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ANN for Profit Predication in Maize Crop Cultivation through Cloud Database

S K Rajesh Kanna[1] Lingaraj .N[2] Muthuvel.C[3] , Mohan.D[4]
Professor Department of Mechanical Engineering Rajalakshmi Institute of Technology India
Assistant professor Department of Mechanical Engineering Rajalakshmi Institute of Technology India
UG student Department of Mechanical Engineering, Rajalakshmi Institute of Technology
Corresponding Author: S K Rajesh Kanna

ABSTRACT— one of the major dispute encountering in the agriculture sector is to maximize the profit margin by increasing the cropping system yield productivity. Further productivity can be increased by predicating the factors affecting the cropping system. But the factors like temperature, irrigation, rainfall, etc might not be predicted exactly and a necessity arises for an intelligent system to forecast. In this research, Artificial Neural Network has been used to predict and forecast the optimal crop. For experimentation, data have been collected for ninety six months from thirty farmers. The collected data have been stored in cloud storage and is the input to neural network. Trained and tested neural model has been used to pinpoint the fittest yielding period for maize crop cultivation. Furthermore, it is capable of forecasting the optimal combination of variables to yield highest productivity of maize crop. Obtained output from the developed module is in-line with the data collected from agriculturist and thus the refined module had been validated.
INDEX TERMS— *Forecasting, Maize cropping system, Artificial Neural Network, Back propagation.*

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I. INTRODUCTION

In general, economy of a developing country mainly hinges on agriculture and in turn agriculture depends on nature. Owing to pollution and global warming, periodic rainfall fails and the farmers have not been possible to predict rainfall. With the result, deficiency in natural reserves like rain, ground water for irrigation, atmospheric temperature, mist, etc will affect growth of the crops, in turn reduces the profit. In a cropping system, numbers of dependable parameters are combined and operate to yield higher productivity within a defined limit. Each crop having unique climatic condition for yielding and having heterogeneous cultivation time. Farmers have to cultivate suitable crops for the climatic conditions, so as the cultivation enhanced and profit increased. In most cases, the climatic parameters are atmospheric temperature, ground water level, ground water or river water irrigation facility, amount of rainfall, rainfall frequency, soil fertility, application of fertilizers, moisture content in air, monsoon behavior, product demand, marketing facilities, price for the crop, labour cost, availability of agricultural workers, etc. A good number of parameters can be found by testing and knowledge. But certain peculiar natural parameters have not been predictable and forecasted. The farm trials and field research may not generate fruitful results in predications. As there is no hard rule and procedure to predict the nature in advance, these methodologies are connected to experience and territory conditions. So researchers are not using these methodologies as universal methodology for all situations.

Thereupon a necessity evolves for a mathematical model to forecast and to predict the future climatic conditions. Because, any complex real time applications can be converted into a mathematical model and can be solved to identify the suitable solution. Thus mathematical models can be an alternative solution providing methodology by considering the constraints of practical real time systems. Still and all, these models have not been utilized for future prediction in agricultural sector for profit maximization. Since, the effectiveness of most of these models has depended on the input variables and these models can be unsuccessful to bring forth the excelling results with incompatible conflicting input parameters. Problems with multiple objectives and unpredictable constraints have been resolved by many researchers in most of the practical applications and explored that the intelligent algorithms such as artificial neural network, fuzzy logic, game theory can be applied to foresee the needed parameters. Artificial Neural Network (ANN) is one among the intelligent techniques which has been cast off in this research to foresee the cultivation level and environmental causes for maize cropping cultivation system. Together with, the live parameters have to be updated in the cloud for effective prediction.

The foremost significant parameters investigated in this research are average amount of rainfall, irrigation facility and atmospheric air temperature. To collect these variables, ground surveys have been conducted among thirty farmers in the villages around Namakkal distict, southern Tamilnadu, India. The data have been collected for ninety six months and stored in the cloud database. Inconsistent and unfeasible data had eliminated from the population for data mining. The left over statistics have been utilized to train and test the developed ANN module. This module is capable of figure out the finest period for cultivating the maize crop and also the desirable climatic condition which will be best fit for cultivation. Thus the developed trained ANN provides support to the farmers in cultivating maize crop with higher profit and also alarms the unsuitable period for yielding, so as the loss can be avoided.

