} = \frac{\sum y}{N}$ and a = $\bar{y}$ - b $\bar{x}$

Using the calculated values of a and b, the regression equation can be written as y = a + bx.

Coefficient of Correlation r = $\frac{SPXY}{\sqrt{SSX \, .SSY}}$ and $r^2 = \frac{SPXY^2}{SSX \, .SSY}$

Thus the RDS provides the following set of multiple linear equations.
y1 = a1 + b1 x for area of Kuruvai season
y2 = a2 + b2 x for area of rice in Samba season
y3 = a3 + b3 x for area of rice in Kodai season

3.2.2 Fitting the multiple linear regression (MLR) equations between years and the rice production for three seasons

The years of rice production from 2005 to 2009 is taken as independent variable x. The number of observation is N, which is 5 in the present case. The y4, y5 and y6 vectors are the rice production in tonnes in Kuruvai, Samba and Kodai seasons respectively. Fitting regression equation between independent variable x and dependent variable y will give the equation of the form y = a + bx. The a4, a5 and a6 are the constants and b4, b5 and b6 are regression coefficients computed based on the theory of fitting regression equation. The values of r_4^2, r_5^2 and r_6^2 are coefficient of correlation computed to understand the type of fitting. The various generic formulae used to fit the regression equation between x and y was given under section 3.2.1. Thus the RDS uses the following set of multiple linear equations:

y4 = a4 + b4 x for rice production in Kuruvai season
y5 = a5 + b5 x for rice production in Samba season
y6 = a6 + b6 x for rice production in Kodai season

3.2.3 Prediction of the area of rice cultivation from the MLR

The prediction of area of rice cultivation in hectare is obtained by inserting x = (2005, 2006, 2007, 2008 and 2009) in the three equations y1 = a1 + b1 x for area of rice in Kuruvai season, y2 = a2 + b2 x for area of rice in Samba season and y3 = a3 + b3 x for area of rice in Kodai season.

3.2.4 Prediction of rice production from the MLR

The prediction of rice production in tonnes is obtained by inserting x = (2005,2006,2007,2008 and 2009) in the three equations y4 = a4 + b4 x for rice production in Kuruvai season, y5 = a5 + b5 x for rice production in Samba season and y6 = a6 + b6 x for rice production in Kodai season.

3.3 Computation of Absolute Relative Error (ARE) for area of cultivation

ARE between the FFBPNN method of predicted area and the multiple regression method of predicted area was carried out using the formula given below:

$$ARE\ \% = \frac{1}{N}\sum_{i=1}^{N}\frac{(FFBPNN\ predicted\ area - MLR\ predicted\ area)}{FFBPNN\ prediced\ area\ of\ rice\ cultivation}\ x\ 100$$

Where N is the total number of data points. ARE in percent were computed for different districts and different seasons.

3.4 Computation of Absolute Relative Error (ARE) for rice production

ARE between the FFBPNN method of predicted rice production and the multiple regression method of predicted rice production was carried out using the formula given below:

$$ARE\ \% = \frac{1}{N}\sum_{i=1}^{N}\frac{(FFBPNN\ predicted\ rice\ production\ -MLR\ \ predicted\ rice\ production)}{FFBPNN\ prediced\ rice\ production}\ x\ 100$$

Where N is the total number of data points. ARE in percent were computed for different districts and different seasons.

3.5 Testing the statistical significance between the FFBPNN and multiple regression methods of predicted data

The t-test is used to test the significance between two sets of paired data. The pair consists of FFBPNN and multiple regression methods of predicted area of cultivation. The calculated t value for N observations was computed as follows:

Let X is the array of values of FFBPNN method of predicted area of cultivation
Let Y is the array of values of multiple regression method of predicted area of cultivation

D = X – Y, Compute $\sum D$, $\sum D^2$ and $\bar{D} = \frac{\sum D}{N}$ where N is the number of observations

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum D^2 - \frac{(\sum D)^2}{N}}{(N-1)}}$$

Standard Error $SE = \frac{SD}{\sqrt{N}}$

Calculated Paired t value = $\frac{\bar{D}}{SE}$ It is a positive value. If negative value then omit the minus sign.

The Degrees of Freedom = N-1

Refer the statistical t table for (N-1) degree of freedom at 5% level of significance to get the table t value. If calculated t value is less than table t value then there is no significant difference between the FFBPNN method of predicted area of cultivation and the multiple regression method of predicted area of cultivation. . If calculated t value is greater than table t value then there is significant difference between the FFBPNN method of predicted area of cultivation and the multiple regression method of predicted area of cultivation. The same procedure is used to compute the t value between the pair of FFBPNN method of rice production and multiple regression method of rice production.

4. Results and Discussions

Table A.1 in the appendix shows the FFBPNN method of predicted area of rice cultivation in hectare for different districts in three seasons. Table A.5 in the appendix shows the FFBPNN method of predicted rice production in tonnes for all the districts. As per the paper published by the authors [2], the FFBPNN prediction was carried out by updating the weights until the error is below the threshold value of 10^{-9}, which was done by repeating the back propagation for 18

iterations. This predicted data was compared with the observed data collected for area and production of rice in different districts. It was found that both observed and FFBPNN way of predicted data are 100% in agreement for three seasons for the years 2005 to 2009. It was found that the FFBPNN method of prediction is exactly the same as observed area. There is 100% perfect prediction. But in practice, rice area of cultivation and subsequent rice production varies based on the variety of seed, availability of water, land and crop management considerations. Hence, the authors wished to couple a more scientific method of realistic prediction by introducing the development of RDS as per section 3.2. Readers of this paper are requested to go through the author's previous publication [2]. The present results and discussion explains the following specific issues:

- Development of MLR equations between the years of rice cultivation and FFBPNN method of predicted area of rice cultivation / rice production
- Prediction of area of rice cultivation and rice production from the MLR equations developed
- Computation of ARE between the FFBPNN method of prediction and MLR method of prediction and its analysis
- Testing the statistical significance using paired t-test between the FFBPNN method of prediction and MLR method of prediction and its analysis

4.1 Development of multiple linear regression equations

As explained in section 3.2.1 and 3.2.2, fitting the MLR equations between years and the area of rice cultivation and also between years and the rice production for three seasons of different districts of Tamilnadu were carried out.

4.1.1 MLR equations developed between and FFBPNN method of predicted area of cultivation

The Rice Data Simulator (RDS) provides the following set of MLR equations for the area of rice cultivation:

$y1 = a1 + b1\,x$ (1) $Kuruvai\ season$
$y2 = a2 + b2\,x$ (2) $Samba\ season$
$y3 = a3 + b3\,x$ (3) $Kodai\ season$

The above set of MLR equations fitted between years in x axis and the FFBPNN method of predicted area of rice cultivation in y axis is shown in Table A.2 of the appendix. The values of a1 and b1 for Kuruvai season, a2 and b2 for Samba season and a3 and b3 for the Kodai seasons are shown in Table A.2. The summary of the values of r^2 for the set of MLR equations for area of rice cultivation in three seasons are given in Table 1:

Table 1: Values of r^2 for the set of MLR equations between years and FFBPNN method of predicted area of cultivation

Statistical Parameters	Values of r^2 for regression equation of area of rice cultivation (Table A.2)		
	Kuruvai season	Samba season	Kodai season
Minimum	0.00	0.00	0.04
Maximum	0.98	0.99	0.89
Average	0.40	0.42	0.46
Std.deviation	0.35	0.27	0.25
No. of districts	25	28	26

Table 1 shows that the r^2 values are widely varying between a minimum of 0 to a maximum of 0.99. If the r^2 values are nearer to 1, it means that the fitting is perfect. If the r^2 values are nearer to 0, it means the there is a poor fitting of the regression equation. Table A.2 shows that some districts has perfect fitting while some are not having perfect fitting. This is unavoidable in the area of rice cultivation because of the reason that agriculture in Tamilnadu is a gamble with monsoon rains. Crop failure occurs at different stages of crop growth due to scarcity of irrigation water, lack of sufficient nutrients, problems of weeding, pest and diseases etc. It was found that there is wide variation in data collected for different years for the districts mainly due to non availability of water in time. The average r^2 value in area of cultivation is 0.40 in Kuruvai season, 0.42 in Samba season and 0.46 in Kodai season. The standard deviation of r^2 value in area of cultivation of rice varies from 0.25 in Kodai season to 0.35 in Kuruvai season. All these discussion implies that there are wide fluctuations in data pertaining to area of rice cultivation in different years for some of the districts. However, the researcher has fitted the MLR equations by using non linear FFBPNN prediction coupled with RDS to get a scientific way of predicting the area of cultivation.

