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Artificial Intelligence Revolutionizing Indian Agriculture: An Empirical Analysis

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Abstract: In a time when land fertility is declining due to climate change, excessive use of fertilizer and water & unscientific agriculture practices with burgeoning population needs surpassing the available agricultural produce, resorting to modern technologies in agriculture can become a panacea for Indian agriculture problems. This paper mainly deals with applications of AI in Indian Agriculture, Its Adoptions, and Challenges with the empirical study of the Saagu-Baagu project.

Keywords: Artificial Intelligence, Precision agriculture, Total Factor productivity, Paired t-test.

Introduction: The agriculture sector is on the verge of a paradigm shift in favour of adopting smart solutions, particularly in light of climate change, volatility, evolving dietary needs, and a growing shortage of physical production components. Productivity has increased as a result of the quick development of agricultural technologies and applications.

Background studies on how technologies revolutionized agriculture: In India, research on genetic improvement of important agricultural products has been given top emphasis. The genetic enhancement research over the years has addressed a variety of issues in various phases, including (1) yield enhancement, (2) resistance to biotic and abiotic stresses, product quality improvement, (4) adaptation and mitigation of climate change, (5) fortification of nutrients, and (6) genetically modified commodities. The research efforts paid off favourably by providing food security, raising farmer incomes, lowering poverty, creating job possibilities, and boosting the export of agricultural products (Joshi et al. 2005) Generally speaking, the total factor productivity (TFP), which captures the contribution of the quantum leap is also revealed through enhanced technology. World Bank projections between 1980 and 2009, the TFP grew at a rate of 1.3% (World Bank, 2014). It rose from 0.9% between 1997 and 2003 to 1.7% between 2003 and 2009. 5.4% is a relatively high growth rate for TFP according to recent estimations for the period 2005–12 (Jain et al., 2017). The estimates of TFP growth from a few studies (Janaiah et al. 2006; Chand et al. 2012) are summarised in Table no.
2. Learning from the past experience it is now time to use technologies under IR 4.0 to enhance further productivity of Indian agriculture and help farmer double their income.

Table 2: Total Factor Productivity Growth

	Janaiah *et al.* (2006)			Chand I (2012)	
	1970-1985	1986-2000	1970-2000	1975-2005	
		Rice		Wheat	
Andhra Pradesh	0.7	2	1.3	0.5%-1%	n.a.
Karnataka	1	-0.4	0.2	0.5%-1%	n.a.
Punjab	3.6	-0.8	1.2	>2%	1%-2%
Uttar Pradesh	2.5	0.6	1.4	1%-2%	1%-2%
Assam	0.8	0.7	0.7	0.5%-1%	
Bihar	-1	4.4	0.5	<0.5%	0.5%-1%
Madhya Pradesh	1.1	-0.6	0.3	<0.5%	0.5%-1%
Orissa	0.2	2.4	1.2	<0.5%	
West Bengal	1.9	0.9	1.4	<0.5%	0.5%-1%
Haryana	n.a.	n.a.	n.a.	<0.5%	1%-2%
Tamil Nadu	n.a.	n.a.	n.a.	1%-2%	
Rajasthan	n.a.	n.a.	n.a.	n.a.	0.5%-1%
Gujarat	n.a.	n.a.	n.a.	n.a.	1%-2%
Himachal Pradesh	n.a.	n.a.	n.a.	n.a.	Negative
All India	n.a.	n.a.	n.a.	n.a.	n.a.

Table no. 2

Digital Technologies:

Digital technology use and dissemination in agriculture can contribute to the transformation of Agricultural systems towards sustainability. An expanding body of research on this topic reveals the use of technology like artificial intelligence, robotics, and remote sensing.

Remote sensing technologies that can control weeds, plant development, pests, and illnesses are made possible by mechatronics, AI, and computer vision that are advanced. For in-depth field analysis, crop monitoring, and field surveys, proximity sensing, the Internet of Things, and image-based precision farming are being employed for intelligent data collection.

Several intriguing instances and their effects on the agriculture and food systems are shown in a recent FAO research (2019):

(i) Farmers can plan their production choices for the future by using mobile applications to track historical and present prices.

(ii) Mobile applications created to give early notice about disease in livestock help reduced the hazards associated.