II. LITURATURE SURVEY

Dillon et al (1992) considered the cost of the input parameters, demand for the crop in the market and output prize to calculate the profit [4]. Dillon et al (1993) focused on the small scale farmers by executing a research in farm management in improving the profit margin with less investment [5]. Jehle et al. (1998) identified the best system to yield maximum profit using the approaches such as cost function approach, mathematical optimization, profit function approach, production function approach and dynamic programming [12]. Fleisher (1999) explored the factors and parameters which are all influencing the cropping system [9]. Jehle and Reny (1998) used agriculture and resource management for developing the economic theory to improve the profit margin. Kothari (1999) implemented the quantitative approach simulation model to increase the profit and cultivation [15]. Stockle et al (2003) found that the simulation methodologies and techniques are underestimating the yield of cropping system. Stockle (2003) proved that the mathematical models are very efficient and can solve the coping system problems with real practical conditions [22]. Grabisch (2003) utilized the probability technique and developed a heuristic model for maximizing crop cultivation. Giardini et al (2004) conducted experimentation on two types of cropping system and simulated the both for maximizing the profit through EPIC and CropSyst [10]. Jha et al (2004) mainly conducted experiments on climatic changes on the river basin and found the major impacts over the cropping systems [13]. Alva et al (2004) developed heuristic model for predicting the optimal parameters for potato crop which can yield maximum potato and in turn the profit of the cultivation [1]. Cantelaube and Terres (2005) proved by experimenting on the seasonal forecasting to provide more profit and predicted the changes in the seasons, so that the cultivation can be done accordingly [2]. Ines and Hansen (2006) proved that the rainfall plays a major role in yield of the cropping system. So the author studied the impact of rainfall in yielding and simulated the cropping system based on the quantity of the rainfall through the mathematical models [11]. Di Luzio et al (2008) proved that the best yield can be obtained for the crops growing at the desirable temperatures. So the author considered the temperature as the fore most parameter and conducted analysis for developing the simulation model in identifying the suitable temperature for the cropping system [3]. Zhang et al (2009) evolved with genetic algorithm and Bayesian model for optimizing the parameters which can yield maximum profit in crop cultivation [24]. Kelton (2003) developed and simulated a mathematical model which can produce the result for the agriculture management [14]. Lordanova (2007) developed Monte Carlo model for analyzing and identifying the parameters and the suitable conditions that can yield maximum profitability [16]. Staggenborg and Vanderlip (2005) conducted research in improving the profit margin of the cropping system and proved that the mathematical models are simulating the predictions as expected for the cropping system [20]. Francoise (1998) used the ANN model for the industrial applications and proved that ANN model producing better results for the real time practical applications [6].

From the collected literatures, it has been inferred that the researchers are considering different parameters and simulated the models to yield maximum profit for different cropping systems. In the continuation, in this research, amount of rainfall, atmospheric temperature average for both day and night and availability of irrigation facility had been taken for experimentation and increased the yielding capacity of maize cropping system. Also the model has been reinforced with simulation for identifying the better crop that can be suitable for the predicated climatic conditions.

III. MATHEMATICAL MODELLING

At most in all over the world, maize is a commonly consumed commercial crop. Maize can be used as direct food and also additives in different food items. Maize properties are having many benefits and having more consumption all over the year. i.e. the demand for the maize is existing all around the year, so the demand persists continuously. In the light of the above, the maize cultivating farmers are highly motivated in earning more profit from the maize cropping system. This motive has been affected by the nature, so the framers are in need of a model that can predict the future environmental conditions, so that the cropping can be done and can yield maximum profit. For satisfy this need, researchers are using the tools like Ants colony algorithm, mathematical models, ANN, Genetic algorithm, Fuzzy logic, Tabu search, Expert systems, etc. At most the models are depend on some assumptions or conditions specific to the crop and have not predict properly for all the universal conditions, moreover, It fails in predicting all the parameters which are influencing the maximization of crop cultivation and defective in confining the dynamically changing variables apart from consuming more computational time. So in this research work, ANN module has been developed to foretell the factors affecting the cropping system and optimize the parameters that can yield maximum maize crop cultivation. As the developed ANN model uses the past history of data and intelligence with flexibility for predicting the variables, it has been proved by many researchers as a best model. Also the performance of the ANN model depends on the past data, a cloud storage had developed and the farmers have to update the data periodically, thus ANN uses the latest available data to predict the near future with higher efficiency.

