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STATE OF THE ART OF THE USE OF REMOTE SENSING IN AGRICULTURE IN SLOVAKIA AND HUNGARY

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State of the art of the use of remote sensing in agriculture in Slovakia and Hungary

Abstract: This paper aims to present a state of the art of remote sensing in Slovak and Hungarian agriculture. A similar methodology has been applied in order to have comparable data on both countries, mainly through research and exchanges with actors involved in this field, both public and private. About fifteen actors were identified in Slovakia; and around thirty in Hungary, from companies providing remote sensing images to others offering services directly to farmers, or public institutions. Those last ones have shown the interest of the State, at least in Slovakia, in the field of remote sensing for agricultural purposes. Especially by mapping certain areas with precise indicators in order to identify agricultural areas in decline, or to provide free access data to various users. However, the involvement of the state/public institutes in training, funding, projects and market structuring is low compared to Hungary. Research shows some differences between the two countries in terms of commercialized services in remote sensing, especially in the agricultural areas concerned and their scale, the diversity of the services offered, the tools used and the proportion of interested farmers. The drivers for the adoption of remote sensing by farmers are broadly similar between the two countries, although they do not concern the same proportion of users: they are mainly financial motivations, with a possible increase in profit or decrease in production costs. Another motivation, to a small extent, may be environmental preservation, and adaptation to the climate change that is beginning to impact agriculture in Slovakia. The main obstacles noted are the lack of organizations structuring agriculture (cooperatives, advisors) in Slovakia, which limits the dissemination of know-how and knowledge in the field of innovation and precision agriculture, including remote sensing, as well as the lack of means to carry out these investments, the lack of insurance, and the time required for this type of activity.

Keywords: precision agriculture, remote sensing, farming in Slovakia and Hungary, agricultural land use

Foreword

This study took place in collaboration between two public institutions, the French Observation Center of Digital Agriculture Adoption (*L'Observatoire des usages de l'agriculture numérique de la Chaire AgroTIC*), of L'Institut Agro (Montpellier) and the *Department of Physical Geography and Geoinformatics from the Faculty of Natural Sciences in Comenius University* (CU) in Bratislava. The operational team belongs to AgroTic, from the Joint Research Unit in Information-Technologies-Environmental Analysis-Agricultural Processes of INRAE, L'Institut Agro (UMR ITAP). The missions and objectives of this cooperation are to disseminate and exchange knowledge about digital agriculture. The Observatoire takes an interest in the situation in other European countries and works in collaboration with foreign universities, including CU.

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The cooperating structure and hosting organization was the Department of Physical Geography and Geoinformatics from the Faculty of Natural Sciences at CU in Bratislava. They also work in cooperation with public institutes (Geography Institute of Bratislava) that lead public projects, and also with Széchenyi István University and Hungarian University of Agriculture and Life Sciences (MATE) in Hungary.

Introduction

For a few years now, *l'Observatoire des usages de Numérique* de la Chaire AgroTic in France have been leading studies to better understand the use of technologies by farmers. New tools are appearing on farms to meet challenges to various issues, such as environmental, qualitative, or working conditions, but there is still little visibility of real use of these tools by farmers. Therefore, the Observatoire has been conducting surveys to specifically identify the uses of satellite, drone, and aerial imagery for crop management [1]. This showed that 9,3% of the field crop area in France had been mapped by one of these services, and this represented 2,2% in viticulture, mostly thanks to satellites imagery. And a strong increase of the free remote sensing (RS) services has been noticed, implemented by the access of satellite data from Sentinel-2 [2].

Those tools are part of the **remote sensing** techniques, which can be defined as *the process of detecting and monitoring the physical characteristics of an area by measuring it's reflected and emitted radiation at a distance. This measurement is done by special cameras or sensors placed on satellites, aircrafts or unmanned aerial vehicles (UAV, also called drones). Those cameras collect remotely sensed images, that are treated to show various indicators*. They serve many purposes, and in agriculture, they give indication support tools to help with the surveillance and the management of crops. Remote sensing is a technic of **precision farming**, which is "*the management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production*." [3].

In this context and inspired by the results of the French surveys there was research about the use of these services in other European countries: *are these services more or less used than in France? For which agronomic applications? Are there specificities according to the countries, and if so, what are they due to?* Therefore, a collective project has been conducted in collaboration with 5 other European universities to have a perspective at the European scale, commissioned by the *Centre National d'Etudes Spatiales* (CNES). The objective is to observe, measure and quantify the adoption of agricultural remote sensing in European countries, (Germany, Spain, Italy, Hungary and Slovakia; the last two are the ones in this study). *There are therefore issues of homogenization of the method and expected results, explaining the details on this subject throughout the report.*

In this study, we focused on the situation in Slovakia and Hungary. The final aim was to make a state of the art of the uses of remote sensing in Slovakia and Hungary, answering the following key questions: *How is the agriculture structured in Slovakia? Who are the farmers and what tools do they use? What is the adoption rate of remote sensing tools in Slovakia and Hungary? For which uses? Who are the actors involved in the value chain of Remote Sensing? And most importantly, what are the factors and obstacles to adoption?*

1. The structural context of Slovakian and Hungarian farming

In order to make comparisons with other countries about the use of remote sensing in agriculture, it seemed important to evaluate the situation and the organization of farming in Slovakia and Hungary.

1.1 Finding the data, methodology and objectives

The accessibility of the data and their concordance

Information source in Slovakia is different from Hungary. There is no structural organisation such as the Hungarian Society of Precision Agriculture, nor a lot of scientific publications about research topics were available. We used official sources and statistics such as those from the Statistical Office of the Slovak Republic [4], the Ministry of Agriculture and Rural Development of

the Slovak Republic [5], the National Agriculture and Food Centre of the Slovak Republic [6], Agriculture and Rural Development Spending Review Final Report [7], Farm structure survey [8], Agriculture and Food in the Slovak Republic for the year 2019 - Green Report [9], FinStat [18], the Slovak Chamber of Food and Agriculture [19] and FarmIS GSAA [20]. For Hungary, the information is based on the work entitled "Economic and Social Barriers of Precision Farming in Hungary" (2021) [10] published on the website of the Observatoire [11]. Data from 2016 to 2020 were updated from the Hungarian Central Statistical Office [12], especially about the crop concerned by precision farming.

Other sources were from the FAO reports [13] and the database from Eurostat [14]. Those organizations at a European or Global scale allow us to do a proper comparison, to have similar data between Hungary and Slovakia and re-contextualize their situation among other countries. The situation is described with data and publications from 2019/2020, assuming that there have not been great changes in the last two years. It was important to have data from similar years and with the same type of information, in order to establish proper comparison.

The similarity of crops in the two countries at different scales

The land use

In Slovakia the group of crops most cultivated (on 780 000 ha, 58% of arable land) is composed of winter wheat (26%), spring barley (14%) and maize (10,2%). The second more important group are the oil crops (200 000 ha, 14%), and then vineyards (not the most represented with only 14 380 ha (2022), but present in 6 (of 8) regions and with higher added value). In Hungary, the four most important arable crops are wheat (1 016 000 ha), maize (1 028 000 ha), sunflower (564 000 ha), and rapeseed (301 000 ha). Vineyards represent 68 400 ha, and the crops are globally more diversified than in Slovakia (Fig. 1).

There are similar crops in the two countries, but not cultivated on the same scale, with Hungary having larger agricultural areas. That may imply different typologies of farmers, means and tools, so different abilities to use remote sensing. Moreover, the averages on farms have been calculated with a totally different number of farms: in Slovakia, we may think they have bigger areas, but it's mostly because there are a few big owners with huge areas. Those differences can partly be explained by the environmental and geographical conditions, different in the two countries.

It's important to note that in Hungary ⅔ of the country's land are flatlands, with good and homogeneous climatic conditions whereas in Slovakia there is a bigger variability on climatic conditions and the topography. Landuse is also one of the most concentrated in Europe in Hungary, which suggests specific management that cannot be applied in Slovakia.

