International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Transdisciplinary Approach for Sustainable Rural Development

Rajkumar Murugesan, S . K. Sudarsanam

Abstract **:** ***In Asia, around 1 billion rural people migrate to urban areas for employment because of factors like poor crop yield , low income from farming and higher aspirations . UN Agenda 2030 for sustainable development wanted to ensure the implementation of new systems and practice , to increase crop yield . Innovative Technology solutions and money for farmers, to buy them will yield the desired results . Current paper focus on Trans Disciplinary Approach (Consortium of Industry, Academia, Government, Non - governmental Organizations (NGO) , Financial Institutions) to support villagers in smart farming (use of Information & Communication Technologies in farming), resulting in improvement of quantity and quality of crop yield . Increase in income and drop in expenses will lead to more money with farmers, which can help in meeting their aspirations (ability to pay for better education , healthcare , house).. This paper analyses the various reports on how trans disciplinary approach can contribute to the sustainable rural development and help in forecasting crop yield using Autoregressive integrated moving average (ARIMA), Data captured using UGV's , UAV's etc..***

Index Terms**:** ***Internet of Things (IoT), Disruptive Technologies(DT), Agriculture 2.0, Smart Farming, Quantitative forecasting of crop yield , ARIMA , MATLAB Big hairy audacious goals , Blue ocean shift, Creative Destruction***

I. INTRODUCTION

Development which meets the needs of the present without compromising the ability of future generations to meet their own needs is sustainable development [2]. World Bank's Annual Report 2016 has highlighted that "IMPRINT" is the prerequisite for sustainable rural development. IMPRINT stands for Introducing solutions (from the areas of engineering, science) , Money (micro finance approval through cloud), Precision agriculture and advisory services, Renewable energy and energy harvesting using wireless sensor network (WNS), Instruments for remote health care (wearable), Nutrition consumed and calories burnt (wrist band with sensors connected to server through cloud), Technology (Internet of Things (IoT) , Big Data Analytics, Agribots (Agriculture robot), Block Chain, Cognitive IoT, Artificial Intelligence, Machine Learning. According to the Census of 2001 , there are 6,38,000 villages in India. There is a huge gap in per capita income , purchase power, education, skill development, occupation, healthcare, energy, credit, sanitation (cloak room) between urban and rural population. Removing the ignorance among villagers (by connecting relevant rural and semi- urban areas) will help in achieving sustainable rural development. Trans disciplinary (TD) approach [1] using ICT as the underlying platform will address the societal needs like sustainable rural development through (i)collaboration between Corporate, Civil society, Government, Academia, Non-Governmental Organisation (NGO), Financial Institution, (ii) CSR contribution (2% of the net profit) from corporates (iii) integration of fields like technology, medicine, science and disruptive trends (iv) support like LoRa [18] Kit of SEMTECH to build prototype (or) solutions for rural problems like wastage in warehouse. ICT usage will lead to Cyber physical farm management cycle [22]. Agriculture is the main source of income for rural people. Till date, agriculture has been considered as low tech activity. For sustainable development - overall improvement of village, non-farming income (daily and weekly wages in un-organised sectors) and increase in crop yield are essential. Increase in crop yield is possible through technology. Use of technology for agriculture is Agriculture 2.0 (Ag2). Confluence of technologies like IoT, Machine Learning, Robotics, Drones is the driver of Ag2. Food and Agriculture Organisation (FAO) of UN estimates that world population will reach a staggering 9.6 billion by 2050 (as per UN report - published on 13th June, 2013) 70% of the population is expected to move to urban areas , to meet their aspirations. This can lead to pressure on urban infrastructure. Enhancing crop yield, providing urban amenities will help in controlling the migration of people from rural to urban areas.

II. RURAL PEOPLE

www. data. gov. in gives the data about India's crop yield.. Growth of India's staple food rice and wheat yield between 1970 and 2012 was 177 %, 192 % respectively .

Revised Manuscript Received on 30 May 2019.
***** Correspondence Author
Rajkumar Murugesan*, VIT Business School , Vellore Institute of Technology , Chennai , India
Sudarsanam Kidambi , VIT Business School , Vellore Institute of Technology , Chennai , India

Whereas the cotton yield growth was 323% , during the same period . i.e. More focus was on cotton production (Industry requirements) than on food (citizen requirements), as cotton yield lead to export earnings.

