



## Disparities between developed and emerging economies in digital divide and ICT gap to bring agricultural sustainability

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### ARTICLE INFORMATION

### ABSTRACT

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Evolution of community into the cognitive one has had a significant impact on the value and role of information. Could the adoption of ICT be the means to achieve agricultural sustainability in developed and emerging economies? A startling plunge of food yield growth rates and risks of food insecurity in the future, especially after the global population projection of 9.7 billion people by 2050, highlights the pertinence of this question which finds no clear insights in the past literature. Not every person has the same internet access, communication tools, the same level of information approach, or makes the same benefit of available digital gadgets. Digital dividends have lagged the ICT penetration behind. ICT tools have been unevenly distributed. Developed economies have been able to make use of such tools as a support for development of sustainable agriculture. However, this case has potentially not been achieved in emerging economies due to the illiteracy of the farmers. This suggests the need for extension education, ICT tools demonstrations with application, investment in technology, training programs, workshops, and so on. The internet has been accessible to 86.6% of the developed countries, while it has just been 47% of people from developing ones. So, future research should focus on the strategies to increase the application of ICT tools in farming to bring agricultural sustainability in both developing and developed economies.

**Keywords:** Information and communication technology, agriculture, sustainability, internet



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## 1 Introduction

The global digital divide shows global disparities, mainly between the countries with developed and emerging economies, in regards to access to data and information resources such as the Internet and the opportunities obtained from such access. Developed countries have not only more progressive economies, but also more highly developed infrastructures of Information and Communication Technology (ICT). Emerging economies generally have evolving manufacturing bases with unsophisticated infrastructure of the components of ICT. Agriculture is a significant basis for economic development on

which most countries rely, particularly those with emerging economies (UN, 2020). The Sustainable Development Goals (SDG) initiative of the United Nations also aims to achieve more effective and more sustainable agriculture, emphasizing technological innovations (UN, 2020). Nevertheless, technological constraints, such as poor accessibility to ICT, have impeded the goal of agricultural sustainability in many developing nations. Technological advancement in agriculture is nowhere evenly achieved in view of different extent to which rural areas are digitally equipped across developed countries and emerging economies (FAO, 2017). The Sussex Manifesto in the 1970s underlined the impact of innovations in 'eco-

conomic transformation through agriculture' (Kaplin-sky et al., 2009). Since then, it has become even more apparent that ICT is crucial for agricultural development, and that those countries with high economic achievement tend to have relatively higher technological productivity (Fragerberg, 2005).

Agricultural sustainability rests on the principle that farmers must meet their country's food demands in the present without compromising the potential of future generations to meet their needs (Feenstra et al., 2019). ICT plays a role in creating sustainable food systems and is vital for rural economic development (Mchombu, 1992; Gelb et al., 1997; FAO, 2001). Information possessed by farmers means empowerment through control over their assets and decision-making processes (Maningas et al., 2000). ICT has potential to overcome farming constraints by delivering need-based information to farmers via new information technologies (Kaniki, 1989; Ommani, 2005; Morris, 2000). Managerial functions from farm to distribution are successful when relevant information is available on time (Ommani and Chizari, 2008). However, information gaps among farmers have hindered agriculture transformation in many developing countries, thus sustainability is lacking. Farmer income and crop yield have stagnated or even decreased in many emerging economies in comparison to developed ones. This is not wholly due to a lack of investment in quality education, research, or extension, but also to a number of causes such as marketing curbs, adoption of poor technologies (notably in developing and under-developed nations), weak coordination among technicians and biological scientists, and lack of effective agricultural and technological policies (Jackson, 2019).

Agriculture is often called the backbone of the national economy for the majority of countries with developing infrastructure (Khanal et al., 2021). Developed and emerging economies are the two terms with which we define markets. Literally, developed countries have leading economies, advanced infrastructure, more developed capital markets, and higher living standards. These are the most economically affluent countries, with very matured capital markets and high per capita income. North America, western Europe, and Australia have the most developed economies. To the contrary, developing countries with emerging economies are in the process of rapid economic growth, yet they have lower per household income and relatively less matured capital market (Jackson, 2019). ICTs gap between developed and emerging economies have influenced the adoption of tools of ICTs and hence the achievement of agricultural sustainability in different nations.

