Precision Agriculture Adoption: Challenges of Indian Agriculture

Kadambini Katke
Professor, Affiliation: Dayananda Sagar Institutions, Shavige Malleshwara Hills, Kumarswamy Layout, Bangalore

Received: January 23, 2019 Accepted: March 03, 2019

ABSTRACT: *World demand for food is anticipated to increase by 70 percent contrary to this, agriculture input equation is changing in the form of decline in the agriculture labour, shrinking agriculture productive land, raising temperature, shifting weather patterns and land degradation; challenging every stake holder in agriculture sector in meeting food requirement of future. Precision farming can bring in some solution with its integrated technology-communication- management approach to several needful decisions in agriculture production cycle. Socio-economic environment is pushing hard this technology adoption due to its massive benefit in agriculture productivity. However, its required to study is Indian agriculture sector is ready for precision technology adoption? Which are the challenges creating obstacles? Any technology transition is possible only when we understand and addresses these challenges. This study is aims at addressing these research questions.*

Key Words*: Precision agriculture, technology adoption, challenges, strategies*

Introduction:

UnitedNations'17SustainableDevelopmentGoalstookeffectatthebeginningof2016,launchingthe countdown to achieve inclusive sustainable development and economic growth by 2030(GAP Report 2016). Many goals are aimed at enhancing agricultural and forestry development and growth. The Sustainable Development Goal -2 calls the world community to "end hunger", achieve food security and improve nutrition and promote sustainable agriculture (GAP Report2016).

By2050,worldpopulationwillbe9.7billion;foodconsumptionisanticipatedtoincreaseby70percent (FAO). Contrary to this, agriculture input equation is changing in the form of decline in the agriculture labour, shrinking agriculture productive land, rising temperature, and shifting weather patterns, Poor land management leads to land degradation, further reducing the soil fertility and waterproductivity (Hakkim, Joseph, Gokul and Mufeedha, 2016).

With these challenges accelerating agriculture productivity to feed world can be achieved through regenerativesystemofagricultureandfoodproduction.Agriculturalprocessshouldadoptandpractice modern technology and information sciences for effective utilization of agriculture inputs. 'precision agriculture' initiative by US government in the year 1983 can provide solution to these complex challenges (Lowenerg 2015). It rules out the hypothetic approach and adopts the site-specific management approach with suitable micro management practices (Hakkin et al 2016). Precision farming is combination of ICT, satellite technology, mechanization, and effective management of all these agriculture resources for greater productivity (Shukar ABD).

Precision farming is changing the way people do farming as it offers benefit of profitability, productivity, sustainability, crop quality, environmental protection and rural economic development (Liaghat and Balasundram 2010),(Fountas, Pedersen and Blackmore, 2004), (Anue et al, 2017) (Singh).

India being second largest populated and agri dominated country has greater responsibility towards meeting the need for global agriculture produced. The present age-old farming practices are no more suitableandfavorableforfarmersandeconomyaswhole.TheICTadoptionintoagriculturesectorhave indicatedfavorable(maynotbeasanticipatedbuthasdefiantlymadechangeintheattitudeoffarmers towardstechnologyadoption)results.PrecisionfarmingcanchangetheIndianagricultureproductivity if systematic phase wise collective efforts are taken by different stake holders of agriculture sector towards its adoption. Time and situation demand for embracing the precision farming for the benefit ofall.

Technology adopted in precision farming and its benefit offerings

1. Yield Monitor- yield monitors are becoming more common in North America. During harvest cropyieldinformationisrecordedongridbasis.Yielddifferencesareanalyzedthroughcomputer technology;thisinformationisusedforfinetuningthevariablerateofapplicationofagriculture inputs to various grids. Study conducted by Taylor (2016) on commercial grape yield monitor reflects

usefulness and effectiveness of Yield Monitor. Further the study confirms possibility of using a harvest sensor mid-season to mechanically estimate fruit load from small point sample and to map the amount of fruit removed during fruit thinning operations. This will improve the quality of information available to understand fruit and crop load.