This was due to factors like poor farmer education , poor technology support for agriculture, less credit at affordable rate , inadequate knowledge about market condition for farmers . The people migrate from villages to cities , for employment and growth . environment and inadequate livelihood opportunities outside agriculture would make them restless - apart from worsening conditions of small , isolated and stagnant villages . Effective implementation of the policy of inclusive growth will be the key. Influx from rural areas if not checked, smart cities initiative would again be flooded with challenges. Already, numerous smart city initiatives have run into delays, dialed down its goals due to cost factors. For cities to attract Foreign Institution Investment (FII) and drive future economic growth, rural development is the crux.

III. AGENDA FOR SUSTAINABLE RURAL DEVELOPMENT

As on 2014, 47 % of the country's labour force (agriculture) is contributing to only 17 % of the country's economy. UN General Assembly's development objectives for the year 2030 (adopted at UN Sustainable development summit on 25th September, 2015) include…. agricultural research, double productivity of agriculture, knowledge to farmers, promote public and civil society partnerships, building cloak room, access to quality healthcare, provide affordable credit, reduce post harvest losses.

IV. BACKGROUND

Science of Extenics was published in 1983 by Dr . Wen Cai. It can be used to transform the insoluble problem into solvable problem. Extenics studies the possibility of extending methods of developing innovation with formalized patterns [13]. Research indicates that crop yield prediction, use of [14] disruptive technologies (DT) and innovation [17] is vital for increasing crop yield in rural areas of India. The paper to address on these areas and the possible benefits of trans disciplinary research. Creative Destruction [15] is required in farming, to meet the requirements of burgeoning population. Blue ocean strategy [19] can lead to explosive growth in the income of rural peoples. The initiative has been taken up to help KAAYAR village in Tamil Nadu (9 kms from our campus).

V. APPLICATION OF DT FOR SRD USING TD

V. A Disruptive Technologies

To ensure timely and reliable data, to improve yield and income for farmers - we propose smart farming [22] solutions (Sundmaeker et al., 2016) using cloud, analytics, mobility and social network. This includes Internet of things (IoT), robotics, unmanned aerial vehicles (drones), machine learning .Galelio Boards of INTEL, IoT kit of SEMTECH, Bluemix of IBM are available We propose to use them and develop solutions to monitor soil moisture content. With the support of SANDHYA Technologies we propose to design drones [8] , to monitor crops. Fig .2 represents disruptive technologies [9] and the same was coined by C. Christensen

V. B Transdisciplinary

TD view [3] of sustainable rural development includes Sensors and Instrumentation (drones), mKrishi platform of Tata Consultancy Services as a service (PaaS) in KAAYAR village.

