Role of ICT on Agriculture and Its Future Scope in Bangladesh

Sushan Chowhan and Shapla Rani Ghosh

1Adaptive Research and Extension Division, Bangladesh Institute of Nuclear Agriculture, Sub-Station, Ishurdi, Pabna, Bangladesh.

2Department of ICT, Madhupur Higher Secondary School (Collegiate School), Kumarkhali, Kushtia, Bangladesh.

Authors’ contributions

This work was carried out in collaboration between both authors. Author SC planned the study, collected relevant materials, review of literatures and wrote the initial draft of the manuscript. Author SRG wrote the IT related technical parts, prepared the tables and figures of the article. Author SC provided the final revision and optimized the literature search. Both authors read and approved the final manuscript.

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ABSTRACT

Agriculture is the oldest profession in the world. Since the historic human civilization periods, it has gradually developed. Technologies have enriched this occupation with the pace of time. Modern agriculture nowadays is so much dependent on ICT. A thorough review of secondary data sources; i.e. overlook of literatures from web, online published articles, reports, news etc. on some selective districts of Bangladesh was made to study the current features of ICT, its exercise and future prospects in the context of agriculture information and communication. Findings revealed that the majority of the farming group and thereby involved extension workers (SAAO) have limited access, usage, knowledge and capacity on the use of ICT tools and media. Farmers mostly use AICCs (Agriculture Information and Communication Centre), non-smart cell phones, TV and radio for agricultural communication. Conversely, SAAOs (Sub Assistant Agriculture Officer) used mobile phones, demonstrations and consulted AEO (Agriculture Extension Officer) for information and communications. Their utilization level of ICT based service was found much lower. Solutions to
1. INTRODUCTION

Bangladesh is an independent sovereign country located in the South-East Asia. It has borders with India and Myanmar (Burma) and is one of the most densely populated countries in the world (ranked 9th). Bearing world’s 8th largest population of 163,882,000 and the total area of 147,570 km² (ranked 92nd) makes it quite challenging for ensuring social safety issues to the public [1]. Due to geographical position it has predominantly rich fertile land, meaning good, arable land and has many rivers; thus, it’s been an agro-based country. In 2019, agriculture accounts for 14.23% of GDP and employs 40.60% of the labor force directly [2]. World population is expected to reach 9 billion by 2050, and agricultural production has to be increased by 60 percent from its 2005-2007 levels to meet additional food demand. Information and Communication Technology (ICT) applications may play a vital role to meet the new global food needs [3]. ICT is defined as “any device, tool, or application that permits the exchange or collection of data through interaction or transmission”. It “includes anything ranging from radio to satellite imagery to mobile phones or electronic money transfers” [4]. In a broad sense, ICT includes all the media that can record information (such as hard disk, CDs, etc.), technologies that broadcast information (such as wireless technologies), and technologies that enable people to communicate via audio or video (such as video cameras, mobile phones, etc.). The advances in ICT have spawned everything from small home electronic datasheets to large enterprise software packages, online software services, and the hardware and software used to deliver information over the Internet [5]. When these technologies are applied in agriculture; i.e. application of ICTs in agriculture is referred to as e-agriculture. Currently a considerable number of ICT tools are being used in the agricultural sector of Bangladesh. It has contributed directly or indirectly to the overall agricultural development of the country. It can send fast, consistent and exact information in a user-friendly manner for practical application by the end user [6]. ICTs can be used to enable, fortify or replace existing information systems and networks. Its utilization in agriculture can promote and distribute new and existing farming information for bringing social and economic changes [7]. It acts as a bridge in the communication gaps among development workers, rural organizations, farmers and enables bottom up articulation of needs. Information sharing of local knowledge and strengthening university-research-extension-farmer linkage can be quick, easy and hassle-free through modes of different ICT media [8].

Inception of ICT usage in Bangladesh agriculture was struggleful. Agriculture Information and Communication Centre (AICC) was established during 2009-2010 with the view to sharing of farm information to the people of farming communities. Now, 245 AICCs in the country providing services like weather information, crop cultivation techniques, insect disease information and latest price information to 40-50 farmers per day per AICCs which is not really sufficient [9]. However, the expenses involved in physical dissemination of information at right time, and difficulties in reaching the target audiences at different locations, have also created the urgency of introducing several ICT based media outlets in agricultural information exchange [10]. All these have been playing a pivotal role in the transfer of agricultural and non-agricultural technology transfer.

Due to favorable agricultural policies and the effective use of modern technologies, Bangladesh has become a role model in the agricultural sector globally. Today it ranks 2nd in fiber (jute), 3rd in dairy, 4th in rice, 5th in meat,
7th in potato and 10th in fish production. Though ICT has covered a large area in the farm sector but still a vast group of farmers, producers and growers are untouched by the blessings of ICT and its applications. These progresses are significant and enviable worldwide. Considering the above facts, the present review paper was prepared to investigate the critical parts of ICTs in the agricultural arena, their application in the grass-root level and to unhide the real scenario and situations faced by the farmers and extension workers for access to IT related services. The possible future scope of ICT, probable solution of the existing farming problems or systems were also reviewed during making this manuscript.

