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Perception of Agricultural Extension Staff of Tennessee State University about IoT Applications

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ABSTRACT

The study was conducted in 2022 to investigate the perception of the agricultural staff of extension system of Tennessee State University (TSU), USA about IoT concept and IoT applications in agriculture. Seventy-eight agricultural staff were randomly selected and administered the pre-tested questionnaire (Google form). The results revealed that majority (90%) used the internet every day for 1-10 h. Furthermore, all the scientists had smart devices and had been using them for more than two years and had Wi-Fi at their offices and home. Only 18% of the respondents belonged to 'high' perception category and nearly three-fourth (70.5%) of the staff belonged to 'moderate perception about IoT concepts' categories. Data were analyzed and ANOVA revealed that the mean scores of perception about IoT applications in agriculture differed significantly among different categories of TSU agricultural staff (Ag. teacher, college faculty/ specialist and extension agent/director) at 10% level of significance. This study is suggestive of significant effect possibly with a larger sample size and recommends further studies about the new concept IoT and its applications in agriculture.

Key words: Internet of Things (IoT), agriculture, agricultural extension, Tennessee State University

INTRODUCTION

The Internet of Things (IoT) represents a set of emerging technologies that can revolutionize the agricultural sector and can enable farmers to cope with the enormous challenges in the 21st century (Zhang *et al.*, 2018). The internet of things application (IoT) in agriculture gained lot of research attention in recent times. Also, agriculture 4.0 is a new concept in developed countries as disruptive technologies are utilized in decision making, analyzing the enormous amount of heterogeneous data generated/collected by IoT devices in real-time. Agriculture 4.0 is set to transform agricultural productivity by using Precision Agriculture (PA), IoT, Unmanned Aerial Vehicles (UAVs), IoUT (Internet of Underground Things) and other technologies to increase agricultural produce for growing population, while addressing various farm-related problems in real-time (Raj *et al.,* 2021). The adoption of Agricultural IoT (Ag IoT) can assist farmers to update their production from often low-efficiency conventional mode to a digital farming that is supported by time-sensitive production information (He *et al.*, 2021). IoT and UAV based framework with sun tracker device and flight mode UAV is deployed in the Yangtze River Zone of China and the results demonstrated that wheat was susceptible to disease when the temperature was between 14 to 16°C, and high rainfall decreased the spread of wheat powdery mildew (Gao *et al.*, 2020). IoT embedded device in cloud computing and IoT applications in agriculture 4.0 is the emerging area for agricultural scientists in both developing and developed countries. More specifically, IoT-based agricultural applications including smart fertilization, smart irrigation, crop diseases management, pests control, various equipment automation, smart livestock farming and real-time data collection have lot of potential in near future. Google scholar lists 377000 results when the key word 'internet of things application in agriculture' is searched in the website which shows the growing

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interest of the researchers on this emerging area. The U. S. currently leads the world in IoT smart agriculture, as it produces 7,340 kg of cereal (for example : rice, wheat, maize, barley, etc.) in per ha of farmland, compared to the global average of 3,851 kg of cereal per ha (Sridevi *et al.*, 2017). In the USA, large science and innovation programs of a few universities are also focusing on digitalization of agriculture, for example–Cornell institute for digital agriculture (CIDA) and the Open Agriculture initiative of MIT media Lab. Lalitha *et al.* (2018) provided a conceptual frame work for implementation of IoT applications in teaching, research and extension of Indian State Agricultural Universities (SAUs). Antony *et al.* (2020) in their study for IoT applications implementation for small holder agriculture reported that the major evolving challenges in agriculture due to climate change would motivate implementation of the IoT to improve resilience and secure safety nets for global food supply.