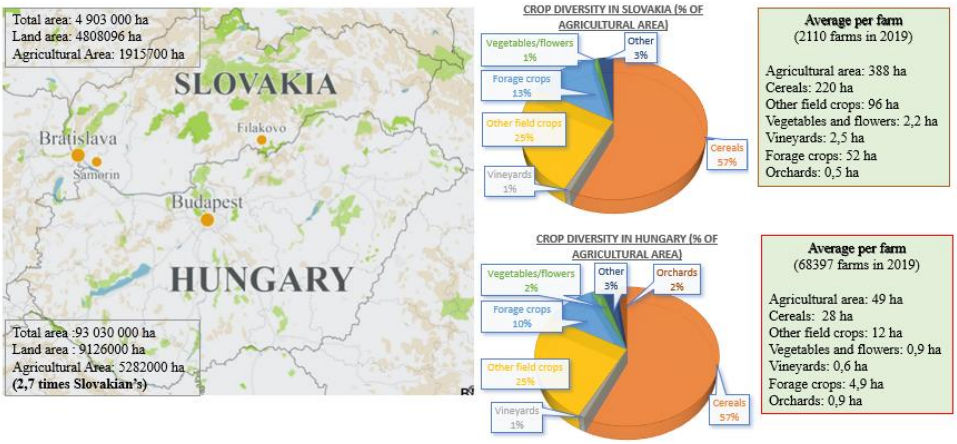

Fig. 1. Schematisation and comparison of the land use in the two countries (Sources: [15] Original map, [16] Graphic, [9] Green Report, [10] Precision farming in Hungary, [13] FAO)

The crop subject to remote sensing services

One of the aims of this project was to determine the ratio of the cultivated area with the use of remote sensing tools and to know what type of crops are concerned. A first approximation about Hungary was established in the article [10], which presented the typology of crops concerned by precision farming. Remote sensing is one of the precision farming technologies, the ones described in this article mainly concern precise mapping of yields, modulation of fertilization, automatic control, plant protection and tillage, and harvesting. It stated that around 0,3% of the national sown area was concerned by precision farming, so the results obtained for remote sensing were expected to be of the same order of magnitude or *a bit less important than this number, as some Precision framing technologies do not require remote sensing* (Tab. 1).

Table 1. The first estimation of the crops and areas potentially concerned by remote sensing services in Hungary

Crops	Surfaces concerned by precision farming	Total cultivated areas	The ratio of total cultivated area in Hungary	Uses
winter wheat	4161 ha	1015640 ha	0,4 %	mainly in nutrient supply **
maize	4019 ha	1027590 ha	0,39%	mainly during sowing
sunflower	2795 ha	564110 ha	0,49%	mainly during sowing
rapeseed	2016 ha	300600 ha	0,67%	mainly in nutrient supply
Total cereals		2337648 ha		
vineyard	…	64920 ha	…	…
orchards		79560 ha		
other	…	…		…
Total	…	5282000 ha	**Around 0,3 %**	

Legend: … No precise data
** probably not with remote sensing, so the ratio is below this number

Source: [10], [12]

In Tab. 2 we summarized the different estimations given later, with a critical point of view. The last line shows our estimation, established from a global understanding of the situation.

All entities interviewed mostly agree about the crops concerned by remote sensing in Hungary: mainly arable crops; with wheat, barley, rapeseed and corn. Vineyards are also indicated by some people, but only half of them talked about orchards. Nevertheless, they were not all able to provide estimations of the areas concerned, and those who did give very wide and different estimations. It's complicated to establish an estimation with so few and different answers, but it questions the estimation of 0,3% of the agricultural sown area, given by the article about precision agriculture. It would more likely be more than 5%.

In Slovakia, we didn't find scientific sources to establish first estimations as in Hungary; there is no study about the adoption of precision farming or official data and investigation about precision farming. The estimated ratio has been determined by interviews (itw) with different stakeholders and their respective estimations/approximations, summarized in Tab. 3.

All entities were interviewed by standard interview – overview of questions:

General presentation

- introduction about the company/institution
- position of company/institution in the remotely sensing market
- what tools/services are sold/offered?
- what remote sensing data sources are used?
- who are the targets of company/institute
- examples of clients, examples of services provided

Table 2. Approximation of the ratio of the crops cultivated covered by remote sensing services in Hungary, according to the different estimations given

Person/company making the estimation	The legitimacy of the point of view	Crops concerned (their opinion)	Surface estimated (their opinion)	Ratio estimated
Kuhn, Agrotec Service providers, work with remote sensing before 2016	No detailed information (areas, partner, competitors)-> I don't really know their influence	cereals mostly, vineyards (fewer services, without details)		
Kite Services providers since 2016 at least, in arable crops and vineyards. 3000 customers, lots of competitors, they know the state of the market	One of the **most reliable stakeholders** to give an estimation, 3 people from the company answered (itw + questionnaire). Considered 'leader' by competitors	cereals (wheat, triticale, rapeseed, corn, barley), vineyards, orchards, livestock	cereals: 233 700-351 000 ha vineyards: 650-13 000 ha fruit gardening: 16 000 ha Total: **250 000-380 000 ha**	cereals:10-15% vineyards: 1-20% fruit gardening: 20% tree gardening: 5% livestock: 1% Total: **5-8%**
Agrontech A provider since 2016, is well-established in the market. Provide themselves for "*a few thousand ha"*	Reliable stakeholder to give an estimation, itw with the co-founder, knows the market	main cereals: wheat and corn (+ expensive)	Total (mainly cereals): **246 000-492 000 ha**	5-10%
Envirosense	Itw to come			
Danuba A provider since a few years, is small but remaining company	Quick discussion during a farm show, and no detailed information but the estimation seems reliable	main crops: corn, winter wheat, barley, rapeseed	Total (mainly cereals**):** **246 000-492 000 ha**	>>40000 ha for the cereals
Sombereki Zrt Agricultural cooperative, users of remote sensing since 2018 for arable crops (900 ha managed with it in 2021 for harvesting / fertilization)*	Users + cooperate with cooperatives: may have a wide point of view, but seem very 'optimistic' in the estimations.	cereals, vineyards, fruit gardening, orchard, livestock	cereals: **1 636 000** ha, vineyards: **6 500 ha** orchards: **8 000 ha** Total: **1 650 000 ha**	cereals: 70%, vineyards:10% fruit gardening: 10% orchards: 10% livestock: 5% Total: **>30%**
Farmers The 3 who answered the questionnaire, one of them: more than 15 000 ha	They are big users so they know what they use, and the general crops but they are maybe not aware of the situation of the whole country	cereals: wheat, corn, barley, rapeseed		
Our estimations after the analysis of the different points of view	**Different actors, various points of view influenced by their position users/providers, the crops and technology personally used. Agreed about the crops, not the scale.**	**mainly cereals: wheat, corn, barley, rapeseed; vineyards; orchard; a very little use for livestock**	**250 000 to 1 500 000 ha**	**5-30% (closer to 5)**

Legend: number/estimations given
Bold: number/estimations deducted
*Answers from the questionnaire, I couldn't ask for explanations or precisions

Remote sensing

– brief description of marketed services/technologies (data source, mode of communication)
– what is the business model of company/institution?
– what data do farmers use most? What do farmers focus on? Is there a direct contact to farmers?
– for which uses each sector of farming (arable crops, viticulture, gardening, livestock)?
– proportion associated with each use
– what agronomic models (Decision Support Tools) are based on services?

– what area data obtained by satellite/aircraft/drone are sold
– main trends observed in last ten years
– estimate the number of farmers using remote sensing in country
– which sectors are concerned by use of remote sensing in farming
– are there specific regions where remote sensing is more used?
– what are the main drivers or the adoption of remote sensing?

