Demand of Digital Services in Agriculture

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Abstract

The entry and use of digital services is becoming more and more an invariable process in front of the perspectives and development of the Agriculture sector.

This paper examines data for the state and use of digital agriculture market in demand side. The study presents readiness for using of digital services among the agricultural producers, the municipalities and suppliers. The paper presents results from the surveys carry out in the frame of the project "Theoretical models for digital agricultural development" – DIAGRO, financed by the National Fund for Scientific Research, Bulgaria.

Integrating digital technologies can increase the efficiency of agriculture. Many more actors can get involved in shared platforms and in virtual/cloud services. The research results show quite large differences both in the use of digital services among farmers in different regions in Bulgaria.

There is a lack of knowledge about the opportunities that digital services provide for sustainable rural development. As a result from there are several recommendations which can stimulate and impose on the process of digitalisation in agriculture.

Key words: development; digital services; agriculture; sustainability

Търсене на цифрови услуги в българското земеделие

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Резюме

Въвеждането и използването на дигиталните (цифрови) услуги става все по-неизменен процес пред перспективите и развитието на селскостопанския сектор. Тази статия представя данни за състоянието и използването на пазара на дигитални услуги в земеделието от страна на търсенето. Изследването представя готовността за използване на цифрови услуги сред земеделските производители и общините. В статията са представени резултати от проучване, извършено в рамките на проект „Теоретични модели за цифрово развитие на земеделието" – ДИАГРО, финансиран от Фонд „Научни изследвания" (ФНИ), България.

Въвеждането и използването на цифровите технологии може да увеличи ефективността на селското стопанство. Резултатите от изследването показват доста големи разлики както при въвеждането, така и при използването на цифрови услуги сред фермерите в различните региони на България. Някои от земеделските стопанства използват цифрови услуги за специализирани метеорологични информационни услуги, навигационни системи. От страна на управлението на земеделските стопанства ползите от използването на цифрови услуги фермерите оценяват, че най-важни са за ефективното управление на стопанството. По-голямата част от земеделските стопанства научават за цифровите услуги, предлагани от интернет страници и платформите на доставчиците на тези услуги.

Ключови думи: развитие; дигитални услуги; земеделие, устойчивост

1. Introduction

Historically, agriculture has undergone a series of revolutions that have driven efficiency, yield and profitability to previously unattainable levels. Market forecasts for the next decade suggest a 'digital agricultural revolution' will be the newest shift which could help ensure agriculture meets the needs of the global population into the future.

Digital agriculture has the potential to deliver economic benefits through increased agricultural productivity, cost efficiency and market opportunities, social and cultural benefits through increased communication and inclusivity and environmental benefits through optimized resource use as well as adaptation to climate change (Trendov, Varas and Zeng, 2019).

This paper examines data for the state and use of digital agriculture market in demand side. The study presents readiness for using of digital services among the agricultural producers and the municipalities.

Integrating digital technologies can increase the efficiency of agriculture. Many more actors can get involved in shared platforms and in virtual/cloud services. The research results show quite large differences both in the use of digital services among farmers in different regions in Bulgaria.

Digital farming or digital agriculture is basically the use of IT in agriculture and it involves applications of connected machinery and other digital agriculture technologies. Digital farming is used to improve overall farm production, to improve financial performance and to help farmers to boost their farms productivity by means of advanced digital technology. Further, involvement of digital technology in farming is an evolution in agriculture sector and has positively impacted the efficiency and sustainability of the farms. Digital farming deals with use of biology and technology together in order to help farmers to do precise farming.

Global digital farming market is primarily driven by factors such as growing global population and rising need for effective agriculture solution which can boost efficiency and production of arable lands. In addition to this, rising penetration of advanced technologies in agriculture sector coupled with growing need for high production of grains and vegetables are key factors which are likely to drive the growth of global digital farming market. Under the Digital Single Market strategy, the Communication "Digitising European Industry" sets out its objective to ensure that "any industry in Europe, big or small, wherever situated and in any sector can fully benefit from digital innovations to upgrade its products, improve its processes and adapt its business models to the digital change" (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016DC0180&from=EN). In the Communication "Building a European Data Economy" the EC explores how data can potentially bring many opportunities for European industry, including the agri-food sector (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0009&qid=1502273159265&from=EN). The concepts of precision agriculture (PA) and sustainability are the fundamental part of DF. From the first time a global positioning system was used on agricultural equipment the potential for environmental benefits has been discussed. Intuitively, applying fertilizers and pesticides only where and when they are needed, should reduce environmental loading.