## 2 Agriculture: present and past

Today, agriculture limits itself to rural parts. In the past, almost all the population used to depend on farming for sustenance of life. During that time, traditional method of farming was in practice. Farmers of present era are able to use modern technologies which allow them to attain more yield in less time. Traditional farming was mainly limited to cultivate one crop a year, but nowadays the farmers are able to grow two or more crops a year. On account of this, the development of ICTs has been acknowledged to be a boon for farmers. The percentage of population involved in farming has decreased over years as people started preferring other jobs which promises them more income and security (Manipal Blog, 2018). The global population is expected to reach an estimation of 9 billion by 2050 (Simmons et al., 2011). So, the present days' agriculture has been facing the problems of food insecurity. During 18th century, more than 90% of population in the USA were engaged in farming and produced food for themselves. The farming was of subsistence type— just for household consumption. However, the 21st century have made incredible development in the farming sector, with only 2% of the US population being engaged in farming but also producing surplus of food products (Prax, 2001). Over the time, farmers use technology to make advances in producing more food. Each farmer is competent to feed 155 people today, compared to 1940, where one farmer could feed only 19 people (Prax, 2001). ICTs development have helped farmers and revolutionized the agricultural system reducing the number of resources needed on the farm (Cap-per et al., 2009). In the past, farmers would have to acquire information through word of mouth, pigeon-conveyed message, couriers, etc. which used to take a long time. Delayed in getting information would result in ultimate yield loss. Contemporary farmers take the advantage of ICTs. Cooperatives, input suppliers, traders, processors, and retailers make their work more convenient through use of different informative tools. Early agriculture was almost the same in both developed and emerging economies. Today, agriculture in developed economies, usually, attain the balance in demand-supply curve, agricultural sustainability, increased production, effective use of the scarce resources and so on, while it is not balanced in most of the emerging economies. ICTs extent and way of use for farming vary to a wide range between countries with developed and emerging economies.

## 3 ICT in agriculture

### 3.1 Developed economies (DE)

The developed economies are typically characteristic of the developed countries with a relatively high

level of economic growth, high per capita income, advanced level of industrialization, improved living standards, and developed technological infrastructure (Majaski, 2020). Farmers in developed economies over the last twenty years have already been using ICT in farming, including irrigation, farming equipment, soil analysis, weather forecasting, e-marketing, and more (Zarco-Tejada et al., 2014). To reach these farming advances, the fast pace of technological breakthroughs in information and communication allows and helped for increasing data storage and analytics (FAO, 2017). Developed economies have greater access to particular ICTs, thus have developed ICT diffusion. The emergence of the internet and electronic gadgets has already substantially increased the outflow of information among the farmers in technologically developed countries like the USA, China, Japan, Russia, Europe, Canada, etc. Precision Agriculture (PA) is an achievement in farm management technology, mostly applicable in the developed nations, that uses information technology (IT) to assure that the plants and soil receive precisely what they need for optimum yield. The objective of PA is to ensure profitability, sustainability and protection of the environment through agriculture. For example, technological advancement in wireless facilities during the last few years have completely changed the telecommunication scenario in Japan, China, Mexico, Russia, etc. In the southern part of the United Kingdom, the application of ICTs in agriculture has shown commercial benefits in economic aspects and nature conservation and ecological sustainability (Wilson et al., 2014). To communicate, learn and experience new forms of expression and entertainment, a large number of people use online social networks in highly advanced countries, while fewer people used in the least developed countries. Social networks have developed into virtual communities, where farmers interact and agriculture is a crucial part of society both real and virtual (Dollarhide, 2000). Serious games, which is a modern technological approach in developed economies, is a digital gaming environment that is not just for fun but to train the people in solving the problems (Laa-marti et al., 2014). It has often been designed to ease the agricultural problems in the developed countries. However, its application in emerging nations is yet not common. Mexico is a developed country with approximately 60% of the population using the internet (Statistica, 2020c). A stylish game, RESOTRES, is an ICT tool that is rich in economic outcomes with a variety of incentives enabling farmers in making quick decisions, is popular in farming communities in Chiapas, Mexico (Speelman et al., 2014).

### 3.2 Emerging economies (EE)

ICT can potentially help countries with emerging economies deal with numerous agricultural problems

