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Web Annex for document ERC/18/3: E-agriculture: the Use of Information and Communication Technologies (ICTs) for the Development of Sustainable and Inclusive Food Systems and Trade Integration

1. This note defines in detail the concept of e-agriculture, presents key technologies and e-agriculture applications, both on-farm and focusing on inclusive value chains.

Defining e-agriculture

2. E-agriculture involves designing, developing and applying innovative ways to use information and communication technologies (ICTs) in the rural domain, with a primary focus on agriculture and food, including fisheries, forestry and livestock. Technological application, facilitation, support of standards and norms, capacity development, education and extension belong to the broader concept of e-agriculture (Figure1). The definition extends beyond the e-government aspect of agriculture, since it includes not only agricultural services provided by governments to citizens (e.g. farmers and rural communities) via ICTs, but it also encompasses a whole range of products, services and infrastructure provided by government, the private sector, public research and extension organizations, non-governmental organizations (NGOs), farmers' organizations, and intergovernmental organizations.

Figure 1. ICTs in Agriculture (Source: FAO)

3. The information and communication technologies that can be harnessed for e-agriculture may include devices, networks, services and applications. These can range from cutting-edge Internet-based technologies and sensing tools, such as big data, Internet of Things, artificial intelligence, cloud computing and machine-to-machine (M2M) (Box1), to traditional technologies e.g. radio, telephones, mobile phones, television and satellites.

Box 1: New generation of information and communication technologies

Big data are large volumes of information that can come from different sources such as telecom records, social media, sensors, point-of-sale terminals, Global Positioning System (GPS) devices, and so forth. Using innovative tools, these large volumes of granular data can be analysed to produce meaningful information serving agricultural and food sectors, livestock, fisheries, etc. This can continuously provide information in real time and at a lower cost.

Machine- to-machine (M2M) refers to direct communication between devices using any communications channel, including wired and wireless. M2M communication can include industrial instrumentation, enabling a sensor or meter to communicate the data it records to application software that can use it.

Internet of Things (IoT) is a combination of sensors and various tiny devices embedded in physical objects and linked through wired and wireless networks that generate huge data volumes (often big data) analysed in dedicated applications. IoT offers an advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications and covers a variety of protocols, domains, and applications.

Artificial intelligence (AI) is intelligence demonstrated by machines that become increasingly capable of replacing human operations. AI in agriculture is emerging in three major categories: (i) agricultural robotics, e.g. next generation of drones; (ii) soil and crop monitoring; and (iii) predictive analytics.

Cloud computing is an information technology paradigm that enables universal access to shared pools of configurable system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet.

4. The Food and Agriculture Organization of the United Nations (FAO) and the International Telecommunication Union (ITU) adopted the term e-agriculture after the World Summits on the Information Society in 2003 and 2005. Since then, other terms have emerged such as smart farming, precision agriculture and digital agriculture. These definitions place stronger emphasis on the challenges brought by the new generation of ICTs, or are limited to certain on-farm technology applications, while FAO and ITU refer to a broader definition that would provide diverse technological solutions in addressing existing problems in agriculture and rural development. At the same time, the term e-agriculture goes beyond sole technological applications in food and agriculture highlighting that enabling environments and capacity development go hand in hand for achievement of the e-agriculture objective.

5. Access to information empowers stakeholders, enabling informed and inclusive decision-making and increasing the productive and sustainable use of available resources.

6. FAO has been promoting the use of e-agriculture and has focused on ICT innovation to improve agricultural production and value chains (Figure2). Examples show that:

- Food traceability systems using ICTs as an important risk-management tool have allowed food business operators and authorities to contain food safety problems and promote trust in the value chain, both across the value chain and among value chain operators;
- Geographic information system (GIS) and agro-meteorological technologies have contributed to better land use planning, crop forecasting and early warning systems. Space technology is also essential to monitoring threats from the growing number of natural disasters;
- The use of mobile phone technology for information exchange such as disease surveillance and pest tracking has become routine in many countries in Europe and Central Asia (ECA);
- In the Europe and Central Asia region FAO has implemented projects that included the establishment of a rural radio in Armenia and of national online networks enhancing collaborative action among Agricultural Innovation System actors in Albania and Armenia; it also has assisted national AGROWEB platforms and thematic networks for food safety, medicinal and aromatic plants, fisheries and more.