4.1.2 MLR equations developed between the years and the FFBPNN method of predicted rice production

The RDS provides the following set of MLR equations for rice production:

$y4 = a4 + b4\,x$ (4) $Kuruvai\ season$

$y5 = a5 + b5\,x$ (5) $Samba\ season$

$y6 = a6 + b6\,x$ (6) $Kodai\ season$

The set of MLR equations were fitted between years of rice production in x axis and the FFBPNN method of predicted rice production in tonnes in y axis, which is shown in Table A.6 of the appendix. The values of a4 and b4 for Kuruvai season, a5 and b5 for Samba season and a6 and b6 for the Kodai seasons are shown in Table A.6. The summary of the values of r^2 for the set of MLR equations for rice production in three seasons are given in Table 2:

Table 2: Values of r^2 for the set of MLR equations between years and FFBPNN method of predicted rice production

Statistical Parameters	Values of r^2 for regression equation of rice production (Refer Table A.6)		
	Kuruvai season	Samba season	Kodai season
Minimum	0.00	0.00	0.00
Maximum	0.87	0.98	0.99
Average	0.31	0.23	0.42
Std.deviation	0.30	0.23	0.27
No. of districts	25	28	26

Table 2 shows that the r^2 values are widely varying between a minimum of 0 to a maximum of 0.99. It is found from Table A.6 that some districts in a season has perfect fitting with r^2 value nearing 1, while some other districts in a season are not having perfect fitting because r^2 is nearing 0. It is found that the average r^2 value in rice production is 0.31 in Kuruvai season, 0.23 in Samba season and 0.42 in Kodai season. The standard deviation of r^2 value in rice production varies from 0.23 in Samba season to 0.30 in Kuruvai season. This discussion implies that there are wide fluctuations in data pertaining to rice production in different years for a district due to complexities of water scarcity, rice husbandry and management.

4.2 Prediction of area of rice cultivation and rice production from the MLR equations developed

The predicted area of rice cultivation was computed for 2005 to 2009 by inserting year of cultivation from 2005 to 2009 in the MLR equations shown in Table A.2 of appendix for three seasons. Similarly, the predicted rice production was computed by inserting year of cultivation from 2005 to 2009 in the MLR equations shown in Table A.6 of appendix for three seasons.

4.2.1 Prediction of area of rice cultivation from the MLR

The predicted areas of cultivation are shown in Table A.3 of the appendix. The statistics of the predicted area of cultivation from the set of MLR equations as per Table A.3 for three seasons are given in Table 3.

Table 3: Statistics of the predicted area of cultivation from MLR for three seasons

Parameter	Statistics of the predicted area of cultivation from MLR, hectare				
Year	2005	2006	2007	2008	2009
	Kuruvai season				
Minimum	1369	1176	905	634	363
Maximum	41757	40870	39984	39097	38210
Mean	13595.32	13212.08	12828.96	12445.84	12062.52
Std. deviation	11070.78	10835.56	10644.48	10499.97	10403.82
	Samba season				
Minimum	4854	3963	3071	2180	1288
Maximum	141026	141925	142823	143722	144621
Mean	53324.54	52298	51271.5	50245.11	48998.96
Std. deviation	43865.85	44295.53	44841.75	45500.54	46484.37
	Kodai season				
Minimum	94	257	285	178	-225
Maximum	35035	34069	33103	32137	31171
Mean	6449.88	5897.69	5345.62	4793.50	4241.23
Std. deviation	8939.42	8206.36	7539.40	6957.60	6484.13

Table 3 brings out the fact for the Kuruvai season the minimum range of predicted area of rice cultivation varies from 363 ha to 1369 ha. It was also found out that the maximum predicted area varies from 38201 ha to 41757. The average predicted area varies from 12052.52 ha to 13595.32 ha. Similarly, the standard deviation varies from 10403.82 ha to 11070.78 ha. It was found that the predicted area of rice cultivation gradually reduces from 2005 to 2009.

With regard to the Samba season, the minimum predicted area of rice cultivation varies from 1288 ha to 4584 ha. The maximum predicted area varies from 141026 ha to 144621 ha. The average predicted area varies from 48998.96 ha to 53324.54 ha. Similarly, the standard deviation varies from 43865.85 ha to 46484.37 ha.

With regard to the Kodai season, the minimum predicted area of rice cultivation varies from -225 ha for Coimbatore district in 2009 to 285 ha for Pudukottai district in 2007. The negative value of -225 ha cannot be acceptable prediction. The reason for the negative prediction of area is mainly due to wide variations of observed area of cultivation, which causes the regression equation not true representative to provide the correct prediction. This type of error can be avoided only when more input data are available to build the MLR equations. It was also found that the negative prediction of area was found only for Coimbatore and Namakkal districts. The prediction worked well for other districts. The maximum predicted area varies from 31171 ha to 35035 ha. The average predicted area varies from 4241.23 ha to 6449.88 ha and the standard deviation varies from 6484.13ha to 8939.42 ha.

4.2.2 Prediction of rice production from MLR equations

The predicted rice productions are shown in Table A.7 of the appendix. The statistics of the predicted rice production from the set of MLR equations for rice productions for three seasons are given in Table 4.

Table 4: Statistics of the predicted rice production from MLR equations for rice production

Parameter	Statistics of the predicted rice production from MLR equations, tonnes				
Year	2005	2006	2007	2008	2009
	Kuruvai season (25 districts produce rice)				
Minimum	4176.00	3560.00	2945.00	2329.00	1714.00
Maximum	144870.00	143808.00	142746.00	141683.00	140620.00
Mean	45132.88	45368.24	45603.76	45839.12	46074.48
Std. deviation	36372.19	35870.94	35735.12	35968.55	36564.20
	Samba season (28 districts produce rice)				
Minimum	15444.00	14126.00	12808.00	11491.00	10173.00
Maximum	398311.00	374415.00	353250.00	354486.00	355724.00
Mean	136481.96	134516.29	139693.29	137727.54	128619.00
Std. deviation	100385.35	98086.32	100527.40	99779.97	96856.03
	Kodai season (26 districts produce rice)				
Minimum	417.00	898.00	980.00	633.00	-97.00
Maximum	107903.00	107148.00	106394.00	105639.00	104884.00
Mean	20573.50	19291.49	18009.82	16727.93	15446.07
Std. deviation	27967.16	26246.86	24704.93	23376.33	22299.37

Table 4 brings out the fact that for the Kuruvai season, the minimum predicted rice production varies from 1747 tonnes to 4176 tonnes. It was also found out that the maximum predicted rice production varies from 140620 tonnes to 144870 tonnes. The average predicted rice production varies from 45132.88 tonnes to 46074.48 tonnes and the standard deviation varies from 35735.12 tonnes to36564.20 tonnes. It was found that the predicted rice production fluctuates every year and does not follow any particular trend because of complexities like weather and crop husbandry aspects.

With regard to the Samba season, the minimum predicted rice production varies from 10173 tonnes to 15444 tonnes. The maximum predicted rice production varies from 353250 tonnes to 398311 tonnes. The average predicted rice production varies from 128619 tonnes to 139693.29 tonnes and the standard deviation varies from 96856.03 tonnes to 100527.40 tonnes.

The predicted rice production from MLR for the Kodai season season is shown in Table A.7 of the appendix. The minimum predicted rice production varies from -97 tonnes for Namakkal district in 2009 to 980 tonnes in 2007 for Pudukottai district. The negative value of -97 tonnes cannot be acceptable prediction. The reason for the negative prediction of area is mainly due to wide variations of input observed rice production, which causes the regression equation not true representative to provide the correct prediction. This type of error can be avoided only when more input data is available to build the MLR equations. The maximum predicted rice production 104884 tonnes in 2009 to 109903 tonnes in 2005. The average predicted rice production varies from 15446.07 tonnes to 20573.50 tonnes and the standard deviation varies from 22299.37 tonnes to 27967.16 tonnes.

4.3 ARE between the FFBPNN and MLR methods of prediction

As per the explanation in section 3.3 and 3.4, the ARE percent was calculated for area of rice cultivation between FFBPNN and MLR methods of predicted area of rice cultivation. The ARE percent for rice production was also calculated between FFBPNN and MLR methods of predicted rice production.

4.3.1 ARE between the FFBPNN and MLR methods of predicted area of cultivation

ARE between the FFBPNN and MLR methods of predicted area of cultivation was worked out and shown in Table A.4 of the appendix. The summary of the ARE percent is given in Table 5.

Table 5: Summary of the ARE percent between the FFBPNN and MLR methods of predicted area of cultivation

Statistical parameters	ARE percent between the FFBPNN method and MLR methods of predicted area of cultivation, %		
	Kuruvai season	Samba season	Kodai season
Minimum	2.04	0.61	2.61
Maximum	63.48	38.13	58.71
Mean	15.58	8.04	26.34
Std. deviation	16.34	8.96	17.32
No. of districts	25	28	23
Remarks	During Kodai, Namakkal and Coimbatore districts has negative prediction and Nagapattinam has high error % .		

