A survey of pig and poultry farmers' readiness and attitudes towards smart technologies

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Abstract

Digitalization in livestock farming can foster economic and environmental efficiency of production, as well as the improvement of animal health and welfare. Several newly developed information and communication technologies (ICTs) are available on the market; thus, a number of studies focus on exploring these solutions and assessing their impact on productivity and sustainability. At the same time, much less attention is paid to farmers' (especially in the pig and poultry sector) willingness to adoption, expectations and experiences with advanced technologies and the barriers of technology uptake. This study investigates the readiness and attitudes of pig and poultry farmers towards smart technologies. The assessment relies on a survey conducted in January 2022 in five European and one Middle Eastern country. Standardized on-line questionnaires were completed by 121 pig farmers and 145 poultry farmers. Based on the responses it was found that various factors, such as the level of automatization of farms, average age of the buildings and production technology, internet connection opportunity and the existence of network within the livestock building (which is able to connect to the internet) were strongly influencing ICT-tool use, hence determine the ICT-readiness of the farms. Depending on whether respondents were users or non-users of smart technology, their perceptions differed significantly regarding the ease of access to these technologies on the market, their operational reliability, costs of maintenance and the ease of access to technical assistance to them. This study improved our current understanding of factors influencing technology adoption rates on commercial farms.

Keywords: smart technologies, farmers' attitudes, barriers of adaption, pig farming, poultry farming

1. Introduction

Drive for improved profitability, animal health and welfare, and reduced environmental impact of livestock farming stimulate the need to improve the knowledge about farmed animals and their relationship with their living environment by collecting and evaluating data and information (Banhazi et al., 2022b). Precision livestock farming (PLF) technologies allow farmers to monitor groups or individual animals in a timely manner, capture information, process and analyse data sets to provide credible information and alerts regarding animal welfare, health and productivity by using modern technologies (Guarino et al., 2017; Krampe et al., 2021).

A number of PLF technologies are commercially available for monitoring pigs and poultry, such as cameras, accelerometers, microphones, photoelectric sensors, radio-frequency identification (RFID) for tracking, load cells and flow meters and so on (Gómez et al., 2021; Schillings et al., 2021). Papers related to PLF are largely focusing on reviewing these state-of-art technologies (Benjamin and Yik, 2019; Berckmans, 2015; Fountas et al., 2015; Neethirajan and Kemp, 2021), introducing technology innovations (Banhazi et al., 2011; T M Banhazi et al., 2012; Neethirajan, 2022), investigating what can be learned by using a technology (Banhazi et al., 2015; Fournel et al., 2017; Scheel et al., 2017; Tikász et al., 2022) and exploring the added value to farmers gained by using PLF technologies (Bewley et al., 2015; Kamphuis et al., 2015; Rojo-Gimeno et al., 2019). In contrast, social issues associated with PLF technologies as regards the applicability of the tools and the expectations and experiences of especially pig or poultry farmers with advanced technologies, as well as the barriers of uptake have been much less investigated, though the number of papers have been published about these matters in the past few years (Akinyemi et al., 2023; Hartung et al., 2017; Krampe et al., 2021). Therefore, the aim of this study was to investigate the readiness and attitudes of pig and poultry farmers towards smart technologies.

2. Materials and Methods

Questionnaire survey, as a quantitative research method, was used to study the conditions and attitudes of pig (specialized in farrow-to-finish, grow-to-finish, or mating-farrowing-weaning) and poultry (chicken meat and commercial egg production) farmers towards smart technologies. Standardized on-line questionnaires with a total of 21 (pig farmers) or 22 (poultry farmers) technical questions (single choice, multiple choice, matrix and Likert scale type of questions) and 5 segmenting type of questions (as regards the age, education, position of the respondents and the size and legal form of the farm they represented) were developed and made available in five European (Denmark, Estonia, Hungary, Poland and Sweden) and one Middle Eastern (Israel) country in January 2022. The questionnaires consisted of three main technical parts: (1) infrastructural conditions, (2) respondents' expectations and experiences as regards the benefits, availability and operation of PLF technologies, (3) information on the users' application practices and satisfaction regarding smart technologies. Questions were grouped by (1) users, (2) potential users (respondents who plan to use smart technologies within a short time) and (3) non-users to investigate each type of technology users in the PLF product chain.