2. Soilfertilitymanagement-itinvolvesdivisionoffieldintoseveral small equal parts using the sub-inch accuracy of GPS. Soil sampling from each grid is mechanically collected. These samples are tested on various parameters. Through computer simulationcompositecolor-gramarecreated.Thechieffunctionofthisactivityisforbalancing soil fertility of the field with respective major and micro nutrients. Study conducted by Taylor (2013) reveals that the imagery-derived covariates helped explain the uncertainty (variance) in soil depth data. Study conducted by Whelan (2012) shows that optimum response data can be obtained using the experimental technique which can help in calculating 'net wastage' in fertilizer and yield resulting from the customary, spatically uniform input management.
3. GlobalPositioningSystem-Crop scouting can be done using GPS system to monitor crop conditions, weed patches, insects, crop tissue nutrient status and fungal infestation. A timely treatment can minimize the loss.
4. Remote Sensing –these technologies are used to collect data through satellite. These remotely sensed data provide a tool for evaluating crop health; moisture, nourishments, compaction, crop diseases can be easily detected in overhead images.
5. GeographicInformation System-Computerhardwareandsoftwareareusedtorecord,storeandanalyze thedatacollectedbyyieldmonitorandGPS.Thedatacollectedwillbepresentedbysysteminausable format-such as maps, graphs and charts. The important function of GIS is to store layers of information, such as soil survey maps, yields, remotely sensed data, crop scouting and soil nutrients
6. Variable Rate Application- Control computer, Locator and Actuator are three components of Variable Rate Applicators. The computer uses application map and GPS receiver to direct product delivery controller which change the resource application according to map.
7. Combine harvesters with yield monitors- yield monitor continuously measure and record the flow of grain in the clean grain elevator of combine. When linked with GPS receiver, yield monitor furnish necessary data for yield maps.

Need for adoption of precision farming in India

The Indian Green revolution is also associated with negative ecological/environmental consequences. 182 million hector (of total 328.8 million hector) is affected by land degradation of which 141.33 Ha due to water erosion, 11.50 million ha due to wind erosion and 12.63 and 13.24 million ha due to water logging and chemical erosion. This gives an early warning to take appropriate measure to overcome present and future adversities (Shanwad et al 2004). Excessive usage of agriculture input can be controlled through precision farming techniques which will protect the environmental degradation.

Precision farming aims to optimize field level management with regard to crop management, environmental protection and optimizing economies. India being agriculture dominating country has greater opportunity to adopt precision agriculture for following reasons-

1. Optimizing production efficiency- Intelligent farming practices are need of the day to feed population tomorrow. It calls for accurate timely decision making by farming community. Farmer needs to take around 40 odd decisions during one farming cycle from pre-harvesting to post harvesting phase. Precision farming helps the farmer in informed and scientific in each of these 40 odd decisions (Tech Mahindra). The basic organizing principle of precision agriculture is to determine the best agriculture input combination (i.e seeds, fertilizer and chemicals) and the proper application of these to optimize crop yield in sustainable manner (Brummel 2014).

   Information to Act on- GPS and GIS provides information land fertility, weather condition, information of yield monitor will help in effective planning of all agriculture activity further enhances the agriculture productivity.
2. Optimizing quality- Information and technology adoption and effective management of agriculture input enhances the quality of agriculture produce. Grid technology adopted helps in planning pesticides/insecticide usage which avoided excess usage damaging the quality/nutrient level of the produce-Minimizing environmental impact- Remote Sensor and GIS technology ensures the effective field management strategies for chemical application, cultivation and harvest. Excess usageof fertilizers, pesticides can damage ecologicalbalance.

Can precision agriculture adopt in India?

A systematic phase-wise technology penetration enhances its acceptance and adoption (Tech Mahindra). In addition, the agriculture research institutes, different departments established by government for farmers' welfare, public and private organization's collective effort can result into technology adoption for collective growth. Money spent to waive farmers loan (Maharashtra waives Rs 34022 corer to waive loans of 89 lac farmers)(Times of India 7th June 2018) can be properly planned towards investment of precision agriculture technology and providing aid to the farmers. This government initiate will defiantly facilitate smooth technology transition among small and medium size farmers.

Precision Farming Initiatives in India

TATA Kisan Kendra (TKK) precision farming initiatives has potential to bring in greater transformation in agriculture sector. TCL's extension Services are brought under TKKs, use of remote sensing technology to analyze soil, inform about crop health, pest attack and coverage of various crops predicting final output (Mandal 2009) can be good move towards adoption of technology.

Tamil Nadu Precision Farming Project is aggressive in implementing Precision agriculture in covering larger geographical area. Its initiatives for drip irrigation and crop production has widely accepted with initial resistance from the farmers (Mandal 2009)

ISRO, Ahmadabad initiative to study Role of Remote Sensing in mapping the variability with respect to space and time at Central Potato Research Station (Shanwad 2004) will help in potato crop specific farming in the region.