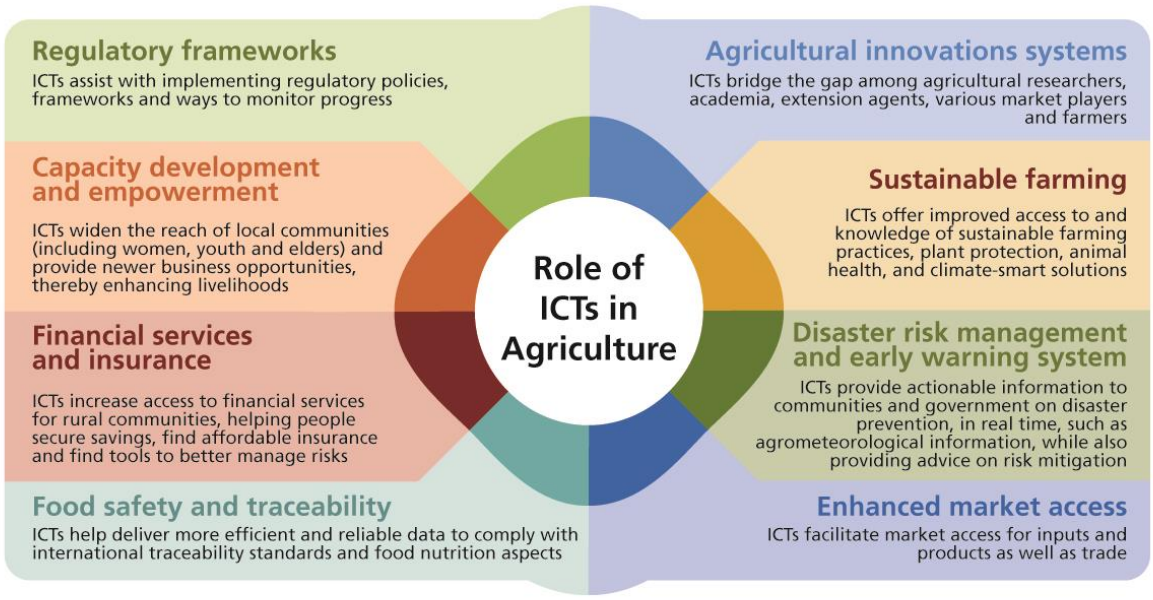

Figure 2. The role of ICTs in agriculture (Source: FAO)

7. Other benefits of modern e-agriculture include:

- Increased production – optimized crop treatment such as accurate planting, watering, pesticide application and harvesting directly affects production rates.
- Water conservation – weather predictions and soil-moisture sensors allow for water use only when and where needed.

- Real-time data and production insight – farmers can visualize production levels, soil moisture and sunlight intensity, and more remotely in real time to accelerate the decision-making process.
- Lowered operation costs – automating processes in planting, treatment and harvesting can reduce resource consumption, human error and overall cost.
- Increased quality of production – analysing production quality and results in correlation to treatment can teach farmers to adjust processes to increase product quality.
- Accurate farm and field evaluation – accurately tracking production rates by field over time allows for detailed predicting of future crop yield and the value of a farm.
- Improved livestock farming – sensors and machines can be used to detect earlier any reproduction and health events in animals. Geo-fencing location tracking also can improve livestock monitoring and management.
- Reduced environmental footprint – all conservation efforts such as water usage and increased production per land unit directly affect the environmental footprint positively.
- Remote monitoring – local and commercial farmers can monitor multiple fields in multiple locations around the globe from an Internet connection. Decisions can be made in real time and from anywhere.
- Equipment monitoring – farming equipment can be monitored and maintained according to production rates, labour effectiveness and failure prediction.

8. Technology challenges in applying e-agriculture include triple divide, complexity of using large sets of data and their analysis, open data, data ownership and data sovereignty, interoperability, slow adoption of innovations in agriculture and security concerns, related to cybercrime. Cybercrime includes "offences against confidentiality, integrity and availability of information and communication infrastructure"; "computer-related traditional crimes"; "content-related offences"; "offences related to infringements of copyright and related rights". High usage of the Internet enhances one's vulnerability to those crimes. Furthermore, the costs of cybercrimes are economic, political and social (UNCTAD, 2014). It is therefore important to extend conventional crime legislation to cover online activity and new forms of crime as listed above.

