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# Main Motivational Factors of Farmers Adopting Precision Farming in Hungary

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**Abstract:** The basic question of our research is what crop-producing farmers know about PF (precision farming), and how economic value and social factors motivate the acceptance and implementation of PF. We conducted a cross-sectional survey, using standardized questionnaires, in 2018, that was nationally representative of Hungarian crop producers. Besides this, we conducted 30 semi-structured interviews about the meaning of PF, with the farmers who use PF in practice. They defined it as a tool of strategic planning, to serve input savings, using state-of-the-art technologies. Based on the questionnaire, we found that the farmers currently applying PF do not seem to have such a significant impact on the agricultural society that would make others want to move to precision technology, following their example. As a result of the factor analysis, we could differentiate direct and indirect factors. Potential human resources are undereducated, their willingness to improve their knowledge is low, and the level of cooperation ability is low, making it excessively difficult, or even impossible, to acquire the equipment necessary for a technology switch and to purchase the necessary services. It can be concluded that age, production, and technical usefulness carries greater weight over things like monetary factors, productivity of cultivated land, knowledge capital, and willingness of Hungarian farmers to cooperate.

**Keywords:** precision farming; factor analysis; arable farming; farmers' motivation; social factors

## 1. Introduction and Literature Review

Numerous definitions exist for precision farming (PF), all of which emphasize the pursuit of economic, environmental, and social sustainability [1–5].

### 1.1. Interpretation of PF

The board of directors has recently recognized the following definition as the official one of the International Society for Precision Agriculture (ISPA): “Precision Agriculture is a management strategy that gathers, processes and analyzes 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". According to the former Home-Grown Cereals Authority (HGCA), PF is a form of crop management that provides information for decision-making, using computerized GPS and remote-sensing systems. The United States Department of Agriculture (USDA) defines this activity as "just-in-time" management, which is an information- and technology-based, site-specific activity, and it is—partly or entirely—based on optimizing the following data, in order to procure maximum income and to achieve environmental sustainability, i.e., soil quality, plant species/variety, yield, nutrient management, and plant protection [6]. The definition of PF has been changed in previous decades; these tendencies are detailed on the website of the University of Lleida [7]. Considering the common elements of the definitions of PF, we recognized that PF is an optimization-based, efficiency-oriented form of crop management. Technical content is a significant part of applying PF, but it is mainly based on human knowledge and willingness.

Since extra investment is necessary for PF and the typically intensive production requires great expertise and precision, the main obstacle of PF is human capital [8]. From the aspect of PF becoming widespread, it is crucial that farmers know, and are willing and able to apply PF.

### 1.2. Factors Affecting Future Spreading of PF

PF is viewed as "just another" technological development which is exogenous and has a pre-specified life cycle. Nowadays, it is widely accepted that the effective use of PF technologies depends not only on the ability of technology to produce results, but also on farmers and other players involved in food production and supply chains. Key questions on the use of big data in farming have been examined by Lioutas et al. (2019) in light of cyber-physical-social systems [9]. The integration of PF technologies can achieve automated operations requiring minimum supervision of agricultural vehicles [10]. The work of Regan (2019) highlighted the call for discourse-based management of risks in Ireland [11]. The importance of a multidimensional theoretical framework has been studied by several authors [9,11–14], in regard to the need to support adopters by framing adoption with rules and by supplying them with knowledge.

One of the possible limits of the future spreading of PF could be the lack of trust and transparency surrounding data ownership [15,16].

Regarding the multiple motives behind adopting of technologies, it is well documented that farmers' decision is not framed only by economic incentives, but social influences, as well as other factors, play vital roles [17]. Cooperative innovation in local areas is becoming more and more accepted [18], and green ingenuity might have an ongoing impact on the decision-making of farm enterprises [19,20].

According to Mytelka's classification [21], farmers who currently use precision technology are considered to be pioneers. They are the ones who are constantly confronted with the uncertainties and risks of the socioeconomic-legal-political environment.

Farmers' sets of values can be changed only gradually, and since they—especially the elders—respond to changes more slowly, this presents a major barrier to the further spreading of new socioecological systems, such as PF [22]. According to Burton [23], the ideal farmer manages intensive technology on good-quality land (both crop production and livestock management) and has significant social status. In our opinion, this is a conservative approach and sheds light on why the spreading of new technologies is slow from a psychological aspect. Hansson-Kokko [24], based on in-depth interviews conducted with 15 Swedish farmers, also emphasized the importance of changing the farmers' traditional set of values and of deviating from conventional cultivation methods.

The concepts based on chain models (e.g., Kline and Rosenberg [25]) emphasize the role of feedback and highlight the activating effect of knowledge growth. For this reason, we also examine how important the involved farmers consider the role of knowledge, skills, information, and willingness to cooperate, as well as the state of the local society to be. Due to the rather low number of precision

farmers, there is no paradigm shift at this point. Therefore, we examine the knowledge, information, and the social factors that farmers themselves consider important in adopting PF technology and farming practices. These include the effects of structural factors and the intrinsic motivation of farmers:

- Areas and opportunities for acquiring knowledge;
- Reasons for choosing precision or non-precision farming;
- Forms of accessing information and flow of information;
- Factors influencing the development of precision farming: cost factors, human resources, knowledge, skills, information, local social environment, legal-political environment, and market environment; and the positive and negative social and economic consequences of precision farming.

