POSSIBLE USE OF ICT IN AGRICULTURE FOR A SUSTAINABLE DEVELOPMENT

Georgeta-Mădălina Meghișan-Toma[1] and Vasile Cosmin Nicula[2]
[1)]The Bucharest University of Economic Studies, Romanian Academy, National Institute of Economic Research "Costin C. Kiritescu", Romania
[2)] The Bucharest University of Economic Studies, Romania
E-mail: madalina.meghisan@fabiz.ase.ro; E-mail: vasilecosminnicula@gmail.com

Please cite this paper as:

Meghișan-Toma, G.M. and Nicula, V.C., 2020. Possible Use of ICT in Agriculture for a Sustainable Development. In: R. Pamfilie, V. Dinu, L. Tăchiciu, D. Pleșea, C. Vasiliu eds. *6th BASIQ International Conference on New Trends in Sustainable Business and Consumption.* Messina, Italy, 4-6 June 2020. Bucharest: ASE, pp. 1287-1295

Abstract
In agriculture, digitization is one of the tools that can bring a major contribution to the processes' optimization, from a sustainable perspective. The main research approach in this paper is to establish the determinants of ICT usage at the level of the European Union's countries (E.U.-28) for the period 2012-2019, for further possible benefits in creating a sustainable agriculture. The current research opens up the perspective for further analysis, based on the following aspects: sustainable agriculture and information communication technology (ICT) during all the logistics chain (food production, food processing, food distribution, food consumption)

Keywords
ICT, agriculture, greenhouse gas emissions, pollutants from agriculture, Internet users, sustainability

JEL Classification
M20, M10, N54

Introduction

Information and communication technology (ICT) is widely used in all fields for its characteristics of enabling resources' efficiency, enhancing productivity and strengthening security. (Svenfelt and Zapico, 2016) In agriculture, digitization is one of the tools that can bring a major contribution to processes optimization, from a sustainable perspective. The main research approach in this paper is to establish the determinants of ICT usage at the level of the European Union's countries (E.U.-28) for the period 2012-2019, for further possible benefits in creating a sustainable agriculture.
The research article has the following structure. In the "Literature review part", the main research results, in the field of ICT influence on pollution decrease, are presented. The "Research methodology" part focuses on the main pollutants in agriculture industry, together with establishing the main ICT usage determinants, based on available data on Eurostat for

the period 2012-2019, at the level of the European Union's member states. The "Results" part underlines the main ICT usage determinants that can be used for further analysis in determining the influence on agriculture pollutants. The "Conclusions" part states the importance of this approach and opens up the research towards the concept of precision agriculture.

Literature review

The 2030 Agenda for Sustainable Development emphasizes the priority for all countries to implement the 17th Sustainable Development Goals (SDGs), among which we mention: "No poverty"; "Zero hunger"; "Responsible consumption and production" (SDG, 2020).

Agriculture industry had a contribution of 1,1% of European Union's GDP in 2018 (Eurostat, 2019). The total surface used for agricultural production at the level of European Union is 173 mil. hectares, representing 39% of the total land area of E.U. (2016)

The Common Agricultural Policy (CAP) was updated with 9 objectives beyond 2020: "to ensure a fair income to farmers"; "to increase competitiveness"; "to rebalance the power in the food chain"; "climate change action"; "environmental care"; "to preserve landscape and biodiversity"; "to support generational renewal"; "vibrant rural areas"; to protect food and health quality" (Eurostat, 2019). In order to achieve these objectives, it is compulsory to create a solid base for innovation and technological development. ICT could play an important part in improving the sustainable development in agriculture.

There were several studies made with regard to the connection between ICT penetration rate and emissions of CO2. Danish et al. (2019) reached the conclusion that ICT diminishes the emissions of CO2 only in countries with high and middle income while, for the countries with low income ICT increases the CO2 emissions. Park et al. (2018) conducted a research in this field and the results underlined that ICT reduces CO2 emissions. Also, Ozcan & Apergis (2018) reached the conclusion that Internet usage reduces CO2 emissions. On the other hand, the results of the research of Avom et al. (2020) underline that an increase of ICT penetration rate "both in terms of internet users and mobile phone subscribers" impacts negatively "the environmental quality by increasing carbon emissions".