According to Hatfield (2000), a farming system is comprised of many elements, but the variations that exist within a field can be summarized in three classes of variation: (1) natural, such as soil and topography; (2) random, such as rainfall; and (3) managed, the fertilizer or seed application. The interaction among these three sources of variation results in offsite impacts.

Kachanoski and Fairchild (1996) illustrated the spatial scaling problem and the value of taking into account the spatial variability of fields. Their results suggested that since the relationships among yield response, soil test, and applied fertilizer are non-linear, a single soil test calibration cannot exist for fields with different spatial variability. Another challenge is to show that PA can have a positive impact on the environment. Unfortunately, only few studies deal with this objective directly, most of them arrive to that conclusion as a by-product of other studies (Hatfield, 2000). Such studies can be categorized as (1) nutrient management, (2) pest management, and (3) soil and water quality.

However, high cost of digital farming solutions resisting the adoption of digital farming among the farmers. This factor is a major challenge to the digital farming market and is likely to hamper the growth of global digital farming market. Apart from this, lack of awareness towards digital farming is also a major factor which is likely to dampen the growth of global digital farming market in near future.

Related to this issue Bulgaria has developed and adopted a Strategy for Digital Agriculture in order to easily and effectively meet the new challenges facing farmers, businesses in the agri-food chain and consumers in the introduction and use of digital services.

The precision farming market is likely to increase in the long term after the COVID-19 outbreak, as precision farming makes it possible to monitor the state of the crops while not being physically present through the usage of automation, minimizing the need to contact other people, which is crucial during these times. This farming is an approach where inputs are utilized in precise amounts to get increased average yields, compared to traditional cultivation techniques. However, in the short term, COVID-19 would affect the market and the growth of the market would be relatively slower in the first and second quarters of the year 2020 due to economic slowdown and inflation.

2. Material and Methods

The main methodological approach of the research is the questionnaire method. This requires the preparation of a representative sample of agricultural holdings for the country, which will be surveyed and the results obtained will be extrapolated to the general population with a certain degree of guarantee probability.

For these purposes, the zoning method combined with the two-stage nesting model was used. The territorial attribute was used as a zoning criterion. At the first stage of the sample formation, 20 districts from the 6 planning regions were selected as nests. In the second stage, observing the principle of proportionality, the required number of agricultural holdings from each nest is selected. (Gatev, K., 1986; Kish, L., 1965; Bohn., 1996).

In determining the number and composition of the districts (nests) and the agricultural holdings, the requirements were observed, guaranteeing the possibility to include in the sample the districts, which reproduce to a sufficiently high degree the structure of the agricultural holdings by their specialization. In order to achieve the necessary correspondence between the structure of the production specialization of the agricultural holdings from the general population and that in the sample, two variances were calculated: one called inter-nest represents the size of the variance in each planning area, and the second refers to the variance within the planning area or so-called intra-nest dispersion.

The determination of the average error is done by the method of construction and is performed according to the following formula:

$\mathbf{\mu^2_{\theta r} = (\sum N_h^2 \times \mu^2_{\theta h})/(\sum N_h)^2}$,

where:

N_h is the total number of agricultural holdings in the region h (h = 1, 2...6)

$\mu^2_{\theta h}$ represents the regional stochastic error and is determined by the following formula:

$\mathbf{\mu^2_{\theta h} = (\sigma^2_{\theta r h}/m_h) \times (1 - m_h/M_h) + (\sigma^2_{Bh}/m_h * M_h) \times (1 - \check{n}_h/\tilde{n})}$,

where:

$\sigma^2_{\theta r h}$ is the inter-nest dispersion;

σ^2_{Bh} is the intra-nest dispersion;

m_h is the number of nests (areas) to monitor in an area h;

M_h is the total number of nests (areas) in an area h;

$\check{n}_h$ is the average number of units (agricultural holdings) to be observed in one nest in an area h;

$\tilde{n}$ is the average number of units (agricultural holdings) in a nest in an area h.