Table 5 brings out the fact that the minimum, maximum and mean ARE percent was 2.04%, 63.48% and 15.58% respectively for Kuruvai season, 0.61%, 38.13% and 8.04% respectively for Samba season and 2.61%, 58.71% and 26.34% respectively for Kodai season respectively. The reason for the highest error of 63.48% in Tiruvarur district in Kuruvai season,38.13% in Coimbatore district during Samba season and 58.71% in Salem district during Kodai season are due to wide fluctuations in the observed data.

4.3.2 ARE between the FFBPNN and the MLR methods of predicted rice production

ARE between the FFBPNN and MLR methods of predicted rice production were worked out and shown in Table A.8 of the appendix. The summary of the ARE percent is given in Table 6.

Table 6 Summary of the ARE between the FFBPNN and the MLR methods of predicted rice production

Statistical parameters	ARE between the FFBPNN and the MLR methods of predicted rice production		
	Kuruvai season	Samba season	Kodai season
Minimum	3.96	1.64	2.21
Maximum	56.19	35.05	59.22
Mean	17.00	11.80	24.60
Std. deviation	13.56	7.83	15.93
No. of districts	25	28	23

Table 6 brings out the fact that the minimum, maximum and mean ARE percent are 3.96%, 56.19% and 17.0% respectively for Kuruvai season, followed by 1.64%, 35.05% and 11.80% respectively for Samba season and 2.21%, 59.22% and 24.60% respectively for Kodai season. The standard deviation varies from 7.83 % in Samba season to 15.93% in Kodai season. Namakkal district showed the predicted rice production of -97 tonnes for 2009 (refer table A7) and hence it was omitted for prediction for want of more data. Similarly, Coimbatore district showed the predicted area of rice cultivation of – 225 has (refer table A.3) and hence it was also omitted for further prediction for want of more input data. Nagapattinam district showed the high mean ARE percent of 581.49% due to the extreme ARE percent of 2832 % for the year 2007 as per table A.4 in appendix. Hence, Nagapattinam district was also omitted for further prediction

for want of more years of data to get consistent result. This caused the number of districts predicted in Kodai season is reduced to 23 districts.

4.4 Test of significant difference between the FFBPNN and MLR methods

The t-test as explained in section 3.5 is used to test the significance between two sets of paired data. The first data field is the FFBPNN method of predicted area of cultivation and the second data field is the MLR method of predicted area of cultivation. The two data items for a year form a pair. The same procedure is used to compute the t value between the pair of FFBPNN and MLR methods of rice production.

4.4.1 Paired t test between the FFBPNN and MLR methods of predicted area

The t-test was conducted as per section 3.5 between the FFBPNN and MLR methods of predicted area of rice cultivation. There are 25 observations for Kuruvai season. The table t value for the degrees of freedom of 24 at 5% level of significance was taken up from the t table. If the calculated t value is less than the table t value then there is no significant difference between the two samples. This procedure is repeated for different years of rice cultivation for Kuruvai, Samba and Kodai seasons. The summary of the t test is given in Table7.

Table 7 shows the fact that the calculated t value is less than the table t value at 5% level of significance for all the years in Kuruvai season, i-e there is 95% confidence level between the FFBPNN and MLR methods of predicted area of rice cultivation. It is interpreted that there is statistically no significant difference between FFBPNN and MLR methods of predicted area of rice cultivation for the Kuruvai season.

With regard to the Samba season, the calculated t value is less than the table t value at 5% level of significance for all the years excepting 2007 and 2009. The predicted area of rice cultivation by FFBPNN method and MLR method are significantly different for 2007 and 2009. But, it is found that there is statistically no significant difference between FFBPNN and MLR methods of predicted area of rice cultivation for the years 2005, 2006 and 2008.

Table 7: Result of t test between the FFBPNN and MLR methods of predicted area of cultivation

Season	No. of districts	DF	Table t at 5% level	Calculated t value for area of cultivation for different years					Remarks
				2005	2006	2007	2008	2009	
Kuruvai	25	24	2.064	1.673	1.949	1.884	1.968	1.615	No Significant difference at 5% level for all the years
Samba	28	27	2.052	1.665	1.101	4.022	0.104	2.742	Significant difference for the year 2007 and 2009.
Kodai	26	25	2.056	3.065	2.845	3.725	1.624	0.654	Significant difference for the years 2005 ,2006, 2007.

Note: DF: Degrees of Freedom

With regard to the Kodai season, the calculated t value is less than the table t value at 5% level of significance for the years 2008 and 2009. There is statistically no significant difference between the FFBPNN method of predicted area and MLR of predicted area for the years 2008 and 2009.

For the year 2005, 2006 and 2007, it was found that the calculated t value is greater than the table t value, it means that there is statistically significant difference between the FFBPNN method and MLR of predicted area of cultivation for the year 2005,2006 and 2007.

The conclusion of the t test shows that the idea of building MLR equations by taking the FFBPNN method of predicted area of cultivation as dependant variable (y) and the years of cultivation as independent variable (x) for the three seasons and the subsequent use of RDS to predict area of cultivation worked very well excepting for the 2007 in Samba season, 2005, 2006 and 2007 in Kodai seasons.

4.4.2 Paired t test between the FFBPNN and MLR methods of predicted rice production

The paired t-test is used to test the significance between two sets of paired data items. The first data item is the FFBPNN method of predicted rice production and the second data item is MLR method of predicted rice production. The two data items form a pair. The calculated t value between the two sets of 25 observations for Kuruvai season was compared with the table t value at 24 degrees of freedom at 5% level of significance. If the calculated t value is less than the table t value then there is no significant difference between the two samples. This procedure is repeated for 2005 to 2009 for Kuruvai, Samba and Kodai seasons. The summary of the t test is given Table 8.

Table 8 shows the fact that the calculated t value is less than the table t value at 5% level of significance for the years 2005,2006 and 2007 in Kuruvai season, 2005,2008 and 2009 in Samba season and 2006,2008 and 2009 in Kodai season. Hence, it is found that there is statistically no significant difference between the FFBPNN and MLR methods of predicted rice production for the years 2005,2006 and 2007 in Kuruvai season, 2005,2008 and 2009 in Samba season and 2006,2008 and 2009 in Kodai season respectively.

Table 8: Result of t test between the FFBPNN and MLR methods of predicted rice production

Season	No. of districts	DF	Table t at 5% level	Calculated t for rice production for different years					Remarks
				2005	2006	2007	2008	2009	
Kuruvai	25	24	2.064	1.771	0.472	0.006	2.719	6.300	Significant difference for 2008 and 2009.
Samba	28	27	2.052	1.007	2.472	2.160	1.685	1.759	Significant difference for 2006 and 2007.
Kodai	26	26	2.056	2.916	1.817	3.421	1.699	0.095	Significant difference for 2005 and 2007.

Note: DF: Degrees of Freedom

Table 8 also shows the fact that the calculated t value is greater than the table t value at 5% level of significance for the years 2008 and 2009 in Kuruvai season, 2006 and 2007 in Samba season and 2005 and 2007 in Kodai season respectively. It is interpreted that there is statistically significant difference between the FFBPNN and MLR methods of predicted rice production.

5. SUMMARY AND CONCLUSIONS

Prediction of annual rice production in all the 31 districts of Tamilnadu is an important decision for the Government of Tamilnadu. Rice production is a non linear and complex process involving soil, crop, weather, pest, disease, capital, labour and management parameters. FFBPNN software was designed and developed to predict area of cultivation and rice production. As per [2], the predicted results were found to be exactly equal to the observed values. It showed that the prediction was 100% accurate. Rice Data Simulator is software developed based on the MLR equations of the rice data. RDS used the inputs of FFBPNN predicted data and the years of rice cultivation and the output from the RDS is the MLR method of predicted data. The predicted data from the FFBPNN and MLR methods were tested using the t test and also analyzed based on the ARE. The summary and conclusions drawn from the present research is given below:

1 The fitting of multiple regression equations between the years of rice cultivation and the area of cultivation/rice production is judged by the r^2 values. It was found that the r^2 values are widely varying between a minimum of 0 to a maximum of 0.99. If the r^2 values are nearer to 1, it means that the fitting is perfect. If the r^2 values are nearer to 0, it means the there is a poor fitting of the regression equation. The average r^2 value in area of cultivation is 0.40 in Kuruvai season, 0.42 in Samba season and 0.46 in Kodai season. The standard deviation of r^2 value in area of cultivation of rice varies from 0.25 in Kodai season to 0.35 in Kuruvai season. Similarly, it is also found that the average r^2 value in rice production is 0.31 in Kuruvai season, 0.23 in Samba season and 0.42 in Kodai season. The standard deviation of r^2 value in rice production varies from 0.23 in Samba season to 0.30 in Kuruvai season. The conclusion drawn from the results and discussion is that there is wide yearly variation of area of cultivation and rice production in some districts which is having the r^2 near to 0. It is unavoidable in rice cultivation because of the reason that agriculture in Tamilnadu is a gamble with monsoon rains and also due to complexities of soil, weather, fertilizers, weeding, pests, diseases etc. The districts having r^2 near to 1 have perfect prediction. The wide variations in some districts can be reduced if the input data is available for more number of years.