9. FAO piloted a regional eAGRI index assessing Europe and Central Asia countries' demand and preparedness to formulate and implement a strategy towards transforming their agricultural sectors through digitalization. The index is based on 90 existing indicators on the status of adoption of ICTs in the country,[1] the enabling environment for ICTs[2] as well as agriculture-related macroeconomic indicators[3]. It provides guidance on the areas of emphasis/de-emphasis of the national e-agriculture strategies, such as infrastructure, rural and gender divide, business environment, government preparedness to use ICTs etc., thus offering a possibility for cost-efficiency during strategy implementation, while also indicating knowledge transfer opportunities with relevant Europe and Central Asia champion countries. Three clusters have been identified based on the importance of the agriculture sector for the national economy. Countries

[1]Main ICT indicators used are: (i) Percentage of Internet users; (ii) Percentage of the population covered by at least a 3G mobile network; (iii) Percentage of the population covered by at least LTE/WiMAX mobile network; (iv) Active mobile-broadband subscriptions per 100 inhabitants; (v) Estimated proportion of households with Internet access at home. Source: ITU WTID 2017

[2]Main ICT environment indicators used are: (i) Availability of latest technologies; (ii) Government success in ICT promotion; (iii) ICT use and government efficiency; (iv) Importance of ICTs to government vision; (v) Laws relating to ICTs. Source: WEF NRI 2016 (Executive Opinion Survey)

[3] Main agricultural macroeconomic indicators used are: (i) Agriculture, value added (percent of GDP); (ii) Employment in agriculture (percent of total employment); (iii) Agriculture value added per worker (constant 2010 USD); (iv) Total Factor Productivity growth (2005-2014) (TFP). Source Word Bank and USDAERS

attaching low importance to agriculture and a high ICT-enabling environment may decide to cover e-agriculture challenges through a holistic digital economy strategy, while countries attaching high importance to agriculture shall adopt a sectoral e-agriculture strategy (Table 1 and 2, and Figure 3).

Table 1. Share of agriculture in the economy

High share of agriculture in the economy	1. High level of worker productivity and/or Total Factor Productivity (TFP)
	2. High or medium level of TFP
	3. Low worker productivity and TFP
Medium share of agriculture in the economy	4. High productivity and TFP
	5. Average productivity and high TFP
	6. Average or low productivity and TFP
Low share of agriculture in the economy	7. High and medium level of worker productivity and TFP
	8. High and medium level of worker productivity and low level of TFP

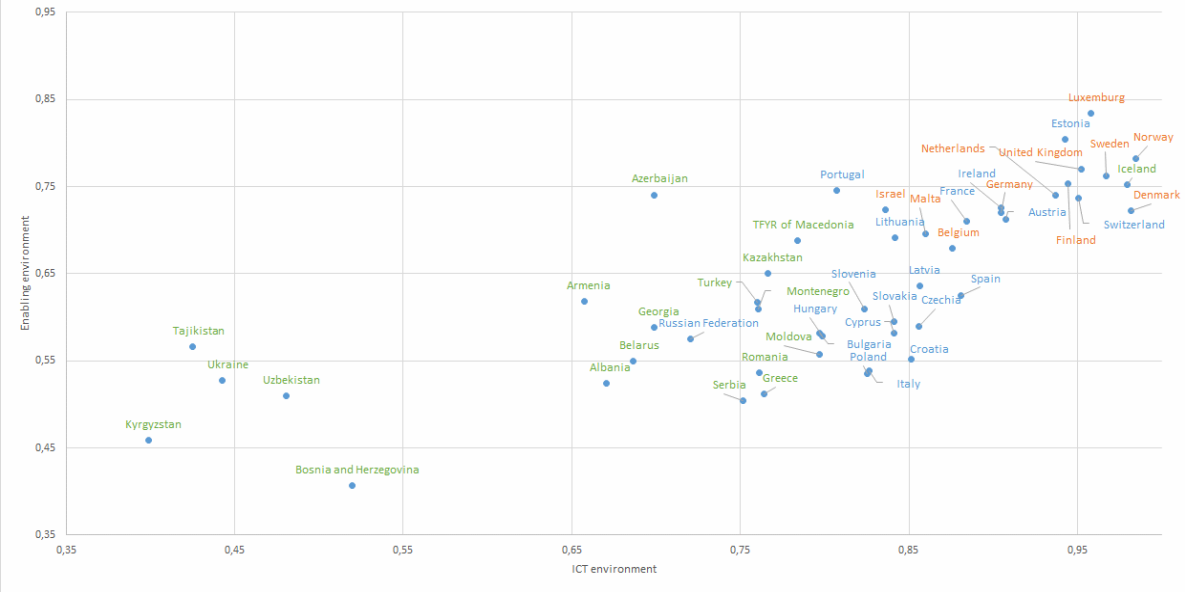

Figure 3. Mapping of Europe and Central Asia countries according ICT environment, enabling environment and share of agriculture