### 1.3. Utilization of PF in Hungary

PF technologies started to spread 15 years ago in Hungary; however, a significant knowledge gap still exists regarding PF [26], as only 50% of plant producers have heard of it [27] and only 44% use such technologies [28]. Half of those using PF used GPS, 30% used autopilot, and 25% used PF technologies during sowing and fertilizer dosing. The role of plant protection, irrigation, and drones is negligible [29]. According to Lencsés et al. [30], PF users in Hungary are farmers under the age of 40, who perform their activities on at least 300 ha, which is also in conformity with international trends.

Currently, the agricultural policy that has the greatest impact on the legal environment of PF is partly within the competence of the EU and partly of the member states; therefore, its predictability depends in part upon the governance of the member states and partly upon that of the EU.

It is interesting (and a distinctly Hungarian feature) from the aspect of PF that a significant part of Hungarian agricultural land is grown for plants that do not correspond to the natural conditions and the challenges of climate change, similar to the use of farming technologies [31], plot sizes were also determined unfavorable [32]. Thus, the benefits of PF could be better realized after a future government-initiated land redistribution.

Hungarian legislation has not yet adapted to the new technologies, e.g., the regulation of drone use is way too bureaucratic, precision irrigation is not encouraged by water management rules, and geo-data cannot be freely accessed [33].

### 1.4. International Experiences Based on Questionnaires

It is not surprising that the lower the level of education, the lower the legal knowledge. It can be assumed that this phenomenon also influences the judgment of the role of land-use legislation, but it does not explain the differences in farm size.

According to Daberkow and McBride [34], mainly young, well-trained, and large-scale farmers are interested in introducing, as well as applying, PF, as the use of technology is unimaginable without using a production site-specific GPS system (Global Positioning Systems) and automatically controlled VRT (variable rate technology) applications capable of delivering data in the most accurate and fastest way possible, in terms of both input and yield data. Since a large number of employees are involved in the use of PF on large farms, their training is essential for effective operation.

According to Fuchs et al. [35], the easiest way to reduce costs is to join horizontal integration and outsource certain special management tasks. In Germany, mainly two segments of farmers are concerned: (1) small farms that are unable to finance the new technology and (2) the larger farms whose owners do not have the appropriate qualifications, so they may outsource certain management tasks over time. Moreover, these farms are unlikely to provide the financial or personal conditions for using PF on their own.

According to the Delphy survey conducted by Busse et al. [36], two-thirds of the farmers surveyed said that the most important prerequisite for success was the development of an appropriate support, as well as funding, system. According to these farmers, enhancing future competitiveness, as well as safe and quality food production, is unimaginable without using PF.

The role of obtaining information from various sources is not negligible, either. Studies by Kutter et al. [37] show that, in Germany, personal relationships (farmers living next to each other, consultancy) and relevant journals play an important role in spreading PF, while in Denmark, consultancy organizations (farmers' union) are more significant in this respect. The latter phenomenon is probably due to the fact that consultancy in Denmark covers 90% of agricultural land; therefore, these organizations can seriously influence farmers' decisions. Reichardt and Jürgens [38] consider it necessary to teach PF techniques more thoroughly within specialized agricultural training. However, according to the performed survey, teachers find it rather difficult to teach this subject in Germany.

According to the Southern Cotton Precision Farming Survey (2009) and its multinomial logit model estimation procedure, automated technologies are more acceptable to future-oriented and long-term-thinking farmers whose primary goal is cost-saving [39].

PF is in fact a new type of farming in Hungary, and farmers' attitude toward and knowledge of it may be a decisive factor in its spread. Therefore, the aim of this paper is to explore Hungarian farmers' knowledge of PF, as well as the economic, social, and value motives for evaluation and implementation of said system. The basis of our research is that Hungarian farmers who cultivate the land know about PF and what economic, value, and social factors motivate the acceptance and implementation of PF. We also sought to figure out where the Hungarian farmers' knowledge and information about PF originated from, which social factors are considered to be the most important in the spreading of precision technology, and which of these, in their opinion, encourages and hinders the transition to PF. Though several papers are available about the technical and economic side of PF in Hungary (especially in Hungarian), the international publication of the social side, supported by both statistically reliable data basis at the national level and deep interviews, has been neglected, and our paper would like to fill this gap.

## 2. Materials and Methods

We considered the methodology of previous studies, to design our methods, and firstly we wish to introduce the most relevant two samples.

### 2.1. Description of the Questionnaire

The survey of Barnes et al. (2019) [40] included 971 farmers with different structural factors and adoption rates. Farmers were selected on the basis of current non-adoption and current adoption of PF. The count data were assembled to reflect a farmers' status with respect to the threshold technologies and their intended status with respect to the number of contingent technologies (scaled 0–3). The evaluation was executed typically by the use of a 3-point scale and a 5-point Likert attitudinal scale. Qualitative analysis was grouped by using the categories non-adoption and adoption.

In the study of Adrian et al. (2005) [41], a survey instrument—using structural equation modeling and multivariate analysis—was developed to measure constructs of the following factors: (1) perception of usefulness, (2) perception of ease of use, (3) attitude of confidence, and (4) perception of net benefit. Although the perception of usefulness, perception of ease of use, and computer confidence attitudes constructs were used in the information systems and education fields, they have not been used specifically for precision agriculture technologies before. While the potential for creating efficiencies is possible with precision agricultural tools, the various combinations of tools, the steep learning curve of these technologies, and the initial investment of each of the tools complicate farmers' decisions [41].