Research methodology

Analysing the farm area at the level of the countries of the European Union, Romania has 3.422.030 agricultural holdings, representing 32,7% of EU-28 farm area, followed by the other EU countries, such as: Poland (1.410.490 agricultural holdings), Italy (1.145.710 agricultural holdings), Spain (933.060 agricultural holdings) etc. (2016) (Fig. no. 1)

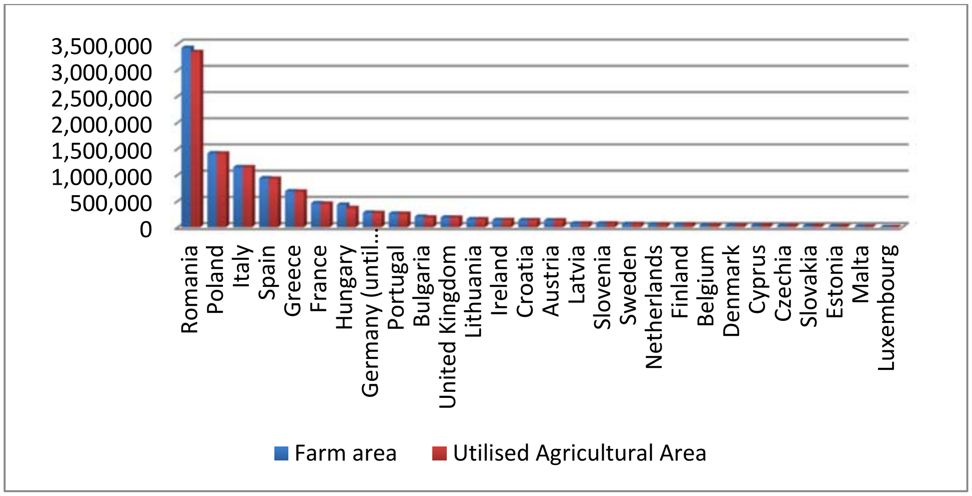

Fig. no. 1 Farm area vs utilised Agricultural Area at the level of the European Union' states (agricultural holdings) (2016)
Source: EUROSTAT, 2020

Agricultural holdings represent an important number at the level of the European Union's member states. Agriculture sector should target towards sustainability, by diminishing the pollutants in air, soil and water.
According to the official data, over 75% of ammonia emissions are produced in agriculture (Eurostat, 2017). The following European Union's states have the highest level of ammonia emissions from agriculture: Germany (647.625 tones in 2016 and 639.807 tonnes in 2017), France (569.858 tonnes in 2016 and 6568.243 tonnes in 2017), Spain (453.398 tonnes in 2016 and 469.857 tonnes in 2017), Italy (370.022 tonnes in 2016 and 362.178 tonnes in 2017). (Fig. no 2)

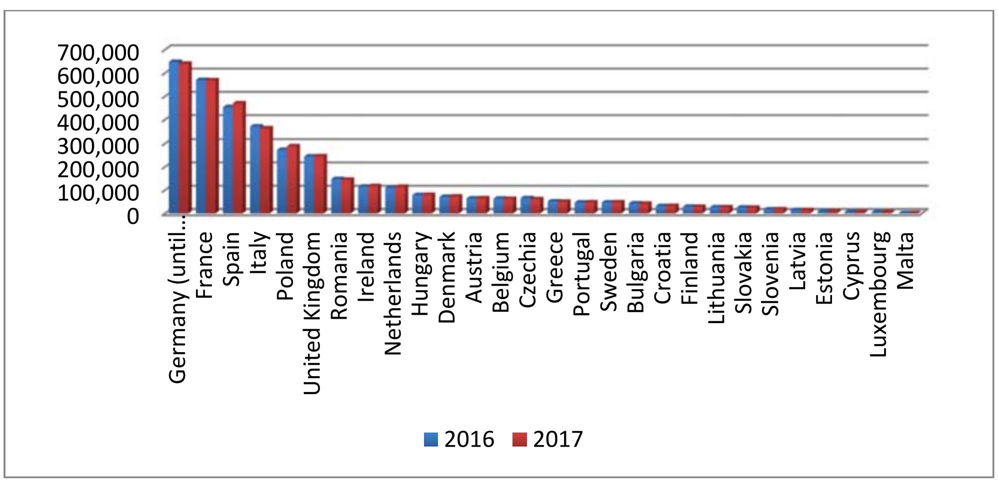

Fig. no. 2 Ammonia pollutant from Agriculture (tonnes) (2016-2017)
Source: EUROSTAT, 2020

Energy emissions generated 80,7% of the emissions of greenhouse gasses, followed by agriculture (8,72%), Industrial processes and product usage (7,82%) and waste management (2,75%) at the level of the year 2017 (Eurostat, 2018). In European Union's countries, France generates the highest amount of greenhouse gasses from agriculture (75.786,9 thousand tonnes in 2016 and 76.208,53 thousand tonnes in 2017), followed by Germany (66.536,07 thousand tonnes in 2016 and 66.272,9 thousand tonnes in 2017) and United Kingdom (40.890,88 thousand tonnes in 2016 and 41.247,44 thousand tonnes in 2017).