The data for approximately hundred months have been surveyed and collected form forty farmers, taluk officers, and from the common peoples in the market places. For surveying, questioner have been circulated and for further information and recollection brainstorming sessions also been conducted. The collected data had been stored in the cloud storage and filtered for inconsistency and redundancy. Because, the data are collected for long period back, so inconstancy became unavoidable. Then the feasible data have been segregated and separate table had generated in the cloud storage. The next stage is the formulation of the mathematical fitness function based on the collected data. For that purpose, Minitab software was used in this research and the mathematical relation were generated between the inputs. The generated mathematical function was collated with the developed ANN model as the objective function. The scatter data obtained from the software is given in the Figure 1.

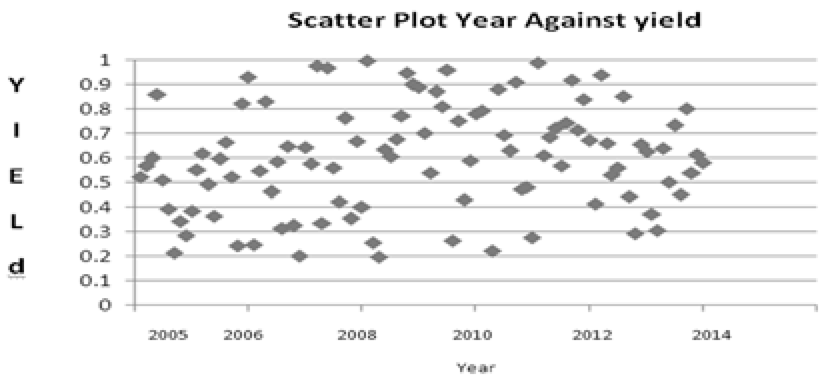

Figure 1: Scatter Data Plot

The generated fitness function is considered as the yield function Y(x) for the developed module and is given in Equation 1.

$$Y(x) = (10.135 * r) +(37.291 * i) – (4.435 * t) + (12.642 * i) – (14.121 * r * r) + (1.823 * i * i) + (7.078 * t * t) + (0.238 * i * r) + (23.138 * r * i) + (3.938 * r * t) – (4.337 * r * i) – (22.867 * i * t) + (8.981 * i * r) + (7.324 * t * i) + 189.578 \quad (1)$$

Whereas, ‘r’, ‘i’ and ‘t’ represent the rainfall, irrigation and temperature respectively.
The Equation 1 is a non-linear discrete equation bounded by multiple constraints with normalized variables. This equation has been used as training function for ANN.

A. Artificial Neural network

Functioning of the ANN module is similar to the working concept of a human brain. Human brain is subjected to multiple number constraints and conflicting information which need to be satisfied simultaneously to control the body by Welstead [21]. In artificial casting, multiple heterogeneous pieces of data are to be processed simultaneously without violating the user defined constraints with in prescribed boundaries. ANN believes that information are processed through the interaction of highly interconnected processing elements called neurons by Martein et al [17]. Researchers have developed a similar tool artificially with network of artificial neurons represented by nodes and tails with links. The links are connected with all other neurons, capable of doing processing in the same manner as that of human brain by Robert [19]. The developed model control parameters underwent the sensitivity analysis to enhance the speed of processing by analyzing most of the possible conditions. With the data of hundred months, the developed system directly perceives what the farmers and agriculturists are executing in the practical crop cultivation. In neural network, several models like BAM, Adaline and Madaline, Hopfield memory, Back-propagation, Counter propagation, etc., are available by Richard [18]. Back-propagation (BPN) has comparatively many advantages over the other models. In BPN the step size can be varied, training speed can be dynamically changed by the user, unlimited stopping conditions can be imposed, network size is set by the user as required, easy to prune the developed network, etc by Richard [19]. So in this research, Back-propagation model have been used for predicting the environmental variables for maize crop cultivation.

B. Back-Propogation Network (BPN)

Back-propagation is a gradient descent technique with backward error propagation [17]. In BPN, obtained error value is propagating backward over the hidden neurons (layers) and updating the associated weight and threshold values. The activation function considered is tan-sigmoid function and can accommodate large and small signals without saturation and without excessive attenuation. Tan-sigmoid function used is given in the Equation 2.