General view/opinion of the use of remote sensing

– which remote sensing data sources are most used by farmers?
– what are the contributions of Sentinel-2 in remote sensing?
– what are the main issues in the remote sensing market today?
– what is the role of agricultural advisor in relation to the use of remote sensing?
– estimation of number of companies (institutions involved on remote sensing in country

Table 3. Approximation of the ratio of the crops cultivated covered by remote sensing services in Slovakia, according to the different estimations given

Person/company making the estimation	The legitimacy of the point of view	Crops concerned (their opinion)	Surface estimated (their opinion)	Ratio estimated
Agronom in Cifer's agricultural cooperative crop production, 850 ha, 500 ha remotely sensed using satellite data	*One of the first cooperatives to use remote sensing, aware of the opinions and difficulties of similar users,*	Arable crops: winter wheat, maize, barley, rapeseed, and beans. Few vineyards		0,5-1% of the total agricultural area
Owner of Saftra 3D mapping a recent and small company, services with drones, personally remotely sensed 10 000-20 000 ha in 2020	*Recent start-up, in cooperation with other companies, aware of the state of the market, but still with a small activity*	**Arable crops,** some vineyards, some 'special' crops (walnuts, potatoes). 'No perspective in orchards'	max. 200 000 ha cereals < 150 000 ha vineyards < 1 000 ha others < 200 ha	less than 2% of the vineyards, less than 10% of arable crops
Sales manager of Agroservis the biggest company for agricultural activities. 1 000 customers, 50 interested in remote sensing. **6 000 / 7 000 ha** documented from drones	Big company, a real representation of the market, even if remote sensing is new. Estimation based on their services + other companies they know + their clients using their own drone	**Arable crops:** winter wheat, maize, barley, rapeseed, small grass, soybeans and sunflower Vineyards	***20 000-30 000 ha it's growing***	***1-1,6% of the agricultural area***
Aurus big IT company involved in remote sensing for a few years (software development), in cooperation with different stakeholders	*Global overview of the situation but no precise data for the surfaces*	**Arable crops:** winter wheat, rapeseed, corn, barley	***it could be half a million ha*** but not especially for precision farming	
National Forest Center	Itw to come	**Cereals** and **vineyards**		
Two **researchers** in the **institutes of geography** of Bratislava and Kosice	Involved in projects using remote sensing in agriculture, they know the tools available, the companies and the services	**Cereals:** wheat, rapeseed, barley, sunflower, corn. **Vineyard:** not really extended in Slovakia, but 'high value' crop; so concerned	***< 190 000 ha***	*far* ***less than 10%*** *of the agricultural area*
Our estimations after the analysis of the different points of view	***Different actors, various points of view influenced by their position users/providers, the crops and technology personally used. They all agree to a ratio inferior at 10% and about the crops concerned***	***Cereals: winter wheat, maize, barley, rapeseed, beans, (small grass, soybeans, sunflower). Vineyards: a few big ones. Other: potatoes, walnut, …***	***30 000–50 000 ha***	***1,5-2,6% of the agricultural area***

There are different estimations, to reconsider carefully: the different actors may have their points of view influenced by their respective positions.

If we summarize the data from the people interviewed and the surfaces for which they provide services/ they use services (the users not using the services of the providers mentioned but from others): we already have almost 30 000 ha, without considering the Hungarian and Czech companies also providing services in Slovakia.

We could honestly consider that we have had around 30 000 and 50 000 ha remotely sensed in the last year, so around 1,5 and 2,6% of the agricultural area concerned by marketed services based on remote sensing in Slovakia.

A different structural organisation and the context for the uses of remote sensing

Both Hungary and Slovakia are former socialist countries and have faced many structural reorganizations in the last decades, which also concerned the agricultural environment.

In Slovakia, the re-structuring of the farm sector has involved privatization of several state farms in after the change of system in 1989. Cooperative farms continue to exist, but they have been transformed into new types of business entities. A new big private holding appears in agriculture [5].

In Hungary, the current regulations on land policy focus on increasing the number of family farms [10]. At the same time, fragmentation or concentration of holdings is not prevented by Hungarian law, so the structural or ownership arrangements are a bit confusing. Nevertheless, land ownership seems shared between agricultural enterprises and private holdings. The agricultural enterprises are less numerous but own larger lands.

Fig. 2 represents the current repartition of the ownership of arable land in Slovakia (with data from 2019 from the statistical office [4] and the LPIS (Land Parcel Identification System) from the Green Report 2019 [9]).

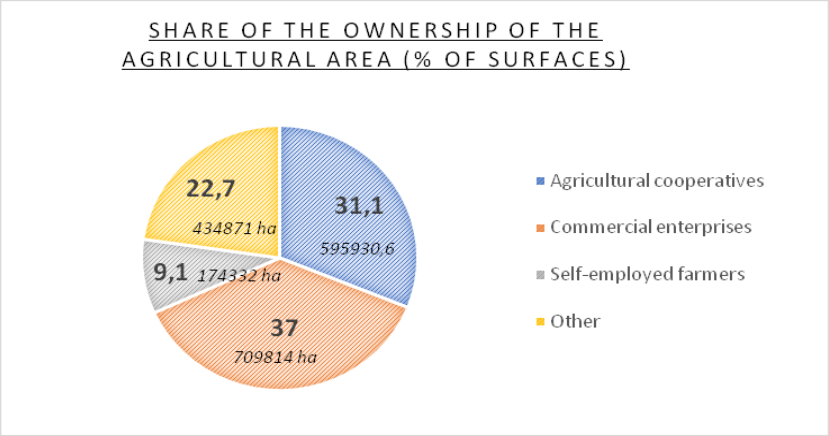

Figure 2. Representation of the repartition of the land ownership in Slovakia

In 2021, according to the LPIS, the total land area was:1 899 039.86 ha, representing 174 629 cultural plots, 254 517 parcels (crops), and there were 17 872 applicants for agricultural subsidies, who own on average 102.78 ha.

The general idea is the same with the different sources; some big farmers own a majority of the land, and they are the ones possibly requiring remote sensing services.

In Hungary, there are much more farms and workers: 148 000 individual owners, with a lot of very small farms (200 000 with an area <1 ha on 900 000 households producing for themselves). The average cultivated surface is 149.5 ha, but around 2.5% of the production units (13.830 farms)

use ¾ of agricultural land, and around 1750 farms use 44% of it (2 032 474 hectares). Only 58% of employees work in large farms that farm size is more than 100 hectares and up to 30% of employees work in small farms managing up to 10 hectares. In 2013 7000 agricultural enterprises owned 2 155 214 ha of agricultural area while 448 093 private holders owned 2 435 255 ha. [12, 17].

2. A mapping of the systems around remote sensing in agriculture: different objectives and services between the countries/the actors of the chain and the services proposed

There is a main structuring actor in Hungary that does not have an equivalent in Slovakia: The Hungarian Society of Precision Agriculture, which is a nongovernmental organizations (NGO) that regroups the different companies or institutions working on precision agriculture. In Slovakia, there is no such global structure. The system around remote sensing is divided between state institutions and companies producing images and other stakeholders, using those images, which are the state through the Agricultural Paying Agency (APA - the agency controlling subsidies) and private companies producing tools or services. Fig. 3a. summarizes this ecosystem in Slovakia, Fig. 3b. positions the actors identified. Fig. 3c. represents the situation in Hungary but is less accurate.