The inter-nest and intra-nest dispersion are modified forms of the general formula by which the dispersion is calculated in the ordinary sample:

$\sigma^2 = \sum (X_{idh} - \bar{X}_{dh})^2/(n_{dh}-1)$,

where:

the index *i* identifies the type of agricultural holding (i = 1,...8);

Xidh means the number (or relative share) of the agricultural holdings in area *d* of region *h*;

Xdh is the average number of agricultural holdings in district *d* of region *h*;

ndh is the number of different groups of agricultural holdings.

After determining the average stochastic error, the so-called maximum allowable estimation error is calculated, taking into account the confidence level and the corresponding guarantee factor *t*. The most commonly used values are 95% guarantee probability of the obtained evaluation results and t = 1.96. The formula by which the maximum permissible error is calculated is as follows:

$\Delta_\theta = \pm t * \mu_{\theta r}$

The general formula for determining the sample size in elementary units (in this case agricultural holdings) for a two-stage nesting sample is as follows:

$\mathbf{n_\theta = (t^2 * \sigma^2_\theta)/(\Delta_\theta^2)(1 + \delta * (\tilde{n}-1))}$, where the individual symbols have the semantic meaning noted above.

Results from the application of the methodology for determining the model and the sample size

At the first stage, the obtained results show that the sample includes 20 districts from the 6 planning regions. These are the districts: Montana, Lovech, Pleven, Silistra, Razgrad, Veliko Tarnovo, Targovishte, Varna, Dobrich, Burgas, Sliven, Yambol, Kardzhali, Smolyan, Pazardzhik, and Plovdiv, Blagoevgrad, Kyustendil, Pernik and Sofia region. As can be seen, the number of selected areas from each planning region is not proportional to their total number in the respective region. The reason is the different degree of scattering between the areas in the different planning regions and within the areas themselves (Table 1).

Table 1. Values of inter-nest and intra-nest dispersion

Planning regions (NUTS)	Total number of agricultural holdings (2016)	Inter-nest dispersion	Average for the region intra-nest dispersion
Northwestern region	22140	27.26	15.87
North Central region	23100	23.61	14.90
Northeastern region	22080	34.14	161.53
Southeastern region	28120	27.87	143.44
South Central region	64500	46.70	145.56
Southwestern region	42780	50.23	159.57
Total	202720	x	x

Source: Eurostat and own calculation.

In the South-West and South-Central planning regions the values of the inter-nest dispersion are higher in comparison with the other regions. This in turn determines the need for a larger number of units (agricultural holdings) from these areas to be included in the sample.

In the South-Central region the number of agricultural holdings is the largest, in contrast to the Southwestern region, which predetermines, together with the high values of the inter-nest dispersion, the largest number of agricultural holdings to be included in the sample. Of particular interest for consideration is the Northeastern region. The intra-nest dispersion is very high, but due to the larger average size of one agricultural holding in the region compared to the others, the total number of agricultural holdings in it is relatively smaller. In addition, the value of the inter-nest dispersion is average. Therefore, the required number of agricultural holdings in the sample should not be higher than in the other planning regions. There are many but small farms in the Northwestern region. Therefore, despite the low scattering values in the sample, it is necessary to include a relatively larger number of agricultural holdings.

As a result of the applied methodology for determining the volume and structure of the sample population, a value of 197 holdings was obtained.

The total number of agricultural holdings in the sample amounts to 197, which is approximately 0.1% (0.096) of the total number of agricultural holdings in the country in 2016. Given the declining trend in the number of insurance companies, it can be assumed that in 2020 it is smaller than in 2016. Therefore, the real share of the surveyed farms is higher than 0.1%. For the whole sample, the number of crop holdings exceeds that of livestock and mixed holdings. This is typical for all planning regions.

In order to ensure the necessary representativeness of the sample, the method of self-random selection is applied when selecting the specific agricultural holdings included in the sample. In this regard, attention is drawn to the fact that representation is at the territorial level (planning regions).