M S Swaminathan Research Foundation, Chennai I collaboration with NABARD has adopted Dindigul district of Tamil Nadu for experimenting Variable Rate Input Application (Shanwad 2004)

Indian Agriculture Research Institution is experimenting precision farming techniques at institution farm.

Project Directorate for Cropping Systems Research (PDCSR), Modipuram and Meerut (UP) in collaboration with Central Institute of Agriculture Engineering (CIAE), Bhopal has initiated Variable Input Application in different cropping system.

Research Gap and need for research study:

Behavioral, technological and economic factors are major influencing factors for precision technology adoption. Most of the available research has focused on technology factors in isolation without giving much Weightage to economic and behavioral dimension which has major role to play in acceptance of this technology. However, these factors have to be studied collectively a due to their inter dependencies for greater understanding of the challenges and to enforce suitable measures for effective technology adoption.

Literature survey reveals various technology adoption and integration into precision farming. Few studies have listed its benefits in enhancing farm productivity, quality of produce, and environmental protection. Though precision agriculture offers multiple benefits it is not widely adopted into India agriculture. Therefore, it has become important to know the reasons for its slow penetration to take corrective action and enhance the socio-economic status of farmers. This study aims at analyzing the challenges of precision technology adoption by Indian farmers.

Research questions of the study:

This study deals with the following tworesearch questions-

1. Why Indian agriculture need for precision farming to enhance agricultureproductivity?
2. What are challenges of precision farming adoption into Indian agriculturesector?

Research methodology:

Thisisaconceptualstudy.Nationalandinternationalresearch publications have beenreferredto understand various technology used/adopted and benefits of precision farming. FAO and GAP Reports have provided insight into international demand for food and initiatives taken by these bodies towards meeting the food requirement of future. Further research papers have helped in understanding technology adoption challenges. Annual Reports of Ministry of Agriculture and Farmers Welfare referred to understand the Indian agriculture environment and status. Newspaper reading provided information regarding government initiatives towards farmers' welfare.

Based on the literature this study has clustered challenges into three broad categories namely technology, economic and behavioral.

Findings of the Study:

Findings of the study have grouped into two broad categories; namely, challenges for technology adoption and second one is, strategies for precision farming adoption in India.

Challenges of Precision Agriculture adoption in India

High illiteracy among Indian farmers holds them back from adopting technology in agriculture practices. Various initiatives taken by public and private sector towards ICT adoptability in agriculture has not generated desired result in terms of awareness, and adoptability though they have proved beneficial in improving productivity, reducing cost and fetching higherreturns. Study conducted by Sahoo reveals in general Indian farmers find difficulties in understanding the following technical aspects of precision farming

- Inadequate understanding of agronomic factors,
- Lack of understanding of geo-statistics necessaries for understanding spatial variability of crop and soil adopting mapping software and
- Limited ability to integrate information from diverse sources with varying resolution and intensity

Other than these challenges farmers are resistant to adopt precision agriculture technology due to following three reasons.

Technology related challenges

Illiteracy among Indian farmers reduces technology adoption and trial possibilities.

Four variables under technology challenges have been studied as under-

- Complexity of technology usage- Education level of farmers increases his ability to obtain, process and use information relevant for new technology adoption (Mignouna et al 2011; Lavison 2013; Namera et al 2013).Technology adoption is preconditioned with the technology under consideration (Margerate and Samule, 2015). Precision farming requires some degree of competence in the use of software and hardware. Especially technology like GPS, GIS, remote sensing, remote sensing computers and sensors (Tekin and Sindir, 2019) (Sahoo) which slower the process of adoption among larger group of farmers with low literacy.

However,Study conducted by Vaiene et al (2009) reveals greater access to Extension services will enhance the technology adoption. Extension agent acts as link between innovators and users of that technology (Margerate and Samule, 2015). Indian Agriculture extension establishments and initiatives taken by public (Gram Panchayat Extension Services) and private organizations (e-Chopaletc) if starts functioning effectively and efficiently will defiantly pave way to reduce the resistance for technology adoption.