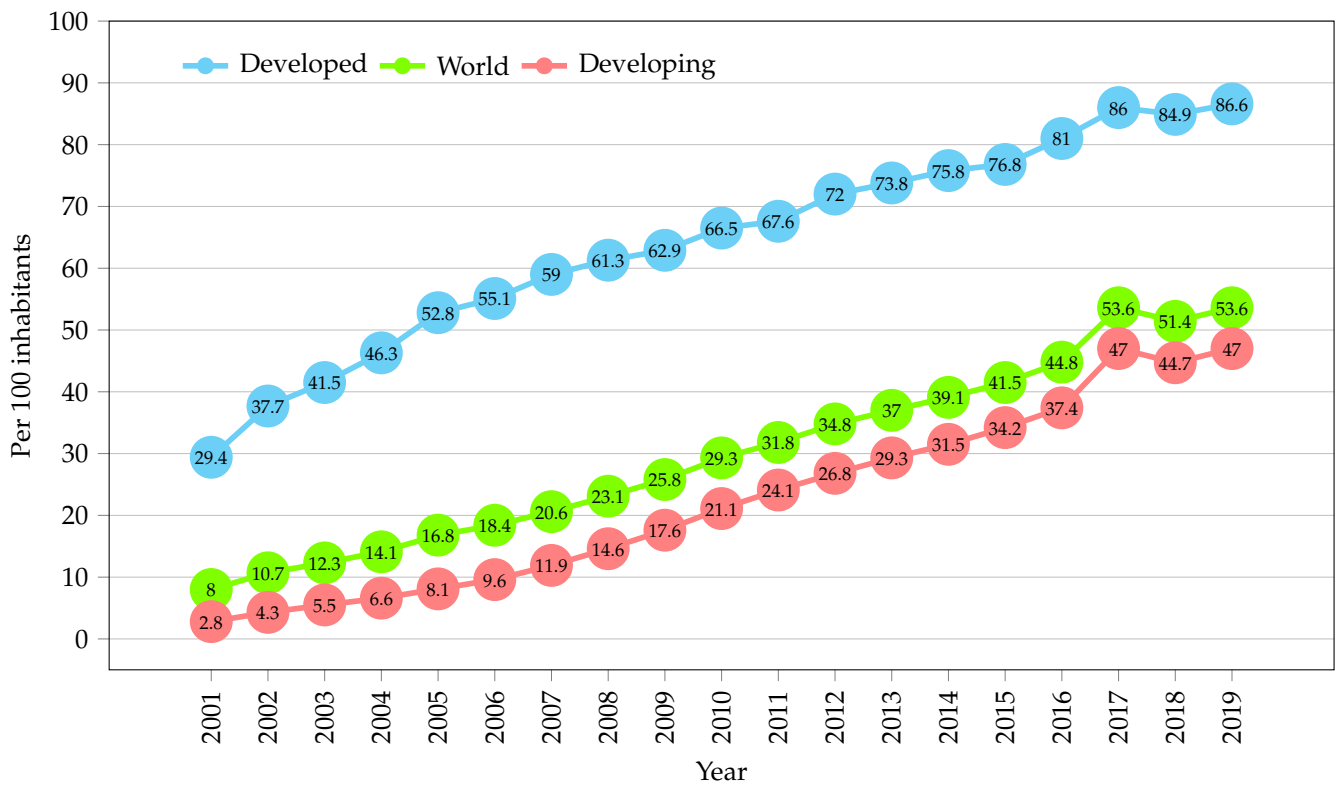
by improving access to information and enabling communication. Agricultural sectors of emerging economies usually consist of small farmers with poor access to physical infrastructure, market and extension information (Nakasone et al., 2014). Relatively in a developing country, there is need for a greater number of extension agents to reach geographically dispersed and rural farmers, interact with and advise them on innovative productive technologies that can be crucial for maintaining agricultural sustainability. For example: Kenya, which has emerging economy, has developed a cashless micro-credit programme. It has helped connect financial institutions, smallholder rural farmers, retail providers, and the consumers (FAO, 2017). By using a pre-established line of credit from banks, producers gained access to inputs (e.g., Seeds, fertilizers, pesticides) from local input providers, where DrumNet provided the bank with a credit rating score for each farmer (FAO, 2016). The developing countries in Africa uses a combination of mobile and web services; along with the advisory call centres, video call and call centers. In developing countries, virtually three-fourths of the world population own a mobile phone and from 1 billion in 2005 to an approximated 3.2 billion in 2015, the number of internet users has more than tripled in a decade (World Bank, 2016). Also, this number is anticipated to be burgeoned in 2022.

## 4 Digital divide in DE and EE

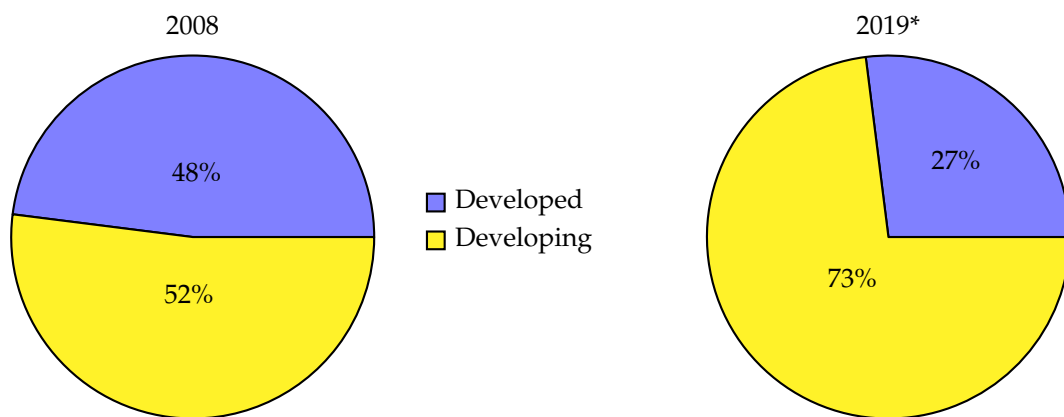
ITU estimates that at the end of 2019, 53.6 percent of the global population, or 4.1 billion people, are using the Internet. Developed countries account for 86.6 per cent of the population and Developing countries account for just 47 percent of the population using the internet through different means (Fig. 1). This makes us clear how the countries are digitally dividing on the basis of digital penetration.