2. METHODOLOGY

To extract relevant literature on different roles of ICT in agriculture, abstracts and citations were traced through a search using the google search engine from March 2020 to April 2020. This paper mainly depends on the secondary data. Different published reports, journals and book reviews mainly supported in providing data in this paper. This is completely a review paper. Information elicited from these sources were synthesized towards addressing the set objectives of this review manuscript. It has been prepared by Internet searching, comprehensive studies of various articles published in various journals, books and proceedings available in the libraries of agricultural university (BAU, BSMRAU), academy (NATA) and research institutes (BARI, BRRI, BINA, BLRI, BFRI BARC). Some sources of data were also collected from the department of agricultural extension (DAE), department of livestock (DoL) and department of fisheries (DoF). Valuable information has been gathered through personal contact with respective resource personnel to enrich this article. Finally, all the related information was compiled to prepare this article.

3. RESULTS AND DISCUSSION

3.1 Use of ICT: Global and Bangladesh Perspective

Crop production, animal husbandry, fisheries, forestry, etc. are integral components of agriculture. Crops, however, undoubtedly constitute the largest and most important sector of Bangladesh agriculture. The Government of the state recognizes ICT as an indispensable tool in the fight against poverty. Consequently, it is also understood that ICT can enhance the contribution to agriculture and rural development tremendously [11].

Bangladesh ranked 147th among 176 countries in the ITU (International Telecommunication Union) ICT Development Index (ITU IDI) 2017 (Table 1), maintaining a similar position as last year in the medium and low IDI groups [12].

A mere rate of just 0.5% fixed telephone subscriptions (Table 2) resulted in the higher IDI ranking for Bangladesh [12]. Public are not interested to take a fixed phone subscription because of its inconvenience and lack of user-friendly service. But the number of mobile cellular service is gradually increasing due to it’s quality service, acceptability and convenient handling. It was observed that, European countries had the maximum rate (86.5%) of household internet whereas African states had the minimum (17.8%) rates. Asia and Pacific countries lied in the middle position contributing almost 51% (Fig. 1) [13]. On the other hand, usage of internet per 100 habitants (Fig. 2) were more in the developed countries (over 80%) compared to the developing countries (approximately 40%) [13]. This variation of user and usage may be due to the ICT facilities, policies, education level, employment, mode of usage and digitalization of different basic needs of the countries.

A significant amount of improvement was made in the mobile cellular telephone subscriptions worldwide reaching over 100% per 100 inhabitants; contrary, fixed telephone subscriptions has reduced drastically to below 10% due to the lack of ICT development. The rate of fixed broadband subscriptions and its enrichment was also seen to be unsatisfactory. Mobile broadband connection has been risen gradually in the last 10 years (Fig. 3) [13]. People nowadays want to use ICT enabled services from their mobile location; thus, immobile services showed a declining or steady trend.

Bearing a population of 16.5 million people; Bangladesh has gained a mobile cellular subscriber of about 16.2 million (Table 3) [13]. It is not likely that all of them have a SIM (subscriber identity module); but it’s the telecommunication policy that enables that one can subscribe to more than one SIM and company. The actual number of cellular phone user may be much less than the above-mentioned data.
Table 1. ICT development index (IDI)

| Country     | IDI 2017 rank | IDI 2017 value | IDI 2016 rank | IDI 2016 value |
|-------------|---------------|----------------|---------------|----------------|
| Sri Lanka   | 117/176       | 3.91           | 116/176       | 3.77           |
| India       | 134/176       | 3.03           | 138/176       | 2.65           |
| Bangladesh  | 147/176       | 2.53           | 146/176       | 2.37           |
| Pakistan    | 148/176       | 2.42           | 148/176       | 2.21           |

Source: [12]

Table 2. Different types of IT facilities used per 100 inhabitants in the South Asian countries

| Country     | Type of subscription/service | Year 2016 | Year 2015 |
|-------------|------------------------------|-----------|-----------|
| Sri Lanka   | Fixed telephone              | 11.4      | 15.2      |
|             | Mobile cellular              | 118.5     | 110.6     |
|             | Internet usage               | 32.10     | 30.0      |
| India       | Fixed telephone              | 1.9       | 2.0       |
|             | Mobile cellular              | 87.0      | 78.10     |
|             | Internet usage               | 29.50     | 26.0      |
| Bangladesh  | Fixed telephone              | 0.5       | 0.5       |
|             | Mobile cellular              | 77.90     | 81.9      |
|             | Internet usage               | 18.20     | 14.40     |
| Pakistan    | Fixed telephone              | 1.6       | 1.9       |
|             | Mobile cellular              | 71.40     | 66.90     |
|             | Internet usage               | 15.50     | 14.0      |

Source: [12]

Fig. 1. Percentage of households with internet by region in 2019

Source: [13]