In our primary research, we conducted a cross-sectional survey, using standardized questionnaires, in 2018. The survey was carried out by the Research Institute of Agricultural Economics (herein referred to as AKI). The sample was taken from the farms included in the test farm system of AKI, in accordance with the prescriptions of EUROSTAT [42].

The respondents represented the Hungarian crop producers, which is nationally representative of the farming of more than 2 hectares. Therefore, we had the opportunity to get to know the opinion of the overwhelming majority of plant growers regarding PF.

We compiled a standardized questionnaire consisting of five parts (including 15 subtopics). The farm-specific test data were taken from intel collected by AKI annually.

The composition of the questionnaire consisted of the following four question groups:

- Awareness and spreading of precision field crop production;
- Applying precision technology on the farm;
- Questions aiming at farmers' opinions;
- Sociodemographic characteristics of the farm and the farmer.

Our results were also evaluated internationally. The comparison is based on a study recently published by Barnes et al. (2019) [40], representing five countries, in which the opinions of farmers on PF and the previously published study [41] were presented. In our survey, the number of participant farmers and the rate of current adoptions were lower than in the case of Barnes et al. (2019), because of the present situation of PF in Hungary. Our research method is similar, save for the forming of the groups based on the farmers' self-declaration, introduced by our qualitative analysis.

In our research, most of the questions asked in the questionnaires related to farmers' motivations were measured on a scale of 1 to 5 on the Likert scale. In the case of questions focusing on the conditions of agreement, 1 corresponded to complete disagreement in textual form, while 5 represented the respondents' full agreement. In the case of certain questions, 1 on a five-grade scale meant that the respondent would not be affected by the given question, and 5 meant that it would seriously affect the respondent. The sociodemographic variables of the questionnaire were categorical.

We asked the farmers what factors would help them to spread PF in general. There were five categories to choose from, which they had to set in order of significance. The following options were available for respondents:

- More and/or more detailed information;
- Availability of a more skilled workforce;
- Possibility of consulting;
- Vocational training relating to farming;
- Compatibility between technologies;
- Higher profitability;
- Income supplement support for technology users;
- Higher buy-in price (e.g., certificate providing benefits);
- Investment support in the Rural Development Program;
- Support for commonly used devices (e.g., machinery rings);
- Renting from integrators;
- Renting from external contractors;
- Investment and hired service through borrowing.

In this research study, we also examined which factors weaken the motivation and willingness of farmers to introduce PF technologies. We asked those who do not yet apply PF (92.9%) about the reason for this decision. When answering, they had to mark the first five most important reasons in order of importance. The following options were available for respondents:

- Lack of adequate information and knowledge;
- Additional investment costs;
- Additional operating costs;
- Time needed to introduce a new technology;
- Lack of operational experience;
- Mistrust in new technologies;
- Lack of adequate funding;

- Lack of available consulting;
- Lack of a suitably qualified workforce;
- Does not fit the size of the farm;
- Difficulties concerning the farm structure;
- It is not possible to use the missing technology elements as a service.

## 2.2. The Semi-Structured Interviews

In addition to the questionnaire survey, we also prepared 30 semi-structured interviews with 25 farmers and 5 farming experts who use PF in practice, for a better understanding of farmers' knowledge of and opinions about the meaning of PF. The prerequisite for farmers to be included in the sample was to perform PF, apply precision technologies at least to a minimum extent, or plan to apply them. The interviews were conducted with personal inquiries, and the farmers' contact list was compiled, using the AKI database. In every case, we made a word-by-word transcript of the recorded audio. The average length of interviews was 1.5 h. The interview was based on the examination of four main dimensions, and we created several sub-dimensions. The main dimensions of the research were as follows: (1) the essence and characteristics of PF, according to the respondent; (2) the detailed description of the farm and farm management activities of the respondent; (3) the opinions on the situation of PF in Hungary; and (4) the obstacles of the spreading of PF, according to the respondent. Interviews with experts were conducted before devising our survey, to establish a sound research project in terms of the dimensions and questions of our quantitative questionnaire. We conducted semi-structured interviews with farmers involved in precision farming after collecting survey data, to be able to qualitatively explore and explain obstacles to the spread of precision farming that we found in our survey study.

### The Meaning of PF for Hungarian Farmers

Based on our interviews with farmers using precision technologies, we determined that the concept of PF is not clear. Due to the critical approach and uncertainties of the interviewed respondents, in most cases, they do not dare to declare themselves to be precision farmers (regardless of the fact that they use precision technologies). Another consequence is that "precision identity" can hardly be developed or cannot be developed at all, which is also a barrier to the spreading of PF.

