Adopting Sustainable Farming: Implications of Renewable Energy and ICT

S. Dash\textsuperscript{a}, S. Choudhury\textsuperscript{b}

\textsuperscript{a,b} North Eastern Regional Institution of Science and Technology, Nirjuli, Arunachal Pradesh, India.

Email: soumyadash2003@gmail.com

Abstract: Contemporary sustainable farming balances higher productivity with a focus on green technological intervention. The green intervention such as renewable energy and information communication technology (ICT) though have been widely accepted by other sectors, farming community yet to yield the dividend from these two tools. In this paper, a modified technology acceptance model has been presented with a focus towards the adoptability of actual sustainable farming. Further, a success story of sustainable farming with the intervention of ICT is discussed. Finally, interdependency of renewable energy and ICT is elaborated with a focus to formulate a generalized theme towards feasibility of actual sustainability farming is presented.

Key Words: Renewable Energy, ICT, Sustainable Farming.

1. Introduction

Information and Communication Technology (ICT) and Renewable energy has played a pivotal role to accomplish holistic growth objectives of both developing and developed economy. The World Summit on the Information Society in 2003 addressed e-agriculture and featured the application of ICTs as a priority in agricultural development. ICT help to provide adequate knowledge to many farmers. It offers predictive information regarding weather, fertilizers and pest intake, as well as to bring transparency in processes like land litigation, and market pricing. E-governance has empowered farmers of interior location to access adequate information with all convenience (Ghosh and et al., 2020). Agriculture is the foundation and backbone of the Indian economy and 68\% of Indian population is chiefly dependent on agriculture for their livelihood and stake in gross domestic product (GDP) is found to be nearly 20 percent. The agricultural sector in India is lagging behind in many aspects and characterized by poor infrastructure in connectivity along with disintegrated and diversified market. The fragmented land ownership of farmers with less adoptability of technology in farming often faces challenges in accessing reliable and timely information. ICT has enabled the reform in the traditional practices of
agriculture for augmented productivity and sustainability (Gangopadhyay et al., 2019; Karanasios and Slavova, 2019; Lindblom et al., 2017). Appropriate applications of ICT in farming sector is expected to resolve the issues of food security. Customised ICT plays crucial role in facilitating marginal farmers for optimal utilization of available limited resources. ICT enables in defining, storing, and retrieving data for dissemination in agriculture sector with the support of both public and private agencies. Thus farming community are able to access information with the help of user friendly need based information of their respective geographic location. Hence, ICT in agriculture has become an important field of research and application related to e-agriculture. ICT has great impact in agriculture sector because it provides information about business activities related to agriculture supply chain, profitability of farmers as well as value to the customers. Further it helps in retaining of existing stakeholders, as well as acquiring new dimension for financing, and investment avenues. Tools and techniques of ICT helps in accessing formulating market strategy for sourcing and delivery systems. Internet is a significant source for gathering the present information on every part of agriculture and transforming agricultural sector into modern digital agriculture.

In various rural development projects, such as rural cluster electrification and enhanced agricultural technology, information and communication technologies have been introduced to make agriculture more sustainable (Choudhury et al., 2016, Ghosh et al., 2020). Renewable energy systems are those that are not prone to degradation and use primary energy supplies. Examples of green energies include solar, wind, geothermal, and biomass. Solar energy is the light that comes right from the Sun. It is the most concentrated source of energy on Earth, including nuclear weapons. Photovoltaic cell, which transforms sunlight directly into electricity, is the fastest growing form of renewable energy, rising at 50 per cent a year. The Sun provides more than 10 000 times the electricity actually consumed by humans per year. The renewable energy was implemented in different agriculture system and successful results were achieved (Khan et al., 2018; Liu et al., 2017; Chel et al., 2011). The renewable energy can be implemented to compensate the energy shortfall in a cost-effective and environmental sustainable manner (Choudhury et al., 2018). Different cost-effective approaches have been developed by various researchers using solar power, wind power, hydroelectric power for use in various industrial sectors, technical institutions and underdeveloped rural areas (Parida and Chatterjee, 2016; Parida et al., 2016a; Parida et al., 2016b). The different energy sources, e.g. solar, wind, hydraulic, biomass, organic waste, biofuels, and combined heat and electricity, provide the electric generator with a simple, reliable and efficient solution. Conserving important non-renewable natural fuels without causing degradation to the atmosphere. Solar energy can be used in its different ways, e.g. solar photovoltaics, direct solar thermal, and green energies and wind can provide the solution to the world's energy challenges and potentially making the atmosphere safe for future generations by reducing air emissions from the use of fossil fuels.