Two non-governmental organizations are involved in the implementation of the survey – National Union of Small Family Farmers and Producers and Association of agri-environmental farmers. Both organizations attached an accepted questionnaire among their members from all planning regions.

3. Results and Discussion

Advances in digital and analytics technologies offer a way to optimize the agriculture supply chain. The agriculture industry is capturing more data than ever, on everything from agronomy to the weather to logistics to market price volatility. Data storage capacity has increased, storage cost has plummeted, and computational power has grown. Meanwhile, both predictive data science and prescriptive optimization techniques have matured and gained visibility.

These practices save time and costs: reduce fertilizer and chemical application costs; reduce pollution through less use of chemicals. Also, they help in monitoring the soil and plant physiochemical conditions: by placing sensors to measure parameters such as electrical conductivity, nitrates, temperature, evapotranspiration, radiation, and leaf and soil moisture, so that the optimal conditions required for plant growth can be achieved. These factors help to obtain a greater output with limited labor force during COVID-19 pandemic situation where there is a shortage of labor and thus would help in a regular supply of food, thereby ensuring food security.

One compelling way to use digital and analytics technologies is to create a digital twin of the physical supply chain – from farmers to end customers – and use it to run virtual simulations and optimizations. Digital twins can include all elements of the supply chain and its interfaces, including procurement, production, inventory points, transportation, warehousing, and points of sale for finished goods. Players can calibrate mathematical models to include a variety of objective functions, such as profit, throughput, cycle time, or inventory optimization, depending on the organization's needs.

Digital agriculture is the use of new and advanced technologies, integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to improve food production.

Most of today's farmers make decisions such as how much fertiliser to apply based on a combination of rough measurements, experience and recommendations. Once a course of action is decided, it is implemented but the results are normally not seen until harvest time.

In contrast, a digital agriculture system gathers data more frequently and accurately, often combined with external sources (such as weather information). The resulting combined data is analysed and interpreted so the farmer can make more informed and appropriate decisions. These decisions can then be quickly implemented with greater accuracy through robotics and advanced machinery, and farmers can get real-time feedback on the impact their actions.

3.1. Analysis of demand from agricultural holdings

» Description of the sample

The distribution of the agricultural holdings according to their location is as follows: the largest share of the surveyed farms are from Plovdiv district – 16%, Pazardzhik district – 12.6%, Kardzhali district – 11.8%, and Sofia district – 10.1%.

The data show that in the studied set of agricultural holdings, those who specialize in the cultivation of cereals and essential oils predominate – 28.2% of the total surveyed sites. They are followed by livestock holdings with 17.6% of the total surveyed agricultural holdings. The holdings with vegetable specialization also occupy a significant share of the surveyed number – 13.9%.

The next criterion by which the agricultural holdings in the studied population are identified is their size. The analysis of the survey data shows that small agricultural holdings predominate (up to EUR 8,000), namely their share is 44% of the total surveyed sites. They are followed as a significant group by the medium-sized holdings (amounting to EUR 8,000 to 50,000), whose share is 30.1% of the total surveyed holdings. The results of the survey indicate that the most common form of property management of agricultural holdings is registration - an individual, 88.7% of total surveyed holdings use it. Only 7.5 of the surveyed holdings are registered as commercial companies.

» Profile of the surveyed agricultural holdings

The surveyed agricultural holdings are a total of 197 in number. The main criteria for studying their profile are: gender, age, education and experience in agribusiness.

The results of the survey show that more than half of the agricultural holdings fall in the range of 41 to 60 years. Next is the group of farmers aged 18–40 years, respectively, young farmers are 26.9% of the total respondents.

The next criterion by which the respondents were surveyed was their education. It follows from the findings that 39.9% of the respondents have secondary education, followed by the persons with higher education, respectively they occupy 32.8% of all respondents. It is noteworthy that only 20% of the surveyed farmers have obtained a higher education degree in the field of agriculture, veterinary medicine and zoo-engineering.

Another criterion for the analysis of farmers is the experience gained. According to the survey data, 47.7% of agricultural holdings have experience over 11 years in the field of agricultural business, 30.5% of agricultural holdings have experience between 6 and 10 years. The smallest is the group of agricultural holdings with up to 5 years of experience, only 21.8% of the total respondents.