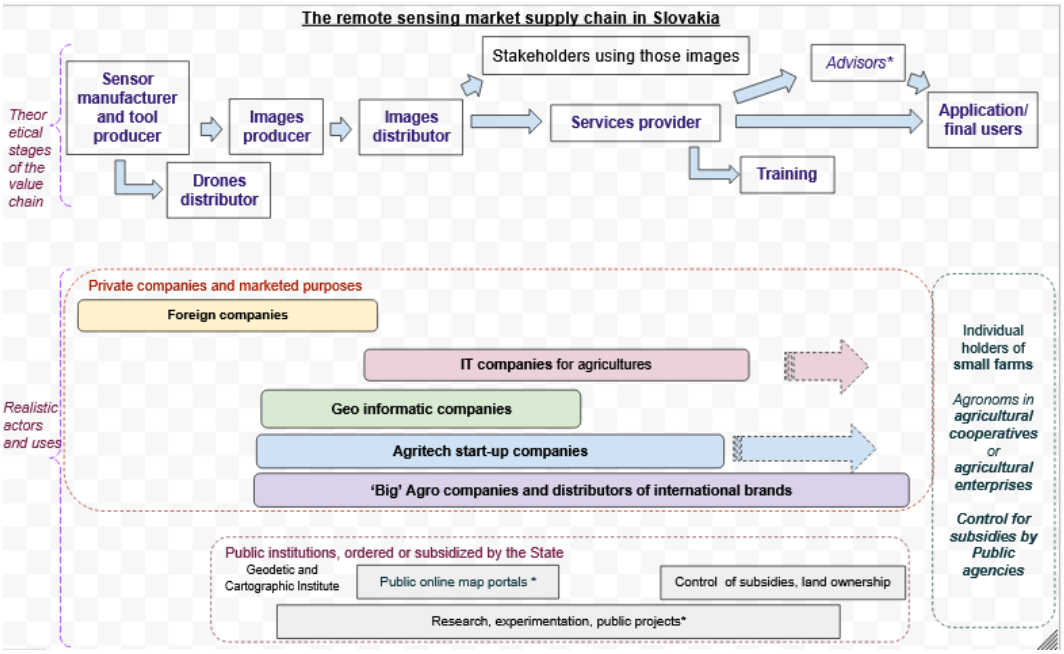

Figure 3a Value chain of the remote sensing market in Slovakia

Value chain of the remote sensing market in Slovakia From top left to down right:

The first half at the top is a theoretical representation of the different stages of the chain, the system being divided between different stages:

– Sensor manufacturers who sell sensors like cameras to image producers. The manufacturers are mostly from abroad and export their technology to Slovakia.

– Images producers buy those sensors and tools and use them to produce images. They use different technologies; drones, satellites, aircrafts, or helicopters with onboard sensors (RGB cameras, multispectral cameras, thermal cameras, …). Then they provide raw data like

'basic' maps or processed images they produce through corrections or modifications showing specific indicators.

– The produced images are then transferred to distributors who will provide them to the users. Those users may want the images directly, or search for services. In that case, there is another stage:

– The services providers, can produce farming tools including remotely sensed data, that they sell to different users, or services like advice (with prescription maps, …).

– Before the final users, who are managing directly in the fields thanks to the remotely sensed images they got, there can be advisors. Those advisors can be agronomists, making an intermediary between the image sellers and the buyers.

The second half is categorisation of the different kinds of actors that we can find in the Slovak market. Those actors can have activities at different stages of the chain:

– The IT companies initially provided services related to subsidies and landownership, they try to widen their activities and adapt their software. They work mainly from satellite data, through partnerships with foreign providers.

– The geospatial companies propose various remote sensing services for different industries, and occasionally for agricultural purposes. They analyse satellite data or provide drone/plane flights on demand.

– The Agritech start-up companies are collecting, processing and analysing remote sensing data (+ occasionally providing advice) for farmers only. They are new (started around 2016-2018) or foreign, and work with satellite data (providing foreign software) or drones.

– Finally, there are the 'big' Agro companies and distributors of international brands, already proposing various services and distributing tools for farmers. They start using remote sensing in addition to their usual business, with software (foreign) based on satellite data, or drone flight.

The manufacturer of tools (drones, sensors) and producers of software are exclusively from abroad.

About the public institutions: they are *using principally technology based on* ***satellites or planes***. The APA is the Agricultural Paying Agency, controls the demands and distributions of subsidies. Fig. 3b shows the same graphical form with the main actors identified.

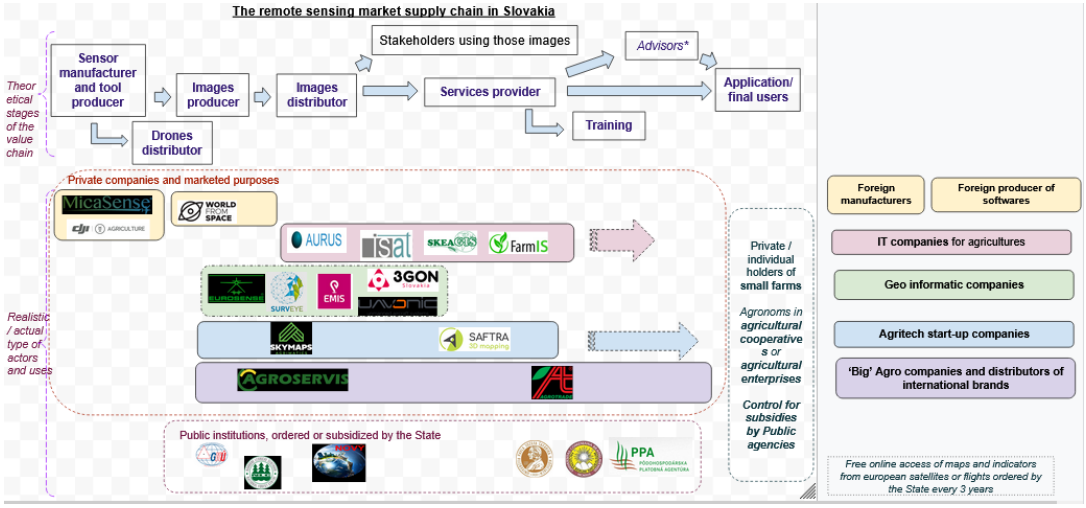

Figure 3b. The remote sensing market in Slovakia in agriculture, with the real stakeholders

If we do not consider the foreign companies and the geospatial companies, there are 8 companies which are with the estimations given by all the people interviewed.

Some stakeholders can be at several stages of the theoretical chain, for example the same company can be a producer and distributor of images and also a services provider from its own images. *For example, Saftra 3D Mapping is a company producing images thanks to sensors on drones, which also distribute the data produced directly to users, and also provides services like agronomic advice through the production of prescription maps, and has also some activities like drone spraying*.

The public image producers or producers and distributors are the National Forest Centre, and the Geodetic and Cartographic Institute, which provides data through the Geoportal web (distributor only). The public users are: the APA which uses it to check the attribution of subsidies, the Institute of Geography in Kosice, the institutional centres using remote sensing for research and experimentation or public projects in Bratislava and Nitra.

The most interesting ones for the global subject are the actors from the images supplying to the services provided. We represented identified companies, with activities in Slovakia. Lots of information were available on websites, but we realized that there are a lot of 'starting' companies with more projects and tests than real activities with farmers so far.

There could be a few others that we might have not identified yet, but in total, they shall not be more than 15 companies. We can present a similar graphical form for the actors in Hungary (Fig. 3c). Compared to Slovakia, there are more foreign manufacturers proposing tools in Hungary (drones, sensors and mostly software). There are more companies in general, with activities more diversified.