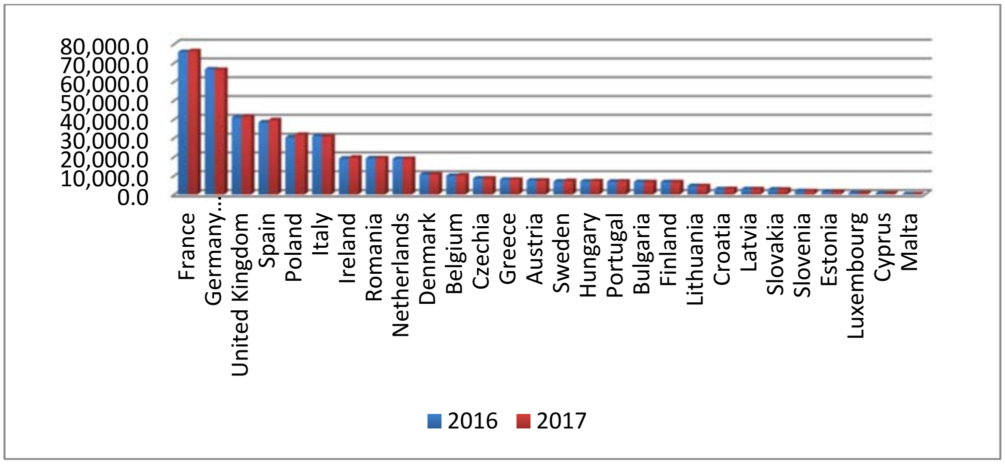

Fig. no. 3 Greenhouse gasses (Co2, N2O in CO2 equivalent, CH4 in CO2 equivalent, HFC in CO2 equivalent, SF6 in CO2, NF3 in CO2 equivalent) from agriculture (thousand tonnes) (2016-2017)
Source: EUROSTAT, 2020

ICT can be used as a transition tool, "due to their disruptive potential" (El Bilali and Allahyari, 2018), using "mobile/cloud computing, Internet of Things, location-based monitoring (remote sensing, geo, information, drones etc), social media and Big Data" (Wolfert, 2015; Poppe, 2016), for a sustainable agri-food system.
In order to assess the level of Internet use from individuals within European Unions' countries (E.U.-28), a set of variables was chosen, taking into consideration the availability on Eurostat database, for the period 2012-2019 (224 cases). (Table no. 1)

Table no. 1 Variables for level of internet access

Variables	Sources and approaches for measurement
(Item 1) Individuals used a laptop, notebook, netbook or tablet computer to access the internet away from home or work	The variable is integrated in Eurostat set of indicators: Individuals- Places of internet use
(Item 2) Individuals used a portable computer or a handheld device to access the internet away from home or work	The variable is integrated in Eurostat set of indicators: Individuals- Places of internet use
(Item 3) Last internet use: in last 3 months	The variable is integrated in Eurostat set of indicators: Individuals- Internet use
(Item 4) Last internet use: between 3 and 12 months ago	The variable is integrated in Eurostat set of indicators: Individuals- Internet use
(Item 5) Last internet use: in the last 12 months	The variable is integrated in Eurostat set of indicators: Individuals- Internet use

(Item 6) Last internet use: more than a year ago	The variable is integrated in Eurostat set of indicators: Individuals- Internet use
(Item 7) Individuals who have ever used the internet	The variable is integrated in Eurostat set of indicators: Individuals- Internet use
(Item 8) Individuals who used the internet more than a year ago or never used it	The variable is integrated in Eurostat set of indicators: Individuals- Internet use
(Item 9) Internet use: never	The variable is integrated in Eurostat set of indicators: Individuals- Internet use

Source: Authors' own processing data; EUROSTAT, 2020

The Pearson correlation matrix was used in order to assess the level of connection between the variables from the analysis. We can observe that all the items are correlated. Thus, there is a positive correlation between (Item 1) Individuals used a laptop, notebook, netbook or tablet computer to access the internet away from home or work; (Item 2) Individuals used a portable computer or a handheld device to access the internet away from home or work; (Item 3) Last internet use: in last 3 months; (Item 5) Last internet use: in the last 12 months; (Item 7) Individuals who have ever used the internet, whereas there is a negative correlation between the other items. (Table no 2)