Table 2.[4,5] *eAgri index and country clusters*

Countries with low share of agriculture in the economy	**ICT environment score**	**Enabling environment score**	**eAGRI score**	**ICT environment rank**	**Enabling environment rank**	**eAgri Rank**	**eAgri Group rank**
Belgium	0.87592	0.67876	0.77734	16	21	17	10
Denmark	0.98194	0.7219	0.85192	2	14	7	5
Germany	0.90471	0.72028	0.81249	13	15	12	7
Israel	0.83583	0.72381	0.77982	24	13	15	8
Luxemburg	0.95815	0.83393	0.89604	5	1	1	1
Malta	0.85971	0.69584	0.77778	17	18	16	9
Netherlands	0.93688	0.74023	0.83856	10	10	10	6
Norway	0.98481	0.78265	0.88373	1	3	2	2
Sweden	0.96701	0.76231	0.86466	4	5	5	3
United Kingdom	0.95214	0.76961	0.86087	6	4	6	4
Countries with medium share of agriculture in the economy	**ICT environment score**	**Enabling environment score**	**eARI score**	**ICT environment rank**	**Enabling environment rank**	**eAgri Rank**	**eAgri Group rank**
Austria	0.90748	0.71255	0.81001	11	16	13	5
Bulgaria	0.79695	0.58169	0.68932	31	33	30	16
Croatia	0.85134	0.55214	0.70174	20	38	29	15
Cyprus	0.84137	0.58198	0.71167	23	32	27	14
Czechia	0.85594	0.58939	0.72267	19	30	23	11

[4] Color-coding of Table 2: The red color in the table indicates the highest cluster's rank; the grey color is for the lowest rank; while the colors of the countries show the classification from Table 1 above.
[5] For Andorra, Monaco and Turkmenistan no data is available in this matter.

Estonia	0.94285	0.80432	0.87359	9	2	3	1
Finland	0.94415	0.75303	0.84859	8	6	8	2
France	0.88443	0.71034	0.79738	14	17	14	6
Hungary	0.79869	0.57851	0.6886	29	34	32	17
Ireland	0.90476	0.72558	0.81517	12	12	11	4
Italy	0.82645	0.53815	0.6823	25	40	34	18
Latvia	0.85635	0.63594	0.74614	18	23	21	10
Lithuania	0.8418	0.69138	0.76659	21	19	19	8
Poland	0.82524	0.53487	0.68005	26	42	35	19
Portugal	0.80728	0.74542	0.77635	28	8	18	7
Russian Federation	0.72052	0.57535	0.64793	39	35	38	20
Slovakia	0.84148	0.59557	0.71852	22	29	25	12
Slovenia	0.82336	0.60974	0.71655	27	28	26	13
Spain	0.88099	0.62502	0.753	15	24	20	9
Switzerland	0.9504	0.73688	0.84364	7	11	9	3
Countries with high share of agriculture in the economy	**ICT environment score**	**Enabling environment score**	**eARI score**	**ICT environment rank**	**Enabling environment rank**	**eAgri Rank**	**eAgri Group rank**
Albania	0.67028	0.52435	0.59732	43	44	44	14
Armenia	0.6577	0.61841	0.63805	44	25	41	11
Azerbaijan	0.69899	0.74061	0.7198	40	9	24	3
Belarus	0.68653	0,55*	0.61827	42	39	43	13
Bosnia and Herzegovina	0.51957	0.40732	0.46344	45	49	48	18
Georgia	0.69864	0.58888	0.64376	41	31	39	9
Greece	0.76391	0.51223	0.63807	34	45	40	10

Iceland	0.9794	0.75192	0.86566	3	7	4	1
Kazakhstan	0.76634	0.65032	0.70833	33	22	28	4
Kyrgyzstan	0.39874	0.45918	0.42896	49	48	49	19
Republic of Moldova	0.79695	0.55768	0.67732	30	37	36	7
Montenegro	0.76079	0.61005	0.68542	36	27	33	6
Romania	0.76144	0.53694	0.64919	35	41	37	8
Serbia	0.75173	0.5045	0.62811	38	47	42	13
Tajikistan	0.42501	0.56605	0.49553	48	36	45	15
The former Yugoslav Republic of Macedonia	0.78419	0.68819	0.73619	32	20	22	2
Turkey	0.76001	0.61726	0.68863	37	26	31	5
Ukraine	0.44258	0.52715	0.48486	47	43	47	17
Uzbekistan	0.48056	0,51**	0.49528	46	46	46	16

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