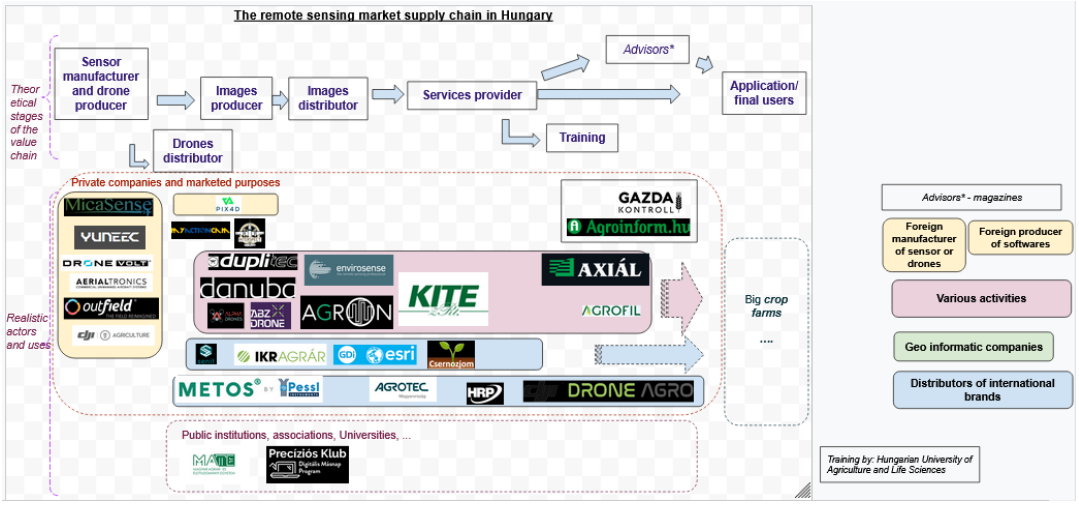

Figure 3c. The remote sensing market in Hungary in agriculture, with the real stakeholders

2.1 Typology of the main private actors involved in remote sensing, their technology and respective objectives

Technology

There are companies involved in remote sensing at 3 levels for the production of satellite, aerial images and maps and with 3 main types of sensor support: satellites, aerial planes and UAV, helicopters can also be used, but this is rare as they are more expensive. Concerning aerial planes, usually, data are ordered by the state with the objective to be freely accessible to anyone needing them. Every 3 years the state makes aerial images, of the whole area of the country. It produces

ortophotomosaics of a precision of 0,5 m and a resolution of 20 cm/pixel, available through public geoportal with access free of charge. The images are mainly used by institutions and farmers for the theme of the subsidies, or for global information for the Ministry of Agriculture and Rural Development of the Slovak Republic.

There are satellite data, using the public system, Sentinel-2 from Copernicus mainly [2]. All the people interviewed who use satellite data talked about Sentinel-2, and only one answered also Sentinel-1 and Landsat 7-8 (KITE). Google Maps has also been mentioned as a source of data. Those are producing data at a European level, and most of them are freely accessible to anyone interested. They are apparently not used a lot by the farmers in Slovakia, more in Hungary. Some companies considered it as a good complementary source for drones imaging. As it is free of charge but not precise enough they consider using it to have a wide overview of the fields and determine where the drones should be flying to get precise images of the areas the more relevant (Saftra company, Agroservis). In Slovakia, some private companies develop services from Satellite data, there are more numerous in Hungary. The main use of satellite data in Slovakia still seems to be to produce free data by public institutions. In Hungary, the big companies use satellite data for the software they distribute (Cropio, Pix4D, …) created by foreign companies.

UAVs are mostly used by private companies that create maps and services on demand. According to some actors this is the easiest technology, the more accessible, and can also be directly owned by the farmers, even if this is not really spread yet. It is practically impossible to determine the number of UAVs on the market today. Though it could be the future, according to the interviews: it's more interesting for the companies and the farmers to share the work like this: if farmers had their own drones, they could fly directly, get the data and send them to the companies.

Nevertheless, the legislation is quite strict about their use, a special license is needed depending on the size of the machine, and there are limitations about the authorized flying altitudes and areas.

The main brands of drones and sensors mentioned were:
– Drones from DJI, with phantom multispectral, classic phantom 4 RGB camera, DJI Mavick 2 advanced camera, Matrice 210 V2, with thermal camera and RGB, multispectral (5 or 10 bands),
– Sensors from Micasense, multispectral (5 bands) or thermal cameras.

Tab. 4. shows the advantages and inconvenient of those technologies according to the different interviews (similar answers in Slovakia and Hungary) and classified by order of importance.

Table 4. Characteristic and respective advantages/disadvantages of each technology

Satellite	Drone	Plane
Sentinel: free of charge, frequently available compared to the State's plane imaging in Slovakia; Faster, big surfaces covered, 'richer'; Raw data; Good frequencies for big areas	More accuracy, less delay and available as needed; Relatively not too expensive; Flexibility of use, Passage below the clouds; Cost 'more attractive' (Kite)	Aircraft flights ordered by the State: free of charge
Some frequencies are depending on the clouds; Resolution is not always sufficient, especially for Google images; Flexibility of use	Not adapted for big areas: too long, the time to do the flight it is too late to use the data (and not necessary for small areas-> farmers go directly in the fields)	Available only every 3 year; Expensive for the other; Not a lot of companies in Slovakia

Costs were also mentioned as advantages for satellites as for drones, compared to aircrafts. It is mostly the flexibility of use of the drones that seduces the users.

In most cases, the main index used is the NDVI. The area is a conditioning factor for the choice of the technology: for small fields, a small drone can be enough, but for big ones, it takes too much time to remotely sense it and to get the data by the time they are needed.

Sentinel-2 data are free of charge, but depending on the character of the problem, time, the financial conditions, the periodicity needed, on the accessibility (weather and cloud…) it's the most common but not always the most adapted. The local conditions have an important influence.

The main services and products provided

The services are similar in the two countries, but more developed in Hungary.

More commonly, in both countries:
– Check or plan the fertilization (*mainly nitrogen fertilization, for arable crops*),
– Plan harvesting (*to check the hedges and identify the part to harvest at a certain time*),
– Follow up the crop conditions, with simple crops maps (*to help better manage crops, irrigation, and nutrient application strategies*),
– Plant protection: damage detection (*storm, water, mouses*), weed detection (*to see where to use herbicides and not waste the products*),
– "Simple" maps of the parcels with indications about the timeline, crops, basic indexes (NDVI, LAI, etc.) and details,
– Intra-plot mapping.

More rarely, heard in Hungary:
– "General" monitoring services: to check big areas and get a state of the art quickly, to follow up on the growth of the plants,
– Drone spraying, though it is complicated to judge if it is a part of remote sensing service or a simple use of drones,
– "Check the energy efficiency of your buildings",
– "Air monitoring", to check the air quality of the farm.

Most of the services include the measure of the fields, the processing of the data and identification of the special parts, and the creation of maps. Those maps are then displayed in different forms: the more 'elaborate' companies, have their own online platforms where each customer has access to a complete service and state of his farm and fields, with other services not related to remote sensing. This is mostly the case in Hungary, in Slovakia, some companies (AgroServis, Aurus) are trying to adapt their platform to include the result of remote sensing service on them, but didn't meet a big enthusiasm from the farmers yet.

The results can also be given through software provided by foreign companies, but in Slovakia, there are not a lot of those companies present.

The other form to transfer the result to the farmers 'the processed data' is also through USB key, to directly connect to the machines, especially for maps related to fertilization (either prescription maps directly presenting the parts and quantities, or just the maps representing the different zones of a field – service more frequent in Slovakia).

3. Analysis of the adoption factors and barriers

The methodology and the information looked for, their accuracy with the subject and the diversity of opinion

The main objective was to determine the commercialized uses and applications of remote sensing in Slovakian and Hungarian farming, even if we also got contact and information about the activity of public institutions in Slovakia. It is complicated to interview each farmer personally about their personal use or interest in remote sensing. Consequently, to get the user's point of view we planned to pass through agricultural cooperatives or producer associations, but they were not easy to identify and contact and didn't provide a lot of information.

The approach by the supplier was privileged to have the widest and most exhaustive vision possible, and to be homogeneous with the methodology used by the Observatory for studies in France and in other countries. The objective is to get the point of view and the characterization from each actor of the chain; from the companies producing images, distributing them, those making tools or machines which use data obtained by remote sensing, or at least most of them.

The main actors in the remote sensing market in Slovakia and Hungary

Tab. 5 is a summarization of the main companies identified, and how we position them/how they position themselves on the remote sensing market. In highlighted in orange are the organizations with which we already had an interview / answers, and in grey are the ones unsuccessfully contacted.