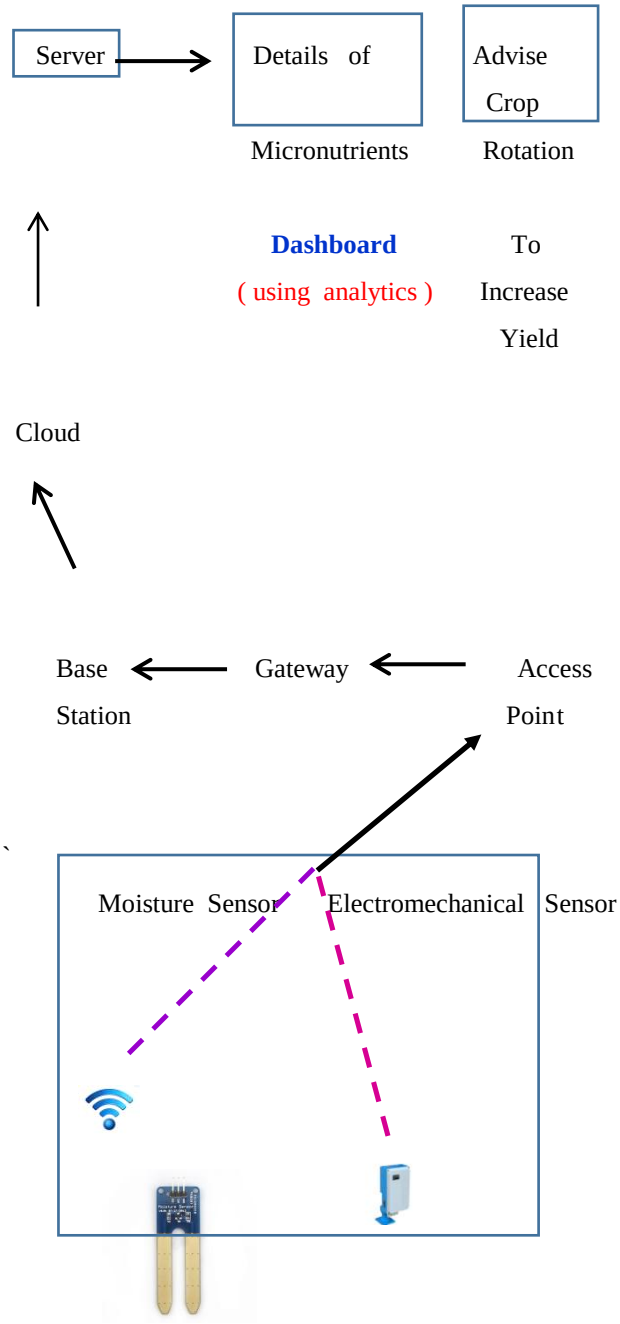

Figure . 1 Proposed IoT Solution

V. C Precision Agriculture and Advisory Services

Use of information technology for farm management is called as precision agriculture [4]. Fig . 1 represents the proposed solution - i.e. to develop an instrument using IoT, to measure 15 micronutrients (including Nitrogen, Phosphorous, Potassium ,Calcium, Magnesium, Boron). Crop rotation [16] based on local agronomic conditions will add organic matter to infertile soil (for better nutrition), increase water retaining capacity, reduce compaction and pest levels and help in increasing the yield.

V. D Advisory App

Use of information technology for improving agricultural productivity is the function of Advisory services [5]. Emphasis should be on local language & visual format . (i.e. from the stage of seeding to harvesting). Artificial Intelligence is used, to help the farmers in knowledge delivery [21]. Award Winner (INTEL Innovators) to work with us and help rural people to manage the crop effectively, on their own .

V. E Analytics for Agriculture

Collection of dataset [6] about crop yield , weather conditions and propose predictive analytics (PA) in agriculture, to give insight for farmers .

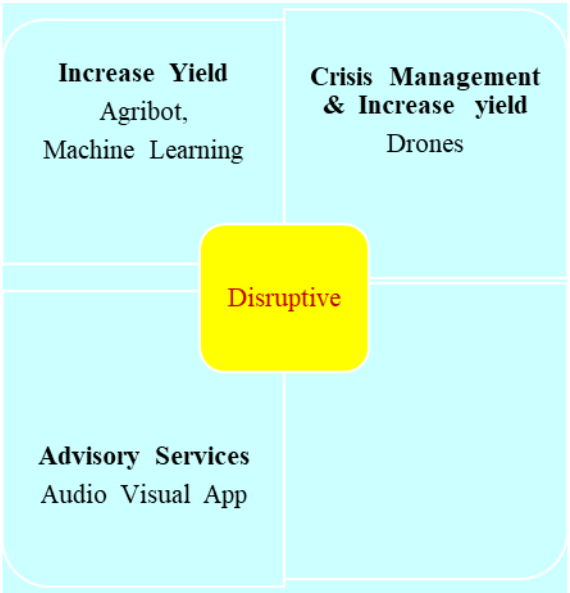

Figure . 2 Proposed Solutions (Disruptive)

VI . PROPOSED METHODOLOGY

KAAYAR village (Fig. 3) has been chosen to use the proposed solutions (Refer Figure . A - UGV, UAV, Machine learning) This village is chosen because of proximity to VIT, chennai campus (9.5 kms) and LoRa can be comfortably used for 10kms .. When we deploy IoT solutions in Kaayar village, data captured through sensor can be sent to server (VIT, chennai) .Corporate like Tata communications, Tata consultancy services have visited the village already (when they came to chennai campus).. Experts from different field (TDR group) can visit the village easily & it will help the village towards SD.