(iii) Farming robots to process the information on the field and assist farmers in measuring and optimizing input use.

(iv) A forecasting tool that uses geospatial mapping, crop planning, individual farm plans, weather, soil, pest, and crop data to provide virtually real-time assistance to farmers in making the best decisions possible.

(v) Programming using artificial intelligence to offer farmers immediate assistance.

Significance of AI in Agriculture:

Artificial Intelligence is about creating self-learning patterns that would help the machines to find out answers to the question like a human would do. It is a branch of computer science that aims to create computers or machines with human intelligence. AI technologies were being employed to address various challenges faced by Indian farmers, improve productivity, and enhance the overall efficiency of agricultural practices. Here are some ways AI was being used in Indian agriculture:

1. Precision Agriculture: AI was being used to analyze data from various sources such as satellite imagery, weather forecasts, and soil sensors to provide farmers with actionable insights. This helped optimize the use of resources like water, fertilizers, and pesticides, resulting in increased crop yield and reduced environmental impact.

2. Crop Monitoring and Disease Detection: AI-powered systems were being developed to monitor crops and detect diseases and pests early. This allowed farmers to take timely action and prevent large-scale crop losses.

3. Predictive Analytics: AI algorithms were being used to predict crop yields based on historical data and current conditions. This information helped farmers plan their harvests, storage, and distribution more effectively.

4. Market Access and Price Prediction: AI-driven platforms were being developed to provide farmers with market information, including commodity prices and demand forecasts. This helped farmers make informed decisions about when and where to sell their produce.

5. Farm Management Systems: AI-powered farm management tools were being used to streamline various processes such as irrigation scheduling, planting, and harvesting. These tools aimed to

improve overall farm productivity and reduce manual labor.

6. Automated Machinery: AI and robotics were being integrated into agricultural machinery to perform tasks like planting, weeding, and harvesting. This was especially helpful in addressing labour shortages and increasing operational efficiency.

7. Education and Advisory Services: AI-based mobile apps and platforms were being used to deliver personalized agricultural advice to farmers. These platforms provided guidance on best practices, weather forecasts, and pest management.

8. Soil Health Monitoring: AI technologies were being employed to assess soil health and fertility, guiding farmers in making informed decisions about soil management practices, optimize the supply chain.

Adoption of AI in agriculture in India:

Prospera: It has created a cloud-based solution that gathers information from farmers, including data from air images, land water sensors, and other sources, Gramophone (agstack technology): They use picture recognition capabilities to assist farmers in receiving the appropriate information, techniques, and resources at the appropriate time to obtain the best potential a yield, Jivabhumi: It is developing an intelligent market to optimize supply and demand for agriculture, which is frequently insufficient, Blue River Technologies combines computer vision, robotics, and AI to reduce the cost and quantity of pesticides used, IBM India Private Limited and the Government of India agreed to conduct a pilot study in the districts of Bhopal, Rajkot, and Nanded, AI sowing App- Microsoft

Empirical analysis:

Project Saagu Baagu was spearheaded by the Telangana government in collaboration with the World Economic Forum, the Bill & Melinda Gates Foundation, and Digital Green. Telangana has prioritised agriculture, which has fuelled its growth in recent years. The state, which has an estimated 5 million farmers, has been moving from cereals to commercial crops, posing issues for small and marginal farmers. AgNext, Krishitantra, and Kalgudi are three agricultural technology companies working with C4IR India, the Government of Telangana, and Digital Green to lead the pilot program.

It is concentrating on the following specific activities and technologies throughout the chilli crop cycle as the project implementation partner:

-Farmer data aggregation: Digital Green created and launched Kisan Diary Enterprise, Android-based software that allows farmers to control and collect data. This improves market access, particularly for small landholders through farmer producer organisations and other collectives aimed at improving farmers' access to inputs, expertise, money, and markets.

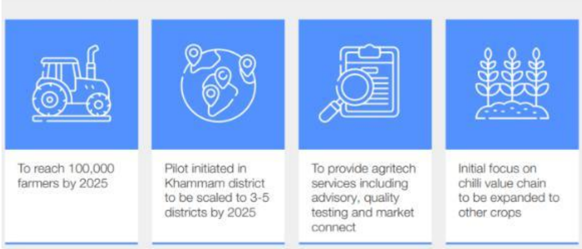
-Digital extension, advising, and capacity building: In conjunction with Facebook, Digital Green created an AI-powered WhatsApp chatbot.