Fig. 2. Individuals using the internet per 100 inhabitants

Source: [13]
Table 3. Trend of mobile cellular connections and internet usage in Bangladesh

| Year | Mobile cellular connections | Percentage of Individuals using the Internet |
|------|-----------------------------|---------------------------------------------|
| 2000 | 279,000                     | 0.07                                        |
| 2001 | 520,000                     | 0.13                                        |
| 2002 | 1,075,000                   | 0.14                                        |
| 2003 | 1,365,000                   | 0.16                                        |
| 2004 | 2,781,560                   | 0.20                                        |
| 2005 | 9,000,000                   | 0.24                                        |
| 2006 | 19,130,983                  | 1.00                                        |
| 2007 | 34,370,000                  | 1.80                                        |
| 2008 | 44,640,000                  | 2.50                                        |
| 2009 | 51,359,315                  | 3.10                                        |
| 2010 | 67,923,887                  | 3.70                                        |
| 2011 | 84,368,700                  | 4.50                                        |
| 2012 | 97,180,000                  | 5.00                                        |
| 2013 | 116,553,076                 | 6.63                                        |
| 2014 | 126,866,091                 | 13.90                                       |
| 2015 | 131,375,724                 | 14.40                                       |
| 2016 | 135,981,846                 | 18.02                                       |
| 2017 | 150,945,000                 | 15.00                                       |
| 2018 | 161,771,617                 | *                                           |

* Data not available

Source: [13]

3.2 Role of ICT in Agriculture

To adopt modern agricultural technologies and enhance production in a sustainable manner, ICTs can be efficiently used for collecting and sharing timely and accurate news on weather, inputs, markets, and prices; by feeding information into research and development initiatives (Fig. 4) [3,14]. Application of ICT in agriculture; i.e. e-agriculture promotes a multi-stakeholder, people-centric, cross-sectoral platform that will bring together all stakeholders, especially farmers and enable them to access timely and relevant information, exchange opinions, experiences, good practices and resources related to agriculture [15]. It allows easy access to ICTs including cell phones, radio, tv etc. for information dissemination this will also promote the integration of technology with multimedia, knowledge and culture. The urgent needs of ICT in e-agriculture [16] are as follows –

- Collecting, storing, maintaining data and information to provide farmers with real time information related to integrated crop management, input availability, dosage, irrigation, soil quality, fish culturing,
livestock, poultry etc. at the community level.

- Strengthening the existing information channels and develop new ones for a demand-driven, decentralized and localized extension program with proper management and efficient delivery.
- Fostering market access with necessary information and training to promote, support and enhance rural farm and non-farm enterprises locally and internationally.
- Mobilizing finance for rural farmers who are underserved by the commercial banking system and/or the country's microfinance NGOs.
- Build the capacity of farmers and extension workers through distance learning and by using local and relevant multimedia content and other means of ICTs.
- Organize/unite farmers nationally to enable exchange of knowledge, information and to ensure their collective voice and participation in policy formulation.
- Recognize and promote women’s role in agriculture.

3.3 Present Scenario of ICT in Agriculture

In the past few years, agriculture, fisheries and livestock ministries of GoB (Government of Bangladesh) and NGO (Non-government organization) took numerous initiatives to harness ICTs more effectively for strengthening extension systems, perform need-based research and deliver information services to the farmers. Below are a few of such examples-

3.3.1 AICCs

Agricultural Information and Communication Centers (AICCs) were set up as a common access points in the community for sharing information and services. There are 245 AICCs throughout the country covering all AEZs (Agro Ecological Zones). This center is managed by registered farmers’ cooperative organizations. In each AICC there’s a desktop computer, laptop computer, digital camera, internet facility, modem, multimedia projector, scanner and other digital devices. DAE and AIS (Agriculture Information Service) officials acts as facilitators to provide livelihood-based information (ICT, print and audio-visual contents) on agriculture, fisheries, poultry and livestock, education, non-farm initiatives, appropriate technology, human rights, employment, disaster management etc. [17].

3.3.2 Cellular mobile phone-based services

As most of the rural farmers don’t have internet facility and compatible cell phones. A series of cellular mobile based services are being introduced for them. “Krishok Bondhu Phone Sheba” is recently launched. Any registered farmer of a particular village can call to 3331 and take required service(s) from the agricultural extension department. To ensure fair value of the farmers’ hard-earned produce. Banglalink (GSM cellular mobile operator) is running an IVR (interactive voice response) based service “Banglalink krishi bazaar”. Farmers’ can avail this service by dialing 2474; this have empowered producers with important market information and eliminated the middle men effect. “Krishi Jigyasha” is another agro solution service of the same operator. Farmers’ have to dial 7676 and they can easily get agriculture related information and solution to thousands of problems. AIS has “Krishi call centre” service; which delivers similar service by dialing 16123 from any mobile phone. e-Purjee a text message service provides information on cultivation and supply of sugarcane. It built a network of sugarcane farmers in sugar plants across 15 districts. e-Purjee enabled timely supply of sugarcane, payment information and contributed to the increase in sugar productivity [15]. A Short Message Service (SMS) based gateway is also functioning for the agricultural communities; which enables them to receive weather forecast, important management actions to be taken, precautionary measures and other important messages. All these modes of communication have made farm communities aware and prepared for any given situation.