Lalitha *et al.* (2020) reported that even though agricultural scientists of a State Agricultural University (SAU) in southern India had been utilizing the internet and ICT devices for more than 10 years, only 12% of the respondents belonged to 'high' perception category of IoT applications in agriculture. To maximize the potential of IoT technologies, it is necessary to improve the education and qualifications of agricultural staff in regards to digital technologies and creation of platform solutions for agricultural producers that integrate the internet of things, cloud solutions, networks (Solodovnik *et al.,* 2021). IoT allows schools to track the key resources, and enhance access to information which facilitates teachers to create "smart lesson plans". Educational institutes have to integrate IoT platforms into science and engineering curricula to help students develop digital literacy and innovative skills (Pervez *et al.,* 2018).The study conducted at College of Agriculture, Tennessee State University illustrated the use of e-nose as a versatile analysis tool and alternative method for measuring volatile compounds in soybean seeds with minimal sample preparation time (Ravi *et al.,* 2019). This study was conducted in the months of April and May, 2022 at College of Agriculture, Tennessee State University (TSU) with the objective of researching the perception of the agricultural teachers, faculty, and extension agents/directors under Tennessee State University extension system about IoT concepts and IoT applications in agriculture for planning any future interventions. TSU, USA was selected purposively for the study because the first author was a visiting research scholar at the College of Agriculture, TSU to study American agriculture with a focus on internet of things applications and integration in agriculture.

MATERIALS AND METHODS

This study was conducted during the months of April and May, 2022. To elicit the perception about IoT concept and IoT applications in agriculture of TSU Agricultural extension system a structured questionnaire was prepared by consulting IoT experts for its relevance to the objectives of the study and the same was pre-tested with 10 non-sample respondents. Finally, the pre-tested questionnaire was administered to the actual respondents through e-mail. A total of 78 extension staff responded to the questionnaire. Out of the 78 respondents, 92.3% studied agricultural sciences, 3.8% studied human sciences and 3.8% belonged to other categories (sciences). Designation-wise, 52.6% were agricultural teachers, 29.5% were extension agents/directors and 17.9% were college faculty/specialists. A total of 14% respondents held a Ph. D. degree and 51% had a master's degree. Data were solicited on a Likert-type five-point scale, namely, 1=strongly disagree, 2=disagree, 3=unsure/not sure, 4=agree and 5=strongly agree for questions related to perception. In case of questions (Serially numbered as 26, 27 and 28 in the Google form) with negative connotation, the scoring for their responses was given in reverse order (1=strongly agree; agree=2; unsure/not sure=3; disagree=4; strongly disagree=5). Maximum obtainable score was 115 and minimum obtainable score was 27. The data were collected, coded and analyzed using descriptive statistics such as frequency, percentage, mean and standard deviation and ANOVA for unequal sample size.

RESULTS AND DISCUSSION

Profile of the respondents indicated that majority of them were middle aged with a good to fair knowledge on ICT devices usage. More than half of the respondents were teachers (53%) therefore their internet usage was less than five hours per day as they were engaged in regular teaching activities (Table 1). Cent per cent of the respondents expressed considerably less exposure to IoT component usage (more than two years only), knowledge about IoT architecture (20%) and knowledge about possible upgradation of ICT device into IoT component (58%). This might be because of the minimal upgradation of the teaching system to IoT components and usage. IoT being an emerging area especially in agriculture, the findings are justified.

The majority of the staff reported moderate (70.5%) to high (18%) perception for the concept of IoT and its applications in agriculture. The reason might be because the concepts such as IoT, big data and artificial intelligence, etc. were relatively new terms in agricultural field and hence majority of the staff fell under 'moderate perception' category. As a result, it can be established that the majority of the TSU staff were interested to adopt new technologies such as IoT in order to enhance their performance at work and extending IoT based agricultural technologies at field level for the benefit of the farmers and other stakeholders (Table 2). Also, Lalitha *et al.* (2020) who studied perception of agricultural scientists of SAUs in India reported moderate perception about IoT concepts and about IoT applications in agriculture.