$OUTPUT = 1/ (1 + e^{ai})$ (2)

$a_i = \sum w_{ij} * O_j + t_i$

Whereas 'a' is activation level, 'w' and 't' represent the weight and threshold values for i^{th} and j^{th} neuron respectively.

C. Developed BPN

Figure 3 shows the flow chart of the developed BPN model. Different level of the developed model is explained as follows.

Initializing the Network: Initially, the network has to be build by the user and the size depends on the application. No hard bound rules exists in framing the network and in setting the number of layers and number of neurons in each layer. So for experimenting and to reduce the computational time, sensitivity analysis had been performed with different set of values and the developed model is performing better with four layers of 12, 200, 75 and 8 neurons in input, hidden layer 1, hidden layer 2 and output layer respectively. The sample set of encoded input data set is shown in the Figure 2.

ANN Encoded Input 1: 312 415 01 02 08
ANN Encoded Input 2: 078 029 01 07 10
ANN Encoded Input 3: 126 036 01 12 07
ANN Encoded Input 4: 349 042 00 04 11
Figure 2: A Sample Set of ANN Input

In Figure 2, the length of each encoded string having 12 integer digits, in which the first three digits represent the average amount of rainfall in millimetres.

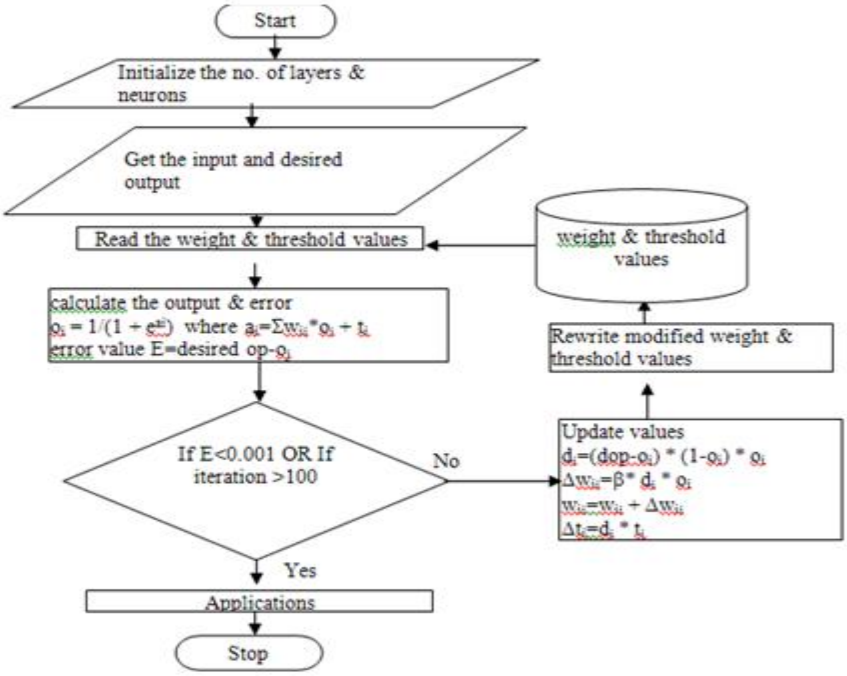

FIGURE 3: Back-propagation Algorithm

The second set from fourth to sixth digit represents the average atmospheric temperature for the month in degree centigrade. The next two consecutive digits represent the availability and non availability of irrigation facility with '01' and '00' respectively. The next four digits represent the month and year. Each decimal digit has been given as input to each neuron in the input layer. For example, first sample input is for the January 2005 having rainfall of 10 mm and average day temperature up to 28 degree centigrade with irrigation facility.

Setting Training Values: Upon trainning the developed ANN, 75 % of the collected and filtered date had been used for training and the remaining 25 % had been used for testing the network. With the purpose of avoiding convergence, the training data for ANN have to be taken at random from the available data in the cloud storage. Also the cloud storage are updating periodically. Weight values and threshold values are generated at random and stored in the cloud database for further training and testing.