VI . A UGV's

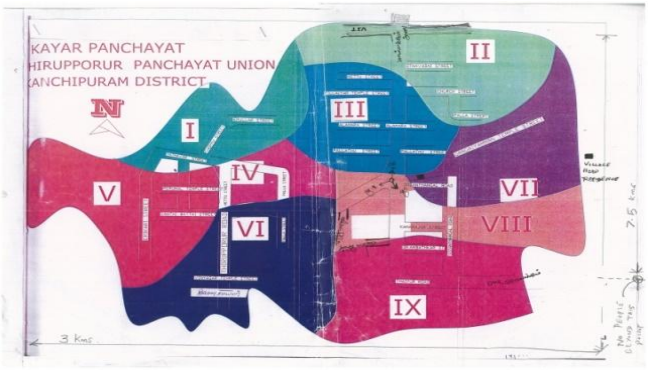

Fig . 3 - Map of Kaayar Village

A current trend in the agricultural area is the development of mobile robots [7] and autonomous vehicles for precision agriculture . Unmanned ground vehicles (AgriBoT) with sensors to be deployed in the village. AgriBOT utilizes intelligent algorithms to traverse across the the fields and with the aid of mechanical arrangements.

Fig . 4 testing the prototype of AgriBoT in Kayaar village

IoT

Sensors to capture data and send it to server for processing. Processed Data is sent to farmer's mobile, for decision making

UGV (Agriculture Robot)

To optimize water usage and to get better crop yield.

UAV (Drone)

To minimize the time (to identify disease) and to maximize the quantity and quality of crop yield

AI (Machine Learning)

To predict the crop yield , based on past data like soil nutrients , rains etc..

AI (Deep Learning)

To identify the disease in plant quickly and to enhance the quality of crop yield

MATLAB

To predict the crop yield from the past Data (Year , Crop yield etc.. for a specific period)

Figure. A Technology Usage

It measures the soil parameters at regular intervals at specific locations of the field, which are determined by the algorithm that breaks the field into grids that are equispaced. AgriBOT is supported by IoT which streams real time values of soil parameters such as humidity , temperature , Ph, moisture content. This allows farmers to remotely monitor their field.

Prototype was developed and tested (Fig. 4) in the village. Materials used to build prototype include Raspberry pi, water flow sensor , Beagle bone (low power open source single board computer produced by Texas Instruments in association with Digi Key and Newark element 14) TPS62097 - Q1, Motor driver , li - ion batteries , water potential sensor , motors, etc.. UGV to measure the moisture content of the soil, help in optimizing the water usage and maximize the crop yield

VI . B UAV's

Unmanned aerial vehicles (UAV), commonly known as drones [22], can be used for non-military purpose .We propose to use drones to monitor crops remotely (using GPS). Data (Images) to be captured and compared with database for identification of the challenges within a few hours. (normally it takes 5 to 6 days , for the farmer to identify the damaged crops)

VI . C MACHINE LEARNING

Software like Python (or) R can help in predictions (using machine Language (12)). 50 years of data (winter, rabi crop) will give 100 rows of data. Crop yield , temperature, moisture content, salinity , rainfall %, Sand %, clay % can give 6 columns of data. 600 cells can be used to give better predictions compared to ARIMA. Getting these data in India could be a challenging task

VII IMPLEMENTATION.

Implementation of one part (Refer 6.1) of the proposed solutions - i.e. Prediction of crop yield - by academia), is covered in this section.