The data show that the share of the participants with project proposals to the individual measures of the Rural Development Programme (RDP) prevails – 51.3% of all surveyed agricultural holdings. The most common measures that have received funding are measure 121 "Modernization of agricultural holdings" (RDP 2007–2013), measure 10 „Agroecological payments" (RDP 2007–2013), Measure 6.1 "Start-up support for young farmers" of the RDP 2014–2020.

Another criterion for differentiating the group of surveyed farmers is the type of source of income from agricultural activity. The presented data show that the majority of farmers form their income from agricultural activity – 38.3% state this. Next is the group of farmers who declare that agriculture is the only source of income for them and their families – 37.8% of all respondents.

» Profile of the requested digital services (main determinants of the demand)

The next part of the analysis focuses on the main determinants of demand for digital services by agricultural holdings as well as the identification of the main barriers limiting access to these services.

On the question "What digital services do you use in your business?". The data from the survey show that most often agricultural holdings use digital services such as "specialized in meteorological information services, navigation systems, specialized software", 63.4% of total respondents. Secondly, farmers indicate that they use digital services specialized in the management of technological processes, 24.2% of the total respondents indicated this type of service. Lastly, as a preferred digital service, farmers indicated the one that specializes in management of management services, 12.4% of the total respondents.

The next question in the survey is "How do you assess the benefits of the digital services you use?". The purpose of the question is to gather information about the generated benefits of the use of digital services in carrying out the daily activities of the farmer on his agricultural holding. Figure 1 shows the assessment of the bene-