Perception questions (S. No. 14, 7, 10, 15 and 8) were the top five questions that contributed to form perception about IoT applications in agriculture and also how IoT could improve their work performance. The five questions were perceived as most relevant by the staff. The question –'Do you think your present IoT component (smart phone, internet, sensors, wi-fi, 4G/5G mobile data over cellular network, etc.) have positively impacted your work?' scored highest mean (4.03) as the staff perceived the smart devices (IoT component) and technology increased their efficiency at work on a daily basis. The question–Do you think IoT application is possible in sectors such as health, transport, retail, smart homes, smart cities, etc.? scored a mean of 3.97 (ranked II). The respondents perceived that concept such as IoT that is an upgradation over ICT devices to obtain data can be beneficial in important fields such as health,

Table 1. Individual profile of the agricultural extension staff (n = 78)

S. No.	Profile characteristics	Category	Agricultural scientists	
			Frequency (f)	Percentage (%)
1.	Age X=45.47 σ =11.90	Young age (up to 34 years)	14	18
		Middle age (35-56 years)	48	62
		Old age (>56 years)	16	20
2.	Designation	Agriculture teacher	41	53
		College faculty/ specialist	14	18
		Extension agent/director	23	29
3.	Discipline/specialization category	Agricultural sciences	72	92
		Human sciences	3	4
		Other	3	4
4.	General computer knowledge or smart devices /ICT devices usage	Excellent	6	8
		Good	32	41
		Fair	36	46
		No knowledge about such things	4	5
5.	Everyday Internet Usage frequency (hours)	>10 h	8	10
		6-10 h	27	35
		1-5 h	43	55
6.	IoT components Usage/ smart devices usage (years)	More than two years	78	100
		Less than two years	-	-
		Never	-	-
7.	Knowledge about main components of IoT	Correct	76	97
		Not correct	2	3
8.	Knowledge about IoT architecture (layers)	Correct	16	20
		Not correct	62	80
9.	Knowledge about possible upgradation of ICT device into IoT component	Correct	45	58
		Not correct	33	42

Table 2. Distribution of extension staff based on perception about IoT concept and its applications in agriculture (n = 78)

S. No.	Dependent variable	Category	Respondents	
			Frequency (f)	Percentage (%)
1.	Perception of the staff about IoT X = 80.58 σ = 9.30	Low (<71)	9	11.5
		Moderate (71 to 90)	55	70.5
		High (>90)	14	18.0

Table 3. ANOVA for determining variance among extension staff of TSU in regards to IoT applications in agriculture (n=78)

S. No.	Particulars	df	SS	MSS	F
1.	Between three categories of staff	2	472.60	236.30	2.867***
2.	Within three categories of staff	75	6182.44	82.43	
3.	Total	77	6655.04		

***Significant at 0.1 level.

retail and smart cities, etc. The question–Do you think IoT application is possible in all fields of Agriculture? was the fifth question to score a mean of 3.79 (ranked V) and it is pertinent with this study objectives/goals (Table 3).

The question–IoT is useful in teaching, research and/or extension activities? scored a mean of 3.95 (ranked III) is directly relevant to the job chart of the TSU staff and it is interesting to note that none of the staff disagreed with the question. The question–Do you think through IoT 'REAL-TIME data collection in agriculture' can be achieved? scored a mean of 3.81 (ranked IV) and was perceived as most relevant because it was possible to collect real-time data through IoT connected devices for decision making.

As most of the staff had minimum education background of bachelors and up to Ph. D. the positive perception about IoT concept can be utilized for training and planning interventions related IoT applications in near future. In case of questions that imply negative perception (S. No. 17, 18 and 19), only 6% of the respondents (S. No. 19) felt that advanced countries such as the U. S. did not require IoT applications in agriculture (Table 4). The reason might be due to the fact that the even though the U. S. used latest technologies in comparison to developing countries, the 6% of the staff were not enthusiastic about IoT applications in agriculture.

Null Hypothesis

Ho–The mean scores of perception about IoT applications in agriculture did not differ significantly among different categories of TSU extension staff.

H_1–The mean scores of perception about IoT applications in agriculture differed significantly among different categories of TSU extension staff.

ANOVA test was performed to verify the null hypothesis. The calculated F-value was 2.867 which was higher than the critical value of 2.375 at 10% level. Even though F calculated values were non-significant at 5 and 1% level, it was interesting to note that F calculated value was higher than critical value at 10% level of significance. This study is a preliminary study on perception about IoT applications in agriculture among TSU staff, hence, it made sense to report findings at σ =0.10. IoT is a new term for many agriculture staff even in developed countries such as the U. S. This study is suggestive of significant effect possibly with a larger sample size and recommends further studies about the new concept IoT and its applications in agriculture.

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