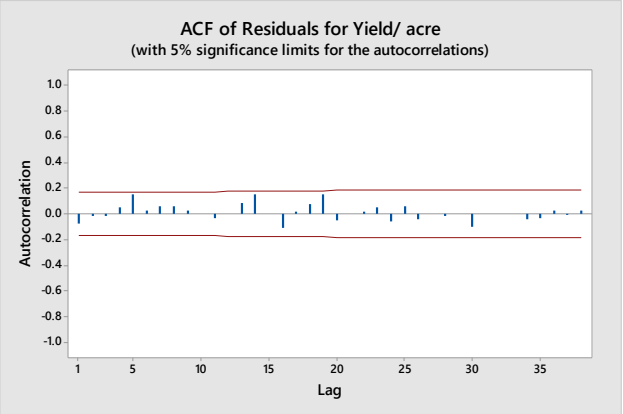

Figure . 5 ACF of Residuals - Autocorrelation

Similarly other proposed solutions to be implemented , data to be collected with the support of partners (Transdisciplinary Research) like Government , FORTUNE 500 members, Indian corporates, Financial institutions, NGO's [20], hospitals, other academic institutions in future

VII . A PREDICTION OF CROP YIELD

Prediction of crop yield [9] to farmers can help them to plan. When the past data is available, one can find the pattern and predict through quantitative forecasting method.

VII .1.1 DATA AND METHOD

This paper focus on prediction of crop yield. **Box - Jenkins Methodology** performed a de trending operation on 150 years linear data of Corn production in USA. (i.e. data from 1866 to 2016), taken for the study. The same method can be used to predict, by collecting data from Agricultural Statistics published by the Directorate of Agriculture and Food Production, Government of Tamil nadu, India. This can also be used to predict the trade balance, foreign exchange.

Forecasting from these data is possible through Machine Learning algorithms (using python) in agriculture domain [28, 29] or through decision tree algorithm . Crop yield can also be predicted through Neuro - fuzzy inference system (ANFIS) by using the data on soil moisture content [11]. When the data is in the form of uni-variate time series analysis [10] [12], ARIMA model has been used extensively . While using IoT, for agriculture the real time data is generated from geo tagged sensors (indexed in time order). The ARIMA models include autoregressive (AR) terms, moving average (MA) terms and differencing (or integrated) operations. Model is called as AR model , if it contains only the autoregressive terms. Model is known as MA model if it contains only the moving average terms. It is known as ARMA model , when both the terms (autoregressive and moving average) are involved. When a non-stationary series is made stationary by differencing method, it is known as ARIMA model.

The different Box-Jenkins models are identified by the number of autoregressive parameters for Non seasonal (p,d,q) & seasonal (P,D, Q)

p : The number of lag observations included in the model , also called the lag order

d : The number of times that the raw observations are differenced , also called the degree of differencing.

q : The size of the moving average window , also called the order of moving average.

Any such model can be written using the uniform notation ARIMA (p,d,q), ARIMA (1,1,1) can be written as follows :

$$Y_t = c + Y_{t-1} + k_1 Y_{t-1} - k_1 Y_{t-2} + e_t + m_1 e_{t-1} \quad (1)$$

$\mathbf{Y_t}$ is the dependent variable

$\mathbf{e_t}$ is the error

c is the constant

$\mathbf{Y_{t-1}}$ and $\mathbf{Y_{t-2}}$ shows the lags of the variable indicates constant term of the model
$\mathbf{k_1}$ and $\mathbf{k_2}$ are the parameters to be estimated by using ordinary least square method (OLS).

VII . B ARIMA MODELING

This includes stages like Identification, Estimation, Diagnostics checking , Forecasting.

VII . B . 1 IDENTIFICATION

The ARIMA modeling procedure starts with identification of the model, however, stationarity of variables of interest is also required.

The stationarity can be tested both through graphics (using MATLAB) i.e. Fig . 6 represents the partial Auto-correlation Function (PACF), Fig . 5 represents the Auto correlation Function (ACF). If the variables of interest are found non-stationary at level, the data need transformation in such a way to make them Stationarity. The model can be identified through PACF and ACF. After identification of the model, the next step is the estimation of model parameters which is done through ordinary Least Square method .