- Limitation of technology usage- Multiple technologies are used in precision farming for various farming jobs, highly specialized approach enforces multiple tools and techniques which demand greater expertise and technical knowledge. Every technology and tool has limitation in its usability and functional benefits. Therefore, marginal farmers find it not worth to invest into this technology. More than 58 percent of sample farmers have reported limitation of technology.
- Lack of installation and training- local technical expertise and assistance is another obstacle for precision agriculture (Shanwad 2004). Local assistance and trainingcenters for Precision farming as experimented by TANU in Tamil Nadu should be emulated and established in multiple places will enhance the adoptability to new technology further; it will also communicate the success stories to motivate farmers for adoption (Tech Mahindra).
- Availability and accessibility of technology –acquisition of information about technology is another determinant of technology adoption. Access to information reduces uncertainty about technology performance hence may change their attitude (Caswell et al., 2001; Bonabana- Wabbi 2002).

1. ***Economy related challenges***- Economic factor and size of the land holdings are interdependent. One of the most highlighted constraints to agriculture technology adoption is the size of the cultivable land holdings (Carletta et al, 2007). Larger the land holdings facilitate experimentation with new technology and also determines the pace of technology adoption. Farmers with larger size of landholdings are more likely to be early adopters .

Indian agriculture is predominantly featured as small and marginal land holdings. Further, ownership restrictions, lower agriculture productivity; greater economic dependency on agriculture and market irregularities has pushed Indian farmers into greater economic poverty (Sahoo) (Shanwad et al, 2004).It's difficult to expect this segment to adopt high cost involvement technologies used in precision farming.

Economic challenges can be clustered into following three categories.

- Higher initial cost-Precision farming includes many expensive machines and tools which are beyond the economic reach of small and marginal farmers. Sophisticated technologies cannot be used due to high cost and maintenance and often not even available (Aune 2017). The perceived initial cost by farmers creates a blockage to adopt the technology (IAS Express, 2018). Small and marginal land holdings and greater dependency on farming provides very less scope to high cost investment options like precision technology. On the other side due to indebtedness farmers are at the mercy of waiving of debts by the government.
- High operational cost- Operational cost of machine and tools under precision agriculture are the fear factor for its adoption.
- Lack of knowledge about government subsidies- Financial credit to farmers can help to stimulate agriculture technology adoption (Vaiene et al, 2009). Indian government financial initiative towards ICT adoption is slowly gearing up. Many schemes and policy were been designed to facilitate adoption process. However its communication to target framers is low.

2. ***Social and behavioral factors***- Research study conducted by Far (2018) reveal strong positive relationship between farmers'perception, attitude and adoption of precision farming.
   - Lack of awareness – The lack of awareness and absence of dedicated education of precision agriculture among farming communities is major obstacle (Tech Mahindra) for its adoption. In low income countries, precision agriculture mainly depends on farmers' observation, and experience (Modal and Basu 2009).
   - Rigidity to adopt change/technology-Economic analysis of technology adoption has sought to explain adoption behavior in relation to personal characteristics and endowment of imperfect information, risk and uncertainty (Feder et al, 1995; koppel, 1994 and Uaiene, 2009). Indian farming is predominated by age old farming practices. The same agriculture practices are being carried out from generation. Resistance and rigidity are two major hurdles in adoption of precision farming.
   - Influence of people-Rural social structure is reflects into small group of farmers who have strong influence on each other. These groups are largely following the opinion leaders (Kashyap 2016). Opinion leaders are normally Sarpanch, Teacher, Village Development Officer, Extension Officer and Bank Manager. Lack of knowledge and awareness among these groups blocks the potential adopters.

Strategies for PA adoption in India:

Public and private sector support and back-up are essential to promote rapid adoption of Precision adoption. Few of the measures are listed below:

Most of the regions share common cropping patterns(like TurDal in Gulbarga, flowers aroundBangalore,SilkinRamnagaradistrict, Rice in Godavari basin etc). Government should conduct organized dynamic soil sampling and should create nutrient map with the help of already developed technology. This information can be provided by local agriculture extension centers.

In case of fragmented land holdings, crop specific initiative will help (Singh), Indian farming reflect contiguous field with same crop (mostly under similar management practice), many crops are grown regional basis, and focus should be on crop specific area rather individual land holding (Shanwad 2004). However, models like contract/co-operative farming should be the approach.

The revenue spent for welfare of farmers and establishment of various supporting agriculture services establishments can be utilized towards precision farming initiatives in regional agriculture sectors whichshare a common regional crop.

Promote precision farming through progressive farmers (Singh) who can afford required capital expenditure due to their economic status and larger land holding.

Study conducted by Fountus et al reveals that technical skills and knowledge of agronomics is the major drawback for precision agriculture in Denmark and USA. India being the country with low literacy rate and high resistance, technology adoption process will be even slower. However, phase-wise precision technology adoption can help for effectiveadoption.