-Soil testing: Digital Green has teamed up with KrishiTantra to deliver an AI-powered soil testing service that offers findings on 12 criteria in 20 minutes. Farmers used to rely on laboratories, which took 20-25 days to provide results.

-Quality testing: Currently, chilli quality is assessed visually, resulting in subjectivity and considerable price volatility. AgNext, a quality assessment service provider, offers AI- and stereoscopy-based quality testing for the issuance of quality certifications.

-Market connection via e-commerce: Kalgudi, an e-commerce platform, provides farmers with input and output market links as well as advisories.

FIGURE 1 | Project scope



The World Economic Forum's Artificial Intelligence for Agriculture Innovation initiative Project Saagu-Baagu intends to improve agriculture in the state in a scalable, inclusive, and sustainable way by harnessing new technology. In its first phase, the initiative focuses on the chilli value chain, with plans to scale up and encompass various areas and crops in the following phases. Project Saagu-Baagu has already had a beneficial influence on smallholder farmers' income and well-being by offering customized advice, quality testing, and e-commerce services to over 7,000 farmers.

Research Objective:

To analyze the impact of AI and other technologies on agriculture production on 40 chilli farmers of Telangana under the Saagu- Baagu project.

Research methodology:

To analyze if there is a significant difference between the means of 2 observation lists on the same group(Pre & post project implementation), a paired t-test is conducted.

Secondary data is taken from the inside report of WEF in collaboration with Government of Telangana.

A sample of 40 farmers is taken to run a Paired t-test (one tail @ 5 % level of significance). Left-hand tail as the alternative H is of less than type. There are 2 lists of observations, one the level of output before applying modern technologies and one after using it.

Research findings:

Null Hypotheses– There is no significant difference between their means.

Alternative Hypotheses – The mean of the second observation is greater than the mean of the first observation.

Test statistic= 2.67632E-06.

Table value = 1.684.

It is evident that the test statistic is lower than the table value hence we reject the null hypothesis @ 5% level of significance. It shows there is a drastic increase in the output level of the chilli farmers when they use Artificial intelligence and modern technologies.

Similarly, more than 3000 farmers in the adjoining states of Karnataka were added to the pilot program in 2017. In 2017, this larger set of farmers who received text alerts from the AI-sowing app guidance had a yield per hectare higher than 10-30%.

Challenges of Precision Agriculture adoption in India:

There are many challenges India faces in adopting these new technologies. First is technological, it includes complexity of use (Mignouna et al., 2011), lack of technical knowledge, accessibility and availability (Caswell et al., 2001). Second is Economic, Modern technologies require large land holdings to perform test but 85% of landholding is small and marginal types (Carletta et al., 2007). Third is Socio-behavioural, which includes lack of education and awareness (Tech Mahindra), Presence of risk, uncertainty, and lack of information (feder et al., 2005), Rural social structure is shown in a tight-knit group of farmers who have a lot of influence over one another. According to Kashyap (2016), these groups largely follow the opinion leaders.

Conclusion-

In this paper, we have seen the impact, challenges, and adoption of modern technologies i.e. Artificial Intelligence in particular and others in general.

Saagu Baagu Project can be a role model in implementing other such projects in India. Climate change, lowering fertility & burgeoning population demands the use of IR 4.0 technologies in Indian agriculture.

Way forward:

Public and private both need to support the rapid adoption of Precision farming. The Government should do active soil and nutrient mapping with the help of remote sensing technologies. Models like contract farming where corporate provide high-end technologies to the farmers should be adopted. Farmer producer organisation can provide modern tools on lease to the farmers. The active role of Krishi Vigyan Kendra can be a booster. Awareness generation through government programs is a must to break the stigma attached to new technologies. The Land fragmentation problem can be solved via pooled or cooperative farming. National e-Governance Plan in Agriculture (NeGPA) deep and machine Learning, drones for precision farming. Policy must evolve for efficient technology transfer and ensure complete end-to-end technical support to farmers (early technology adopters) (Mandal et al, 2009). Such stories will reduce the resistance to modern farming and increase its adoption even through private channels.

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