VII . B . 2 ESTIMATION

Estimation of corn yield is given (Table -1) along with standard errors & T values

VII . B . 3 DIAGNOSTIC CHECKING

Many diagnostic tests are used on the residual of the model. When the model passes through the test successively, then estimated Coefficients are used for calculations. The residual auto correlation were uniformly small with no apparent pattern. We are ready to use the fitted model, to verify the forecasts produced by Minitab

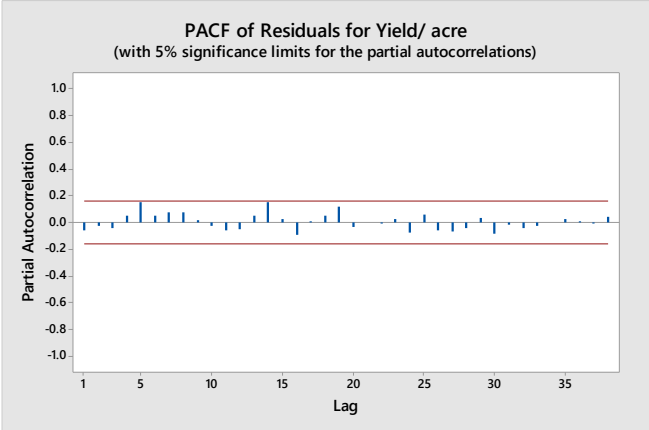

Figure . 6 PACF of Residuals - Autocorrelation

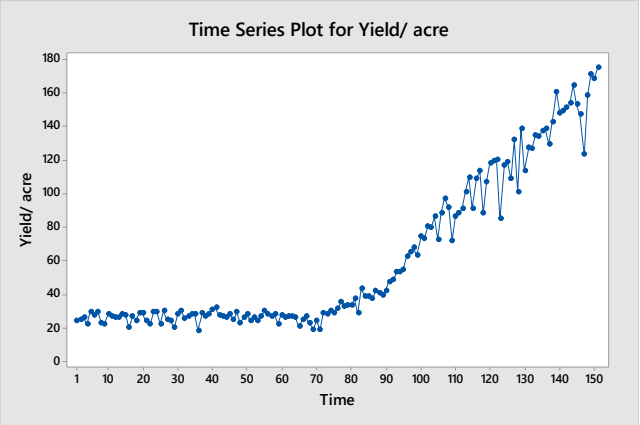

Figure . 7 Plotting of Time Series

VII . B . 4 Plotting of the Data

Table 1. Final Estimates

Type	Coef	SE Coef	T-Value	P-Value
AR 1	0.55	1.07	0.51	0.611
AR 2	0.47	1.08	0.44	0.664
MA 1	0.31	1.09	0.29	0.776
MA 2	0.284	0.823	0.35	0.73
SMA 10	0.7667	0.0952	8.05	0
Constant	0.04027	0.08377	0.48	0.631

Fig . 7 represents the plotting of the available data and to view the trend (i.e.. from 1885 to 2016) of yield per acre

VII . B . 5 FORECASTING

ARIMA (2,0,2) (0,1,1) was found to be the best fit model.

"Minitab " software output of a) Autocorrelation pattern for the available data is shown in Fig.5, for the ARIMA $(2,0,2)(0,1,1)10$ and b) time series plot for yield is shown in Fig . 6;

The L Jung - Box chi square statistics , for groups of lag m = 12, 24, 36, 48 were clearly not significant as evidenced by their large P - values. **Note** :- The parameters estimates for corn yield is given in Table - 1 , with their standard errors and t-ratios. Table - 3 gives the Chi square values.

Fig. 8 represents the predicted yield for year 2017 . At 95 % limit , is as follows …

Table 2. Crop Prediction

Lower	154 . 397
Forecast	170 . 797
Higher	187 . 196

Crop yield has been predicted using ARIMA. The same prediction is possible through Disruptive Technology i.e. Machine Learning (using Python, R etc..). Similarly other disruptive technology can be effectively used, for rural development.

The same method can be used in Kaayar village by collecting the existing data from local government (possibly for last 10 years or more). Data about weather conditions (temperature , rains , wind speed) for kaayar village can be taken from IBM weather company for the same period ; Instead of 100 rows and 2 coloumns (200 cells) , we can use 20 rows and 6 coloumns (120 cells) to begin with - for predicting crop yield in kaayar village

VII . C. CONTRIBUTION FROM CONSORTIUM

Transdisciplinary [9] to handle complex real world issues, through consortium . Industry (2 % of the net profit has to be spent for enhancing the status of society, as Corporate social responsibility (CSR), Institute (through transdisciplinary research), Government (Ministry of rural development, Ministry of women and child development , Department of Science and Technology (DST)), Smart Village Committee ,NGO's (Non government organizations) Financial Institution (Government , Private players), Micro finance companies to work together and ensure the proper implementation of technology.