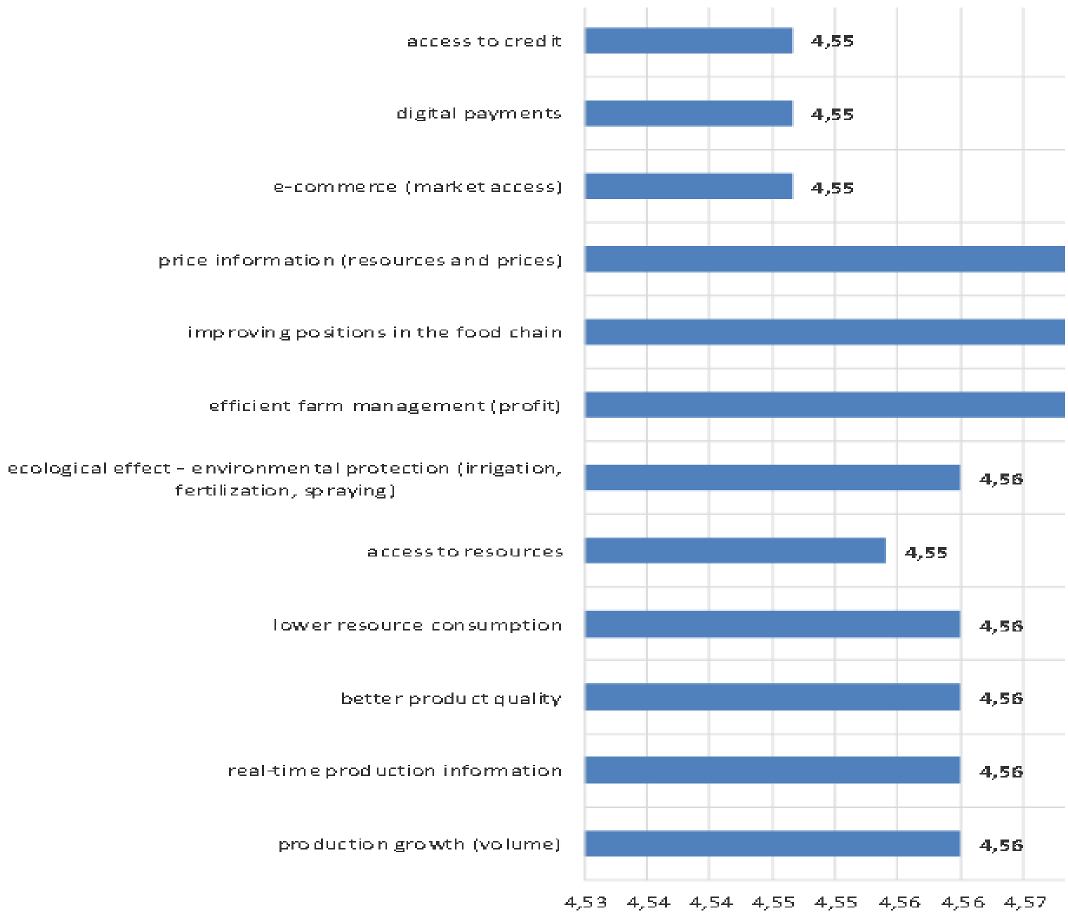

Fig. 1. Evaluation of the benefits of using digital services

Source: Data from a survey among 197 respondents, 2020. (scale 1-5 used, with 1 being the weakest and 5 being the strongest).

fits of using digital services in farm management. Farmers rate the following benefits as the most significant: (1) effective farm management (average score – 4.57); (2) improvement of the positions in the food chain (average score – 4.57) and (3) price information – average score 4.

The next question in the survey is "Where do you get information about digital services?". Figure 2 shows the percentage distribution of the responses received by the surveyed agricultural holdings. The data presented in this way show that the majority of agricultural holdings learn about the digital services offered by the websites and platforms of the providers of these services – 35.3% of all respondents indicated this answer. The next most important source of information are the sales representatives of digital services – 19.8% of all surveyed agricultural holdings recognize them as a reliable source of information. Another reliable source for obtaining information is the specialized media – 17.1% of surveyed agricultural holdings trust them.

The next question included in the survey is "Where is the digital service provider?". The information presented in this way shows that regional providers of digital services are used – 46.5% of the total surveyed agricultural holdings, indicate this answer.

By including the next question in the survey, the aim is to obtain information on barriers to farmers' access to digital services. The main barriers to the use of digital services analysis of the survey data shows are: 1) the lack of experience in the use of digital services by agricultural holdings – 23.5% indicated this factor as the most significant problem; (2) the high price of the offered service – 21.4% of the total surveyed agricultural holdings and (3) the complexity of the digital service – 19.6% of the surveyed agricultural holdings stated that they do not use due to the complex nature of this type of service.

Another factor that was examined in the survey is the provision and sharing of access to digital services offered in the sector. The data shows that farmers prefer to use digital services individually – 73.1% of the surveyed agricultural holdings stated this. Next is the group of agricultural holdings who use digital services on a subscription basis – 19.9% of total surveyed holdings.

The next question in the survey is "Do you participate in specialized information events related to digital solutions?". Of all farmers surveyed, 50.9% said they participated in seminars and conferences on the issue.

3.2. Analysis of demand of digital services from municipalities

The purpose of the study is to analyze, on the basis of analysis, the level of use and implementation of digital services in the municipalities and to evaluate the readiness of the municipal administration to prepare and implement a strategy for

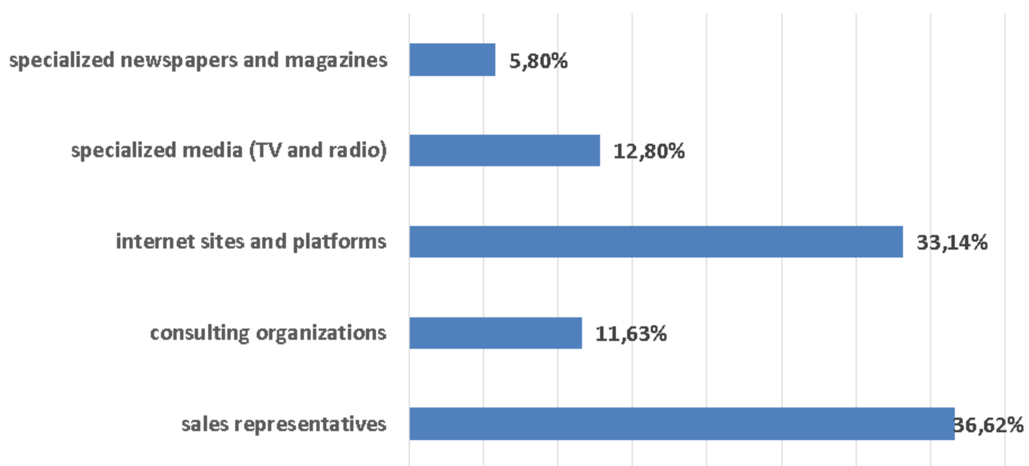

Fig. 2. Preferred information sources on the digital services offered on the market
Source: Data from a survey of 197 respondents, 2020.