Non-probability judgemental sampling method (Malhotra, 2010) was used, since there has been very limited information available about the characteristics of the sample population. A common request was to preferably reach farms that can be considered as intensive, in terms of the number of animals raised. The threshold of intensive rearing of pigs and poultry is defined in the IED Directive (Directive 2010/75/EU, 2010), that is more than 750 places for sows and/or 2000 places for production pigs (over 30 kg), while more than 40,000 places for poultry. The reason of focusing as much as possible on intensive farms was the hypothesis that early users of PLF technologies are mainly capital-intensive farms with large herd. As total, 266 responses (121 from pig farms and 145 poultry farms) were received, out of which 81% were intensive farms (66% of pig farms and 93% of poultry farms) (Table 1).

Statistical analyses were conducted by MS Excel and IBM SPSS (27.0.1) on 269 surveys (121 from pig farms and 148 from poultry farms) as 3 poultry farms producing both chicken meat and commercial eggs were split into 6 individual farms. Descriptive statistics, such as the sum and distribution, mean and standard deviation were calculated by using MS Excel Pivot Tables to determine the general characteristics of the sample. Pearson Chi-square tests were used to compare differences by the following categories: users (n=177), potential users (n=56) and non-users (n=36).

Table 1. Distribution of the responses by countries and intensity of farms

Countries	Pig farmers			Poultry farmers		
	Distribution of respondents		Intensive farms	Distribution of respondents		Intensive farms
	N	% of total	% of country total	N	% of total	% of country total
DK	28	23%	86%	29	20%	79%
EE	11	9%	82%	3	2%	67%
HU	36	30%	97%	48	32%	98%
IL				25	17%	100%
PL	23	19%	17%	22	15%	91%
SE	23	19%	35%	21	14%	100%
Total	121	100%	66%	148	100%	93%

In regard to specialization, Figure 1. shows that 52% of responding pig farms specialized in farrow-to-finish (FF), 26% in growing finishing (GF) and 22% in mating-farrowing-weaning (MFW). The distribution of respondents was almost equal in Denmark (32% FF, 39% GF and 29% MFW), while FF specialisation dominated (50-82%) in all other countries. Out of the respondents of poultry farmers, 70% represented chicken meat production (CMP), 30% egg production (EP). Near to 50-50% was the share of CMP and EP respondents in case of Denmark (45% and 50%) and Poland (55% and 45%). At the same time, the distribution of CMP and EP was around 70-30% in Hungary respectively, while in Estonia, 100% of the respondents represented EP, in Israel and Sweden the same was true for CMP (Figure 1).

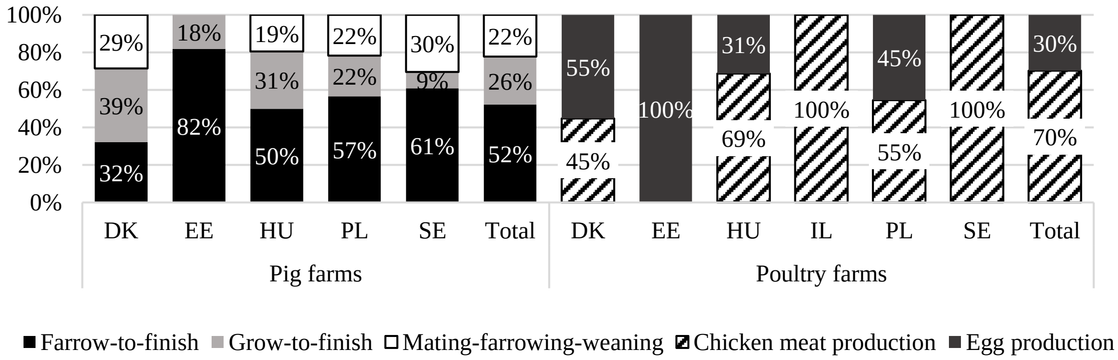

Figure 1. Distribution of the responses by specialization of the responding farms

