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Development of Smart Farming Framework

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Abstract

UN Report on " World Population Prospects " dated 17th Dec 2019 has projected that world population to reach 9.7 billion by 2050. India is one among the 9 countries that will make up for greater than 50 % of the projected growth. UN has predicted that world might face food supply challenge due to mismatch between growth in population and crop yield . Root Cause Analysis (RCA) suggest that quantity and quality of the crop yield has not increased to the desired level. To handle VUCA world (Volatile, Uncertain, Complex and Ambiguous) and address the challenge, traditional methods are no longer sufficient. Solution given by Bill George of Harvard Business School is VUCA 2.0 (Vision, Understanding Courage and Adaptability). Doubling the crop yield up to year 2050, will prevent starvation and will help us to move towards UNSD - 2030 Agenda. Innovation is the key to achieve this Big Hairy Audacious Goal (B - HAG), in the age of disruption , agriculture 4.0 and agriculture 5.0. Many countries have started using ICT (Internet of Things (IoT), Machine learning (ML), Deep learning (DL), Unmanned ground vehicles (UGV), Unmanned aerial vehicles (UAV)) at different stages of farming and enjoyed the benefits But, usage of ICT in farming, is yet to gain popularity in India. Barriers in adoption of technology innovation by Indian farmers includes high investment and lack of knowledge . The paper recommends adoption of Blue Ocean Strategy (BoS), Creative Destruction (CD) and suggest a framework using Trans Disciplinary Research (TDR).

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I. INTRODUCTION

World leaders met in UN General Assembly (2015) has recognized that eradicating the poverty is the greatest global challenge and an indispensable requirement for sustainable development. They said it is possible through revitalizing global partnership, by mobilizing all the available resources including government, civil society, financial institution, domestic and international private business, Online Crowd Sourcing [78] and by addressing issues like science, technology, innovation and capacity building… Trans Disciplinary Approach.[96]

World Bank has indicated that agricultural development is one of the most powerful tools to end extreme poverty and to boost shared prosperity.

Growth in agriculture sector is 2 to 4 times more effective in raising income among the poorest compared to other sectors. Food and Agriculture (FAO) indicated that 9.7 billion people [1] have to be fed in 2050. Developing countries like India have to double the production of crop yield between 2007 and 2050, to match the requirements of burgeoning population.

Creative Destruction (Johnson and Lewis, 1995) is the only solution to achieve this big hairy

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audacious goal of doubling the crop yield ..i.e.. stop the old or traditional habit (100 % dependency on manpower) in farming, by using ICT (Information and communication technologies)

Application of technology in farming was used for 5 years from 1983 and published in 1989 [1]

This has resulted in generating more revenues (enhanced crop yield) and reducing the expenses (drop in usage of fertilizer)

II. SMART FARMING

Use of ICT (Kamilaris, Gao, Prenafeta-Boldú, & Ali, 2016) in farming is known as Smart Farming (or) Agriculture 4.0 ; Use of Artificial Intelligence with unmanned aerial vehicles for , is known as Agriculture 5.0[95]. Smart farming [94] is linked to three consanguineous technology fields : agricultural automation and robotics , precision agriculture and management information systems (Kernecker et al., 2016).

Smart farming to cover solutions like Internet of things (Liakos et al., 2018) [79] , Machine Learning [80], Image processing [73][81], Deep Learning (LeCun, Bengio, & Hinton, 2015), [82], Remotely piloted aircraft systems (RPAS) or Unmanned aerial [68] [69] [70] vehicle (i.e…Drones with hyperspectral camera and intelligent functions like obstacle avoidance , night operation , right time kinematic position), Unmanned ground vehicles (i.e..Agriculture robot) [83], Virtual reality[86], Augmented reality (Azuma,1997) [84] [85], Remote monitoring through satellite communications [93], Nano technology[92], LIDAR [82], Swam farm robot [91], Nanostructured sensors [71], Cyber physical systems [72] [75] [77], Mobile agriculture robot swarms [72], Block chain [74], web of things [75],Next generation internet [76], Digital Twin[87] [90], Reinforcement learning [88], Cybernetics [89] [90], Edge Computing [98]