## 5 Internet user scenario

Fig. 2 shows the number of populations in 2008 and 2019 who were under the accessibility of internet and ICT tools. In 2008, 811 million (52% of global population) people from developing countries were using the internet, and 754 million (48% of global population) people from developed countries were ICT users. However, this decade has significant rise in users from the emerging economies due to increased consciousness of sustainable agriculture. 73% of developing countries were using ICT in 2019 and 27% from developed economies. The population of emerging economies are higher so is the percentage of users. But, developing countries are unable to make full uses of the available ICT means.



**Figure 1.** Individuals using the Internet per 100 inhabitants during 2001-2019. Source: ITUWT (2020). The values of 2019 are approximate estimation.



**Figure 2.** ICT accessibility in 2008 and 2019 in developed and developing countries. Source: ITUWT (2020). Asterisk (\*) designates an approximate estimation, users in million.

**Table 1.** ICT users in Developed economies in the year 2020

SN	Developed economies	GDP (trillion USD) <sup>†</sup>	ICT users (million)	Percentage <sup>§</sup>	Source
1	United States	21.00	292	89	IWS (2019)
2	China	9.20	854	61	IWS (2019)
3	Japan	5.20	118	93	IWS (2019)
4	Germany	4.20	79	95	IWS (2019)
5	United Kingdom	3.20	63	94	IWS (2019)
6	India	2.90	560	41	IWS (2019)
7	France	2.90	60	89	IWS (2019)
8	Brazil	2.00	149	71	IWS (2019)
9	Italy	1.94	54	89	IWS (2019)
10	Canada	1.80	33	86	Statistica (2020b)
11	Russia	1.57	116	79	IWS (2019)
12	South Korea	1.53	48	93	Statistica (2020d)
13	Australia	1.32	21	82	Watt (2019)
14	Spain	1.31	42	91	World Bank (2020a)
15	Mexico	1.15	88	70	IWS (2019)

Percentage of whole country's population inside the parentheses; <sup>†</sup>Global Pro Services (2020); <sup>§</sup>Percentage of country's total populaiton

**Table 2.** ICT users in Emerging economies in the year 2020

SN	Emerging economies <sup>†</sup>	GDP (billion USD) <sup>‡</sup>	ICT users (million)	Percentage <sup>§</sup>	Source
1	Argentina	449	31.54	70	TE (2020)
2	Bangladesh	302	94	58	Statistica (2020a)
3	Indonesia	1119	171	64	Statistica (2020a)
4	Philippines	376	79	73	Statistica (2020a)
5	Vietnam	261	68	70	Statistica (2020a)
6	Iran	445	67	80	
7	South Africa	351	37	62	
8	Nigeria	448	126	63	Statistica (2020a)
9	Thailand	543	57	85	Statistica (2020a)
10	Egypt	3030	49	48	Statistica (2020a)
11	Turkey	754	69	84	Statistica (2020a)

Percentage of whole country's population inside the parentheses; <sup>†</sup>MSCI (2000); <sup>‡</sup>World Bank (2020b)  
<sup>§</sup>Percentage of country's total populaiton

Table 1 shows the number of ICT users in the developed economies. United States, China, Japan, Germany, United Kingdom, France, Italy, Canada, etc. have developed economies, so are the internet users. ICT development has direct correlation with economic development and agricultural sustainability (Dollarhide, 2000).

As compared to developed economies, less percentage of population adopt ICT tools for farming the developing economies. Argentina, Bangladesh, Indonesia, Philippines, Vietnam, Iran, South Africa, etc. are some of the countries with emerging economies. In these countries, the trend of ICT adoption is increasing over years due to technological and education development, and also due mainly to the improving lifestyles of the country's population.

## 6 ICT in agril. sustainability

### 6.1 Extension and advisory services

Developed and emerging economies have an extension gap and differences in advisory services due to which there is also a wide gap in agricultural development among the nations. The gap is literally caused by developed economies being able to make capital out of the poorer economies as they have strong technological power to be able to do so. Consequently, the weak economies suffer from a shortfall of resources and spiral into unsustainable farming which widens the development gap. In developing countries, traditional extension services face several challenges that limit their efficiency and in remote areas, poor infrastructure makes it harder and more

costly. 'Digital Green' is a non-profit international organization that is working to ease the farm work through a digital approach, using locally produced videos and human-mediated dissemination, in most of the developing economies (Yonazi et al., 2012). Developed economies have advanced information delivery systems which include one-way versus 2-way communication between farmer and agricultural specialists, SMS versus voice messaging and oral description of problem versus picture taken in the field (Nakasone et al., 2014). These have improved agronomic practices and thus contributed to sustainable agriculture. With ICTs tools, beyond doubt, they can be promising resources for dissemination of information in modernizing farming system of the country for both developed and emerging economies. Access of extension agents for farmers to gather relevant advices regarding agriculture especially in geographically remote areas is possible with ICT tools such as radio, television, smart phone, call centre, internet etc. in a cost-effective way whenever required by them. ICT-based advisory services help to augment agriculture development by amplifying the information accessibility of the farmers so that they would make the finest decision using their resources in a sustainable manner.