3. Results

3.1. Main characteristics of the farms represented by ICT users and non-user

Pearson Chi square tests were calculated on responding farmers' infrastructural conditions (level of automatization, age of buildings and production technologies, internet connectivity of farm and network availability of individual buildings), size (intensive or not) and legal form (sole proprietorship or corporation) across technology adoption level (users, potential users, or non-users of PLF technologies). Strong significant difference (P<0.01) was found between infrastructural conditions of users and potential users, as well as of users and non-users, while significant difference (P<0.05) showed up between the farm size of users and potential users (Table 2). As it is shown in Figure 2, users can be characterized by being intensive farms in terms of animal places (85%) having highly (55%) or moderately (32%) automatized farm operation, the average age of their buildings and production technology is less than 20 years (84%), or even less than 10 years. Internet, (at least wireless) is accessible by 96% of the farms, while network within the livestock buildings, being able to connect to the internet, is available by 77% of the farms in various forms (wireless: 32%, cable: 16%, both: 29%).

Table 2: Statistical results of survey answers for questions regarding farm characteristics

Q	Farm characteristics	Respon-ses (N)	Response (mean±SD)				P value		
			All	Users (U) (N=177)	Potential users (PU) (N=56)	Non-users (NU) (N=36)	UxPU	UxNU	PUx NU
Q3	Level of automatization	269	2.28±0.74	2.42±0.71	2.07±0.74	1.92±0.73	0.01	<0.001	0.61
Q4	Age of infrastructure	267	3.04±0.81	3.23±0.72	2.84±0.89	2.44±0.77	0.001	<0.001	0.08
Q5	Internet connectivity	268	2.60±1.03	2.59±0.93	2.54±1.19	2.75±1.20	0.02	0.001	0.34
Q6	Network in the barns being able to connect to the internet	265	2.08±1.44	2.39±1.35	1.57±1.46	1.33±1.37	<0.001	<0.001	0.56
SIII	Size of farm (intensive/not intensive)	269	0.81±0.39	0.85±0.36	0.73±0.45	0.72±0.45	0.04	0.06	0.10
SII	Legal form of the farm (sole proprietorship, kind of corporation)	269	1.47±0.50	1.50±0.50	1.36±0.48	1.50±0.51	0.07	0.98	0.17

In contrast to users, potential users and especially non-users have much older farm infrastructure (potential users: in 46% of cases – 10-20 years old infrastructure; non-users: in 44% of cases – 10-20 years old, and in 39% of cases – variously aged infrastructure), despite representing mostly (73% and 72%) intensive farms. On top of that, 9% and 11% of potential users and non-users, respectively, operate in more than 20 years old infrastructure, while the same holds only true for 1% of the users. Automatization level is medium in general at both potential users (46%) and non-users (47%), whereas internet accessibility, compared to users, is a little bit lower, 86% by these two groups of respondents, which means primarily the wireless form (45%) in case of potential users, and both wireless and cable (36%) for non-users. Although there was no major difference in the frequency of internet access between users and potential or non-users, the network availability in the barns of the letter was much less, only 45% in case of potential users and 44% in case of non-users compared to 77% in case of users as mentioned above (Figure 2).