III. BARRIERS IN ADOPTION OF SMART FARMING

Literature survey reveals many barriers in adoption of technologies in farming, by farmers. The list includes capital expenditure (Reichardt and Jürgens - 2009), Awareness (Daberkow and McBride - 2003), Knowledge about IT (Reichardt et al. -2009), net connectivity ,“insufficient broadband availability”(Jensen et al. 2013), risk of accident, complication in handling the equipment and economic efficiency (Reichardt and Jürgens - 2009), perceived complexity of innovation, deficit of the demand from farmers (BellonMaurel&Huyghe (2017)), cost , behavioral component , impact of subsidy, industry bias as perceived by farmers (Barnes et al. (2019)).

Tey&Brindal (2012) has identified 34 factors grouped under conditions related to 1) socioeconomic factors (age, education, gender, credit, risk aversion, credit source, experience in agriculture, experience in use of technologies for agriculture etc), 2) agro ecological factors (farm size, soil quality, productivity etc..), 3) institutional factors

(distance from market , fertilizer shop, region etc..), 4) information sources (access to information, consultants , access to technical companies, agencies etc..), 5) perception of the farmer (profits through technology vs capital intensity of technology), 6) behavioral factors (visibility of results, intention, perceived relative advantage etc..) and 7) technological factors (computer knowledge, farm irrigation structure etc..)

IV. CROP MANAGEMENT AND FARM MONITORING

Smart farming is the solution to address the big hairy audacious goal (BHAG) of doubling the agriculture production . Information driven global agriculture (Mauser et al. 2012) is the crux . Data flow like talking field maps [2] helps in enhancing efficiency and reducing expenses. Use of big data

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application in agriculture, taken using drones[3] is vital but it is yet to penetrate. Farm specific model can help in radical innovation [4] in agriculture. Drones [6] to monitor plant health ; Agriculture Robots [7] to conserve water . Machine Learning [8][13] to help in agriculture statistics service . Deep Learning [9] [16] to help in grading crop yield. Block chain [10] [11] to help in transparency in transactions of crop yield. Swarm Robotics [12] [14] to help in weed management . problems associated with smart farming has been identified and we have proposed a framework for smart farming .

Capital expenditure (Investment to procure technology is high), Ability to use the modern technologies (knowledge transfer by experts) increases the risk of unsustainable intensification process of moving towards Agriculture 4.0 and 5.0 [17], [18], [19].

Monitoring of crops, soil , irrigation [41] can help rural people to identify crops which can match the targets. Wireless sensor network [42] is used to monitor the farms and intruder into the farms in Nigeria. Monitoring Irrigation using sensors [43] [45] using Agriculture RoboT [44]leads to optimum use of water and helps in effective monitoring. Sustainable agriculture [46] through cluster analysis monitoring, is achievable

V. PREDICTION OF CROP YIELD

Artificial neural networks (ANN) can predict crop yield , using sensitivity analysis. 2 crop simulation models WOFOST and LINTUL [47] can predict crop yield, by comparing 5 methods. Regression analysis [48] can be used for the same using factors like rainfall for past 10 years.

Machine Learning (Python, R) can offer more precise prediction of groundnut yield [49] using KNN Algorithm. Machine language through convolution neural network [50] using Levenberg Marquardt algorithm. Mostly computational intelligence, including algorithms neural networks and fuzzy system were used [51]in AI. Now Machine learning in cloud is available as big data and IoT are in place. As of now , effective use of Machine Language is less

due to lack of agriculture data (14 micronutrients , rain , soil quality) in India.

Deep Learning [52] can be used to predict crop yield by identifying damaged crop at a very early stage. Unmanned ground vehicle (Robot), Unmanned aerial vehicle (Drones) can get photos of plants with the high pixel camera attached to the frame of the system and by using deep convolutional scale invariant network algorithm [53]. Soybean crop yield in Argentina has been achieved, using remotely sensed data through satellite images [54].