## 6.2 Improving market access

ICT in Agriculture, can bring significant benefits through better information on market and information is delivered mainly through Short Message Service (SMS), interactive voice response system or mobile applications are also used (FAO, 2017). In 2007, in India (developed economies), Reuter's RML Information Services was launched in the state of Maharashtra, providing an affordable SMS service that shared daily updates on price, markets and weather with subscribing farmers and through a smart phone application. Currently, it provides customized market data reports to banks procurement companies and other organizations on market prices, volumes and other information covering many crops and 1,300 markets across India (Rao, 2011). In Uganda, the dissemination of price information resulted in a 15% increase in farm gate prices for maize and in Peru and Philippines similar results were found by researchers (FAO, 2016). ICT eases traders in gaining customer, product, and market information (Baourakis et al., 2002). Developed economies have advanced E-marketing which reduces the transaction cost, while the traditional marketing system in emerging economies is largely affected by high transaction cost, low transaction efficiency and numerous links while circulating products (Cosmin and Aurel, 2013). Filling up of the space of digital divide and ICTs gap between developed and emerging economies help improve the agricultural market access. The emerging economies

can learn from the developed economies about the application of ICTs tools in agriculture and adopt the possible means.

## 6.3 Financial inclusion

ICTs offer financial services such as Transfer and payments and Credit, saving and insurance. The Cooperative for Assistance and Relief Everywhere (CARE) in East Africa is experimenting with the formal banking system by connecting its village saving and loan association (FAO, 2017). Each association is to have a single account tied to a bank, via a mobile phone which can be tracked and the advantage of these links and use of ICT are that they improve the management and accounting of association's finances, reduce the likelihood of theft or loss of the saving and provide access to additional products from the bank. However, such services haven't been potentially developed in developing countries thus, the countries need to focus on connecting ICTs, Finance, and Agriculture on a common background.

## 6.4 Insurance and risk management

ICT innovations in farm observations, weather predictions and remote sensing, have overcome more transaction costs associated with conventional multi-peril crop insurance with market-based index-insurance product reaching millions of smallholder farmer even in some of the undeveloped areas of the world, many of which were previously uninsurable (Greatrex et al., 2015). While there have been not too many applications of ICTs in emerging economies to manage agricultural shocks, those that exist are proving imperative for sustainable agriculture and conceivably transformative (Sen and Choudhary, 2018). ICTs tools facilitate ground personnel or concerned persons to report more conveniently to whoever is coordinating a response to the shock. Developed economies, owing to high ICTs development, have high access to up-to-date information and also expertise to use that information which reduces the consequences of predicted risk (Mittal and Mehar, 2012). Early warning about natural disasters, disease and pest attack (e.g.; Fall Army Worm and Locust attack in recent) in a particular area, most and its mitigating measures is practicable through the use of ICT. Agrometeorological and weather forecasting ICT devices have made farmers aware of weather variations so that they can plan and prepare in advance what, when and how they will perform farming practices such as weeding, time of pesticides spray, sowing, irrigation scheduling and fertilizers application to manage crop. Accurate anticipation of weather conditions and timely notifying the farmers on the actual and expected weather via different ICT tools can reduce crop loss by doing crop management practices on time.

**Table 3.** Use of agriculture mobile apps in the developed economies

SN	Agriculture mobile apps	Application
1	Agronote	It's one of the best for farm management. Agronote is for recordkeeping of expenses, income, livestock, and machinery procedures.
2	AkerScout	It's an app for farmers market, it helps identify and prioritize crop damage to address problem areas needing immediate attention
3	Bushel	The app platform integrates into grain elevators' accounting systems and provides growers access to their contracts, scale tickets, prepays, cash bids, and markets.
4	Crop Nutrient Advisor	The app allows agricultural producers identify crop nutrient deficiencies, and get product recommendations; check spray tank compatibility and more
5	CropRecords	The app lets users create jobs for spraying, seeding, fieldwork, and harvesting, and track them.

## 6.5 E-learning

Agricultural knowledge is the foremost aspect for every farmer and entrepreneurs to gain more profits from agriculture. FAO of the United Nations provides training to farmers on diverse topics like Agri-marketing, crop production, disease and pest management, animal husbandry, fisheries, post-harvest management, water management, farm technologies etc. using video conferencing across the country, particularly those which have emerging and undeveloped economies. Moreover, short films on agriculture, Agri-news, video clips, success stories of progressive farmers and entrepreneurs which are shared via ICT tools are also assisting farmers to learn about modern and scientific agricultural practices and modern technologies including farm power and machineries. Many governmental bodies and private organizations provide online diagnosis and consultancy services on diverse Agri-problems like plant and animal diseases, pest infestation, post-harvest issues, marketing issues via ICT tools like telephone call, mobile apps, email and SMS in local languages. Thus, ICT tools play a vital role for easy and efficient dissemination of Agri-knowledge to farmers.

## 6.6 Automation

Farm automation practices can bring agricultural sustainability while also lessening the ecological footprint of farming simultaneously. Site-specific application software can decrease the number of pesticides and fertilizer used while also declining greenhouse gas emissions (Linly, 2019). From the preparation of soil and sowing to harvesting and then post-harvest management, automation in agriculture plays a significant role. For the world's emerging economies, the changes unleashed by automation, ICT technologies, and digital development increasingly pose many

challenges. Developed economies have advanced automation, thus have higher agricultural development.