The Technology Acceptance Model (TAM) is an information system theory for using a modern technology which simulates how users embrace and use a technology different studies on implementation of TAM user acceptance of word processors spreadsheets (Mathieson, 1991), e-mail (Szaajna, 1996), voice mail (Straub, 1995), and telemedicine technology (Hu, 1999). The Technology Acceptance Model has been tested empirically and applied in multiple applications (Mathieson, 1991; Taylor and Todd, 1995; Venkatesh, 2000; Moon and Kim, 2001; Liu et al., 2010; Bagozzi, 2007; Davis 1989; Lee et al., 2003; Venkatesh and Davis, 1996; Venkatesh et al., 2003). The overall objective of the research was to analyze the linkage of the Renewable Energy, information and communication technology to agriculture sector for sustainable farming. The specific objectives of the research were to implement Renewable Energy and Information and Communication Technology (ICT) for Adopting Sustainable Farming and evaluate the efficiency of the process. The proposed paper has also outlined the implication of Technical Acceptance Model (TAM) to achieve the same.
2. Research model and hypothesis

2.1. Application of information and communication technologies for sustainable farming

Poor farmers lack credit for the purchase of farm inputs such as seeds, fertilizers, crop protectants. Smaller or more distant farmers always have fewer trading opportunities and they have to rely on a few traders with less attractive credit conditions, or may not at all have access to credit from the commodity market. ICT is one of these alternatives, which has recently unlocked tremendous capacity to directly strengthen agriculture in developed countries. ICT has found a foothold in the booming mobile, telecom and Internet markets, including in vulnerable smallholder farms and their operations. Computer-based technologies and networking mechanisms such as social media, data archives of information (online or offline), digital imagery and film, and cell phones are all included in ICTs.

It enables accessing requisite information embedded with Just-in-Time (JIT) for the beneficiaries located at distant geographic location at an affordable cost. This also guarantee gender equality and involve women in the course of decision making. ICTs have the option of receiving immediate and accurate reports of the software, operation, applied technology or information. It helps to increase efficiency and quick accomplishment of work. The mechanism will reinforce the seed industry, such as timely and updated reports on seed-related issues such as the introduction of new crops, false seeds and seed price information, etc. Sustainable growth of rural & agricultural areas is also supported by ICT. This also helps to empower rural netizens with the conservation of environment by avoiding unwanted exploration through implementation of appropriate technology, and productive strategies for development, markets, banking and financial services. ICT is concerned with recording, extracting and distributing digital data. ICT makes the system more competitive, efficient and attentive to meet the demands.

2.2. Application of Technology Acceptance Model for sustainable farming

The technology acceptance model (TAM) was implemented to predict the acceptability of a mechanism and to define the improvements that may be added to the system. As per TAM, perceived usefulness (PU) and perceived ease of use (PEOU) are decisive factors regarding the acceptability of any information system. In addition to this the technology acceptance model suggests that the use of an information system is determined by the behavioral intention.

![Figure-1: Proposed technology acceptance model for sustainable farming](image)

For sustainable agriculture the behavioral intention is dependent on 3 factors such as attitude towards sustainable farming (AS), intention for sustainable farming (IS), and confidence for implementation of
sustainable farming (CIS). The technology acceptance model for the sustainable agriculture is shown in Fig 1. PU denotes the degree of the conviction of a person that a certain scheme is being used can boost its efficiency. Whereas, PEOU indicates affinity of an individual belief system for easy usage of a specific creative information system. AS is defined as the degree to which a farmer implements ICT and renewable energy for sustainable farming. The intention of sustainable farming (IS) implies the intent of individual users and is characterized as a type of external psycho-motor response quantified by the actual course of action of individual users.

In this study the relationship between ICT and renewable energy and sustainable farming was established. ICT and renewable energy is meant for the implementation for farming system by the farmers. Although there are various real and observable benefit steps a simple approach has been created to quantify and calculate the implements of ICT and renewable energy for sustainable farming. In the selection of the necessary details for the design, a method of survey was implemented. A standardized questionnaire consisting of a series of questions was taken as a testing tool. The methodology of questionnaire surveying was used in order to collect primary results. A major portion of the questionnaire consisted of semi-closed questions such that each respondent could select from the alternatives presented and also share their opinion. The TAM questionnaires were implementing renewable energy and ICT, perceived usefulness, perceived ease of use, attitude towards sustainable farming, and confidence for implementation. The participants were asked to responds the questions asked above using the 5 points (1-5) Scale. The five point scale was designated as 1 as lowest point with denoting ‘strongly disagree’ and 5 as ‘strongly agree’ and subsequently other interval number denotes all other interval values. Twenty elderly people (over 51 years of age), twenty middle-aged people (between 31 and 50 years of age) and twenty younger adults (between 18 and 30 years of age) from the local population were chosen for the study. Every member of the group should be able to use smartphones and computers. An introductory overview on ICT and green energy was presented to all participants. In order to test the model parameters, they were expected to finish a survey and attempt all the given questionnaire and the score had to be provided on the five-point scale.