VI. BLUE OCEAN STRATEGY

Rising needs of consumers and their increasing voice , one has to move in new directions There is a rising need to pursue differentiation at low cost and stand out in the market (whther it is a private sector (or) public sector (or) agriculture . It is called as Blue Ocean [15] strategy (W .C . Kim and R Mauborgne , 2004) .

Software as a service (SaaS) platform is a cloud based tool (Figure - 1) in this direction and helps in sustainable rural development . Industry solutions like mkrishi of TCS, Amazon web services are providing SaaS. Smart Farming is a blue ocean strategy for agriculture.

VII. EVALUATION OF EXISTING FRAMEWORK FOR RURAL DEVELOPMENT

Smart community development framework

(Table - 1 , Table - 2) recommended in Canada [26], Tanzania [27], Ethiopia [28] , Rwanda [29], Yorkshire [60], Extenics Theory [61] Wellbeing framework (McGregor, 2007), Sustainable

livelihoods framework (Scoones , 1998) have been studied to propose a new framework for India .

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"Smart community development framework" propsed [26] was based on the study in the village Unión Victoria, in Guatemala by Luca Fagundes VeigaRibeiro (Canada),during 2016. The framework integrates applied and social science with participatory approach , for sustainable development. Participatory approach is desired but it does not discuss about self help group, external members who can support the rural people.

A. Proposed Framework

High cost of acquiring disruptive technology and limited knowledge are the entry barriers [30] for rural population to adapt smart farming. Higher family income to permit investments in disruptive technology. Training by experts to help rural people use the technology tools . Non farming income [31] [32] [33] [34] [35] [36] [37] and skill based income (youths) to enhance income of family

Figure - 2 is the proposed solution , to adapt smart farming. Support using Trans disciplinary [38] [39] [40] approach (FORTUE 500 members, Multi national companies, Conglomerate , Corporates (technology and financial support (CSR)), Listed companies, Financial Institutions , Micro finance companies , Non governmentorganisation (NGO) , Academia , Experts from Agriculture , Experts from Medical field and Basic science (example : water purification) , Non profit community like Enactus) to help in acquisition technology, tools and right knowledge. It also includes imparting skills to rural youths by corporates like L&T.

VIII. CONCLUSION

Smart farming (Agriculture 4.0, Agriculture 5.0) to address the challenges referred by FAO and UN and help achieve sustainable rural development. Creative destruction , blue ocean strategy and digital transformation will help in achieving better quality , quantity of the crop yield and enhancing revenues generated from the yield. This can lead to the objective of doubling the farmers income , enhance their standard of living and satisfy their aspirations. This will lead to minimization of migration of rural population to cities. Higher income leads to sustainable development and farmers can get urban amenities (better healthcare , quality education cloak rooms) in rural areas – i.e. PURA Scheme , the brain child and the vision of Late President of India Dr. A.P.J. Abdul Kalaam