"There are a lot of things that you can call PF, but I haven't seen any self-proclaimed precision farmer whose practice I couldn't criticize for not being 100% PF. We also use certain elements, but unfortunately, we cannot 100% conform to this direction either. It is hard to meet all requirements" (36-year-old farmer with a higher-education degree)

Two distinct groups can be created from the answers of Hungarian precision farmers. The "technology-oriented uncertain" group is determined primarily by the "testing" and the technological solutions used, but the successful outcome is uncertain. They do not fully believe in precision technologies, but hope to be able to improve their performance in some form, that is, a positive change is expected compared to traditional solutions ("Let's apply precision technology and see if we can achieve the goal, i.e., whether there will be any change compared to traditional solutions"). Curiosity, uncertainty, dependence on consultants, lack of expertise, openness, interest, and cautious risk-taking characterize the entrepreneurs in this group.

"Technological discipline or accurately conforming to the technology are classified as precision farming. Well, honestly, I think it is a form of intensive farming backed by very professional technical development, obviously in line with the soil endowments and weather" (57-year-old farmer)

“To find that balance which works within the field, so that the good parts will not go unused and in the end, as little nutrient is applied as possible, as there is no point in applying high doses on the weak parts. This is my definition of precision farming” (43-year-old farmer)

In the opinion of the “goal-oriented conscious” group, more emphasis is placed on successfully achieving one’s goal, and they see precision technology as one of the tools to achieve their goals. Consciousness, complexity, strategic planning, expertise, and openness to developments characterize the entrepreneurs involved.

“For me, a good example of precision farming is when someone plans their nutrient replenishment activity based on soil analysis results, putting together the plan in a software program and applying the nutrients to their fields in varying doses. Or they can do the same with sowing seeds or pesticides, by not using the same dose for the whole field, but distinguishing zones within the plot and consciously managing them separately based on obtained data” (31-year-old farmer)

“I think that precision farming is a much broader concept than location-specific farming. Precision farming exists because measurement techniques improved a lot as a result of technological development. Consequently, I would define precision farming as decision-making based on real and accurate measurement data and the differentiated implementation of this decision. This intervention could be immediate, i.e., in a fraction of a second, or, as I always say, in a different time and space. It could be done even months after” (48-year-old farmer)

### 2.3. Statistical Analysis

Data were obtained from the responses of 604 farms. In the course of the data analysis, a chi-square test and factor analysis were used, in addition to descriptive statistics indicators. SPSS version 25.0 was used to perform the analysis.

For nominal (categorized) questions, the comparison was performed using a chi-square test of independence. In order to categorize the questions into groups, we have run a factor analysis and examined which issues were grouped together [43]. We attempted to name these factors based on the questions creating the given factor.

## 3. Results and Discussion

### 3.1. The Sample

In our research, we interviewed 604 agricultural farmers. However, not all of them answered all questions. Tables 1 and 2 contain the most important characteristics of the sample.

**Table 1.** Characteristics of the sample among all farmers.

Variables	Mean	SD
<b>Gender of the farm owner and/or manager (1: Male 0: Female)</b>	0.86	-
<b>Education categories (person)</b>	597	
Primary	83	-
Secondary	332	-
Higher	182	-
<b>Age (year)</b>	57.9	12.1
<b>Age categories (person)</b>	541	
Under 40 years of age	51	-
Between 40–60 years of age	228	-
Above 60 years of age	262	-

Table 1. Cont.

Variables	Mean	SD
Sowing area—Total area used by the farm (ha)	149.5	426.9
Sowing area—Land value (thousand HUF/ha)	727.2	235.6
Revenue—Field crop production, grassland management (thousand HUF)	41,070.6	139,955.4
EBITDA (million HUF)	19.9	31.5
Cost of Fertilizers (thousand HUF)	5868.4	19,994.8
Revenue—Whole business (thousand HUF)	72,601.1	476,163.1
Average AK (golden crown <sup>1</sup> ) value of the sowing area	20.4	7.7

<sup>1</sup> Special Hungarian unit for describing land value. Source: own data collection.

Table 2. Characteristics of the sample among different type of farmers.

Variables	Non-PF Farmers		PF Farmers	
	Mean	SD	Mean	SD
<b>Gender of the farm owner and/or manager (1: Male 0: Female)</b>	0.85	-	0.92	-
<b>Education categories (person)</b>	554	-	43	-
Primary	76	-	7	-
Secondary	311	-	21	-
Higher	167	-	15	-
<b>Age (year)</b>	58.3	12.1	53.4	10.4
<b>Age categories (person)</b>	505	-	36	-
Under 40 years of age	51	-	-	-
Between 40–60 years of age	204	-	24	-
Above 60 years of age	250	-	12	-
<b>Sowing area—Total area used by the farm (ha)</b>	116.0	210.2	580.9	1341.2
<b>Sowing area—Land value (thousand HUF/ha)</b>	722.6	239.1	786.9	176.6
<b>Revenue—Field crop production, grassland management (thousand HUF)</b>	30,480.9	60,801.2	177,505.0	456,886.7
<b>EBITDA (million HUF)</b>	17.2	24.5	55.2	69.0
<b>Cost of Fertilizers (thousand HUF)</b>	4269.6	9000.9	26,466.9	64,330.6
<b>Revenue—Whole business (thousand HUF)</b>	46,671.0	21,458.8	185,092.1	167,702.9
<b>Average AK (golden crown <sup>1</sup>) value of the sowing area</b>	20.1	7.6	24.4	7.2

<sup>1</sup> Special Hungarian unit for describing land value. Source: own data collection.