2 It was found that by using the MLR method of prediction, the average predicted area during Kuruvai season varies from 12052.52 ha to 13595.32 ha and the standard deviation varies from 10403.82 ha to 11070.78 ha. This gives the conclusion that the predicted area of rice cultivation gradually reduces from 2005 to 2009 during Kuruvai season. The average predicted area during Samba season varies from 48998.96 ha to 53324.54 ha and the standard deviation varies from 43865.85 ha to 46484.37 ha. The average predicted area for Kodai season varies from 4241.23 ha to 6449.88 ha and the standard deviation varies from 6484.13ha to 8939.42 ha.

3 With regard to the Kodai season, the minimum predicted area of rice cultivation varies from -225 ha for Coimbatore district in 2009 to 285 ha for Pudukottai district in 2007. The negative value of -225 ha cannot be acceptable prediction. Similarly, Namakkal district also has -62 ha. The reason for the negative prediction of area is mainly due to wide variations of observed area of cultivation for the five years, which causes the regression equation not true representative to provide the correct prediction. This type of error can be avoided only when more input is available to build the regression equation. It was also found that the negative prediction of area for Coimbatore and Namakkal districts during Kodai season only, there is no such problems encountered for other seasons and other districts.

4 It was found that for the Kuruvai season the range of minimum, maximum and average predicted rice production varies from 1747 tonnes to 4176 tonnes , 140620 tonnes to 144870 tonnes and 45132.88 tonnes to 46074.48 tonnes respectively. With regard to the Samba

season, the range of minimum, maximum and average predicted rice production varies from 10173 tonnes to 15444 tonnes, 353250 tonnes to 398311 tonnes and 128619 tonnes to 139693.29 tonnes respectively. With regard to the Kodai season, the range of maximum and average predicted rice production varies 104884 tonnes in 2009 to 109903 tonnes in 2005 and 15446.07 tonnes to 20573.50 tonnes respectively where as the standard deviation varies from 22299.37 tonnes to 27967.16 tonnes.

5 With regard to the Kodai season, the range of minimum predicted rice production varies from -97 tonnes in 2009 for Namakkal district to 980 tonnes in 2007 for Pudokottai. The negative value of -97 tonnes cannot be acceptable prediction. The reason for the negative prediction of area is mainly due to wide variations of observed rice production, which causes the regression equation not true representative to provide the correct prediction. This type of error can be avoided only when more input data is available to build the regression equation.

6 It was found that the minimum, maximum and mean ARE percent for the area of rice cultivation was 2.04%, 63.48% and 15.58% respectively for Kuruvai season, 0.61%, 38.13% and 8.04% for Samba season and 2.61%, 58.71% and 26.34% for Samba season respectively. The reason for 63.48% error in Tiruvarur district in Kuruvai season,38.13% error in Coimbatore district during Samba season and 58.71% error in Salem district during Kodai season are due to wide fluctuations in the observed data.

7 For the rice production, it was found that the minimum, maximum and mean ARE percent are 3.96%, 56.19% and 17.0% for Kuruvai season, 1.64%, 35.05% and 11.80% for Samba season and 2.21%, 59.22% and 24.60% for Kodai season respectively. The standard deviation varies from 7.83 % in Samba season to 15.93% in Kodai season.

8 Namakkal and Coimbatore districts showed the predicted rice production of -97 tonnes for 2009 and -225 ha respectively. Nagapattinam district showed the high mean ARE percent of 581.49% due to the extreme data obtained for the year 2007. Hence, Namakkal , Coimbatore and Nagapattinam districts were omitted for further prediction during Kodai season due to want of more years of data to get consistent prediction.

9 The paired t test between the FFBPNN and MLR methods of predicted area of cultivation in Kuruvai shows that there is no significant difference between the two types of predictions. It was found for the Samba season, during 2007 and 2009 there is significant difference between FFBPNN and MLR methods of predicted area of cultivation. There is statistically no significant difference between the FFBPNN and MLR methods of predicted area for the three years 2005, 2006 and 2008 in Samba season. It was found for the Kodai season, during 2005, 2006 and 2007, there is significant difference between FFBPNN and MLR methods of predicted area of cultivation. There is statistically no significant difference between the FFBPNN and MLR methods of predicted area for the two years 2008 and 2009 in the Kodai season..

10 For the prediction of rice production, it was found that for the years 2005,2006 and 2007 in Kuruvai season, 2005,2008 and 2009 in Samba season and 2006,2008 and 2009 in Kodai season, there is insignificant difference between FFBPNN and multiple regression methods of prediction. It was also found that for the years 2008 and 2009 in Kuruvai season, 2006 and 2007 in Samba season, 2005 and 2007 in Kodai season showed that there is statistically significant difference between the FFBPNN method and the MLR methods of predicted rice production. The conclusion of the t test shows that the idea of building the multiple linear regression equations by taking the FFBPNN method of predicted area of cultivation / rice production as dependant variable (y) and the years of cultivation as independent variable (x) for the three seasons and the subsequent RDS predicted area of cultivation /rice production worked very well excepting for some years due to wide variations in observed data which needs more input data for getting consistent results.

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Appendix

Table A.1: FFBPNN method of predicted area of rice cultivation in different districts for three seasons

S. No	Districts	Observed area of rice in Ha for Kuruvai					Observed area of rice cultivation in Ha for Samba					Observed area of rice cultivation in Ha for Kodai				
		2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
1	Kancheepuram	19408	23911	18453	17044	18546	67709	65034	60437	61791	60625	27603	14162	12466	12039	11849
2	Thiruvallur	39196	44682	39051	39812	37197	39047	29668	29615	31119	31644	18751	13517	10066	11309	12101
3	Cuddalore	23555	21336	17896	17646	18779	85331	79079	79760	85548	88010	5405	5025	5142	4623	4728
4	Villupuram	35918	28374	28594	25942	24880	115530	107964	105715	109978	114085	16987	8445	11094	10721	9489
5	Vellore	7245	10079	10489	10230	9741	19942	16728	17667	18110	16309	30976	14880	16170	19077	13715
6	Thiruvannamalai	27958	23108	20831	18540	21958	75525	63095	58947	40212	57727	39261	25256	32370	43134	25492
7	Salem	10058	8423	6072	7806	7858	23052	17771	14609	19749	13963	4218	1289	1030	2374	2561
8	Namakkal	5463	7023	6971	7613	2934	12174	7661	5197	6192	7540	1196	538	37	104	213
9	Dharmapuri	10082	7673	3890	8093	7329	14106	11089	13710	10919	10658	4835	2300	1201	1356	2323
10	Krishnagiri	8031	7910	6564	5930	6641	11935	8955	7662	7954	8591	2014	1025	756	737	1258
11	Coimbatore	1206	1470	1544	1623	1257	4545	3803	4550	939	1519	1655	948	385	11	41
12	Tiruppur	This district is started recently and hence there is no sufficient data for prediction analysis														
13	Erode	12787	10849	9962	8945	9207	29525	26745	27091	26607	27448	1227	954	1307	2501	1459
14	Tiruchirapalli	6066	6997	5120	6953	6816	66579	62906	53207	61962	55341	6931	1819	2962	3615	2139
15	Karur	Rice not cultivated in this season					17711	13341	12121	15190	14580	687	404	312	438	421
16	Perambalur	2033	2637	3262	512	764	42669	38261	34183	8854	10166	1250	1032	676	3033	1159
17	Ariyalur	This district is started recently and hence there is no sufficient data for prediction analysis														
18	Pudukottai	1499	1079	997	534	417	94268	91989	87396	95505	94593	219	297	272	347	292
19	Thanjavur	23440	33264	20922	37177	22037	128668	128954	126227	135261	135621	2793	2025	3079	4656	5280
20	Thiruvarur	10416	32214	9034	30932	13270	141455	142804	140645	143724	145489	4227	1882	1950	3384	7493
21	Nagapattinam	24213	30774	25189	34389	27252	132608	134051	128826	135764	129814	1279	889	25	687	789
22	Madurai	5564	8924	10342	11600	3944	62455	54353	48088	51371	43081	2977	3953	3434	3728	3961
23	Theni	5307	5161	5155	5372	5605	10204	9554	9054	9349	9097	183	200	191	858	669
24	Dindigul	3250	2451	2139	1520	1630	16092	12944	12785	15469	13421	4393	3212	2352	2649	1596
25	Ramanathapuram	Rice not cultivated in this season					127395	128005	122184	127196	132451	2346	2118	1587	1599	1434
26	Virudhunagar	Rice not cultivated in this season					27779	30503	25683	29434	24951	2997	2232	2520	2810	1666
27	Sivagangai	Rice not cultivated in this season					89924	81232	78623	80748	77332	Rice not cultivated in this season				
28	Tirunelveli	19131	22527	25551	27075	18604	53947	64760	54637	57651	65628	13319	4597	3523	6594	1762
29	Thoothukudi	7940	7970	6030	8168	6995	10167	9865	8663	12985	11317	1825	3541	3363	1248	1237
30	The-Nilgiris	1430	1249	1110	775	509	Rice not cultivated in this season					Rice not cultivated in this season				
31	Kanyakumari	10669	10538	10121	8928	8534	11566	10868	10228	9259	8773	Rice not cultivated in this season				
	No. of districts cultivating rice in Kuruvai season = 25						No. of districts cultivating rice in Samba season = 28					No. of districts cultivating rice in Kodai = 26				