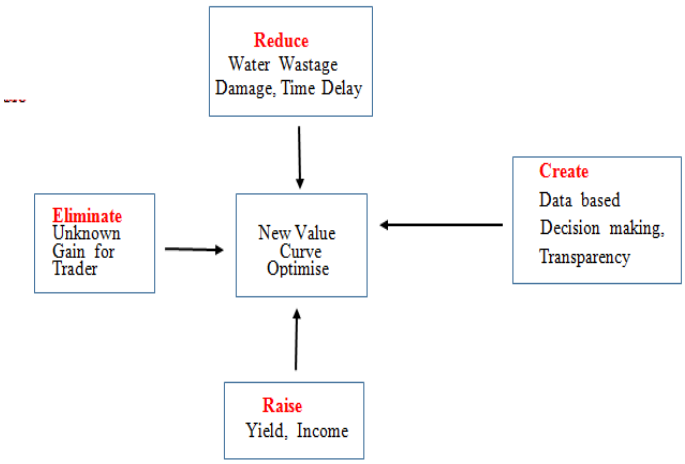

Figure - 1 : Blue Ocean Strategy

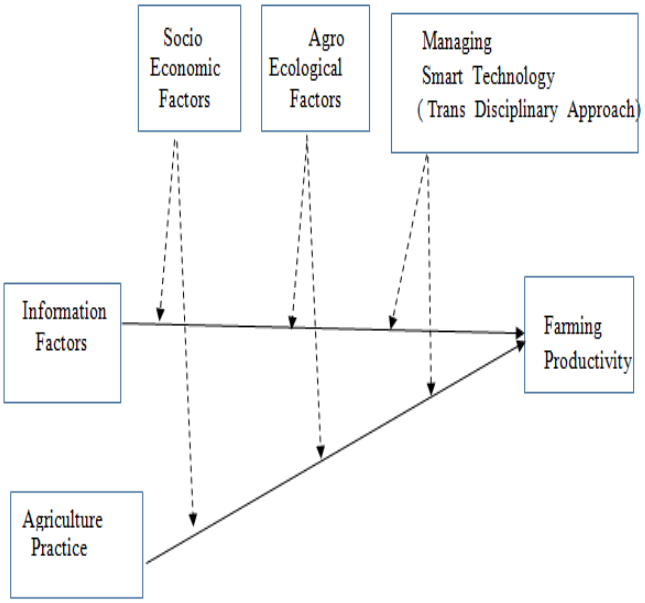

Figure - 2 : Proposed Framework(Trans Disciplinary Approach)

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Table - 1, Framework Analysis

Name	Focus Areas	Rural Area	Researcher Year
Empirical Analysis	Infrastructure, link with towns, non-farm income of people, energy	Ethiopia	Tewodros Tadesse During 2011
Assessment of multidimensional wellbeing	Economical and Technological drivers of change	Rwanda	Neil M. Dawson During 2012
Contrasting Rural Communities	Enhance Knowledge of people	South Yorkshire	Sarah Holland during 2012
GCP (Government Community Partnership)	Members Community Members Education Leaders (DEO, School, Govt)	Tanzania	Amina Nasibu Kamando during 2013
Smart Village Planning framework	Primary education, Skill development Self employment	UK	Limaye, Hongnian during 2015
AR4D (Agri Research for Development)	Farmers knowledge, Public and private Institutions	Africa, Asia	
SPMRM (Shyama Prasad Mukherji Rurban Mission)	Behavior change, help from Corporate, NGO's, VC's	India	Partha Pratim Sahu, Animesh Gosh, 2018
Kg Besting	CSR support, Network With corporate, Finance Institution, Academia, and Hospital, focus on Literacy, Mindset	Malaysia	Norizan Abdul Razak, 2013
SCDF (Smart Community Development FW)		Canada	Lucas Fagundes 2017
University of California, Berkley, USA	Farming Employment	Mori Village AP, India	Professor Solomon

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Table - 2 Framework Strength and Weakness

Name	Strengths	Weakness	Researcher
Empirical Analysis	Effective marketing of crop yield	Does not include about Imparting skills to youth	Tewodros Tadesse during 2011
Assessment of Multidimensional Wellbeing	Conservation of natural resources	Imparting skills to farmers	Neil M. Dawson during 2012
Contrasting Rural Communities		Knowledg acquisitio From corporate	Sarah Holland during 2012
GCP Government Community Partnership	Government Officials and political leaders to Closely work	NGO's Not Included	Amina Nasibu Kamando during 2013
Smart Village planning framework	Inter Disciplinary Approach	Trans Dis Approach	Limaye , Hongnian during 2015
AR4D (Agri Research for Development)	To enhance productivity and income, Academia to work with.	Academia with farm Not activ	
Kg Besting	Building relation with stakeholders	New Ideas of Institn. Not Active	Norizan Abdul Razak , 2013
University of California , Berkley, USA	Focus on farming	Trans Disci plinary not in.	Professor Solomon

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