Considering the references in the literature chapter [41], we assumed that education, gender, and age have crucial relevance in the use of PF; therefore, we introduced the description of the respondents. Overall, 61.4% of the sample farmers have a secondary educational degree, and 33.6% have higher-educational degrees. Gender distribution shows significant male dominance (86% male). The youngest respondent is 23, the oldest is 92 years old, and the average age is 57.9 years. The average age of precision farmers is 53.4 years, while that of non-precision farmers is 58.3 years, so the age difference is not significant. Based on the age distribution, the proportion of young farmers under 40 years of age is only 9.4%, and the overwhelming majority of them are over 40 (90.6%). The educational degree of young people under the age of 40 is significantly higher ( $p < 0.05$ ) than those above 40 years, as more than 50% have higher-education degrees, while the same value is only 31.8% among the older age group (Table 3). This is just the opposite in case of the farmers with a secondary degree (62.9% and 47.1%, respectively), the ratio of primary education is negligible (5% in average).

**Table 3.** All farmers' distribution by age and educational degree (number of people, %).

	Educational Degree			Total
	Primary	Secondary	Higher	
<b>All farmer *</b>				
<b>Under 40 years of age</b>	1 person 2.0%	24 ppl 47.1%	26 ppl 51.0%	51 ppl 100.0%
<b>Above 40 years of age</b>	26 ppl 5.3%	308 ppl 62.9%	156 ppl 31.8%	490 ppl 100.0%
<b>Total</b>	27 ppl 5.0%	332 ppl 61.4%	182 ppl 33.6%	541 ppl 100.0%
<b>Non-PF farmers *</b>				
<b>Under 40 years of age</b>	1person 2.1%	23ppl 48.9%	23 ppl 48.9%	47 ppl 100.0%
<b>Above 40 years of age</b>	26 ppl 5.7%	288 ppl 62.9%	144 ppl 31.4%	458 ppl 100.0%
<b>Total</b>	27 ppl 5.3%	311 ppl 61.6%	167 ppl 33.1%	505 ppl 100.0%
<b>PF farmers **</b>				
<b>Under 40 years of age</b>	- -	1person 25.0%	3ppl 75.0%	4 ppl 100.0%
<b>Above 40 years of age</b>	- -	20ppl 62.5%	12ppl 37.5%	32 ppl 100.0%
<b>Total</b>	- -	21ppl 58.3%	15ppl 41.7%	36 ppl 100.0%

\*  $p < 0.05$ ; \*\*  $p = 0.151$ . Source: own data collection.

The examined farms represented by the sample cultivated 95.3% of the land used by all registered farms. The farmland used by the farms was 41.34 hectares, and one farm employed 1.4 people on average. Only 7.1% of the surveyed farmers are engaged in PF; the majority of them do not perform PF techniques (92.9%). The range of precision farmers was determined on the basis of the positive answers given to the question "Do you use precision crop production technology in your farm?" We used an open-response technique; therefore, the questionnaire did not list specific technological elements, as in Barnes et al. (2019) [40]. Our study aimed to explore the opinions of farmers who are committed to precision crop technology; thus, it was not important whether they had practical experience in PF or not.

### 3.2. Results of the Questionnaire Survey

The majority of interviewed farmers (89.9%) have basic information on the technology of PF. Information is primarily provided through official intermediaries related to a professional organization; primarily, training courses (90.4%), inter-branch organizations (87.3%), specialist consultants (75.7%), raw material or machine dealers (71.4%), and professional demonstrations have an important role to play in providing information on special application of PF. Printed professional journals and online professional sources are the least preferred sources of information, but the acquisition of information from other farmers is not a common practice, either, i.e., neither the collection of personal information nor the personal relationships between farmers are significant sources of information.

In our questionnaire survey, we examined the economic and social factors that, according to farmers, influence the spreading of PF the most. This is an even more important issue because, as mentioned above, the proportion of people working in PF is extremely low, similar to the level of willingness, according to our hypothesis.

### 3.2.1. Factors Contributing to the Willingness to Apply Precision Farming

The most important factors ranked first and second are shown below (Table 4).

**Table 4.** Factors contributing to the spreading of precision farming ( $N = 541$ ).

Most Frequent Factors in the 1st Place	Most Frequent Factors in the 2nd Place
1. Higher profitability (179 people, 29.6%)	1. Income supplement support for technology users (129 people, 21.4%)
2. Investment support in the Rural Development Program (107 people, 17.7%)	2. Higher profitability (94 people, 15.6%)
3. More and/or more detailed information (105 people, 17.4%)	3. Investment support in the Rural Development Program (69 people, 11.4%)
	4. Higher buy-in price (e.g., certificate providing benefits) (66 people, 10.9%)

Source: own data collection.

According to farmers, improving profitability and investment grants could help spread technology. At the same time, more and better information is of paramount importance; that is, it is considered that the quantity and quality of available information does not help to spread PF.

### 3.2.2. Factors Hindering the Willingness to Apply Precision Farming

According to the obtained results (Table 5), the biggest obstacle is the extra investment costs (38.2%) and the difficulties of application and adaptation (22.7%), which is completely in line with the results of Barnes et al. (2019) [40]. Those who identified the additional investment costs as the most important problem mentioned operating costs as the second most common difficulty (57%), and the third main reason was the lack of adequate financing (29%).