Solutions involving high investments and more resources, to be taken by corporate. Solutions involving low investments to be taken by academia; Services involving market regulations to be taken by NGO's. Solutions involving field work like survey to be handled by students.

Corporates have extended support by giving free training in IoT Platforms like Microsoft Azure (or) IBM Bluemix (or) Thinkworx. Students have come out with innovative solutions like agribot (IoT), warehouse solutions for creating smart village.

Students ideas are developed as a prototype in 24 hours competition (Makeathon). Corporate like PTC, Aricent, INTEL, CISCO, Tata Communications, SEMTECH have extended support by giving boards, competition prize money, mentor support, IoT Kit to students in building the prototype through technology support and access to their innovation labs.

Table 3. Modified Box - Pierce (Ljung - Box) Chi - Square Statistic

Lag	12	24	36	48
Chi Square	8.37	26.75	38.95	49.73
DF	6	18	30	42
P-Value	0.212	0.084	0.127	0.193

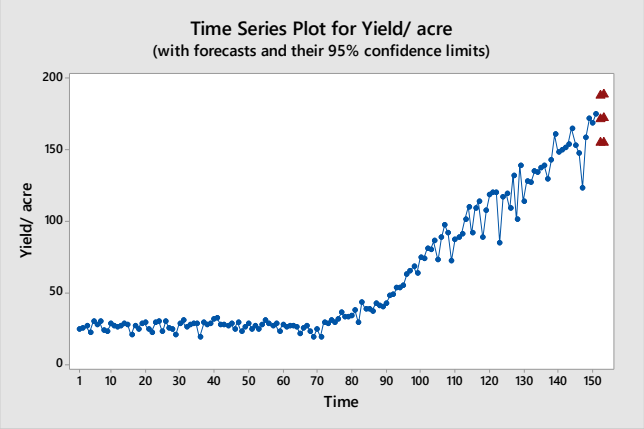

Figure . 8 Plotting of Time Series (Prediction)

VIII CONCLUSION

Study has explained how AgriBoT can help us to measure the moisture content in the field and help the farmer to switch off the motor (remotely using mobile) immediately and to save precious water. Sandhyaa Technology has helped us with some hardware and expertise, to design the AgriBoT.

Study has also shown that ARIMA can predict the crop yield in advance, based on past data (soil moisture, pH , salinity etc...) Farmers can get the vital data and assess his additional income (at the end of the season) and plan his expenses properly. Experts from Academia has helped, to work on MATLAB.

Director of Equitas (NGO) has helped us with the farm data - collected by Government of Tamil Nadu. Using " R " we have proved that prediction with 95 % accuracy, is possible

VIT Alumni (Founder of Sandhyaa Technology) has helped us with the idea of filing a patent (drone). Camera attached to the drone can take images . Captured data can be checked against the master database . This is going to help us in deep learning .

Our research proposal to deploy UGV, UAV in Kaayar village , has been shortlisted by Government agency. Awaiting for confirmation & release of funds.

We got support from corporates like CISCO Microsoft, INTEL etc.. to organize 24 hours Innovation Competition . Many ideas came up in this, to solve the problems of farmers.

The study has confirmed that Trans Disciplinary Approach has effectively helped us , to solve the problem of farmers (crop yield prediction). Increase in farming income , will lead to rural development.

Digital farming will ensure that no farmer will go hungry ever again. Results of the initiatives will be discussed in the future papers.

Combining disruptive technologies, creative destruction and blue ocean shift [19] for village transformation, will have enduring effect on KAAYAR village. Increase in rural growth, food security, non farming income, electronic national agriculture market (e - NAM) member committees, Agritech, is vital for sustaining growth and will contribute in India's GDP growth of $ 5 trillion by 2025.