the effective use of digital public services. The main methodological approach of the research is the questionnaire method. The results of a sample survey conducted with the assistance of the National Association of Municipalities in Bulgaria were used. The results of a sample survey conducted between July and November 2019 were used. The survey conducted included the municipalities of Belogradchik, Zavet, Koprivshtitsa, Ruzhintsi, Rudozem, Hissarya. The number of inhabitants in the studied municipalities varies from 2046 to 14 337. The municipalities that responded to the survey are a sample of all six planning regions (NUTS level 3). All the municipalities surveyed stated that they did not have a digital introduction strategy, but envisaged that such a strategy should be drawn up within 1 to 3 years

Regarding the existence of infrastructure for the introduction and use of digital services on the territory of the municipality, 80% of the surveyed municipalities indicated that they cannot assess, are not aware and do not know that such infrastructure is in place. They have indicated that they are experiencing difficulties in implementing digital services due to a lack of "human capital" and financial resources. The remaining 20% indicated that there was an infrastructure in place for the introduction of digital services, mainly the so-called eGovernment and are used for administrative services to the public and business.

Reasons for not using digital services in administration are the same share (33.3%) between lack of information about the applicability of digital services, lack of opportunities for implementation and use of these services and lack of knowledge on how to use these services

Conclusions

The main objective of agriculture marketing is to reduce the cost of marketing. Use of information and communication technology (ICT) in agricultural sector can be called as e-Agriculture or e-Agribusiness. Digitalization will change every part of agri food chain but require major transformations in farming, rural economics, and marketing of produce. The application of ICT in agriculture has positive effects for farmers in terms of accessing market information and promoting agricultural products. In digital world, we can revolutionize agriculture market end to end digitally. ICT helps small farm holders to find multiple buyers for producer who are willing to pay high price. Small holders deal with only handful buyers who either pickup directly from them.

Improved market access, risk mitigation, disaster management, and logistics have the potential of enhancing agriculture incomes and improving profitability. Linking markets, inputs and trade in a variety of ways can also help with complying with international standards for traceability by providing reliable data.

In the agriculture value chain, producers look for information to improve their productivity, yields and profitability. Digital agriculture services and solutions offer a vehicle to achieve this through better access to productivity enhancing information and technologies and market access. Information on pricing of agricultural products (inputs and outputs) and markets, providing logistics, storage information services and in some cases access to virtual trading floors are much needed.

A major factor in smarter supply chains is the development of eCommerce. With the interconnectedness of the Internet at society's fingertips, consumers are able to access and order easily from their own home or office, increasing the demand of products around the world. If business is easy and accessible, customers are more likely to utilize it. While this new interaction model presents its own set of challenges in keeping up with the demand of commodities, its benefit to agriculture far outweighs the cost. Online supply chain management streamlines inventory administration, warehouse strategies and distribution practices, all fueled by the demand-driven business model that results from eCommerce.

The digital landscape of the industry also boosts internal and external communications throughout the supply chain. Producers are able to interface quickly and customers are digitally connected to the products they are purchasing through innovative technology like blockchain. These solutions ensure that each stage of operation is visible, which subsequently increases quality expectations and cuts down on error time. Digital access promotes digital solutions in any industry, and the new standard of instant access to information, delivery status and timelines is a direct result of a digitized supply chain.

Not only can customers and producers access information instantly, but the production processes also move more quickly in a digitized supply chain. Through online platforms, data moves faster, and communication efforts are optimized.

Lack of interest on the part of municipalities. Most municipalities do not have the "human capital" to implement digital services. There is a lack of knowledge about the opportunities offered by digital services for sustainable rural development. Ineffective use of EU funds for the introduction of digital services due to low awareness and lack of administrative capacity in municipalities.

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European Commission: Digital Single Market strategy (https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:52016DC0180&from=EN