**Table 5.** Factors hindering the spreading of precision farming ( $N = 557$ ).

Most Frequent Mentions in the 1st Place	Most Frequent Mentions in the 2nd Place
1. Additional investment costs (231 people, 38.2%)	1. Additional operating costs (151 people, 25%)
2. Does not fit the size of the farm (137 people, 22.7%)	2. Additional investment costs (116 people, 19.2%)
3. Lack of adequate information and knowledge (72 people, 11.9%)	3. Lack of adequate funding (63 people, 10.4%)

Source: own data collection.

Altogether, all motivating and hindering factors can be primarily interpreted through the following system of aspects: profitability—additional investment costs—financing difficulties—size-related difficulties of the farm—lack of information.

### 3.2.3. Social, Legal, and Political Factors Affecting the Development of Precision Farming

In addition to the earlier economic categories, we also developed five sociopolitical–legal main dimensions, with which we also wanted to measure the factors which determine PF. The five main dimensions were as follows: (1) monetary factors; (2) human resources; (3) knowledge, skills, information, and local social environment; (4) legal–political environment; and (5) market environment.

The opinions related to these dimensions are summarized below. The highest and lowest values of the results obtained from the two groups (precision farmers and non-precision farmers) are included, i.e., the most important and least significant factors are compared according to the given farming type. Respondents could classify each factor on a scale of 1 to 5, in terms of their importance. Table 6 includes

the highest and lowest values and the most significant differences. Values above 4.0 are considered to be the highest values, while the lowest values are below 3.5. Only these values are shown in the Table 6.

**Table 6.** Social–political–legal dimensions determining the development of precision farming, based on farming type (mean values).

	All Respondents (N = 575)	Precision Farmers (N = 43)	Non-Precision Farmers (N = 532)
<b>Monetary factors</b>			
Availability of equity	4.5	4.5	4.5
Access to government funding	4.3	4.2	4.3
Access to non-state funds	4.1		4.1
<b>Human resources</b>			
Appropriately qualified workforce		4.1	
Supply of young farmers from within the family, farm transfer		4.1	
<b>Knowledge, skills, information, and local social environment</b>			
Up-to-date crop production knowledge		4.1	
Skill level of the local society	3.3		3.2
Knowledge capital of the local society	3.2	3.4	3.1
Composition of the local society	3.1	3.4	3.1
<b>Legal–political environment</b>			
Long-term, predictable agricultural policy	4.2	4.4	4.1
Legislation to ensure long-term land use safety	4.1	4.2	4.1
<b>Market environment</b>			
Land market which enables farm extension		4.1	
Predictable, long-term contractual relationships		4.1	
Successful marketing	3.2	3.4	3.2

Source: own results.

Table 6 shows that the most balanced results were measured in the monetary factors' category. The availability of equity and the access to government funding were also rated as very important factors, both by precision farmers and those not using the technology (averaging over 4.2). However, they attribute different importance to the access to non-state funds, as this factor is considered to be less significant by precision farmers than those who do not use this technology on their farms.

In the field of human resources, non-precision farmers have surprisingly underestimated the importance of an appropriately qualified workforce, as opposed to precision farmers, who attach great importance to professional qualifications. Similar results were obtained with the strategic issue of supply of young farmers from within the family and farm transfer, and these factors were perceived as highly important only by precision farmers. As the third part of this dimension, we asked respondents how necessary they consider it to employ people dedicated to PF. Regardless of the form of farming, respondents agreed that it was of no importance.

The points given to questions raised in the dimension of knowledge, skills, information, and local social environment were below average expectations, and the areas studied in this category were considered to be far less important by farmers than impacts on cost factors. Up-to-date crop production knowledge and a skilled workforce are considered to be of paramount importance by precision farmers, as opposed to non-precision farmers, even though the other factors are not considered to be important by the former group, either. In other words, up-to-date IT knowledge, possession of business information, willingness to cooperate, the level of education of the local society, the state of knowledge of the local community, and the composition of this community (farmers attribute the least importance to this factor) are not considered to be priority needs. In fact, the last three factors were assessed unanimously as the least important and decisive concerning PF.

Within the main dimensions of the legal and political environment, the need for legislation to ensure long-term land-use safety was highlighted by respondents, both using and not using PF techniques. This is the only factor within this topic whose importance is not questioned by either

precision or non-precision farmers. Farmers do not assign particular importance to the following areas: fair tax rules tailored to precision farms, precision farming-friendly political environments, and long-term predictable agricultural policies. This differs from the result of Barnes et al. (2019) [40], which highlights the importance of tighter environmental rules, or technological interventions.

In the main dimension of market environment, two factors received high appreciation from precision farmers: The land market that enabled farm extension and long-term contractual relationships were given above-average importance. However, non-precision farmers have not highlighted their relevance, either. At the same time, successful marketing, reliable business partners, and the info-communication atmosphere are not considered to be essential factors in the development of PF, in any category.

The obtained results show that farmers who do not apply PF techniques underestimate the gravity of several areas (especially the long-term agricultural policy and land-use legislation), in comparison with experienced precision farmers. According to Table 5, the need for up-to-date crop production knowledge, a skilled workforce, supply of young farmers from within the family and farm transfer, a land market which enables farm extension, and predictable long-term contractual relationships are considered less critical by non-precision farmers than those applying PF techniques. However, in regard to the other characteristics, the two groups think alike.