3. Results and Discussions

In agriculture system ICT and Renewable energy are used in weather forecasting, taking expert opinion, and for farming techniques by illustrative video. Renewable energy was implemented for generating and storage of electricity which further can be implemented for electricity based water pump and storage of farm output. The Indian farmers are lesser interested for implementation of ICT and renewable energy in agriculture due to their low level of education, and higher initial cost of investment for implementing the technology. The farmers often risk introducing the technique because they are not sure about the yield. ICT is mainly dependent on electricity. Privatized mega-power plant can't afford less efficient rural electrification, so green energy can help marginal farmers make it sustainable by partnership at village level.

3.1. Descriptive statistic for parameters of sustainable farming

The descriptive statistics pertaining to the different factors of sustainable agriculture are shown in Table 1. The mean score of the variables implementing renewable energy and ICT (IRE-ICT), perceived usefulness, perceived ease of use, attitude towards sustainable farming, intention for sustainable farming, and confidence for implementation were 3.43, 3.70, 3.31, 3.60, 3.76, and 4.06 respectively. The score of each variables was higher than average which indicated that the strongly agree with each parameter of sustainable agriculture.
3.2. Correlation between variables of sustainable farming

The correlation coefficients among the various variables are summarized in Table (2). According to the findings obtained there is a positive and significant relationship between the variables implementing renewable energy and ICT, perceived usefulness, perceived ease of use, attitude towards sustainable farming, intention for sustainable farming, and confidence for implementation. It was observed that implementing renewable energy and ICT was strongly correlated with attitude towards sustainable farming \((p < 0.01, r = 0.604)\) and the correlation was found to be significant.

**Table 2 Correlation coefficients between the Technology Acceptance Model parameters**

| Variables | IRE-ICT | PU | PEOU | AS | IS | CIS |
|-----------|---------|----|------|----|----|-----|
| IRE-ICT   | 1       |    |      |    |    |     |
| PU        | 0.558** | 1  |      |    |    |     |
| PEOU      | 0.537** | 0.55** | 1  |    |    |     |
| AS        | 0.604** | 0.426* | 0.572** | 1 |    |     |
| IS        | 0.415*  | 0.522** | 0.354 | 0.566** | 1  |     |
| CIS       | 0.393*  | 0.135 | 0.202 | 0.172 | 0.113 | 1   |

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

The correlation coefficients of implementing renewable energy and ICT with perceived usefulness, perceived ease of use, attitude towards sustainable farming, intention for sustainable farming and confidence for implementation with implementing renewable energy and ICT were 0.558, 0.536, 0.604, 0.414, and 0.393 respectively. Therefore, the use renewable energy such as solar, hydro-power or wind farms in sustainable agriculture is highly beneficial for the farmers. Farmers can use renewable based rural electrification technology for electrical fencing of agriculture land. Irrigation for optimal watering by electric pumps. Post harvest activity can also be achieved by the usage of electric dryer. For this purpose, marginal farmers can use solar panel based irrigation for distantly located farmland. At the same time established farmers can rely upon geothermal heat pumps. The correlation between perceived usefulness and perceived ease of use, attitude towards sustainable farming, intention for sustainable farming, and confidence for implementation were evaluated. Based on the results obtained there was positive and significant relationships between perceived usefulness and perceived ease of use \((p < 0.01, r = 0.550)\) and also relationships between perceived usefulness and intention for sustainable farming was found to be highly significant \((p < 0.01, r = 0.522)\). The correlation between confidence for implementation was found to be significant for implementing renewable energy & ICT whereas the correlation between confidence for implementation and perceived usefulness, perceived ease of use, attitude towards sustainable farming, intention for sustainable farming was found to be insignificant \((p > 0.05)\). The findings of correlation experiments have shown that the model variables are related to each other.
4. Conclusion

This paper analyzed the use of the TAM as deterministic for the acceptance of ICT and renewable energy in sustainable farming. The study has a novel addition of implementation of renewable technologies leading to sustainable farming. This study was conducted to classify and correlate the parameters implementing renewable energy and ICT, perceived usefulness, perceived ease of use, attitude towards sustainable farming, intention for sustainable farming, and confidence for implementation towards sustainable agriculture technologies. There is a significant positive relationship observed between the variables implementing green energy and ICT, perceived utility, perceived ease of use, attitude towards sustainable farming, intention for sustainable farming, and confidence for implementation, according to the findings obtained. ICT would enhance interchange of their experience with an interactive ICT based systems for both tangible and intangible causes. Farmers with minimal access to resources, energy and technology can access information via computer-based apps and networking platforms such as social media, digital database archives, and digital imagery and recording, as well as mobile phones. Farmers with minimal access to resources, energy and technology can access information. The analysis offers valuable perspectives for farmers and decision makers of implementing ICT and renewable energy for sustainable agriculture.

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