Table no. 2 Correlation matrix

		Item 1	**Item 2**	**Item 3**	**Item 4**	**Item 5**	**Item 6**	**Item 7**	**Item 8**	**Item 9**
Item 1	Pearson Correlation	1	0,772**	0,715**	-0,432**	0,718**	-0,422**	0,710**	-0,715**	-0,706**
Item 2	Pearson Correlation		1	0,780**	-0,506**	0,778**	-0,451**	0,769**	-0,772**	-0,762**
Item 3	Pearson Correlation			1	-0,715**	0,997**	-0,513**	0,992**	-0,996**	-0,991**
Item 4	Pearson Correlation				1	-0,668**	0,551**	-0,648**	0,668**	0,648**
Item 5	Pearson Correlation					1	-0,490**	0,997**	-0,999**	-0,996**
Item 6	Pearson Correlation						1	-0,428**	0,487**	0,424**
Item 7	Pearson Correlation							1	-0,996**	-0,999**
Item 8	Pearson Correlation								1	0,997**
Item 9	Pearson Correlation									1
**. Correlation is significant at the 0.01 level (2-tailed).										

Source: Authors' own processing data using SPSS 21.00 software

In order to establish the main items for the level of Internet use from individuals within European Unions' countries (E.U.-28), the factor analysis was employed. With an acceptable value (0,817) of KMO and Bartlett's test, we can keep the results of the factor analysis.

Table no. 3 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,817
Bartlett's Test of Sphericity	Approx. Chi-Square	2568,654
	df	10
	Sig.	0,000

Source: Authors' own processing data using SPSS 21.00 software

One factor allows us to explain 86,262% of the information, using the selected 5 items. (Table no 4)

Table no. 4 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4,313	86,262	86,262	4,313	86,262	86,262
2	0,455	9,092	95,355			
3	0,220	4,406	99,760			
4	0,010	0,199	99,959			
5	0,002	0,041	100,000			
Extraction Method: Principal Component Analysis.						

Source: Authors' own processing data using SPSS 21.00 software

The quality of the representation is above 0,8 for all the chosen variables (Table no 3):

- (Item 1) Individuals used a laptop, notebook, netbook or tablet computer to access the internet away from home or work (0,840);
- (Item 2) Individuals used a portable computer or a handheld device to access the internet away from home or work (0,879);
- (Item 3) Last internet use: in last 3 months (0,973);
- (Item 5) Last internet use: in the last 12 months (0,974);
- (Item 7) Individuals who have ever used the internet (0,974).

Table no. 5 Component Matrix

Component Matrix[a]	
	Component
	1
(Item 1) Individuals used a laptop, notebook, netbook or tablet computer to access the internet away from home or work	0,840
(Item 2) Individuals used a portable computer or a handheld device to access the internet away from home or work	0,879
(Item 3) Last internet use: in last 3 months	0,973
(Item 5) Last internet use: in the last 12 months	0,974
(Item 7) Individuals who have ever used the internet	0,969
Extraction Method: Principal Component Analysis.	
a. 1 components extracted.	

Source: Authors' own processing data using SPSS 21.00 software

The scale has an acceptable viability of internal coherence (Cronbach's Alpha= 0,931). (Table no 6)

Table no. 6 Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
0,931	5

Source: Authors' own processing data using SPSS 21.00 software

Results

The descriptive statistics of the main variables for Internet usage is listed in the Table no 7, with minimum and maximum evolutions at the level of the European Unions' member states (EU-28), for the period 2012-2019. These variables may be taken into consideration for further analysis regarding the possible correlation between ICT usage and pollutants in agricultural industry. The current research opens up the perspective for further analysis, based on the following aspects: sustainable agriculture and information communication technology (ICT) during all the logistics chain (food production, food processing, food distribution, food consumption) Also, the perspective for further development can be filled with a possible analysis on the "labour market performance" (Marcu et al., 2018), especially through the integration of immigrants, in the context of ICT usage in agriculture.