Evolve policy for efficient technology transfer and ensure complete end to end technical support to farmers (early technology adopters)(Mandal et al, 2009). Such success stories will reduce the resistance and fear factor among the early majority to follow technology adoption.

More agriculture research institutes with greater reach need to be established across country in different regions (Mandal et al, 2009). For effectiveness crop based research should be encouraged and should ensure the greater reach to the farmers through various communication modes namely: radio, television, through co-operative societies network, mobile technology and e-Chopal modes of communication.

Implications of the Study:

This study gives insight into opportunities for growth in Indian agriculture sector by adopting precision agriculture technology. It further helps to understand the challenges for its adoption in India. Strategies for precision technology adoption facilitate technology penetration and wide acceptance slowly.

Its need for the hour to change the way Indian farmers do farming. Appropriate technology need to be pushed hard for social, and economic welfare of the farming community and at large a global food requirement of years to come.

References:

1. Aune, B,J., Coulibaly, A., Giller, E K., (2017). Precision farming for increased land and labour Productivity for increased land and labour productivity in Semi-Arid West Africa, A Review., Agronomy for sustainable Development, retrieved from https://link.springer.com/article/10.1007%2Fs13593-017-0424-z on 29/1/2019
2. Bonabana-Wabbi J. (2002).Assessing Factors Affecting Adoption of Agricultural Technologies: The Case of Integrated Pest Management (IPM) in Kumi District, Msc. Thesis Eastern Uganda. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.475.6995&rep=rep1&type=pdf On 7/3/2019
3. Brummel, L., (2014) Precision Decission, Farm Supply Co-ops Helping membersprecision Ag Technology to Boost Productivity, rural Co-opration., PP 9-10
4. Liaghat,S.,Balsundram,S.K(2010)AReview:RoleofRemoteSensinginprecisionAgriculture,Journal of Agriculture and Biological Sciences., Vol 5(1) pp 50-55
5. Lowenberg, J., (2015) The Precision Agriculture Revolution: Making The Modern Farmer, Foreign Affairs, Retrieved from https://www.foreignaffairs.com/articles/united-states/2015-04-20/precision-agriculture-revolution , retrieved on 19-07-2017
6. Far. S.T., Moghaddam.K.R.(2018), Impact of Precision Agriculture Technologies in Iran: An Analysis Experts" Perception and their Determinants. , Information Processing in Agriculture, Vol 5, PP173-184
7. Fountas, S. Pedersen, M, S. Blackmore, S. ICT in Precision Agriculture-Diffusion of Technology. Retrieved from http://departments.agri.huji.ac.il/economics/gelb-pedersen-5.pdf on 28/1/2018
8. Koppel, B.M. (Ed), (1994). Induced Innovation Theory and International Agricultural Development: A Reassessment the Johns Hopkins University Press, Baltimore.
9. Feder, G., E. R. Just and D. Zilberman. (1990). "Adoption of Agricultural Innovations in Developing Countries:A Survey." Economic Development and Cultural Change 33 (1985):255-298.
10. Mondal. P., Basu. M., (2009), Adoption of Precision Agriculture technologies in India and in some Developing countries:Scope, present status and strategies., retrieved from
11. https://ac.els-cdn.com/S1002007109000173/1-s2.0-S1002007109000173-main.pdf?_tid=5a804d0e-9d9f-4526-a05e-7a144175906&acdnat=1547622613_b9036e711a9ca8bdfde8aba38943f1ac on 16/1/2019
12. Shenwad UK., Patil V C.,Honnegowda H., (2004),Precision Farming: Dreams and Realities for Indian Agricultue., MAP India Conference 2004 proceedings retrieved from https://www.geospatialworld.net/wp-content/uploads/images/pdf/mi04115.pdf., on 9/1/2019
13. Sahoo. R N., Application of Remote Sensing and GIS in Precision Farming., IARI., New Dlhi. https://pdfs.semanticscholar.org/d8a7/68c720c2dc01030a4ee654558d9240465d89.pdf
14. Shukar,ABD;Backgroundonappropriateprecisionfarmingforenhancingsustainabilityofrice production;UnitedNationsCentreforSustainableAgricultureMechanizationandMalaysian Agriculture research and Development Institution ; Retrieved from http://un-csam.org/publication/PreRiceFarm.pdf,on19-07-2017
15. Taylor,J.,Sanchez,L.,Sams,B.,Haggerty,L.,L.,Jakubowski,R.,Djafour,S.,BatesT.,R.,(2016) EvaluationofCommercialgrapeyieldmonitorforusemid-seasonandatHarvest,Journal InternationalDesSciencesDelAVigneEtDuVin,Vol50(2)
16. Taylor,J.,Jacob,F.,Galleguillos,M.,Prevot,L.,Guix-Hebard,N.,lagacherie,P.(2013)TheUof Remotely-SensedVegitativeandLerrianCovariatesatdifferentSpaticalResolutioninModellingsoil andWaterableDepth.Geoderma,Vol193-194)pp83-93
17. Tech Mahindra. retrieved from https://www.techmahindra.com/sites/ResourceCenter/White%20Papers/New_Gen_Services/PrecisionAgriculture-PotentialMarket-India.pdf on 4/1/2019
18. Tekin. A B., Sindir.(2019),challenges of precision farming in Turkey., retrieved from https://www.researchgate.net/publication/267400357_PROSPECTS_AND_CHALLENGES_FOR_PRECISION_FARMING_IN_TURKEY on 11/1/2019
19. IAS Express., (2018), Precision Farming in India: merits, Demerits and Challenges, retrieved from https://iasexpress.net/precision-farming-in-india-features-merits-demerits-and-challenges/ on 11/1/2019