3.3.3 TV and radio

Several television and radio broadcasts agricultural related program on improved production technology, new indigenous high value crops, success stories, fishery and livestock related issues. “Mati-o-Manush (Soil and People)” is a joint production of Bangladesh TV and AIS; televised 5 times a week. “Banglar Krishi” made by AIS uploads different episodes regarding agricultural subjects in youtube channel. DoF also contribute segments of the show. Private TV channels also stepped forward. Popular shows like “Shyamol Bangla (Green Bangla)”, “Hridoye Mati O Manush (People and Soil at Heart)”, “Nodi O Jibon (River and Life)” and Krishi 24 all focuses on agriculture and agricultural issues. “Desh Amar Mati Amar”, a
state-run agriculture radio program, jointly designed with AIS, is broadcasted every day for 25 minutes. Regional radio stations also air similar programmes in coordination with respective regional AIS offices in the local dialects. “Green Hour” is another popular program now broadcasted by a FM radio channel with technical assistance form AIS [16]. A good number of community radio are also being running in different divisions of the country. They have reached to the grass root level people as these radio stations use local languages for conduction of programs.

3.3.4 Web-based Services

English based websites have limited access and understanding to the ordinary farmers; considering this in mind Bengali version of all web sites is created to support the agricultural stakeholders. Department of Agricultural Marketing (DAM) disseminates the wholesale and retail prices of major agricultural commodities of the 64 districts on their web (http://ais.portal.gov.bd/site/view/ekrishi/). “Krishi Batayon” is a national agricultural based portal (http://krishi.gov.bd/crop) prepared updated and maintained by DAE holds resource information on crop production, management, input supply, market information, weather, question answering. This portal is also developing farmers’ databases and will have farm level data that could be used in near future. AIS’s digital content “e-Krishi (e-agriculture)” available on http://ais.portal.gov.bd/site/view/ekrishi/. The Agricultural Research Management Information System (ARMIS) is an online web based the knowledge-sharing platform developed by BARC to enhance efficiency of the national agricultural research, thereby increasing profit of agricultural producers in Bangladesh and securing sustainable agricultural technology. All these rich information portals help farmers to enrich and gain new knowledge. Farmers can use the UDC (Union digital center) located at union parishes for taking web-based services.

3.3.5 GIS based services

Geographic Information System (GIS) as a computer assisted spatial information system in Bangladesh started in the early 90s. There are about 30 GIS installation in the country so far but researchers use GIS and RS (Remote Sensing) tools for research on agriculture (SRDI, BRRI, BARI) fisheries (FRI) and livestock (BLRI) as per organizational mandate. Currently there is very little scope for agricultural farmers to use GIS (Geographic information system) and related services [10]. The use of GIS and RS in Bangladesh is still at preliminary stage compared to the agriculturally advanced countries. BARC (Bangladesh Agricultural Research Council) has developed database on soil and land resources (land productivity), crop zoning (crop suitability), climate information management, and hydrology through the application of GIS and RS. SRDI’s customized SOLARIS (Soil and Land Resource Information System) -GIS based database maps soil data based on classification (soil texture, land type, landform, drainage, slope, surface water recession) and condition (crop suitability, land zoning, nutrient status and fertilizer recommendation). This GIS system can analyze data at the upazilla, district and finally at the national level. Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is also using these tools for major crop area monitoring since the last two decades [18].

3.3.6 Apps in smartphone

There are a large number of android apps for agriculture related technologies and other services. These apps have gained popularity in the grass root level people involved in crop, livestock and fisheries sector of Bangladesh. It has opened a new era of agriculture communication and feed-back; which is crucial for technology transfer and adoption. Today growers can easily share their knowledge, information and field related problems via this apps. “Krishoker (Farmers) app” is one of the exceptional android application software where rice growers can sell their produced rice with fare price without the involvement of the middle man in market [19]. It has saved time, cost and visit of the farmers resulting in effective service by the extension and research organizations [20].

On the other hand, weather forecasting and agro-metrollogical related apps have made farmers aware of rainfall, temperature, relative humidity, wind velocity and direction etc. factors (Fig. 5). Now they can plan and prepare in advance what, when and how they will do to manage their crops. Bangladesh government has invested a vast sum of money for the development of ICT sector and also motivating young researcher and extension workers to generate new ideas and innovations for service simplification. The main goal of these is to reduce the large and complex steps included in
service implementation and establish an effective means of communication. So, that a wide range of people (growers, entrepreneurs, stakeholders, extension worker, researchers and general people) may be benefited with limited resources.

3.4 Effectiveness of ICTs in Extension Services

3.4.1 Application of various ICT tools

Islam et al. [21] conducted a study on 110 SAAOs (Sub Assistant Agriculture Officer) of Manikganj district to investigate the use of different ICT tools for official purpose and found that about 94% of the respondents highly used mobile phone followed by smart phone (8%) and digital camera (6%). Rest of the tools had very limited use. It was a major concern that only 3% and 1% respondents (Fig. 6) highly used internet and computer respectively.