## 6.7 Database management

The density of information and data in agriculture is very high and proper management of these data is a principal task. ICT has several platforms for collecting, storing and retrieving both online and offline data. Farmers and entrepreneurs are able to create and manage the data and information of their farm, customers and market via different ICT tools like Data Base Management System (DBMS). DBMS is one of the computer data management system that provides an interface between users and the database. The data about the productivity and production of various agricultural products may be easily maintained with this database management system. Cropping patterns of farm land can also be planned in a proper manner with the appropriate data sets. Furthermore, crop planning, farm mechanism, farm survey, farm record, providing on time soil testing report and other numerous aspects has become easy with this database management system. With this data base management system, farmers/ entrepreneurs can easily access, updates and share data regarding different crops, farm animals, land, sales and stocks anywhere at any time in a few minutes. Data sources such as farm records and surveys form the basis for the majority of agricultural research. Thus, software and hardware application become an integral tool of ICT in the agriculture field.

## 6.8 Decision support system

Farming knowledge, that is an integrated experience of how to grow and produce food, fiber, and bio-products while sustaining a livelihood from the farm, is largely complex, involved of multifarious disci-

plines, persons, with multiple levels of abstraction. Digital technology plays a vital role in farmers and entrepreneur's life in making decision. ICT updates farmers with the latest agricultural news and information, weather and climatic conditions, new crop varieties, new scientific techniques of agricultural productions, quality control market and so on. Dissemination of authentic, adequate and efficient information aid farmers and policy makers in the decision-making process. The timely information and practical solutions to problems assist farmers to have better agricultural practices, good choice of inputs and to plan properly. Majority of the European farmer-innovators are availing themselves of decision support tools so far that can support them in their agricultural operations at field and management level (Eip-agri, 2019). This system collects, compiles and evaluates a range of data, and offer data-driven support and information on how to enhance production in both quantity and quality.

## 7 Need for ICT development

Advancement of technology and accessibility, adaptability and affordability of ICT has made farmers easy to learn about modern agriculture. ICT can even build capacity and raise the livelihood of smallholder farmers in a quick pace. Mobile phones would be one of the best examples. People can access with much information with its accessibility and affordability as well as can share ideas among one another with ease. Information and communication technology are like a bridge to connect innovations to the farmers. Farmers can even get access to know market values of various commodities with the help of these apps. Also, there are various television and radio program broadcasting that discuss about issues on agriculture and also provide expertise suggestions and advice to farmers in need. Economic development has testified agricultural revolutions (green-food grain, yellow-edible oil, white milk and blue-fish), industrial revolution, information technology revolution, and biotechnology revolution. In the developed economies, the realm of electronic communication, encompasses information technology, telecommunication, broadcasting and industries and services is undergoing enormous changes, leading to a Global Information Infrastructure (GII), which will be capable of carrying any type of information like voice, video, text or data. Information is now widely defined to hold voice in telephony, image in video, text in fax and newspapers, data in computer and TV broadcasting. Every information can be digitized, transported, stored, retrieved, modified and then distributed through these devices (Chukwunonso and Tukur, 2012).

E-agriculture is an emerging field that focuses on the intensification of agricultural and rural develop-

ment through improved information and communication technologies. E-agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use information and communication technologies in the rural domain with a primary focus on agriculture. To manage these phases efficiently, all stakeholders of agriculture industry need information and knowledge about it. The information provided by the system must be cost effective, easy to access, in user friendly form and well protected from unauthorized accesses.

## 8 ICT means

ICTs gap and digital divide have brought non-uniformity in accessibility and affordability of many ICT tools in developed and emerging economies. Agricultural sustainability substantially depends upon how we use the existing means of technology in farming. ICT has been emphasized nowadays in emerging economies realizing its potential of economic and agricultural development as well. Developed economies already have developed infrastructure, therefore, farmers in there are conscious on use of such means for farming benefits. Rural people usually do not have high knowledge and awareness on ICT means. Still, Radio and Telephone have been the main source of accessing information in majority of the rural areas in countries of emerging economies. Information is considered as one of the major resources for development. ICT holds tremendous potential for agricultural development by disseminating relevant and timely information to farmers and entrepreneurs. Through the introduction of farm technologies, ICT have also been proved to be a remarkable indicator for agricultural development, where these technologies are acting to enhance agricultural production (Das et al., 2017). Below are the major ICT based tools/means for the development of agricultural sectors:

### 8.1 Radio

Radio as an extension tool can support the procedure of agricultural knowledge transmission from extension agents to farmers (Tata and McNamara, 2016). Mainly in Emerging economies, Radio application is high due to a large number of poor farmers. It is an effective ICT tool which can reach a large number of people including poor as it is affordable. Regular broadcasting of radio program related to agriculture via FM station provides valuable source of Agri-information to farmers. Important information like better farming methods, planting time, quality seeds, suitable crop varieties, marketing, post-harvest handling and soon can be provided using radio (Nakabugu, 2001). In developed economies, Radio has now started to provide modern and ad-



vanced services. It gives farmers an opportunity to interact with concerned authorities like plant and animal expert via different format of program like talk shows, on location broadcast and phone in program. However, for understanding radio program, farmer's literacy is important.