### 3.3. Multivariate Statistical Evaluations of Precision Farming

The reliability of the questionnaire was confirmed by Cronbach's alpha test. As a result, the reliability of the measurement tools can be considered sufficient (Table 7). The validity of the construct was verified by factor analysis, using Varimax rotation of the factors, which is the most common method of rotation [43]. The Varimax rotation of factors is an orthogonal rotation method that minimizes the number of factor variables with high factor loading value, thereby increasing the interpretability of factors [44]. The applicability of the factor analysis was confirmed by the Kaiser–Meyer–Olkin (KMO) test for sampling adequacy and Bartlett's sphericity test [45]. The results of both test methods were satisfactory (Bartlett's test:  $p < 0.001$ , KMO test: 0.854). The hypotheses needed for applying the factor analysis were confirmed. The factor analysis identified five factors with different backgrounds that accounted for 77.57% of the total variance. The adequacy of the compilation of the measurement tools can be considered satisfactory.

As a result of the factor analysis (Table 7), the questions were divided into five separate groups. The first element, the so-called "Direct Factor\_1—Environment for Safe Operation", included five questions. The first of these ("Land market enhancing property") and the second question ("Up-to-date cultivation and technological knowledge") contributed the most to the development of this factor. In the second factor of the "Direct Factor\_2—Finance ability", "Availability of state subsidy", and "Availability of non-state financial resources" are the most prominent. The most powerful elements of the "Indirect factor 1—Positive economic impacts" factor are PF contribution to the development of sustainable agriculture and protecting the environment. It is noteworthy that, at this component, the aspect of "It contributes to the rise of the countryside" is the least significant and has much less weight than other variables. In the case of the factor of the "Indirect Factor 2—Negative socioeconomic impacts", the "It makes farmers vulnerable to large organizations" and the "It gives a competitive edge those with connections" are the most prominent in comparison with PF gives a competitive advantage those who have knowledge of IT and unskilled labor is being pushed out of agriculture. In the case of "Indirect Factor 3—Positive Social Impact", there were only two variables, "The agricultural employment of young people" and "Reducing social inequalities", creating this factor.

**Table 7.** Means and standard deviations of the given answers and the rotated factor weights.

Questions	Mean	SD	Direct Factor_1—Environment for Safe Operation	Direct Factor_2—Financeability	Indirect factor 1—Positive Economic Impacts	Indirect Factor 2—Negative Socioeconomic Impacts	Indirect Factor 3—Positive Social Impact
Land market enhancing property	3.95	0.97	0.75				
Up-to-date cultivation and technological knowledge	3.99	0.94	0.69				
Info-communication environment	3.41	0.93	0.63				
Qualified workforce	3.75	0.95	0.59				
Legislation enabling safety of long-term land use	4.12	0.83	0.56				
Availability of state subsidy	4.33	0.78		0.86			
Availability of non-state financial resources	4.08	0.92		0.69			
Availability of own capita	4.46	0.74		0.62			
It contributes to the development of sustainable agriculture	3.61	1.02			0.91		
It contributes to protecting the environment	3.55	0.99			0.83		
It increases the efficiency of agricultural production	3.75	0.99			0.81		
It essentially contributes to the spread of new production techniques	3.66	1.03			0.77		
It contributes to the increase in prestige of agriculture	3.37	0.96			0.67		
It contributes to the rise of the countryside	3.17	1.05			0.64		
It makes farmers vulnerable to large organizations	3.41	1.02				0.81	

Table 7. Cont.

Questions	Mean	SD	Direct Factor_1—Environment for Safe Operation	Direct Factor_2—Financeability	Indirect factor 1—Positive Economic Impacts	Indirect Factor 2—Negative Socioeconomic Impacts	Indirect Factor 3—Positive Social Impact
It gives a competitive edge those with connections	3.39	1.08				0.77	
It helps to shrink smaller farms	3.44	1.12				0.76	
It increases economic disparity between farmers	3.64	1.01				0.71	
Important production, sales and technology information is collected from the individual farms	3.10	1.02				0.67	
It gives a competitive advantage those who have knowledge of IT and technology	3.60	1.03				0.64	
Unskilled labor is being pushed out of agriculture	3.31	1.02				0.61	
It basically contributes to the agricultural employment of young people	2.86	0.96					0.57
It contributes to reducing social inequalities	2.61	1.01					0.51
Eigenvalue			3.24	2.89	5.07	4.59	2.05
Explained variance by factors (%)			14.09	12.57	22.04	19.96	8.91
Cronbach's alpha			0.81	0.79	0.90	0.88	0.67

Extraction method: maximum likelihood. Rotation method: Varimax with Kaiser normalization. Kaiser–Meyer–Olkin (KMO) = 0.854; Bartlett's test ( $\chi^2 = 8176$ ;  $p < 0.001$ ). Communalities: 0.48–0.81; cutoff point: 0.50; total explained variance: 77.57%, Cronbach's alpha (Total): 0.84;  $N = 604$ .