Table A.2: Multiple regression equations fitted for area of rice cultivation in different districts for three seasons

S.No	Districts	Kuruvai Area in y axis, years in x axis Equation: y1 = a1 + b1 x			Samba Area in y axis and years in x axis Equation: y2 = a2 + b2 x			Kodai Area in y axis and years in x axis Equation: y3 = a3 + b3 x		
		a1	b1	r_1*	a2	b2	r_2*	a3	b3	r_3*
1.	Kancheepuram	1743686.00	-859.10	0.27	3557506.75	-1741.10	0.76	6765365.50	-3363.10	0.62
2.	Thiruvallur	1819791.12	-886.80	0.25	2712567.00	-1335.50	0.29	3487224.50	-1730.80	0.61
3.	Cuddalore	2677511.75	-1324.20	0.68	-2290133.25	1182.70	0.23	357413.81	-175.60	0.77
4.	Villupuram	4947497.50	-2450.80	0.81	286467.59	-87.60	0.00	2564251.25	-1272.00	0.37
5.	Vellore	-1022643.25	514.30	0.38	1198670.00	-588.40	0.43	6105191.00	-3032.50	0.47
6.	Thiruvannamalai	3347676.75	-1656.80	0.56	11795836.00	-5847.90	0.53	1971864.62	-966.00	0.04
7.	Salem	1014955.31	-501.70	0.31	3269168.75	-1620.00	0.47	449654.69	-222.90	0.08
8.	Namakkal	902728.38	-446.80	0.14	2162668.50	-1073.70	0.40	482097.59	-240.00	0.64
9.	Dharmapuri	1028173.62	-508.60	0.13	1430242.50	-706.60	0.45	1200180.62	-596.80	0.42
10.	Krishnagiri	962347.19	-476.00	0.68	1552201.75	-768.90	0.51	362418.00	-180.00	0.29
11.	Coimbatore	-49758.50	25.50	0.05	1792512.38	-891.60	0.67	836523.50	-416.50	0.89
12.	Tiruppur	Newly formed district. It has insufficient data to process and hence omitted								
13.	Erode	1829494.88	-906.40	0.85	888887.62	-429.20	0.33	-402118.12	201.10	0.29
14.	Tiruchirapalli	-285828.81	145.60	0.08	4760393.00	-2342.00	0.44	1566544.75	-778.80	0.56
15.	Karur	Rice not cultivated in this season			900277.69	-441.30	0.11	100401.00	-49.80	0.32
16.	Perambalur	937705.69	-466.30	0.39	18975516.00	-9441.30	0.86	-363643.28	181.90	0.10
17.	Ariyalur	Newly formed district. It has no data to process and hence omitted								
18.	Pudukottai	544601.50	-270.90	0.96	-743366.00	416.60	0.04	-39051.80	19.60	0.45
19.	Thanjavur	-194806.89	110.70	0.00	-3925803.00	2021.30	0.57	-1522756.88	760.50	0.79
20.	Thiruvarur	-869125.00	442.60	0.00	-1661068.12	898.80	0.56	-1608636.62	803.40	0.31
21.	Nagapattinam	-1917021.62	969.30	0.13	909925.12	-387.50	0.04	237961.19	-118.20	0.17
22.	Madurai	121269.60	-56.40	0.00	8427081.00	-4173.00	0.83	-346209.50	174.30	0.44
23.	Theni	-156644.89	80.70	0.48	494944.88	-241.90	0.67	-326720.81	163.00	0.65
24.	Dindigul	839317.69	-417.10	0.89	579514.12	-281.70	0.08	1238550.38	-615.70	0.87
25.	Ramanathapuram	Rice not cultivated in this season			-1739665.88	930.30	0.16	472056.91	-234.30	0.89
26.	Virudhunagar	Rice not cultivated in this season			1377377.50	-672.50	0.20	420703.78	-208.40	0.40
27.	Sivagangai	Rice not cultivated in this season			5232739.50	-2566.80	0.59	Rice not cultivated in this season		
28.	Tirunelveli	-678668.19	349.40	0.02	-3202652.50	1625.30	0.21	4244141.00	-2111.70	0.56
29.	Thoothukudi	347005.00	-169.20	0.09	-1077194.62	542.00	0.28	698471.06	-346.90	0.24
30.	The-Nilgiris	465835.81	-231.60	0.98	Rice not cultivated in this season			Rice not cultivated in this season		
31.	Kanyakumari	1189874.00	-588.00	0.92	14541175.25	-719.50	0.99	Rice not cultivated in this season		
		No. of districts cultivating rice in Kuruvai = 25			No. of districts cultivating rice in Samba = 28			No. of districts cultivating rice in Kodai = 26		

Table A.3: Predicted area of rice cultivation based on MLR equations in different districts for three seasons

S.No	Districts	Multiple regression method of predicted area in Kuruvai					Multiple regression method of predicted area in Samba					Multiple regression method of predicted area in Kodai				
		2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
1	Kancheepuram	21191	20331	19472	18613	17754	66601	64860	63119	61378	59637	22350	18987	15624	12261	8897
2	Thiruvallur	41757	40870	39984	39097	38210	34890	33554	32218	30883	29548	16970	15240	13509	11778	10047
3	Cuddalore	22491	21167	19842	18518	17194	81180	82363	83546	84728	85911	5336	5160	4985	4809	4633
4	Villupuram	33643	31193	28742	26291	23840	110830	110742	110654	110567	110479	13891	12619	11347	10075	8803
5	Vellore	8528	9043	9557	10071	10585	18928	18340	17751	17163	16574	25028	21998	18964	15931	12898
6	Thiruvannamalai	25793	24136	22479	20822	19165	70797	64949	59101	53253	47405	35035	34069	33103	32137	31171
7	Salem	9047	8545	8043	7542	7040	21069	19449	17829	16209	14589	2740	2517	2294	2071	1849
8	Namakkal	6894	6448	6001	5554	5107	9900	8826	7753	6679	5605	898	658	418	178	-62
9	Dharmapuri	8431	7922	7413	6905	6396	13510	12803	12096	11390	10683	3597	3000	2403	1806	1209
10	Krishnagiri	7967	7491	7015	6539	6063	10557	9788	9019	8251	7482	1518	1338	1158	978	798
11	Coimbatore	1369	1394	1420	1446	1471	4854	3963	3071	2180	1288	1441	1024	608	192	-225
12	Tiruppur	Newly formed district. It has no data to process and hence omitted														
13	Erode	12163	11256	10350	9444	8537	28342	27912	27483	27054	26625	1087	1288	1490	1691	1892
14	Tiruchirapalli	6099	6245	6390	6536	6682	64683	62341	59999	57657	55315	5051	4272	3493	2714	1936
15	Karur	Rice not cultivated in this season					15471	15030	14589	14147	13706	552	502	452	403	353
16	Perambalur	2774	2308	1842	1375	909	45710	36269	26827	17386	7945	1066	1248	1430	1612	1794
17	Ariyalur	Newly formed district. It has no data to process and hence omitted														
18	Pudukottai	1447	1176	905	634	363	91917	92334	92750	93167	93583	246	266	285	305	325
19	Thanjavur	27147	27257	27368	27479	27589	126904	128925	130946	132968	134989	2046	2806	3567	4327	5088
20	Thiruvarur	18288	18731	19173	19616	20058	141026	141925	142823	143722	144621	2180	2984	3787	4591	5394
21	Nagapattinam	26425	27394	28363	29333	30302	132988	132600	132213	131825	131438	970	852	734	616	497
22	Madurai	8188	8131	8075	8018	7962	60216	56043	51870	47697	43524	3262	3436	3611	3785	3959
23	Theni	5159	5239	5320	5401	5481	9935	9693	9452	9210	8968	94	257	420	583	746
24	Dindigul	3032	2615	2198	1781	1364	14706	14424	14142	13860	13579	4072	3456	2840	2225	1609
25	Ramanathpuram	Rice not cultivated in this season					125586	126516	127446	128376	129307	2285	2051	1817	1583	1348
26	Virudhunagar	Rice not cultivated in this season					29015	28342	27670	26998	26325	2862	2653	2445	2237	2028
27	Sivagangai	Rice not cultivated in this season					86305	83739	81172	78605	76038	Rice not cultivated in this season				
28	Tirunelveli	21879	22228	22578	22927	23276	56074	57699	59325	60950	62575	10183	8071	5959	3847	1736
29	Thoothukudi	7759	7590	7421	7251	7082	9515	10057	10599	11141	11683	2937	2590	2243	1896	1549
30	The-Nilgiris	1478	1246	1015	785	551	Rice not cultivated in this season					Rice not cultivated in this season				
31	Kanyakumari	10934	10346	9758	9170	8582	11578	10858	10139	9419	8700	Rice not cultivated in this season				
		No. of districts cultivating rice in Kuruvai = 25					No. of districts cultivating rice in Samba = 28					No. of districts cultivating rice in Kodai = 26				