## 8.2 Television

Television is one of the effective tools of the mass media, which transmit information, mostly visually, very fast about farming technology among the farmers community (Chhachhar et al., 2012). Television offers effective channels for communication of agricultural message which could spread information very fast (Irfan et al., 2006). Several TV channels broadcast agriculture related information such as crop care, market price, fertilizer, seed resource, weather and climate through talk shows and on location broadcast. Audio-visual presentations of programs enhance the understanding capacity of audience. According to (FAO, 2001), television is acknowledged as the very important means for communicating with rural people of developing economies.

## 8.3 Computers

Developed economies, relatively to Emerging ones, have a greater number of farmers using computers for collecting, managing, storing, processing and exchanging large data and information related to agriculture. Computer assisted Geographic information system (GIS) and remote sensing assist researchers for research in agriculture. GIS also develop data-based map on soil and land resources, crop zoning, hydrology, climate and other related information of agriculture. Online data and information sharing facility in computer enhance greater interactivity and communication.

## 8.4 Smart phones

Since most of the emerging and undeveloped economies are far from the reach of Internet facilities, the use of mobile phones only for farming has more been observed in developed economies. SMS and voice message delivery system of mobile phone are helpful to farmers for easy communication. Farmers in developing economies are actively adopting smart-phones, and this offers room for mobile applications that can meet their demands. In recent years, various applications have appeared for individual farmers. There are large number of mobile applications related to technologies and other information about agriculture. This application has gained popularity as it has created a new area of agriculture communication and feedback; which is vital for information transmission.

# 9 Emerging economies lagged behind in ICT adoption

For innovation to successfully reach its target user and be implemented, both diffusion and adoption must occur in order (Mahajan et al., 1990). Emerging economies face different problems in ICT diffusion and adoption for agriculture development. Digital divide has resulted in a lack of accessibility of ICTs tools in most of the rural and underdeveloped areas. The economically poor nations cannot invest more in technological development due to which agriculture hasn't been developed to its potential. The users in developing economies are usually unaware of their application and methods of use in farming. The critical need for an 'ICT intermediary' and training have been emphasized by the ever-changing information and internet characteristics which blended with the constant oversupply of ICT innovations and cost reductions. Innovation of new technologies can also be an impediment which blocks the use of older technologies which can often be more effective. In developing nations, numerous obstacles are identified explicitly like lack of leadership, misguided choice of partners, lack of sharing traditional knowledge with ICT supported automatic decision making in green houses, fragmented coordination among donors and failure to adopt participatory measures, lack of fund and start-up support, lack of transparency, outdated legal system, time consuming data input and more (Gelb et al., 2008). The main barrier for effectiveness of ICT based agriculture extension is illiteracy. Since a large proportion of rural economies are illiterate, lacking basic skills required for utilizing the benefits of ICTs (Mansell and When, 1998). Local language and relevancy are also a barrier for adoption of ICT based agro-advisory services (Munyua, 2007). Inability of farmers to understand most technical terms for effective use of ICTs media might be a constraint (Bhavnani et al., 2008). ICT initiatives are still out of access to marginal and rural ultra-poor farmers in emerging economies. Some farmers are satisfied with cost accounting at season's end, sometimes not even that. It means all farmers are not interested in a computerized managerial information system. Due to illiteracy, even after installation, farmers who are dissatisfied using ICT will discourage others to use it. Different farmers may have different preferences. There are some farmers who tried ICT and did not find it user-friendly enough, their special needs were not met so they decided to quit. Many experiences show that farmers unassociated with extension service are left behind professionally, that includes the use of ICT. Due to limited awareness of managerial information systems benefits they have yet to be internalized. Marketing of ICT is non-existent to farmers. These all lead to lack of ICT adoption in some rural villages of the emerging economies. The following ideas

must be adopted, especially by emerging economies, to overcome these impediments:

1. Including communities at all levels develop leadership and agents of change.
2. Share details of successful projects including benefits and their business opportunities (Gelb et al., 2008).
3. Including public/private partnerships secure ICT adoption funding.
4. Ensure leadership within the government and political environment.

## 10 Factors influencing adoption of ICT

ICT adoption rate is influenced by several factors. In emerging economies, accessibility to ICT relies on economic power and purchasing will of the farmers, whether they can afford it or not. Factors that influence IT adoption in Agriculture are grouped into different categories which are briefly describe below:

### 10.1 Access to information technology

The ICT gap between developed and emerging economies is due mainly to the accessibility of tools in every nook and corner of the country. It means an individual must have access to a computer equipped with IT like access to the WWW (World Wide Web) and email. It would not only include the use of a computer with IT ability, but also include the ability to upgrade computer software and hardware to facilitate IT use. Expense of internet use and price of IT equipment are also related to access to IT. To sum up, farmers should be made more accessible to use such means to have agricultural sustainability.