Table 5. The main actors in the remote sensing market identified in Slovakia and Hungary

	Type of company / corporation	Company / institution	Country origin / activity	Technology used (data source)
Public institutions	Maps provider (public)	Geoportal – Geodetic and Cartographic Institute	Slovakia	Satellites
	Maps provider (state owned public-benefit corporation)	Národné lesnícke centrum – National Forest Centre	Slovakia	plane imaging and scanning area
	Public institute (maps and occasional service providers)	Pavol Jozef Safarik University Institute of Geography	Slovakia	Helicopter, drones, Satellites data (Landsat / Sentinel-2)
Private companies providing remote sensing services for farmers in Slovakia	Maps and services providers, 3D mapping company	Saftra 3D mapping	Slovakia	Drones (4, from DJI)
	Service providers (leader in selling of agricultural machinery and services)	Agroservis	Slovakia	Drone (DJI), + sometimes satellite data (Sentinel-2)
	Services provider	Skymaps s.r.o. (Agrimatics)	Czechia / Slovakia	Drones + satellite imagery
	Service provider (market leader' in information systems)	Skeagis	Czechia / Slovakia	Satellite
	Software company/ services	Aurus AGRO	Slovakia	Satellite + drones
	Software company	Isat s.r.o	Slovakia	
	Software company/ services	EMIS s.r.o.	Slovakia	UAV
	Manufacturer	ICS Production	Slovakia	Plane imaging from Slovak government + Sentinel-2
Private companies providing remote sensing services , not excusively focused for agricutlural activities	Maps and services provider (tools supplier / not focused on agriculture exclusively)	Surveye	Slovakia	Aircrafts, + satellites data / drones sometimes
	Maps provider (European leader in RS, aerial surveying and geoinformation / not focused on agriculture exclusively)	Eurosense	Belgium / Slovakia / Hungary	satellites, aircrafts, aerial laser scanning
	Images and services provider (on aerial agroanalysis)	UAVONIC	United Kindom / Slovakia	UAV
	Images supplier	3gon Positioning s.r.o.	Slovakia / Czechia	UAV
Private companies providing remote sensing services for farmers in Hungary	Maps provider (precision agriculture maps)	Interspect	Hungary	
	Service provider	Agrotec Mo Kft.	Hungary	
	Service provider	Kuhn Gép Kft.	Hungary	
	Service provider	Agron	Hungary	Drones
	Service provider	ABZ Drone	Hungary	Drones
	Service provider	Alpha Drones Kft.	Hungary	Drone
	Leading agricultural integrator	KITE ZRT	Hungary	Satellite (Sentinel-2) + drones
	Images producer + distributor + services provider	Envirosense	Hungary	Satellites + airbones laser scanning
	Service provider	Metos	Austria / Hungary	Satellite
	Service provider	Syngenta	Hungary / Slovakia	

	Service provider	Danuba	Hungary/ Slovakia	Satellite data + drones for sparying
	Service provider	Xarvio	Germany/ Hungary / Slovakia	
	Service provider	HRP Europe Kft.	Hungary	
	Service provider	Duplitec Ltd	Hungary	Drone
	Service provider	Drone Agro Kft.	Hungary	
	Service provider	IKR AGRAR	Hungary	
	Service provider + tools distributor	MyActionCam	Hungary	Drones
	Service provider (IT company)	Senit	Hungary	
	Service provider (IT company)	ESRI	Hungary	
	Service provider	Agrofil	Hungary	
	Service provider	HL-Lhd	Hungary	
	Service provider	Eurofins	Hungary	
	Service provider	Szabo Agrokemia Kft.	Hungary	

This summarizes the main remote sensing companies or institutions in Slovakia and Hungary. The information looked for is defined by the interview guide inspired by the one used for the Observatoire's surveys. The goal has not been to make a statistical analysis or to have exhaustive data, but more to get impressions and understand the situation.

In the complete table, different information was filled about those companies, especially:

– Their partners and link to other organizations (for example, Geoportal of the Geodetic and Cartographic Institute, Agroservis is the main representant of the company John Deere in Slovakia, …) this helps to have estimations of the number and diversity of companies as well as the state of mind,
– The type of clients (farmers directly, advisors, public institutions, ...),
– The type of activity, sale, services proposed and the products,
– The technology used (data source; drone/satellite, sensors, data processing and display; index used, …),
– The surfaces covered by the services, the crops concerned and the corresponding areas,
– The development over the last few years,
– The objective is to have a global idea of the total agricultural area remotely sensed, to know by which technologies and through which intermediaries between the image providers and the final users.

There are between 5 and 10 companies focused on remote sensing for agriculture in Slovakia and probably around 20 in Hungary, but it is complicated to have a certain number. In Slovakia, in Fig. 3b we can see more (13), but if we differentiate the categories of companies and do not consider the geodetic companies - which do not have a real activity in farming except the rent of material under special request - and do not count all of the IT companies, we can consider less than 10 companies currently specifically providing services to farmers.

In Hungary, there are more, but it is complicated to know how many exactly, as there are a lot of small companies. Through different interviews and thanks to the questions "*How many partners do you have? How many competitors? Estimation of the number of companies similar to yours in Hungary?*" We discovered 20-25 companies that I assume can be the main ones. Given the diversity of the companies, it has been more complicated to categorize them than the Slovak companies.

The users are mostly field companies and classic field farmers. Viticulture companies is a business very expensive and with a growing market of local vinery makers, there could be an interest from them in the future, but not a lot yet. With a first estimation, it would be around 2 or 3% of farmers in Slovakia using remote sensing services. In Hungary, it could be a higher proportion, or at least a higher number of farmers as they are more numerous than in Slovakia. According to the few estimations I got, we could consider that around 10-15% of the farmers would be involved in the use of remote sensing data. Nevertheless, considering the diversity of farmers in both coun-

tries and the fact that there are a lot of very small farmers and a few extremely big ones, it does not seem so relevant to talk about the number of farmers but more in % of the agricultural area.

The main issues in the remote sensing market today according to the companies

For the existing companies, it is complicated to establish partnerships with farmers, and to convince them of the utility or interests for them in Slovakia.

And the other problem is that there are not a lot of local companies, and the foreign ones are not well represented in Slovakia (more in Hungary). Especially for the ones selling machinery, and not only services. There is one famous brand of machines well represented – John Deere. On the other hand, in Hungary, the main issue is clearly the strong competition among the different companies.

The specificities and the context explaining the obstacles

From the various interviews, we got a representation of Slovak farmers as mainly "*old and conservative*". This influences the mode of communication of the data, and the kind of clients - mostly the "*big companies where they have young people, they are starting to use technology like this*".

Though, "*a lot of farmers are thinking about it, and interested, but not using remote sensing*". They want to try it and be convinced of its utility before spending money on this type of services. Nevertheless, even those interested, and who already have access to this kind of technology, are not always really using it. This can be represented by Fig. 4.

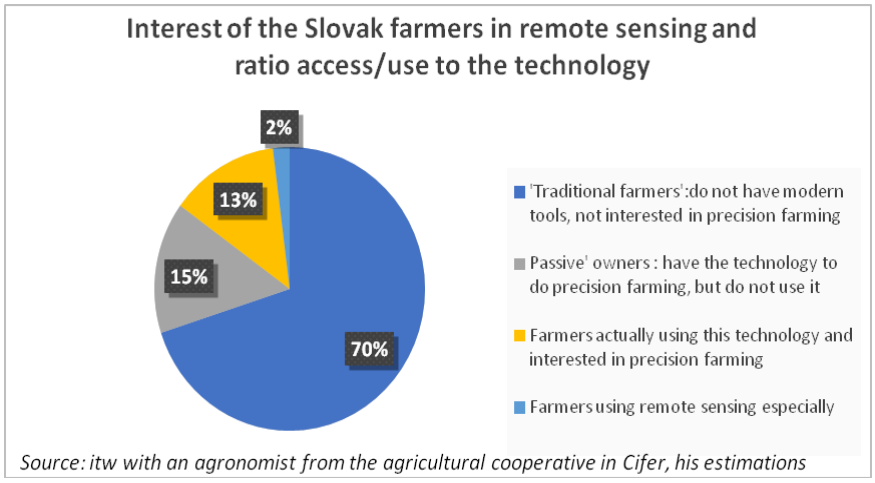

Figure 4. The interest of the Slovak farmers in remote sensing and the real use

According to the interview with Agroservis, we can define 3 groups of customers:
– Those interested in how it looks in their field: get products like NDVI, aerial images. Basic analysis of the fields (weak part of the field/strong part, problems),
– Those interested in more details: get NDVI, prescription map or zones, but without the use of (anything) in the field. This is just theoretically, based on field imagery from drones,
– For the more interested: NDVI, identification of the differentiated zones, and prescription maps'. The prescription maps are transferred to the tractor or sprayer, or else, … but no advisory like the amount of fertilizers.