Table A.4: ARE percent between FFBPNN and MLR methods of predicted area of rice cultivation in different districts for three seasons

S.No	Districts	% Error in Area of Kuruvai season						% Error in Area of Samba season						% Error in Area of Kodai season					
		2005	2006	2007	2008	2009	Mean Error	2005	2006	2007	2008	2009	Mean Error	2005	2006	2007	2008	2009	Mean Error
1	Kancheepuram	9.18	14.97	5.52	9.21	4.27	8.63	1.63	0.27	4.44	0.67	1.63	1.73	19.03	34.06	25.32	1.84	24.91	21.03
2	Thiruvallur	6.53	8.53	2.44	1.80	2.72	4.40	10.65	13.10	8.79	0.76	6.62	7.98	9.49	0.50	34.19	4.15	6.97	13.06
3	Cuddalore	4.52	0.79	10.87	4.94	8.43	5.91	4.86	4.15	4.75	0.96	2.38	3.42	1.28	2.69	3.05	4.02	1.99	2.61
4	Villupuram	6.33	9.93	0.51	1.35	4.18	4.46	4.07	2.57	4.67	0.53	3.16	3.00	18.22	49.43	2.28	6.02	7.22	16.63
5	Vellore	17.71	10.28	8.89	1.54	8.66	9.42	5.08	9.63	0.48	5.23	1.62	4.41	19.20	47.82	17.27	16.49	5.95	21.35
6	Thiruvannamalai	7.74	4.44	7.91	12.31	12.72	9.02	6.26	2.94	0.26	32.43	17.88	11.95	10.76	34.89	2.26	25.49	22.27	19.14
7	Salem	10.05	1.45	32.46	3.38	10.41	11.55	8.60	9.44	22.03	17.92	4.48	12.49	35.02	95.27	122.72	12.72	27.80	58.71
8	Namakkal	26.19	8.19	13.91	27.05	74.06	29.88	18.67	15.21	49.16	7.85	25.65	23.31	Predicted area is negative for 2009.					
9	Dharmapuri	16.38	5.25	90.57	14.68	12.72	27.52	4.23	15.45	11.77	4.30	0.23	7.20	25.60	30.39	100.08	33.19	47.91	47.44
10	Krishnagiri	0.78	5.28	6.87	10.27	8.69	6.38	11.54	9.30	17.71	3.72	12.91	11.04	24.65	30.54	33.17	32.70	36.57	35.52
11	Coimbatore	13.52	5.10	8.03	10.91	17.02	10.92	6.80	4.18	32.48	132.06	15.14	38.13	Predicted area is negative for 2009.					
12	Tiruppur	This district is started recently and hence there is no sufficient data for prediction analysis																	
13	Erode	4.88	3.75	3.89	5.57	7.27	5.07	4.01	4.36	1.45	1.68	3.00	2.90	11.33	35.01	13.93	32.39	29.61	24.45
14	Tiruchirapalli	0.54	10.75	24.80	6.00	1.97	8.81	2.85	0.90	12.77	6.95	0.05	4.70	27.12	134.80	17.93	24.90	9.49	42.85
15	Karur	Rice not cultivated in this season						12.64	12.65	20.35	6.86	5.99	11.70	19.51	24.26	44.87	7.99	16.15	22.56
16	Perambalur	36.45	12.48	43.53	168.55	18.98	56.00	7.13	5.21	21.52	96.36	21.85	30.41	14.64	20.93	111.54	46.85	54.70	49.73
17	Ariyalur	This district is started recently and hence there is no sufficient data for prediction analysis																	
18	Pudukottai	3.40	8.99	9.13	18.75	12.71	10.59	2.49	0.37	6.13	2.45	1.07	2.50	12.33	10.44	4.78	12.10	10.96	10.12
19	Thanjavur	15.81	18.06	30.81	26.09	25.19	23.19	1.37	0.02	3.74	1.70	0.47	1.46	26.75	38.57	15.82	7.04	3.64	18.36
20	Thiruvarur	75.58	41.85	112.23	36.58	51.15	63.48	0.30	0.62	1.55	0.00	0.60	0.61	48.40	58.30	94.21	35.64	28.00	52.95
21	Nagapattinam	9.13	10.98	12.60	14.70	11.19	11.72	0.29	1.08	2.63	2.90	1.25	1.63	24.08	4.16	2832.0	10.33	36.88	581.49
22	Madurai	47.14	8.87	21.92	30.87	101.85	42.13	3.58	3.11	7.86	7.15	1.03	4.55	9.57	13.05	5.13	1.50	0.03	5.86
23	Theni	2.79	1.51	3.20	0.52	2.19	2.04	2.63	1.45	4.38	1.49	1.42	2.27	48.09	28.50	119.90	31.93	11.51	47.99
24	Dindigul	6.68	6.69	2.71	17.11	16.32	9.90	8.61	11.43	10.61	10.39	1.17	8.44	7.31	7.60	20.75	16.01	0.81	10.49
25	Ramanathpuram	Rice not cultivated in this season						1.42	1.16	4.31	0.93	2.37	2.04	2.56	3.12	14.43	1.00	5.95	5.41
26	Virudhunagar	Rice not cultivated in this season						4.45	7.08	7.74	8.28	5.51	6.61	4.50	18.86	2.98	20.39	21.73	13.69
27	Sivagangai	Rice not cultivated in this season						4.02	3.08	5.94	2.65	1.67	3.47	Rice not cultivated in this season					
28	Tirunelveli	14.36	1.32	11.64	15.32	25.11	13.55	3.94	10.90	8.58	5.72	4.65	6.76	23.55	75.57	69.15	41.66	1.48	42.28
29	Thoothukudi	2.27	4.77	23.05	11.21	1.24	8.51	6.40	1.95	22.35	14.19	3.23	9.62	60.88	26.86	33.30	51.84	25.14	39.60
30	The-Nilgiris	3.29	0.16	8.56	1.03	8.25	4.26	Rice not cultivated in this season						Rice not cultivated in this season					
31	Kanyakumari	2.48	1.82	3.59	2.71	0.56	2.23	0.10	0.08	0.87	1.73	0.83	0.72	Rice not cultivated in this season					
		Minimum Mean Error					2.04	Minimum Mean Error					0.61	Minimum Mean Error					2.61

Table A.5: FFBPNN method of predicted rice production in different districts for three seasons

S.No	Districts	Kuruvai Rice Production, tonnes					Samba Rice Production, tonnes					Kodai Rice Production, tonnes				
		2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
1	Kancheepuram	59873	73921	73959	75880	65885	150367	259966	224461	206455	218666	83635	59247	46709	46875	46883
2	Thiruvallur	131182	147022	152448	161389	118686	82774	112342	95886	114794	95404	57626	59104	34673	39681	42204
3	Cuddalore	73958	70800	65342	56311	66245	128440	303320	252016	153782	241709	15947	18264	17761	13789	15008
4	Villupuram	122825	86433	95498	81289	74401	335200	381646	348547	337294	363561	53906	28034	36284	32556	29869
5	Vellore	21859	28817	35617	37469	35249	53912	49127	58762	66332	53379	91680	51249	53988	68072	47206
6	Thiruvannamalai	80459	62284	78566	63224	63557	203421	213751	194535	117503	179153	109648	90016	112813	137217	82274
7	Salem	39236	30964	18766	27313	30384	82209	63971	49664	85384	65453	15846	4876	3653	7686	10627
8	Namakkal	20314	21444	24247	38457	12330	44973	34213	20928	28489	32868	3562	2021	125	355	748
9	Dharmapuri	29504	23617	14919	32687	29411	41917	44334	51007	39873	41900	13969	8121	4469	5167	8364
10	Krishnagiri	25197	20531	21302	21803	27828	27530	27012	24059	27407	32732	5070	3494	2311	3093	4416
11	Coimbatore	3636	5044	6190	6407	4403	11786	15139	16920	14859	5337	5243	3826	1346	4171	144
12	Thiruppur	This district is started recently and hence there is no sufficient data for prediction analysis														
13	Erode	58343	47898	48275	40890	40378	116124	109409	113005	146638	110629	5097	4292	3580	8793	5412
14	Tiruchirapalli	21891	24317	21150	28857	24356	193532	251782	196197	219729	232541	21317	6345	9985	13798	9375
15	Karur	Rice not cultivated in this season					46179	46754	39221	58664	62567	2046	1518	1058	1494	1478
16	Perambalur	4628	7021	8790	6034	2440	106671	121675	85408	101049	35864	3263	3287	1230	6711	4068
17	Ariyalur	This district is started recently and hence there is no sufficient data for prediction analysis														
18	Pudukottai	3861	3452	3851	2099	1460	228055	279417	154779	176487	185964	652	1116	922	1184	1025
19	Thanayur	68044	103851	78049	134675	66501	323251	487409	390235	208459	343248	8188	6900	11359	14027	17393
20	Thiruvarur	27547	84289	32232	129352	41548	203938	495508	271846	62738	414414	11965	6578	7228	14521	27163
21	Nagapattinam	66486	73038	101547	127348	81893	66445	554229	187685	95456	347366	3706	3340	85	2343	2770
22	Madurai	19811	35994	41112	47709	15325	207136	216704	161836	205990	174024	7545	14820	11932	13529	14267
23	Theni	24015	22611	24780	32100	30383	40615	40771	36069	45266	44979	655	827	813	2926	2348
24	Dindigul	8044	10706	8816	5805	7473	52116	54106	50050	54604	63776	15144	16436	8971	12252	7600
25	Ramanathapuram	Rice not cultivated in this season					247079	214277	24500	197535	229846	8931	7957	5379	5454	5054
26	Virudhunagar	Rice not cultivated in this season					87021	148896	84510	96928	59640	11461	9318	8541	6664	5076
27	Sivagangai	Rice not cultivated in this season					192738	108961	78566	131821	138095	Rice not cultivated in this season				
28	Tirunelvali	69911	87814	105078	110704	75424	206949	280193	207825	236438	272985	32205	17271	11041	27072	7468
29	Thoothukudi	32564	31668	25963	41726	34508	41360	45981	34165	60401	56256	7892	16351	4607	6036	5911
30	The-Nilgiris	4716	3995	4287	3046	1783	Rice not cultivated in this season					Rice not cultivated in this season				
31	Kanyakumari	43497	44059	46583	42399	38286	54111	50071	43627	41258	37951	Rice not cultivated in this season				
		No. of districts cultivating rice in Kuruvai = 25					No. of districts cultivating rice in Samba = 28					No. of districts cultivating rice in Kodai = 26				