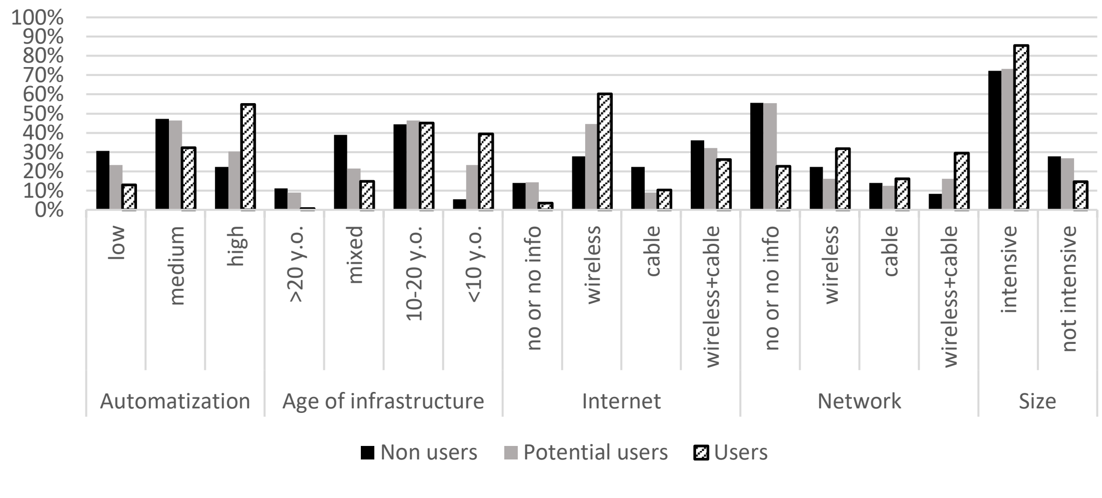

Figure 2: Comparison of responding PLF-technology user, potential user and non-user farms' characteristics

3.2. Main perceiving of PLF users, potential users, and non-users about the technology itself

Results of survey on the perceived characteristics of PLF technologies by users, potential users and non-users of smart technologies are presented in Table 3. Respondents were asked to score a list of statements on the benefits, operation and availability of PLF technologies according to their level of agreement, on a 6-stage Likert scale (0: did not know the answer, 1: strongly disagree,… 5: strongly agree) (Malhotra, 2010). Pearson Chi-square tests were used to establish the differences between the general level of agreement of users, potential users and non-users in each statement. Significant differences (mostly on $P<0.01$ level) were found between the mean scores of users and non-users in 15 out of 19 statements. The same holds true for users and potential users in case of 6 statements (Q9e, Q11b, Q11d, Q9g, Q10a and Q10b) (Table 3). There were only 4 statements (Q9e, Q11b, Q11d and Q10d) where significant difference at the level of $P<0,05$ could be determined between potential users and non-users. This implies that, in case of Q9e, Q11b and Q11d, the perception (about the characteristics of PLF technologies) of all 3 respondent categories was found to be significantly different. No significant difference was demonstrated in case of four statements: respondents agreed moderately (3.37) that PLF technologies have the potential to foster enterprise, marketing and investment decisions, and were neutral with the statements on PLF technologies' ability to cope with labour shortages (3.11), being secure in terms of data management (2.88) and connectivity with equipment and software of different developers.

The general pattern of statements showing significant differences in respondent groups' opinion, that users expressed the strongest (Means: 2.81-4.48), potential users somewhat moderate (2.41-4.09), while non-users the lowest level (1.69-3.89) of agreement. According to Lokeswari (2016), the reason of this is that frequent usage and exposure to ICTs lead to a positive attitude towards ICT usage.

A number of statements on the benefits of PLF technologies received highly positive agreements (where the mean scores were above the value of 3.5). All groups of the respondents agreed that PLF technologies contribute to the increase of production efficiency (average score: 4.19±1.01). The average scores referred on agreement in case of the ability of these innovative technologies to prove/improve transparency within production (3.94±1.21), contribute to the early detection of problems in the herd (3.94±1.15) and help day-to-day decision making in the livestock buildings (3.77±1.33). However only users and potential users were supportive, non-users remain neutral on these issues. On the role of new technology solutions in meeting environmental pollution reduction obligations, users group agreed moderately (3.51±1.56) that it would be helpful, while the other two groups where not convinced about this, but neither were they convinced of the opposite (PU: 3.30±1.44, NU: 2.94±1.39).