All farmers have access to data obtained from remote sensing tools (satellites, with Sentinel and by plane every 3 years in Slovakia). They have to use it to know the state of their lands, and to identify the crop area (the expansion, reduction, …). They need it to ask for subsidies and check in general. So the main use of remote sensing is to see what is new in the field and check the surfac-

es, and the changes. There are also professional uses and applications, but not really by farmers, mostly by state institutions. Farmers try to use small drones, but it's not really common.

There are many drivers for using remote sensing specifically for the purpose of precision agriculture, and the main, similar in Slovakia and Hungary, are the following:

– Regulatory: to justify and plan nitrogen application, it has been mentioned by almost every user and service provider.
– To save costs by saving on inputs: buy better herbicides or pesticides and wisely use them. This motivation is becoming stronger with the Covid crisis and economic crisis inducing an increase in the chemicals prices.
– To increase yields; it depends on the interlocutor: for some of them it is not possible to increase it anymore and the most important is to optimize; for others it is still the objective.
– Agronomic interest: better knowledge of the plot, in Slovakia it concerns mainly the 'big' or wealthy winemakers working in partnership with universities.

To a fewer extent, there are also:

– Curiosity: in cooperatives, the agronomist is curious or knows a bit about drones and all of this technology, and convinces the other workers of the agricultural cooperative, and the owner, to adopt it, to face the economic situation and be ready for any change.
– Environmental: to develop sustainable agriculture and face the consequences of climate change. Some companies, the bigger ones, consider it as a driver for the farmers but some others presented more reserve about this motivation.
– 'Neighbouring effects': when farmers see some 'pilot farms' having good results, they are motivated to try.

Those are similar to the drivers in French agriculture, but there are also other more specific ones:

– Willingness to attract young workers to the farms: agriculture is in lack of workers, but young people are not interested to work in it if they do not have some 'comfort'. Using new technologies can motivate them because they do not go with old tractors, old combine. Young people use modern and smart technology and have many new ideas.

Difficulties or limits of remote sensing

Even if there are a lot of drivers, many obstacles limit the diffusion of remote sensing technologies. There are also mostly similarities in Slovakia and Hungary:

– Conservative farmers: it is hard to convince them of the benefits they could get in using those technologies.
– Legislation and restrictive state regulations, even if they are different in the two countries; for flying, have the license, permit and insurance, and authorisation of the final images (in Slovakia) or spraying (in Hungary).
– Lack of formation and trained employees: "The problem are the people, many companies do not have enough employees" or are not qualified enough, to do the settings for the machines.

To a fewer extent:

– Time and complexity: even if the tools, especially the drones, are easy to use and not so expensive, they require time to be understood and correctly used, and more time to analyse the images they could provide.
– The lack of insurance for drones.

And specifically in Slovakia:

– Mentalities and structure of the agro-companies: disagreement between owner/agronomists, Not enough employees, or not qualified enough to do the setting on the machines,
– Lack of support from the state, 'it's on private costs' and the absence of modern institutions to provide support or training.

Whereas in Hungary:

– Competition, which was almost not mentioned in Slovakia. There are more companies than in Slovakia. Even if it is more a 'difficulty' in the market than an obstacle for the farmers who would like to adopt remote sensing.

– Parametrisation and communication problems. It was not specifically mentioned as a problem in Slovakia, but the companies are smaller with fewer users; they struggle to find them but have time to accompany them, whereas in Hungary the companies are bigger and help more farmers with bigger farms, so the difficulty to communicate has been highlighted as a problem.

4. Development of remote sensing and specificities in Hungary and Slovakia

From the interview (Agroservis, main distributor of John Deere in Slovakia), we can consider a 'curve of implementation' about the use and adoption of RS technologies in agriculture (Fig. 5), where technologies is mostly a reference for drones in this estimation.

Slovakia

We can position the country "in the stepping, before reaching the highest spot"; then it should fall down, before starting to be really used in general in agriculture, "within 1-3 years" (Agroservis). Remote sensing, as new technology in agriculture in general, is rising. The technics and technologies about planes are more developed and more used than before, there are more sources of data than some years ago in Slovakia. The interest of farmers is increasing, apparently because '*The new generation is more opened because the precision agriculture topic and the subject is all around us, in newspapers, in general topic from government, discussions*, this is a subject on different levels.'

– Farmers are more interested, because there are more companies to raise their interest, and also because with the tougher weather and climate impact they see an interest in making agriculture more sustainable, to keep some profit and optimize the processes.

– The technology is more available, the price of drones is falling and the smaller ones are more user-friendly. Technology imported from abroad has become a standard.

– Nevertheless, there is a "*need, for example, to reach the peak and convince people*" and 'authorities', to implement it in a lasting way (*Aurus*), because currently it is "*only the beginning in Slovakia, using these tools to plan using nitrogen, or irrigation*", "only a few farms in Slovakia use it" and basic data "*like the Infrared images*", but it is considered as "*the future of agriculture*", once Slovakia will have faced a "change of generation of farmers." (ICS Production).

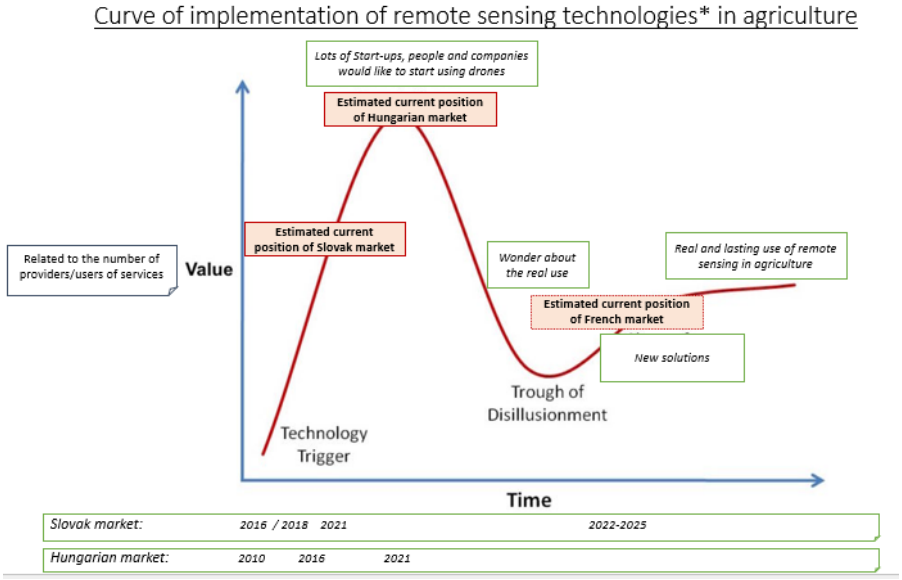

Figure 5. Curve of implementation of remote sensing in agriculture

Hungary

In Hungary, the number of companies, the larger areas covered by the services, and the greater diversity of those, show that uses of remote sensing are more spread across the farming population than it is in Slovakia. Nevertheless, it is complicated to position the country in the previous curve; it is around the peak but possibly right before it or right after.

According to the co-founder of the Hungarian company Agrontech, "*Almost every month a new company is established and another stops its activities*", because it could not find its place on the market. Consequently, we could position Hungary in the peak.