Table no. 7 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
(Item 1) Individuals used a laptop, notebook, netbook or tablet computer to access the internet away from home or work	224	0,00	58,00	28,9821	11,86356
(Item 2) Individuals used a portable computer or a handheld device to access the internet away from home or work	224	0,00	93,00	56,3125	20,52322
(Item 3) Last internet use: in last 3 months	224	46,00	98,00	79,7277	11,52116
(Item 5) Last internet use: in the last 12 months	224	50,00	98,00	81,0982	10,83298
(Item 7) Individuals who have ever used the internet	224	52,00	98,00	83,1071	10,24311
Valid N (listwise)	224				

Source: Authors' own processing data using SPSS 21.00 software

Conclusion

Understanding the determinants of ICT usage can help specialists lead the way towards a deeper analysis of the benefits of precision agriculture. Thus, "investment in tangible fixed assets" (Marcu et al., 2016), together with a change in mentality of the employees towards accepting the usage of ICT in agriculture can represent the first steps towards a sustainable agriculture at the level of the European Union's countries.

References

Avom, D., Nkengfack, H., Fatio, H.-K., Totouom, A., 2020. ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels. *Technological Forecasting & Social Change,* 155(2020) 120028, pp.1-12;

Danish, Zhang, J., Wang, B., Latif Z., 2019. Towards cross- regional sustainable development: the nexus between information and communication technology, energy consumption and Co2 emissions. *Sustain. Dev.,* pp.1-11;

El Bilali, H., Allahyari, M.S., 2018. Transition towards sustainability in agriculture and food systems: Role of information and communication technologies. *Information Processing in Agriculture,* 5(2018), pp.456-464.

EUROSTAT, 2020. *Agriculture - Overview* [online] Available at: <https://ec.europa.eu/eurostat/web/agriculture/data/database> [Accessed 10 May 2020].

EUROSTAT, 2020. *Digital economy and society* [online] Available at: <*https://ec.europa.eu/eurostat/web/digital-economy-and-society/overview*> [Accessed 01 May 2020].

EUROSTAT, 2019. *Dive into the world of agriculture* [online] Available at: <https://ec.europa.eu/eurostat/en/web/products-statistical-books/-/KS-FK-19-001> [Accessed 01 May 2020].

EUROSTAT, 2018. *Emisiile de gaze cu efect de sera pe tari si pe sectoare (Greenhouse gas emissions by countries and sectors*) [online] Available at: <https://www.europarl.europa.eu/news/ro/headlines/society/20180301STO98928/emisiile-de-gaze-cu-efect-de-sera-pe-tari-si-pe-sectoare-infografic> [Accessed 05 May 2020].

EUROSTAT, 2017. *Agricultural sector must reduce emissions and help fight air pollution* [online] Available at: <https://ec.europa.eu/environment/efe/news/agricultural-sector-must-reduce-emissions-and-help-fight-air-pollution-2017-11-16_ro> [Accessed 10 May 2020].

Marcu, N., Siminica, M., Noja G.-G., Cristea, M., Dobrota, C.-E., 2018. Migrants' integration on the European labor market: A spatial bootstrap, SEM and network approach. *Sustainability,* 10(4543), pp.1-20.

Marcu, N., Siminica, M., Cristea, M., Dascalu, D., 2016. The Analysis of the Correlation Regarding the Chemical Industry Main Results in Romania. Experimental Study. *Rev. Chim.,* 67(3), pp.589-594.

Ozcan, B., Apergis, N., 2018. The impact of internet use on air pollution: evidence from emerging countries. *Environ. Sci. Pollut. Res.,* 25, pp.4174-4189.

Park, Y., Meng, F., Baloch, M.A., 2018. The impact of internet use on air pollution: evidence from emerging countries. *Environ. Sci. Pollut. Rev.,* 8, pp.93-113.

Poppe, K., 2016. *Big opportunities for big data in food and agriculture* [online] Available at: <https://www.oecd.org/tad/events/Session2_Krijn Poppe OECD Big Data.pdf> [Accessed 05 May 2020].

SDG, 2020. *Sustainable Development Goals,* [online] Available at: <https://sustainabledevelopment.un.org/sdgs> [Accessed 01 May 2020].

Svenfelt, A., Zapico, J.L., 2016. *Sustainable food systems with ICT*? In: Proceedings of the 4th International Conference on ICT for Sustainability (ICT4S 2016), 29th of Aug.- 1st of Sept. 2016, Amsterdam, pp.194-201.

Wolfert, S., Mulligan, C., 2015. *Future Internet of ICT in Agriculture, Food and the Environment* [online] Available at: <https://www.wur.nl/web/file?uuid=11a80128-82b4-4c90-8980-ce3fd5cb9f83&owner=128fe7fdb753-4930-91d5-3e9a3c1138b8> [Accessed

10 May 2020].