Table A.6: Multiple regression equations fitted for rice production in different districts for three seasons

S.No	Districts	Kuruvai rice production in y axis, years in x axis Equation: $y4 = a4 + b4\ x$			Samba rice production in y axis and years in x axis Equation: $y5 = a5 + b5\ x$			Kodai rice production in y axis and years in x axis Equation: $y6 = a6 + b6\ x$		
		a4	b4	r_4^2	a5	b5	r_5^2	a6	b6	r_6^2
1	Kancheepuram	-2334684.50	1198.30	0.07	-16463578.00	8308.70	0.11	17291982.00	-8587.60	0.72
2	Thiruvallur	2275183.00	-1062.50	0.01	-5461558.50	2771.20	0.11	10135245.00	-5026.70	0.52
3	Cuddalore	6070471.50	-2991.50	0.50	-15238047.00	7700.00	0.03	1291200.88	-635.30	0.29
4	Villupuram	20561884.00	-10199.20	0.73	-21294095.50	1237.00	0.01	8777017.00	-4355.20	0.44
5	Vellore	-7079400.00	3543.20	0.75	-3182795.00	1613.90	0.15	14537926.00	-7212.50	0.40
6	Thiruvannamalai	6665422.50	-3286.40	0.33	29239822.00	-14478.40	0.36	1621076.50	-754.70	0.00
7	Salem	4315281.00	-2135.50	0.21	2497605.50	-1209.90	0.02	1539477.12	-762.80	0.06
8	Namakkal	-186373.09	104.50	0.00	6040048.00	-2993.40	0.29	1465268.00	-729.40	0.65
9	Dharmapuri	-1756991.25	888.40	0.04	945952.69	-449.50	0.03	2850732.75	-1416.40	0.36
10	Krishnagiri	-1288041.62	653.40	0.11	-2139611.25	1079.90	0.30	346673.09	-170.90	0.06
11	Coimbatore	-576291.94	289.70	0.15	2657633.00	-1317.80	0.21	1980443.12	-985.30	0.54
12	Thiruppur	This district is started recently and hence there is no sufficient data for prediction analysis								
13	Erode	8664813.00	-4293.80	0.87	-5146606.00	2623.90	0.07	-1024356.88	513.10	0.16
14	Tiruchirapalli	-1876514.75	947.00	0.25	-9006419.00	4596.50	0.09	3309865.75	-1643.10	0.20
15	Karur	Rice not cultivated in this season			-8917803.00	4468.60	0.54	234330.80	-116.00	0.27
16	Perambalur	1082136.62	-536.30	0.12	32651702.00	-16224.00	0.60	-1006612.00	503.40	0.16
17	Ariyalur	This district is started recently and hence there is no sufficient data for prediction analysis								
18	Pudukottai	1238255.12	-615.50	0.78	37758316.00	-18711.20	0.36	-162390.00	81.40	0.38
19	Thanayur	-5476792.50	2773.80	0.02	48308988.00	-23895.60	0.14	-5113702.50	2553.70	0.89
20	Thiruvarur	-14601152.00	7306.50	0.07	2661561.50	-1181.80	0.00	-7681146.00	3833.90	0.53
21	Nagapattinam	-16994326.00	8512.40	0.30	-20435712.00	10306.90	0.01	578257.06	-286.90	0.10
22	Madurai	-518529.88	274.30	0.00	15634594.00	-7693.80	0.26	-2426688.50	1215.30	0.43
23	Theni	-4433779.50	2222.50	0.70	-2612316.25	1322.30	0.31	-1099325.75	548.50	0.69
24	Dindigul	1220998.88	-604.30	0.28	-4725342.50	2381.80	0.51	3879971.00	-1927.20	0.64
25	Ramanathapuram	Rice not cultivated in this season			10460093.00	-5120.80	0.01	2073158.75	-1029.70	0.85
26	Virudhunagar	Rice not cultivated in this season			21516110.00	-10673.00	0.26	3103808.75	-1542.40	0.99
27	Sivagangai	Rice not cultivated in this season			17475734.00	-8642.60	0.11	Rice not cultivated in this season		
28	Tirunelvali	-6717155.00	3391.60	0.09	-17484344.00	8831.70	0.16	7981382.50	-3967.30	0.36
29	Thoothukudi	-2765676.25	1394.60	0.15	-8825716.00	4421.20	0.42	2873553.25	-1427.70	0.23
30	The-Nilgiris	1371355.88	-681.50	0.85	Rice not cultivated in this season			Rice not cultivated in this season		
31	Kanyakumari	2467822.00	-1208.20	0.40	8300796.50	-4113.30	0.98	Rice not cultivated in this season		
		No. of districts cultivating rice in Kuruvai season = 25			No. of districts cultivating rice in Samba season = 28			No. of districts cultivating rice in Kodai season = 26		

Table A.7: Predicted rice production based on MLR equations in different districts for three seasons