### 10.2 IT training/knowledge

It can be measured with variables like type of IT training, level of knowledge on IT use and days of IT training. It is hypothesized that the use of IT will increase as the quality and level of IT training increases. Framers in advanced countries are more trained and skillful as compared to developing. So, the adoption rate is high in developed economies. This signifies the need of emerging economies to focus on training programs on IT uses.

### 10.3 Demographic category

The adoption factors such as age, gender, education level and income level come under the demographic

category. It is believed that it will not significantly influence IT adoption and use. Although, IT use will be higher for younger, more educated individuals (Batte et al., 1990).

### 10.4 Trust

It is defined as an individual's optimistic expectation about the outcome of an event (Hosmer, 1995). Firstly, it is important to trust by an individual that information technologies will work and beneficial in accomplishing his/her goals by completing tasks. An individual must also trust information which they obtain via IT is accurate and the information they send will not be tampered with and privacy levels will be maintained (Chukwunonso and Tukur, 2012). Some individuals have a fear of IT or feel that it is difficult to use either due to their background or current environment. It is believed that if an individual has a positive thought or high trust level in IT, they will use IT more.

### 10.5 Time

As access to IT becomes more common place, it is believed that individuals will increase their use of IT over time. To evaluate their changes in IT use over time the same group of people may be surveyed twice. By establishing a dummy variable, time can be measured where each survey response from a survey will be assigned a value of zero and one according to the respective year. For each variable time- interaction variables can also be created by multiplying the original variable by the time variable.

### 10.6 Superiority

It is the degree to which an innovation is perceived as being better than the idea it supersedes. It is also expressed in terms of economic profitability or social prestige (Adegbidi et al., 2012). It is the degree of which the adopter believes that using a specific system will enhance his or her productivity. The new and modern ICTs are more easily adopted by the farmers assuming it is superior in application. Highly developed nations manufacture advanced ICTs tools and adopt them to do better farming.

### 10.7 Others

Acceptability, simplicity, observability, and Information quality influence the adoption of ICT in both developed and emerging economies. Acceptability rate is obviously high in developed economies. Simplicity is the degree of easiness to understand and use. In developing countries, the use of ICT is not clearly made understood to the end users. While in developed economies, the farmers are given training with

demonstrations and field experiments. Observability has positive correlation with the intention to adoption of ICTs on precision farming (Rezaei-Moghaddam and Salehi, 2010). For the farmers, the agricultural information must be relevant, complete, and accurate to apply it. Information quality also largely influences the adoption of ICT tools.

## 11 Conclusion

Developed and Emerging economies largely vary in ICT development. Digital inclusion, digital participation, basic digital skills, media literacy, and digital accessibility make a gap in Information and communication technology. ICT are ubiquitous in higher economies and almost all farmers are expected to have access to basic ICT that supports agriculture. Yet there is no uniform ICT distribution in the rural and urban areas. Farmers in developed economies over the last twenty years have already been using ICT in farming, including in irrigation, farming equipment, soil analysis, weather forecasting, e-marketing, and more. Technological advancement in the wireless facilities during the last few years have completely changed the telecommunication scenario in Japan, China, Mexico, Russia, etc. Agricultural sectors of emerging economies usually consist of small farmers with a poor access to physical infrastructure, market and extension information. It has helped connect financial institutions, smallholder rural farmers, retail providers, and the consumers. The data of ITU World Telecommunication in 2020 shows the worldwide total internet users of 86.6 per 100 inhabitants in developed countries, while it shows just 47 per 100 inhabitants in developing countries. Emerging economies like Bangladesh, Indonesia, Argentina, Philippines, Vietnam, Nigeria, etc. now have increasing rate of ICT adoption. The ICT acts to bring agricultural sustainability via better extension and advisory services, improved market access, Insurance and Risk Management, E-learning, Automation, Data-base Management, and Decision support system. Radio, Television, Computers, and smart phones are mostly used. Several Mobile Apps such as Agronote, AkerScout, Bushel, Crop Nutrient Advisor, and CropRecords are popular ICT apps for agriculture in developed economies. However, emerging economies still lack the adoption of modern ICT tools to their full potential. The farmers should be made accessible to such tools and efforts from part of the Government is necessary, especially in emerging economies.

## 12 Future research

The authors suggest that future research endeavors should include in-depth studies so that digital divide and ICT accessibility to farmers can be assessed and

more fully noted. Future research should be emphasized on developing the usage of ICTs by farmers adopting them with clear understanding. Training and extension programs in developing economies have been limited in scope. Initiatives such as extension services, seminars, and demonstrations showing the application methods of tools to make farmers aware of it is necessary. Developing economies need to invest in education services to the farmers and financial management for rural and poor farmers so that they can easily adopt the means of ICTs. It is hoped that the findings of this study present clear insights into efforts that will encourage farmers to use modern ICTs tools and motivate them to adopt effective means of agriculture development.

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## Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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