3.4.2 Utilization of ICTs for rendering service

SAAOs of Manikganj district were categorized into three groups viz. low, medium and high to know the utilization level of ICT for service delivery. Findings exposed that utilization level of ICT for providing services by majority of the respondents was low (Fig. 7). A total of 79% respondents were under low level category followed by 15.5% medium level and only 5.5 percent were under high utilization category [21].

3.4.3 Origin for information gathering

It was observed that majority of the respondents (SAAOs) always get their agricultural information from demonstration (49.1%) followed by consultation with AEO (48.2%) and mobile call (39.1%). A total of 37.3% of respondents used newspaper frequently for information collection. Seminar/ workshop/ conference and television were occasionally used information gathering by 49.1% and 44.5% respondents, respectively. Agricultural universities, different agricultural website, internet browsing and scientific paper/ thesis/ journal were never used as information origin by 82.7%, 66.4%, 52.7% and 51.8% respondents respectively. Only 21.8% (Table 4) respondents had high use of information sources [21]. This might be due to the lack of awareness and knowledge regarding modern information sources and ICT.

![Fig. 4. Role of ICT in agriculture](Source: [14])
3.4.4 Ingression to different ICT based media

Khalak et al. [22] carried out an investigation to find out farmers’ access to different ICT based media for getting agricultural information. Findings (Table 5) revealed that half of the farmers (50%) had limited access to cell phones and a significant portion (18%) do not have access to cell phone. However, around one-third (31.25%) of them had moderate access to cell phone. The reason was they could afford it to some extent. On the other hand, majority (84%) of the farmers do not have access to smart phone. Access to FM radio was better compared to smart phone which was more than one-third (37.5%) of the farmers. 68% of the farmers had limited to moderate access to television viewing. While more than 90% of the farmers do not have and personal computer and internet facilities. Nevertheless, a significant
portion (43.75%) of them had limited to moderate access in internet facilities provided by AICC. It was evident that, majority of the farmers (93.75%) do not had access to social network like Facebook and none of them had any access to e-mail.

Fig. 6. Rate of usage of ICT tools for official purpose by the SAAOs
Source: [21]

Fig. 7. Division of respondents as per utilization of ICT for rendering service
Source: [21]

Table 4. Use of information sources by the SAAOs at different upazilas of Manikganj

| SL. | Potential modes of information | Nature of usage (% respondents) |
|-----|--------------------------------|---------------------------------|
|     |                                | Never  | Rarely | Occasionally | Frequently | Always |
| 1   | Scientific paper/thesis/journal| 51.8   | 32.7   | 15.5         | 0          | 0      |
| 2   | Seminar/workshop/conferences   | 0      | 20.9   | 49.1         | 18.2       | 11.8   |
| 3   | Agriculture Extension Officer  | 0      | 1.8    | 11.8         | 38.2       | 48.2   |
| 4   | Extension specialist            | 1.8    | 13.6   | 32.7         | 21.8       | 30     |
| 5   | Agricultural Universities      | 82.7   | 14.5   | 0.9          | 0.9        | 0.9    |
| 6   | Demonstration                   | 0.9    | 2.7    | 29.1         | 17.3       | 49.1   |
| 7   | Using cell phone call           | 0.9    | 12.7   | 22.7         | 24.5       | 39.1   |
| 8   | Television                      | 0.9    | 10.9   | 44.5         | 22.7       | 20.9   |
| 9   | Radio                           | 15.5   | 32.7   | 27.3         | 15.5       | 9.1    |
| 10  | Newspaper                       | 3.6    | 9.1    | 30.9         | 37.3       | 19.1   |
| 11  | Internet browsing              | 52.7   | 27.3   | 13.6         | 4.5        | 1.8    |
| 12  | Agricultural website            | 66.4   | 13.6   | 18.2         | 0.9        | 0.9    |
| 13  | Union digital centers          | 15.5   | 34.5   | 35.5         | 12.7       | 1.8    |

Source: [21]
Kafura et al. [23] did a research on the extent of use of different ICT tools by the farmers in agricultural and non-agricultural purposes. It was found that (Table 6) in case of agricultural intention, TV ranked in 1st to watch Hridoye Mati-o-Manush followed by 2nd position to watch Mati-o-Manush. Conversely, computer ranked in 9th position. 10th position was jointly occupied by both Grameenphone Community Information Center service and use of CD/DVD. The ranked order on the extent of use of different ICT tools indicates that television and radio are still considered as the most effective tools for receiving agricultural information in traditional level. Contrary, in non-agricultural purposes television acquired the 1st position followed by mobile phone usage (2nd). Usage of internet and computer occupied 4th and 5th positions, respectively. From the above findings it was revealed that, mobile phone along with internet have ample opportunities to be utilized as extension tool to provide the farmers with necessary agricultural information.