ANN Training: To train the model, the real time practical data were collected from the farmers and the peoples related to the agriculture and are stored in the cloud. The developed model reads the data from the cloud and those data are encoded to the ANN format of 12 digit string. These Encoded Input data have to be allowed to propagate through the input, hidden and output layers. In the output layer, final outputs have been calculated. The obtained outputs have to be compared with the desired outputs and the difference is considered as the error value for that trail. If the calculated error value is greater than the mean square error set by the user, then the error is back propagated through the network. During backward propagation, weight for the links and threshold values of the neurons are updated accordingly using the formulas given in the Figure 1. The same procedure has to be repeated until the error value reaches the least minimum [7]. As the consequences, it is considered that the developed ANN had been trained. Then the trained network has to be tested for the effectiveness. Since, over training leads to redundant output and under training leads to worse data. After training, ANN can be implemented for prediction of the maize crop cultivation.

During training phase, the weight matrix, 'w' is updated according to the Equation 3 given by, Yegnanarayana [23],

$$\Delta \mathbf{w}_i(n+1) = \eta \left(\sum_{k=1}^{T_{train}} \partial^k_w \, O_h[j] \right) / T_{train} + \sigma \, \Delta \, \mathbf{w}_i(n) \quad (3)$$

Whereas, T_{train} denotes number of training cases, $O_h[j]$ denote the output value from the j^{th} neuron, $\partial^k_w = (t_k - O_k) * O_k * (1 - O_k)$, t_k and O_k are user desired output and the actual output calculated by the network respectively.

The updating of weight and the threshold values for all the training data will be repeated till the error value reaches the least minimum. In this research, the minimum error value had been set to 0.001 by conducting sensitivity analysis. Overtraining and insufficient training might also lead to wrong prediction. In the continuation, proper training required as it is working on the data available from the cloud storage, each ANN parameter values and the stopping conditions have to be identified suitably by conducting the sensitivity analysis and thereby enhancing the computational speed.

Stopping Conditions: In soft computing algorithms, always a trade-off exists between computational time and quality. Stopping conditions set in this research work are given below.

1. If number of iterations reached 1000.
2. If difference between desired and calculted <= 0.001.
3. If $V_g = V_{(g+8)}$ whereas, g is iteration number.

Once the ANN has satisfied any one of the three conditions, then ANN has been assumed to be trained, again it need be tested before implementing in the application.

Testing: In testing phase, the remaining 25% of the valid data collected from the farmers have to be used. In this work, it has been found that the ANN testing is producing the promising results. Thereby the developed ANN module has been validated for its performance. As the ANN module developed in Visual basic (VB) software, it needs to be validated for its effectiveness, so the developed ANN module was compared with the Matlab 'nntool' module.

D. Validation

The developed ANN is a generalized module and the parameters are set by conducting the sensitivity analysis. Nevertheless, the model were validated with various categories of inputs and to substantiate the effectiveness of the developed ANN, the results of the developed software module had been assessed with a commercial ANN tool, 'Matlab® nntool'. Both the networks are first trained for the collected input data. The outputs are compared for number of iterations. The results were found to be satisfactory. Thus the ANN have been fine tuned and implemented for the application to predict the suitable environmental factors for maize crop cultivation

IV. EXPERIMENTAL IMPLEMENTATION

Maize crop cultivation data along with the related parameters were collected from the villages in and around Karur town, Namakkal district, Tamilnadu, southern region of India. For simulating the model, collected data are segregated into essential and necessary data. Essential data are having higher impact on the crop cultivation directly such as input prices, annual rainfall, output prizes, irrigation availability, atmospheric temperature, taxes and bills. Necessary data are having less and indirect impact on crop such as mist, irrigation facilities, wind velocity, yielding time, workers availability, market demand, distribution centres, water medium, fertilizers, mist quantity, etc. These data were collected from farmers in different villages by circulating list of questionnaires, brain storming, literature survey on Taluk office and by direct interview. The interview and survey were conducted with the farmers cultivating higher quantity of the maize crop per year. Also data have been collected from small scale maize cultivating farmers and the farmers cultivating other types of crops. All the collected data are to be stored in the cloud storage for future research. Among the farmer's data, large scale farmers are having constraints in amount of rainfall and the irrigation expenses, but the small scale farmers are not having much constraint in irrigation and least considering the rainfall. So for implementation of this module, data from the large scale farmers have been taken. The three fourth of the stored data have been utilized to train the developed module and remaining one fourth of the data have been used to test the developed module. Encoding is the process of converting the cloud data to ANN acceptable format i.e. the string of length 12. Thus the input training and testing data set having eighty one and nine inputs with length of twelve decimal digits.