S.No	Districts	Kuruvai Rice Production in y axis, years in x axis					Samba Rice Production in y axis and years in x axis					Kodai Rice Production in y axis and years in x axis				
		2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
1	Kancheepuram	67907	69105	70304	71502	72700	195366	203675	211983	220292	228601	73845	65257	56670	48082	39494
2	Thiruvallur	144870	143808	142746	141683	140620	94697	97469	100240	103011	105782	56711	51684	46658	41631	36604
3	Cuddalore	72514	69522	66531	63540	60548	200453	208153	215853	223553	231255	17424	16789	16154	15518	14883
4	Villupuram	112488	102288	92089	81890	71691	350776	352012	353250	354486	355724	44841	40485	36130	31775	27420
5	Vellore	24716	28259	31802	35346	38889	53075	54688	56302	57916	59530	76864	69651	62438	55226	48014
6	Thiruvannamalai	76191	72904	69618	66332	63045	210629	196151	181672	167194	152716	107903	107148	106394	105639	104884
7	Salem	33604	31468	29332	27197	25062	71756	70546	69336	68126	66916	10063	9300	8538	7775	7012
8	Namakkal	23149	23254	23358	23463	23567	38281	35288	32294	29301	26308	2821	2092	1362	633	-97
9	Dharmapuri	24251	25139	26028	26916	27804	44705	44256	43806	43357	42907	10851	9434	8018	6602	5185
10	Krishnagiri	22025	22679	23332	23986	24639	25588	26668	27748	28828	29908	4019	3848	3677	3506	3335
11	Coimbatore	4557	4846	5136	5426	5715	15444	14126	12808	11491	10173	4917	3931	2946	1961	975
12	Thiruppur	This district is started recently and hence there is no sufficient data for prediction analysis														
13	Erode	55744	51451	47157	42863	38569	114313	116937	119561	122185	124809	4409	4922	5435	5948	6461
14	Tiruchirapalli	22220	23167	24114	25061	26008	209564	214160	218756	223353	227950	15450	13807	12164	10521	8878
15	Karur	Rice not cultivated in this season					41740	46209	50677	55146	59615	1751	1635	1519	1403	1287
16	Perambalur	6855	6319	5783	5246	4710	122582	106358	90134	73910	57686	2705	3208	3712	4215	4719
17	Ariyalur	This district is started recently and hence there is no sufficient data for prediction analysis														
18	Pudukottai	4176	3560	2945	2329	1714	242362	223650	204939	186228	167517	817	898	980	1061	1143
19	Thanjavur	84677	87450	90224	92998	95772	398311	374415	350520	326624	302728	6466	9020	11573	14127	16681
20	Thiruvarur	48380	55687	62994	70300	77606	92052	90871	289689	288507	287325	5823	9657	13491	17325	21159
21	Nagapattinam	73057	81549	90062	98574	107086	229623	239930	250237	260544	70851	3023	2736	2449	2162	1875
22	Madurai	31442	31716	31990	32264	32539	208525	200832	193138	185444	177750	9988	11203	12419	13634	14849
23	Theni	22333	24556	26778	29000	31223	38895	40218	41540	42862	44185	417	965	1514	2062	2611
24	Dindigul	9377	8773	8169	7564	6960	50167	52548	54930	57312	59694	15935	14008	12081	10153	8226
25	Ramanathapuram	Rice not cultivated in this season					192889	187769	182648	177527	172406	8610	7581	6551	5521	4492
26	Virudhunagar	Rice not cultivated in this season					116745	106072	95399	84726	74053	11297	9754	8212	6670	5127
27	Sivagangai	Rice not cultivated in this season					147322	138679	130037	121394	112751	Rice not cultivated in this season				
28	Tirunelveli	83003	86595	89786	93178	96570	223215	232047	240878	249710	258542	26946	22979	19011	15044	11077
29	Thoothukudi	30497	31891	33286	34680	36075	38790	43212	47633	52054	56475	11015	9587	8159	6732	5304
30	The-Nilgiris	4928	4247	3565	2884	2202	Rice not cultivated in this season					Rice not cultivated in this season				
31	Kanyakumari	45381	44173	42965	41756	40548	53630	49517	45404	41290	37177	Rice not cultivated in this season				
		No. of districts taken up for prediction in Kuruvai = 25					No. of districts taken up for prediction in in Samba = 28					No. of districts taken up for prediction in Kodai = 25				

Table A.8: ARE percent between FFBPNN and MLR methods of predicted rice production in different districts for three seasons

S.No	Districts	% Error in Rice Production of Kuruvai season						% Error in Rice Production of Samba season						% Error in Rice Production of Kodai season					
		2005	2006	2007	2008	2009	Mean Error	2005	2006	2007	2008	2009	Mean Error	2005	2006	2007	2008	2009	Mean Error
1	Kancheepuram	13.42	8.98	4.94	5.77	10.34	8.69	13.66	3.56	5.56	6.70	4.54	6.80	11.71	10.14	21.32	2.57	15.76	12.30
2	Thiruvallur	1043	2.19	8.17	12.21	18.48	10.30	14.40	13.24	4.54	10.26	10.88	10.67	1.59	12.55	34.56	4.91	13.27	13.38
3	Cuddalore	1.95	1.80	1.82	12.84	8.60	5.40	5.04	9.77	11.66	2.75	4.33	6.71	9.26	8.07	9.05	12.54	0.83	7.95
4	Villupuram	8.42	18.34	3.57	0.74	3.64	6.94	4.65	7.76	1.35	5.10	2.16	4.20	16.82	44.41	0.42	2.40	8.20	14.45
5	Vellore	13.07	1.93	10.71	5.67	10.32	8.34	1.55	11.32	4.18	12.69	11.52	8.25	16.16	35.91	15.65	18.87	1.71	17.66
6	Thiruvannamalai	5.30	17.05	11.39	4.91	0.80	7.89	3.54	8.23	6.61	13.48	14.76	9.33	1.59	19.03	5.69	23.01	27.48	15.36
7	Salem	14.35	1.63	56.30	0.42	17.52	18.05	12.72	10.28	39.61	20.21	2.24	17.01	36.49	90.73	133.70	1.14	34.02	59.22
8	Namakkal	13.96	8.44	3.66	38.99	91.14	31.24	14.88	3.14	54.31	2.85	19.96	19.05	Predicted area & rice production is negative.					
9	Dharmapuri	17.80	6.44	74.46	17.66	5.46	24.36	6.65	0.18	14.12	8.74	2.40	6.42	22.32	16.17	79.39	27.75	38.00	36.73
10	Krishnagiri	12.58	10.46	9.53	10.01	11.46	10.81	7.05	1.27	15.33	5.18	8.63	7.49	20.73	10.10	59.07	13.32	24.46	25.54
11	Coimbatore	25.30	3.91	17.03	15.31	29.80	18.27	31.03	6.68	24.30	22.67	90.59	35.05	Predicted area of cultivation is negative					
12	Thiruppur	This district is started recently and hence there is no sufficient data for prediction analysis																	
13	Erode	4.45	7.42	2.32	4.82	4.48	4.70	1.56	6.88	3.96	16.68	12.82	8.38	13.50	14.66	51.79	32.36	19.36	26.33
14	Tiruchirapalli	1.50	4.73	14.01	13.15	6.78	8.04	8.28	11.09	11.50	1.65	1.97	6.90	27.32	117.60	21.82	23.75	5.30	39.20
15	Karur	Rice not cultivated in this season						9.61	1.17	29.21	6.00	4.72	10.14	14.42	7.64	43.48	6.09	12.92	16.91
16	Perambalur	48.12	10.00	34.21	13.04	92.99	39.67	14.92	12.59	5.53	26.86	60.85	24.15	17.10	2.37	201.71	37.18	15.98	54.87
17	Ariyalur	This district is started recently and hence there is no sufficient data for prediction analysis																	
18	Pudukottai	8.13	3.13	23.53	10.96	17.33	12.61	6.27	3.50	9.93	5.52	9.92	7.03	25.31	19.44	6.18	10.30	11.41	14.53
19	Thanavur	24.44	15.79	15.60	17.72	44.01	23.51	2.95	3.71	6.62	6.19	7.29	5.35	21.03	30.71	1.88	0.71	4.09	11.69
20	Thiruvarur	75.63	33.93	95.44	5.01	70.95	56.19	11.07	1.62	6.56	46.48	0.96	13.34	51.32	46.81	86.65	19.31	22.10	45.24
21	Nagapattinam	9.85	11.65	11.31	22.59	30.76	17.23	48.32	2.41	1.59	33.02	3.16	17.70	Predicted area error is too high.					
22	Madurai	58.70	11.89	22.19	32.37	112.32	47.49	0.67	7.32	19.34	9.97	2.14	7.89	32.38	24.40	4.07	0.77	4.08	13.14
23	Theni	7.00	8.60	8.06	9.65	2.76	7.22	4.23	1.36	15.17	5.31	1.77	5.57	36.34	16.69	86.10	29.49	11.16	35.96
24	Dindigul	16.57	18.05	7.34	30.30	6.85	15.82	5.74	2.88	9.75	4.96	6.40	5.55	5.22	14.77	34.66	17.12	8.24	16.00
25	Ramanathapuram	Rice not cultivated in this season						4.59	12.37	110.51	10.13	3.52	28.23	3.58	4.73	21.77	1.23	10.77	8.41
26	Virudhunagar	Rice not cultivated in this season						34.16	15.25	12.88	12.59	24.17	19.81	1.43	4.68	5.85	0.08	1.00	2.21
27	Sivagangai	Rice not cultivated in this season						10.44	27.27	17.90	7.91	18.35	16.37	Rice not cultivated in this season					
28	Tirunelveli	18.73	1.62	14.55	15.83	28.03	15.75	7.86	6.21	15.63	5.61	5.29	8.12	16.33	33.04	72.19	44.43	48.31	42.86
29	Thoothukudi	6.35	0.70	28.20	16.88	4.54	11.34	6.21	6.02	39.42	13.82	0.39	13.17	39.56	41.36	77.10	11.51	10.25	35.96
30	The-Nilgiris	4.50	6.28	16.82	5.32	23.50	11.28	Rice not cultivated in this season						Rice not cultivated in this season					
31	Kanyakuman	4.35	0.26	7.77	1.51	5.91	3.96	0.89	1.10	4.07	0.08	2.04	1.64	Rice not cultivated in this season					
		Minimum Mean Error					3.96	Minimum Mean Error					1.64	Minimum Mean Error					2.21
		Maximum Mean Error					56.19	Maximum Mean Error					35.05	Maximum Mean Error					59.22
		Average of 5 years mean errors					17.00	Average of 5 years mean errors					11.80	Average of 5 years mean errors					24.60
		Std deviation of mean error					13.56	Std deviation of mean error					7.83	Std deviation of mean error					15.93
		No. of districts taken up for prediction					25	No. of districts taken up for prediction					28	No. of districts taken up for prediction					23