### 3.4.5 Troubles in getting information

A focus group discussion (FGD) was conducted by [22] to elucidate the problems faced by the farmers in receiving agricultural information using ICT based medias. It was observed that (Table 7)

| SL. | ICT based media          | Adequate access | Moderate access | Limited access | Not at all |
|-----|--------------------------|-----------------|-----------------|----------------|------------|
| 1   | Cell phone               | 0 (0)           | 25 (31.25)      | 40 (50.0)      | 15 (18.75) |
| 2   | Smartphone               | 0 (0)           | 3 (3.75)        | 30 (37.5)      | 47 (58.75) |
| 3   | FM radio                 | 0 (0)           | 3 (3.75)        | 21 (26.25)     | 26 (32.5)  |
| 4   | Television               | 0 (0)           | 1 (1.25)        | 7 (8.75)       | 72 (90.0)  |
| 5   | Personal computer        | 0 (0)           | 0 (0)           | 3 (3.75)       | 77 (96.25) |
| 6   | Internet                 | 0 (0)           | 1 (1.25)        | 7 (8.75)       | 72 (90.0)  |
| 7   | Free internet facilities | 0 (0)           | 4 (5.0)         | 31 (38.75)     | 45 (56.25) |
| 8   | Facebook                 | 0 (0)           | 1 (1.25)        | 4 (5.0)        | 75 (93.75) |
| 9   | E-mail                   | 0 (0)           | 0 (0)           | 0 (0)          | 0 (0)      |

Number in the parentheses indicate percentage of the farmers. Source: [22]

| SL. | Items                                      | HiU | MU | HaU | TS | R   |
|-----|--------------------------------------------|-----|----|-----|----|-----|
| 01  | Use computer to get agricultural information | 0   | 0  | 3   | 3  | 9th |
| 02  | Use mobile phone to get agricultural information | 6   | 14 | 7   | 27 | 4th |
| 03  | Use of any mobile application related to agriculture | 0   | 4  | 0   | 4  | 8th |
| 04  | Use internet for agricultural purpose      | 6   | 6  | 9   | 21 | 6th |
| 05  | Use Banglalink Jigyasha 7676 service for agril. | 0   | 4  | 6   | 10 | 7th |
| 06  | Use of Grameenphone Community Information | 0   | 0  | 2   | 2  | 10th|
| 07  | Use of e-Krishok service in solving agril. Problem | 0   | 4  | 0   | 4  | 8th |
| 08  | Use TV to watch Mati-o-Manush              | 63  | 56 | 14  | 133| 2nd |
| 09  | Use TV to watch Hridoye Mati-o-Manush       | 93  | 52 | 14  | 159| 1st |
| 10  | Use radio to listen Sonali Phashal          | 12  | 14 | 11  | 37 | 3rd |
| 11  | Use radio to listen Desh Amar Mati Amar    | 9   | 10 | 4   | 23 | 5th |
| 12  | Use CD/DVD to get agricultural information | 0   | 0  | 2   | 2  | 10th|

| SL. | Items                                      | HiU | MU | HaU | TS | R   |
|-----|--------------------------------------------|-----|----|-----|----|-----|
| 01  | Use TV to watch other program              | 231 | 30 | 6   | 267| 1st |
| 02  | Use radio to listen other programs         | 54  | 64 | 16  | 134| 3rd |
| 03  | Use computer other than agricultural purpose | 75  | 24 | 10  | 109| 5th |
| 04  | Use mobile phone for non-agricultural purpose | 207 | 38 | 8   | 253| 2nd |
| 05  | Use internet for other purpose             | 102 | 14 | 1   | 117| 4th |

HiU = Highly use, MU= Moderately use, HaU= Hardly use, TS= Total score, R= Rank. Source: [23]
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Majority (61.25%) of the farmers mentioned that poor level of their education is the highest-level problem for getting better access to ICT based media. While more than half (53.75%) of the farmers had problem on lack of knowledge on ICT facilities. Two-third (67.5%) had the highest problem on operation knowledge of computer. Extreme majority of the farmers (88.75%) responded that social religious restriction is not at all (NAA) a problem for them. While more than half of the farmers had high level problem (56.25) of limited number of ICT center locally as well as lack of their personal interest (57.5%). On the other hand, majority (72%) of the farmers felt load shedding and lack of training on ICT as high-level problem.

3.5 Future Aspects for Development

Villagers of Bangladesh are still heavily dependent on agriculture for livelihood. Through ICT developments and technological advancements productivity and farm diversification may increase. Agri-industrialization, new markets, rural enterprises may emerge. Farmers would be economically active, nationally organized and socially conscious [11]. Some of the key points are discussed below where ICT could play a vital role in implementing those.

3.5.1 Human resource development

Education and training in agriculture plays a crucial role in knowledge and skill development of farmers, researchers, educators, extension staff and agri-stakeholders. Priority of ICT is rising in delivering distant education in the rural communities. It may be web based, but it may also include multimedia, besides content delivering it will ensure a high level of participation among farmers, service providers, consumers and administrators both synchronously and asynchronously. Literacy lessons for farmers can be combined with computer courses in the UDCs. Through computer communication e-mail may provide them to connect with remote teachers and trainers. For instance, farmers from one village to another can share their stories and knowledge on video. ICTs have great potentials to support rural women to deploy their resources for development. Women may run or work at small ICT enterprises such as tele-centers or CD-ROM content design. Through small enterprising, rural women can earn money by offering their information and communication services to fellow community members. This will also create opportunities for handicapped, immobile women and girls [11].