20. Kasyap. P., (2012) Rural Marketing. Pearson Publication, Second Edition. pp48-49
21. Vaiene, R. N., Arndt, C., Master, W.A., (2009). Determinats of Agriculture Technology Adoption in Mozambique, National Directorate of Studies and Policy Analysis, No 67E, Republic of Mozambique.
22. IAS Express (2018), Precision Farming in India-Features, Merits, Demerits and Chalenges, retrieved from https://iasexpress.net/precision-farming-in-india-features-merits-demerits-and-challenges/ on 22/2/2018
23. Hakkim A, V, M., Joseph A, E., Gokul A.A J.,Mufeedha M. (2016). Precision Farming: The Future of Indian Agriculture. Journal of Applied Biology and Biotechnology Vol.4 PP 068-072 retrieved from http://jabonline.in/admin/php/uploads/170_pdf.pdf on 5/12/2018
24. Singh, A, K., Precision Farming . retrieved from http://www.iasri.res.in/design/ebook/EBADAT/6-Other%20Useful%20Techniques/14-Precision%20Farming%20Lecture.pdf on 10/6/2018
25. Whelan, B, M., Taylor, J, A., A.B.McBratney, B, A. (2012) A 'small strip' approach to empirically determining management class yield response functions and calculating the potential financial 'net wastage' associated with whole-field uniform-rate fertiliser application. Retrieved from https://www.sciencedirect.com/science/article/pii/S0378429012003474 on 6/8/2018
26. Carletto, C., A. Kirk and P. Winters,(2007). Non-traditional exports, traditional constraints:
27. The adoption and diffusion of cash crops among smallholders in Guatemala and the role of agricultural technology: Direct andJournal of Agricultural Econ
28. Margaret, M., and Kariuki, S. (2015). Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. Journal of Economics and Sustainable Development Vol.6, No.5, pp208-217
29. Lavison, R. (2013). Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra,Msc Thesis, Accra Ghana.
30. Mignouna, B., Manyong, M., Rusike, J., Mutabazi, S., &Senkondo, M. (2011). Determinants of AdoptingImazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya:AgBioforum, 14(3), 158-163.
31. Hall, B. and Khan, B. (2002) Adoption of new technology. NewEconomy Handbook.
32. Namara, E., Weligamage, P., Barker, R. (2003). Prospects for adopting system of rice intensification in SriLanka: A socioeconomic assessment. Research Report 75.Colombo, Sri Lanka: International WaterManagement Institute.
33. GAP Report (2016) . Goal 2: End hunger, achieve food security and improved nutrition and Promote sustainable agriculture. Retrieved from http://www.un.org.lb/Library/Assets/The-Sustainable-Development-Goals-Report-2016-Global.pdf on 5/3/2019
34. FAO. How to feed the world in 2050. Retrieved from http://www.fao.org/fileadmin/templates/wsfs/docs/expert paper/How to Feed the World in 2050.pdf on 5/3/2019
35. Times of India (2018). 65% of Maharashtra govt's loan waiver sum reaches 37 lakh farmers. Retrieved from https://timesofindia.indiatimes.com/city/mumbai/65-of-maharashtra-govts-loan-waiver-sum-reaches-37-lakh-farmers/articleshow/64486812.cms as on 7/6/2018