The order of the average of answers to each question does not always match the sequence of the weight of the questions on the main factor. Of the questions belonging to the “Direct Factor\_1—Environment for Safe Operation” factor, the mean value of the answers given to the question related to legislation enabling safety of long-term land use is the highest, but there is more emphasis on up-to-date cultivation and technological knowledge and more general information about the plant on the factor. Of the questions related to finance ability, the average of availability of own capita is higher than the availability of non-state financial resources. The average of the efficiency of agricultural production and the spread of new production techniques in the positive economic impacts factor is higher than the two questions of the factor related to the PF contribution to the development of sustainable agriculture and protecting the environment, even though they have greater weight. In the case of the factor of the negative socioeconomic impacts, the average of economic disparity between farmers and the average of a competitive advantage those who have knowledge of IT and technology are significantly higher than the average of the answers given to the PF questions, which have a greater weight on the factor. In the case of the positive social impact factor, the order of the average of the agricultural employment of young people and reducing social inequalities is the same. Based on the obtained averages, the variables according to the finance ability and the environment for safe operation were the most important for the farmers concerning the PF.

Based on the results of the statistical analysis, farmers’ motivation we find a unified organizing principle or dimensions with a real weight. Of the variables with stronger explanatory power, production and technical usefulness have a greater weight, while monetary factors, the productivity of the cultivated land, the qualification level of Hungarian farmers or their knowledge capital expressed in any other way, and the explanatory social indicators of knowledge capital, such as age, have a much smaller role. According to relevant international studies [40,41], Western European farmers found rational considerations related to farming the most important of their values, motivations, and opinions on PF. In the study of Adrian et al. (2005) [41], the economic advantage was a key factor in the adoption of precision agricultural solutions, while farm size and farmer educational levels also positively influenced the intention to adopt PF, which do not match our results. Barnes et al. (2019) [40] concluded that education, farm size, younger age, legislation, and state funding are the main explanatory variables concerning the farmers in five countries of the survey, i.e., Great Britain, Germany, the Netherlands, Belgium, and Greece. According to their model analysis, the motivations of Hungarian farmers are quite different from those of Western farmers. The fundamental nature of difference is potentially due to the different interpretation of economic rationality and push and pull factors, the more accurate demonstration of which could be based on a more detailed analysis of primary variables and social factors. In line with our interpretation of the model analysis, the factor of the negative socioeconomic impacts demonstrated that Hungarian farmers’ perception of PF is affected by the example of others and public consensus, the development of which is assumed to be influenced by managing agencies.

#### 4. Conclusions

In Hungary, production and technical usefulness, as well as the composition and prosperity of people living in the surroundings of farmers, have the strongest impact on the application of PF, while the farm’s economic circumstances and the quality of its production area have a moderate effect. This finding shows a very different attitude compared to Western European farmers, who tend to make rational considerations.

However, the level of willingness to cooperate is low, so the producer organizations should play a key role in the spreading of PF in Hungary, which, similarly to the Danish example, may be important not only in the conveyance of information, but the central (managing) company provides the technology, monitors compliance, or even undertakes the related training activity. Experience shows that the latter factor may be the key issue in Hungary. Besides, this activity could be the responsibility

of the Hungarian state in the field of agricultural vocational training, which could function as a form of state support.

Of the research questions pointed out in the introduction, farmers do not accredit particular importance to the impact of the current market environment (land market, business partners, marketing, info-communication environment, and contractual relations), not even those who proclaim to be precision farmers. The importance of legislation that allows land-use safety is the only exception that precision farmers consider essential, but the others have not.

Based on our research findings, the farmers currently applying PF do not seem to have such a strong impact on the agricultural society that others would want to move to precision technology, following their example. In other words, a group of early followers does not appear to be emerging from among the respondents.

At the moment, the future of precision farming is driven by two distinct groups of farmers and their strategies: experimentations and careful risk-taking of a technology-oriented group, as well as strategic planning by a group of goal-oriented, highly determined farmers. The pioneers' experiences, the main introduced technologies and the related accumulated knowledge do not have a strong (pull) effect on others' decisions. Although the pull strategy is based on demand-driven philosophy, the innovation behavior of Hungarian farmers is not affected by this type of adaptation constraint.

The need for government support in its policies and legislative funding scored high in the survey.

Our results show that farmers' openness to improving their knowledge is low and that the resources of social component cannot be interpreted. Potential human resources are unprepared, making it difficult, or even impossible, to acquire the equipment necessary for technology switch and to purchase the necessary services, etc. Although it would be vital for all farmers and workers to have the expertise, commitment, and devotion to PF, the obtained results show that farmers' planning does not include these factors beyond financial returns and other economic considerations; and this hinders the development and spreading of appropriate skills and attitudes.

On the basis of factor analyzes, it can be concluded that the positive economic and the negative socioeconomic impacts have a greater weight, while a much smaller role is associated with the environment for safe operation, the finance ability, and the positive social impact.

According to the results of our research, the motivations of Hungarian farmers differ greatly from the attitudes of Western European farmers, whose decisions regarding precision farming are fundamentally based on rational considerations. The primary element of our policy recommendations is that Hungarian agricultural policy must take greater account of this determinant. We recommend stronger support for the various forms of knowledge and information transfer as a priority. Precision farming has functioning organizations whose activities should be further supported by policy instruments. As a priority area for knowledge transfer, much more effective assistance is needed in organizing forums for the transfer of personal examples. Education on the subject of PF in agricultural vocational training and university training could also be strengthened in the form of separate state funding. Moreover, at the policy level, forms need to be found that allow for the dissemination of personal examples of highly successful precision farmers, in which NGOs are likely to play a key role.

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