3.5.2 Research and development

Agricultural research organizations need to learn lessons from countries which face similar challenges like Bangladesh and devise a similar framework to ensure best use of ICTs in the area of agricultural research. Decision Support System in AGRO Technology Transfer (DSSAT) or similar software can reduce scientists’ or extension personnel’s workload by using computer generated crop simulation data on crop yield, yield contributing characters, nutrient

| SL. | Problems                                      | Extent of problems |
|-----|-----------------------------------------------|--------------------|
| 1   | Poor level of education                      | High: 49 (61.25)   |
|     |                                               | Medium: 31 (38.75) |
|     |                                               | Low: 0 (0)         |
|     |                                               | Not At All: 0 (0)  |
| 2   | Lack of knowledge on availability of ICT facilities | High: 43 (53.75)   |
|     |                                               | Medium: 34 (42.5)  |
|     |                                               | Low: 3 (3.75)      |
|     |                                               | Not At All: 0 (0)  |
| 3   | Lack of operational knowledge of computer     | High: 54 (67.5)    |
|     |                                               | Medium: 25 (31.25) |
|     |                                               | Low: 1 (1.25)      |
|     |                                               | Not At All: 0 (0)  |
| 4   | Social and religious restriction              | High: 0 (0)        |
|     |                                               | Medium: 1 (1.25)   |
|     |                                               | Low: 8 (10)        |
|     |                                               | Not At All: 71 (88.75) |
| 5   | Limited number of ICT center                 | High: 45 (56.25)   |
|     |                                               | Medium: 33 (41.25) |
|     |                                               | Low: 1 (1.25)      |
|     |                                               | Not At All: 1 (1.25) |
| 6   | High cost of internet service                | High: 13 (16.25)   |
|     |                                               | Medium: 57 (72.25) |
|     |                                               | Low: 10 (12.5)     |
|     |                                               | Not At All: 0 (0)  |
| 7   | Lack of personal interest                     | High: 46 (57.5)    |
|     |                                               | Medium: 26 (32.5)  |
|     |                                               | Low: 5 (6.25)      |
|     |                                               | Not At All: 3 (3.75) |
| 8   | Low bandwidth speed of internet              | High: 22 (27.5)    |
|     |                                               | Medium: 42 (52.5)  |
|     |                                               | Low: 16 (20)       |
|     |                                               | Not At All: 0 (0)  |
| 9   | Lack of ICT software                          | High: 21 (26.25)   |
|     |                                               | Medium: 43 (53.75) |
|     |                                               | Low: 16 (20)       |
|     |                                               | Not At All: 0 (0)  |
| 10  | Electricity problem                           | High: 42 (52.5)    |
|     |                                               | Medium: 37 (46.25) |
|     |                                               | Low: 1 (1.25)      |
|     |                                               | Not At All: 0 (0)  |
| 11  | Lack of training facilities                  | High: 50 (62.5)    |
|     |                                               | Medium: 24 (30)    |
|     |                                               | Low: 6 (7.5)       |
|     |                                               | Not At All: 0 (0)  |

Number in the parentheses indicate percentage of the farmers; Source: [22]
uptakes etc. [16]. Conversely, for development of climate change resilient technologies and prediction of future crop yield and weather data; different climate simulation models should also be taken into consideration [24].

3.5.3 Knowledge management

In the case of zoonotic diseases (transmissible between humans and animals, causing infection in both species), an ICT based surveillance system is essential for timely and accurate detection, diagnosis, prevention, and control. Knowledge bank should be comprised of items like production/culture/rearing technology, breed/variety information, environmental management, production planning, decision support, and documentaries etc. needs to be developed through ICTs to ensure proper managements in a sustainable manner.

3.5.4 Digital content for information transmission

Digital content-based advocacy, awareness and capacity development programs can be leveraged even further by utilizing newer channels such as mobile based content deployment to improve the capacity of the farmers. As most farmers are illiterate or only has basic literacy, multi-media content is an effective way to communicate critical and complex messages. ICT can also bridge the gender gap and bring the necessary information and services to women at their doorsteps.

3.5.5 Access to market

ICT can serve as a bridge and provide relevant business and market information to rural areas to reduce their isolation and foster new income-generating activities in the agribusiness and other non-farm activities by improving communication linkages between growers, processors and retailers. IT can enable foreign buyers to track an animal-based product to the farm and can facilitate a substantial boost to export. Labeling for quality, food and bio-safety is emerging as an essential information service for consumers and for participating in global animal products trade. Services like E-Choupal (an India based business initiative by ITC Limited that provides Internet access to rural farmers for procurement of agricultural products) can be initiated. Thus, integration of ICT in livestock production and marketing is becoming important. To ensure better prices to farmers a new supply chain is needed to be evolved by linking telecentres (Union information and service center) with national level retailers and exporters [16].

3.5.6 Rural finance

Innovations in ICT such as a personal computer connected to the internet, an automated teller machine (ATM), a point of sale (POS) device located at a local retail or postal outlets can be a sustainable and affordable alternative to connect rural farmers to formal banking system. Remote mobile loan payments can be initiated using short message service (SMS), and wireless application protocol (WAP) technologies. Payment of electric bill and other utility bills through mobile phone (bKash and similar apps) has also opened doors to re-think the current payment system for input level subsidies [16].