Training Data Set : $\{ T_1, T_2, ... T_{81}\}$ € T
Testing Data Set : $\{ t_1, t_2, ... t_9 \}$ € t

Whereas $T_i = [R_i, T_i, I_i - M_i, Y_i]$

These data have been given as input to ANN for training. ANN should be trained till the termination condition reached. Once the termination condition satisfied, then the trained ANN should be tested with the testing data set. The predictions of the testing are in line with the farmer's survey and were found satisfactory. After completion of testing and training, the developed network obtained the capability of predicting the parameters for the real time maize crop cultivation. Based on the hundred months data, ANN simulation model predicts that the maximum yield for the current year will be fifty nine bags per hector on average, for the current year, lowest yield will be twenty five bags of maize per hector. The same have been verified with the farmers in the zone. The average cultivation of maize crop per year has been predicted by the simulation model as forty maize bags per hector, which is approximately equal to the existing average of thirty eight bags of maize crop per hector. Thus the developed model can be used for the prediction of the maize crop cultivation and there by the farmers can take decision of the type of cultivation and the profit margin can be increased.

As the outcome, the developed simulation model support the farmers in predicting the optimal month for better cultivation. In turn, maximum profit through maize crop cultivation can be obtained. The developed simulation model also explores the value required for the parameters that can yield better cultivation based on the seeding period. Thereby the farmers can compensate and balance the requirements. With this simulation model, the farmers can take vice decision on profit maximization. A report generated by the developed module is given in the Figure 4.

FOR MAIZE CROP CULTIVATION – ANN RESULT

The best temperature : 30'C
The best rainfall : 35-55 cms
The Best irrigation : Available
Best Month : October 2016

Month-wise Analysis
Jan 2014 : Not Suitable
Feb 2014 : Satisfactory with High irrigation
March 2014 : Satisfactory with High irrigation
April 2014 : Not recommended
May 2014 : Not Recommended
June 2014 : Satisfactory with ambient temperature
July 2014 : Best Suited
August 2014 : Satisfactory with irrigation facilities
September 2014 : Satisfactory if night temp. is minimum of 24'C
October 2014 : Best Suited with irrigation
November 2014 : Satisfactory if night temp. is minimum of 24'C
December 2014 : Not recommended

Figure 4 : Trained ANN Output

Apart from this result, ANN also generate the results as shown in the Figure 5. From the result, farmer can know the optimal period for cultivating the maize crop along with the worst and the best condition. So that in the worst condition, the farmer can cultivate some other crops to yield maximum profit.

Figure 5 :ANN SOLUTION

Optimal set of parameters			Best Set of Parameters			Worst Set of Parameters		
Rainfall	Max. Temp.	Irrigation	Rainfall	Max. Temp.	Irrigation	Rainfall	Max. Temp.	Irrigation
198	41	NA	456	50	A	51	32	NA
210	42	NA	420	44	A	14	29	NA
210	42	NA	445	48	A	21	31	NA
211	38	A	458	52	A	59	32	NA
220	43	NA	468	53	A	65	32	NA
230	35	A	472	53	A	62	33	NA
230	51	A	492	53	A	101	34	NA

V. Conclusion

From the experimental results, it has been proved that the developed simulation model is producing the results in line with the real time practical data. The performance of the developed module has been validated with the commercial Matlab software and found satisfactory. Further the sensitivity analysis have been performed to set the optimal values for the ANN control parameters and to reinforce the evaluation. Thus the developed ANN module is found to be efficient and consistent in foreseeing the maize crop productivity and profitability. Also it provides the required information to the farmers in taking right decision in cultivation to get maximum profitability. Further the data are stored in cloud, it can be easily updated by the farmers every year and the developed simulation model also uses those data for more precise predictions.

In future, other than maize crop can also be considered and the model have to be trained with heterogeneous crop, so that the model suggest the farmers on alternative cultivation also. Further the land fertility required for the crop to be cultivated also considered. Further research has to be extended to most of the village in India, so that the agricultural sector grows well in the country.

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