"In Hungary, the role of drones and software in agriculture is now at an advanced stage: their uptake and integration into farming are roughly at Western European levels and interest is growing." (ABZ drones, to consider with some caution because it can also be a marketing strategy to sound so optimistic). Nevertheless, "*Farmers are getting interested in remote sensing data, they start to understand the importance/usefulness of NDVI image*." (KITE), and the "*Utilization of the plane has fallen, the remote sensing using is growing and its application is wider*" (KITE). "*There are growing requirements for precision agriculture*" (KITE).

We could consider that there has been a paradoxical influence of the State in Slovakia: 2017/2018 it introduced this technology, through a change in the process of the subsidies requests. They must be done online, by a few recognized companies (we interviewed Aurus and ICS Production), or by the APA for the smaller farms, on the basis of the images provided by the State through online portals. Those images are obtained by remote sensing, mostly from plane flights every 3 years, and contain basic indexes. They are mostly used to limit the crops' borders, sometimes to identify them. There is also aleatory control from the APA, by satellite images (Sentinel-2). On the other hand, there is no support, which is described as an obstacle. On the contrary in Hungary, there seems to be a stronger implication of the State. There are companies using remote sensing technologies in precision agriculture (at least two companies – ABZ and Agrontech) that talked about partnerships with 3-4 universities). This might explain why the market is more developed.

We could summarize some of the specificities of the two countries, which can explain the differences in the state of the market of remote sensing (tab.6).

Table 6. Some specificities in each country

Slovakia	Hungary
The regulation is stronger than in other countries, it "should be unified in EU" especially about drones flying. The bureaucracy and the government are strong obstacles or at least a lack of help. "*Maybe we are **2 steps back our neighbouring countries**, **because of our government**. In the field of remote sensing and precision agriculture in general*" (Agroservis).	The regulation about flying and spraying is unclear. There is good support and organisation of the market. The companies work to promote the uses of the technologies, whereas in Slovakia they already struggle to get the interest of their customers. The competition is very strong The main part of the country is adapted to agriculture in big fields, big areas, and set up for the use of technologies.

Conclusion

The private use of remote sensing seems to be more expanded in Hungary than in Slovakia, for various reasons:

– They have a more adapted farming environment (large areas, more homogeneous, crops more suitable to the use of remote sensing or precision agriculture);
– The agriculture is more structured, and there is even an organization, especially for precision agriculture;
– The companies involved in remote sensing are more numerous (some of them may also provide services in Slovakia though).

Compared to France, there is stronger interest from public institutions in remote sensing in Slovakian agriculture, but less private companies. In Hungary, there are more companies though. The marketed uses are similar, at least for the crops concerned, but we don't have a lot of explana-

tions about the precise applications. Nevertheless, the scales are different; the marketed services concerned *surface 5 times less important than France in Slovakia (and probably less than that), and it is more complicated to estimate in Hungary, but possibly less in % of agricultural area*.

The organization of the market is similar except for the agronomical advice that seems less important in Slovakia. The same technologies are used, *with maybe a bigger proportion of drones than in France where satellites represent 90% of the Slovak market of remote sensing*.

The motivations and obstacles are similar, except for a few surprising ones, but do not have the same importance: the main motivations are to reduce costs and better plan fertilisation.

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R e s u m é

Využitie diaľkového prieskumu Zeme v poľnohospodárstve na Slovensku a v Maďarsku

Táto štúdia sa uskutočnila v spolupráci medzi dvoma inštitúciami: francúzskym Výskumným centrom pre digitálne poľnohospodárstvo (L'Observatoire des uses de l'agriculture numérique de la Chaire AgroTIC), z L'Institut Agro (Montpellier) a Katedrou fyzickej geografie a geoinformatiky Prírodovedeckej fakulty Univerzity Komenského (Bratislava). Cieľom spolupráce bolo šírenie a výmena poznatkov o digitálnom poľnohospodárstve v Európe. Z Maďarska sa na štúdii podieľali Univerzita Istvána Széchenyiho a Maďarská univerzita poľnohospodárstva a prírodných vied (MATE). Cieľom štúdie bolo prezentovať výsledky výskumu využitia diaľkového prieskumu Zeme (DPZ) v slovenskom a maďarskom poľnohospodárstve.

Použila sa podobná metodológia s cieľom získať porovnateľné údaje o oboch krajinách, najmä prostredníctvom dotazníkov a interview s aktérmi zapojenými do tejto oblasti, tak verejnými, ako aj súkromnými. Na Slovensku bolo identifikovaných približne 15 subjektov a okolo 30 subjektov v Maďarsku, od spoločností poskytujúcich ortofotosnímky z diaľkového prieskumu po ďalšie spoločnosti, ponúkajúce služby priamo farmárom alebo verejným inštitúciám.

Záujem štátu bol identifikovaný tak na Slovensku aj v Maďarsku pre oblasť DPZ a jeho použitie na poľnohospodárske účely. Predovšetkým ide o voľný prístup farmárov, ako aj verejnosti k aktuálnym snímkam poľnohospodárskych pozemkov a ich vybraných charakteristík, prioritne pre účely žiadostí o dotácie farmárom. Zapojenie štátnych/verejných inštitúcií do vzdelávania, financovania, projektov ako aj štruktúrovanie tohto trhu je však na Slovensku v porovnaní s Maďarskom nízke. Výskum ukázal určité rozdiely medzi týmito dvoma krajinami, pokiaľ ide o komercializované služby v oblasti DPZ, najmä v rozmanitosti ponúkaných služieb, používaných nástrojoch a podiele zainteresovaných poľnohospodárov. Dôvody pre zavádzanie metód DPZ zo strany poľnohospodárov sú v oboch krajinách vo všeobecnosti podobné, hoci sa netýkajú rovnakého podielu používateľov. Sú to najmä finančné motivácie s cieľom možného zvýšenia zisku alebo zníženia výrobných nákladov. Ďalšou motiváciou v určitej miere môže byť ochrana životného prostredia a prispôsobenie sa klimatickým zmenám, ktoré začínajú ovplyvňovať poľnohospodárstvo na Slovensku aj v Maďarsku. Hlavnými prekážkami je nedostatok organizácií poskytujúcich služby v danej oblasti poľnohospodárstva (družstvá, poradcovia) na Slovensku, čo obmedzuje šírenie know-how a znalostí v oblasti inovácií a presného poľnohospodárstva vrátane DPZ, a aj nedostatok finančných prostriedkov, nedostatočné poistenia a časový faktor, potrebný na implementáciu tejto technológie.

Obr. 1 Schéma a porovnanie využívania pôdy v oboch krajinách (zdroje: [15] Pôvodná mapa, [16] Grafika, [9] Zelená správa 2019, [10] Precízne poľnohospodárstvo v Maďarsku, [13] FAO)
Obr. 2 Rozdelenie pozemkového vlastníctva na Slovensku
Obr. 3a Reťazec trhu diaľkového prieskumu Zeme na Slovensku
Obr. 3b Trh diaľkového prieskumu Zeme na Slovensku v poľnohospodárstve so skutočnými účastníkmi
Obr. 3b Trh diaľkového prieskumu Zeme v Maďarsku v poľnohospodárstve so skutočnými účastníkmi
Obr. 4 Záujem slovenských farmárov o diaľkový prieskum Zeme a reálne využitie
Obr. 5 Krivka implementácie diaľkového prieskumu Zeme v poľnohospodárstve
Tab. 1 Prvý odhad plodín a oblastí potenciálne dotknutých službami diaľkového prieku Zeme v Maďarsku
Tab. 2 Aproximácia pomeru pestovaných plodín pokrytých službami diaľkového prieskumu Zeme v Maďarsku podľa rôznych odhadov
Tab. 3 Aproximácia pomeru pestovaných plodín pokrytých službami diaľkového prieskumu Zeme na Slovensku podľa rôznych odhadov
Tab. 4 Charakteristické výhody/nevýhody príslušnej technológie
Tab. 5 Hlavní aktéri na trhu diaľkového prieskumu Zeme identifikovaní na Slovensku a v Maďarsku
Tab. 6 Niektoré špecifiká v každej krajine

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