3.5.7 Use of GPS and radio-based technologies

Fishermen can be equipped with Global Position System (GPS) to find their way when lost during extreme climatic condition. Vessel monitoring system (VMS) may be used to ensure fishing vessels comply with regulations designed to promote sustainable management. GPS based technologies linked with satellite can be utilized for fish forecasting and guiding fishermen to the spot in sea where the likelihood of higher catch is brighter. To ensure sustainability, this capability coupled with the knowledge oceanographic conditions affecting fishery population and historical catch data can lead towards forecasting of fish populations and thereby assist in extraction more efficiently. A simple two way radio or even a community radio station in the coastal area can disseminate weather alert in time for safety of the fishing communities [16].

3.5.8 GIS based soil mapping

There is no alternative to increase and apply the use of GIS in the coming years to sustain agricultural production. A GIS based soil mapping system at the union level can analyze data and provide information relating to crop suitability, land zoning, nutrient status and fertilizer dosage. Satellite based data will help to define flooding by its characteristics (river flood, flash flood, tidal flood, rain fed flood) and duration of inundation. This system can also be applied to assess drought, salinity and cold stresses for each soil map unit [11].
3.5.9 Agriculture database and encyclopedia

A powerful agriculture database can be created which will compile and collate the actual location specific need of farmers and classify it in an intelligent format for use by decision makers, researchers, traders and industrialists. On the other hand, a dynamic agriculture-based encyclopedia can be developed for use by farmers, agriculture extension workers, agri-input dealers and various stakeholders. This will provide immense opportunity for the scholars and agriculture scientists to play a dynamic role in the transformation of Bangladeshi agriculture to a sustainable state [11].

3.5.10 Development of a modern extension system

Many of the agricultural threats Bangladesh facing today has a common solution to improve the rate of knowledge and technology transfer to the farmers for adoption of climate smart crop varieties. Specific benefits of ICT enabled extension services are-

- A new range of additional media that can be part of the communication for development “mix” of traditional and/or appropriate media.
- Bottom-up articulation and sharing of information on needs and local knowledge;
- Increased efficiency in use of development resources; as information is more widely accessible;
- Less duplication of activities
- Boosting up communication - locally, nationally and globally
- Lessen communication expenses compared to other available communication choices.
- Provide total digital services from planning to sales
- Proactive digital services based on cultivation calendar, control calendar, growth model and natural condition
- Marketplace for both retail and wholesale
- Smart farming based on IoT (Internet of Things)

In agriculture sector the following services may be incorporated in different organizations to improve the quality of service, communication and information transfer-

- BADC Fertilizer management
- BARI/BRRI/BINA crop management service system
- BARI/BRRI/BINA analysis and seed supply system
- Digital crop development and management system
- Technology, seed and germplasm management system

The most obvious application of ICT in veterinary services can be the use of AI (Artificial Intelligence) smartphones that will cooperate a veterinarian to provide veterinary services remotely and maintain animal records. With imaging capacities of cheap smart phones and digital cameras, veterinary consultancy can further be improved. This is a form of veterinary tele-medicine. Prospect of leveraging call centers at veterinary hospitals and Institutions is also bright to provide the most appropriate solutions. Mobile veterinary clinics equipped with latest technologies including X-Ray camera, digital imaging system, fax, printer, scanner, webcam and internet equipped laptops etc. can allow veterinarians to perform almost the entire range of veterinary services and expand the coverage area of extension. New and emerging technologies like, crop management, improved nutrient balance, and integrated aquaculture techniques are increasingly becoming complex and location specific. On demand consultations based on video call from smart phone can play a very important role in this regard. ICTs can be leveraged to shorten the transmission of new technology and skills form the research laboratories to the field officials for ultimate dissemination in field.

4. CONCLUSION

In an era of globalization and technological advancements it is impossible to learn, earn knowledge and practice the benefits of applied sciences without the usage and application of ICT. Goal of Bangladesh is to become an upper middle-income country by 2040 through Vision 2041. For that all sectors should develop equally. Due to geographic and climatic vulnerability; agriculture of this country is always at challenge and risk. As reviewed above ICT sector of Bangladesh is yet to develop and still a long way to go. But with this limited resources and constraints it has already achieved prestigious and proud position in world agriculture. From the above assessments it was observed that, extension workers (SAAO) and farmers had very limited access, usage, knowledge, interest and
capacity to utilize the ICT based media and tools; but they still sustained the production. To ensure proper and effective ICT based facilities; electricity, dedicated bandwidth, cost of internet data, supply of computer, smartphone, IT trainings must be taken into consideration. In the coming decades agriculture is going to be more complex and difficult. The future of farming will be more information based, computerized, software oriented and wireless. Technologies like drone, artificial intelligence, robotics, nano tech, machine learning, big data analytics are now time demanding issues to be introduced in agriculture and sustain production.

**DISCLAIMER**

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**COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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