REFERENCES

1. J. Roux, R. J. Stirzaker ." Framework for participative reflection on the accomplishment of transdisciplinary research programs ", Science Direct, Vol. 13 , pp. 733 - 741, 2010
2. K . Pezzoli , " Sustainable Development : A Transdisciplinary Overview of the Literature ", Journal of environmental planning and management, Volume 40, pp. 549 - 574, 1997
3. R. Ghambarali , A. Alibaygi and B. Rasekhi, " Challenges of sustainable rural development from perspective of villagers ", International Research Journal of Applied and Basic Sciences, Vol .7 , pp. 253 - 258, 2013
4. J.V.Stafford " Implementing Precision Agriculture in the 21st Century ", *Journal of Agricultural Engineering Research* , Vol. 76, pp. 267 - 275, 2000
5. Desjeux , P. Gasselin " New Challenges in Agricultural Advisory Services from a Research Perspective : A Literature Review,
6. Synthesis and Research Agenda ", The Journal of Agricultural education and extension , Vol. 18, pp. 461 – 492, 2012
7. S. Andrew, Philip , " Addressing uncertainty in adaptation planning for agriculture ", *National Academy of sciences of the United States of America* , Vol . 110 , pp. 8357 - 8362, 2013
8. *A. Mead, "* The Sky's the Limit : Potential of drone usage in rural healthcare ", *ruralhealthinfo.org,* , 2017
9. V.Neelanarayanan, R . Balaji, " Deployment of ICT Application in Rural India - Our experience ", *Conference* , In : DBPL, *Madrid, Spain* , 2004

10. R.J. Lawrence, "Deciphering Interdisciplinary and Transdisciplinary Contributions ",Trans disciplinary Journal of Engineering & Science, Vol . 1, pp.125 - 130 , 2010
11. R.J.A.Chuodhury, J. Jones, " Crop Yield Prediction using Time series models", Journal of Economic and Economic Education Research, Vol. 15, pp. 53 - 67, 2014
12. P. J. Brockwell and R. A. Davis " Introduction to Time Series and Forecasting. ", Springer Press, Newyork, N.Y., 2002
13. S. Mishra , Debahuti Mishra and Gour Hari Santra, "Applications of Machine Learning Techniques in Agricultural Crop Production : A Review Paper ", Indian Journal of Science and Technology, Vol . 9, pp. 1- 14 , 2016
14. S. K . Sudarsanam, "A Neuro - fuzzy decision tree algorithm using C4 . 5 ", Conference, In : ICBAI - 2016
15. R. Limaye , Ramesh Kumar Choudhary , " Smart village planning framework using extenics theory ", Conference, In : SKIMA, 2016
16. M.Perelman, " Retrospectives Schumpeter David Wells and Creative Destruction", Journal of Economic Perspectives explore", Vol. . 9, pp. 189 – 197, 1995
17. P.L. Harris , Profitability key to crop rotations, Farm Press, May 19, 2004
18. N.Clark, " Innovation Systems, Institutional change and the new knowledge market : Implications for third world agricultural Development.", Economics of Innovation and New Technologies, Vol.11 (4-5), pp 353 -368, June 2002.
19. Aloys Augustin , Jiyaz Yi , Thomas Clausen : A study of LoRa : "Long range and low power network for Internet of Things " Future of agriculture is played in ` ocean , La Tribune , 26th Feb. 2013
20. Tytti Nahi , " Co - Creation for sustainable development: The bounds of NGO contributions to inclusive business" , Business strategy and Development , March 2018
21. Bharat Popat, " Connected Agriculture Developing Smart, Connected Rural Communities ", Cisco Internet Business Solutions Group (IBSG) , 2009
22. Sjaak Wolfertet et. all, " Big Data in Smart Farming - A review ", Agricultural Systems, 153 (2017), 69 - 80

AUTHOR PROFILE

Rajkumar Murugesan is a research scholar . He is armed with 25 years of Industry Experience. He has been awarded by Microsoft, SAP. His areas of interests include Creative Destruction , Disruptive Technologies and Trans Disciplinary Research. He has been invited to address on IoT by IET.

Dr. S. K . Sudarsanam, has a Phd from IIT, Madras.

His areas of interest include Fuzzy Logic , Analytics.
He is the Dean of VIT Business School , Chennai
He has received Research Funds from DST, India
He has presented his research work, in many International Research Conference.