In relation to the operation of smart devices/technologies, it was agreed by all three groups of respondents that they provide reliable information (4.04±4.0) in a real time manner (4.32±1.06). At the same time, only the user group confirmed that these new technologies are easy to operate (3.82±1.09) and work in a reliable manner (3.69±1.21), while potential users, just as non-users were unsure about these points (PU: 2.98±1.53, 3.13±1.66 NU: 2.69±1.26, 2.53±1.52). In addition, the difference between the mean scores of users' and non-users' responses was especially large, 30% in case of the easiness and 31% in case of reliability of operation, respectively. The gap between the same two groups increased to 35% as it came to the maintenance costs of PLF technology. The opinion of users and potential users was neutral (3.20±1.27 and 2.61±1.45) while non-users disagreed that the maintenance costs of smart technologies were reasonable (2.08±1.27).

The deviation of the scores was highest by the statements on the availability of PLF technologies. This implies that the difference between the mean scores of users and non-users was above 32% by every statement. Accessing these technologies on the market and getting information on them and their distributors seemed not being a problem for users (3.95±1.24, 3.55±1.38), while potential users expressed neutrality accompanied by a high standard deviation (3.21±1.52, 3.18±1.53) and non-users a week disagreement (2.42±1.42, 2.39±1.38). Mean values of all scores on easiness of getting technical assistance, just like obtaining proper education on smart technologies remained below 3.0. Out of the three clusters, mean scores of users group was the highest (3.15±1.40, 3.10±1.50) whereas non-users scores reached only 1.89 and 2.11 average values, respectively. Securing technical assistance for these innovative technologies appeared to be especially challenging for non-users, their mean score remained 40% below the same value of users. A large gap was also identified between users' and non-users' opinion on the statement regarding the purchase price of smart technologies, as this statement reached the lowest level of agreement of all (2.58±1.25). This means that besides users showing a week neutrality (2.81±1.19) on that topic, the mean scores of potential users (2.43±1.26) and especially non-users (1.69±1.04) expressed obviously that they did not consider the purchase price of PLF technologies to be affordable.

Table 3: Statistical results of survey answers for questions regarding perceiving of ICT users, potential users and non-users

Q	Statements on PLF technologies	Responses (%)						Responses (N)	Response (mean±SD)				P value		
		0	1	2	3	4	5		All	Users (U) (N=177)	Potential users (PU) (N=56)	Non-users (NU) (N=36)	UxPU	UxNU	PUxNU
Benefit of PLF technologies. They…															
Q9e	… enable to increase the effectiveness of production.	1%	2%	3%	13%	32%	48%	269	4.19±1.01	4.38±0.82	4.04±1.19	3.53±1.23	0.01	<0.001	0.03
Q9f	… prove/improve transparency within production.	3%	2%	6%	15%	34%	40%	269	3.94±1.21	4.14±1.12	3.68±1.34	3.39±1.23	0.11	<0.001	0.59
Q9i	… contribute to the early detection of problems in the herd.	1%	3%	7%	16%	33%	39%	269	3.94±1.15	4.10±1.06	3.79±1.20	3.44±1.36	0.61	0.00	0.35
Q9b	…help day-to-day decision making in the livestock buildings.	2%	8%	7%	14%	32%	37%	269	3.77±1.33	3.92±1.25	3.70±1.39	3.14±1.46	0.46	0.00	0.31
Q9d	…help to meet environmental pollution reduction obligations.	4%	11%	10%	21%	20%	33%	269	3.39±1.52	3.51±1.56	3.30±1.44	2.94±1.39	0.20	0.04	0.15
Q9c	…help enterprise, marketing and investment decisions.	4%	8%	12%	23%	27%	25%	269	3.37±1.41	3.33±1.46	3.57±1.31	3.25±1.30	0.48	0.44	0.41
Q9a	…help to cope with labour shortage.	4%	19%	12%	19%	19%	27%	269	3.11±1.57	3.27±1.58	3.00±1.50	2.53±1.52	0.86	0.19	0.17
Operation of PLF technologies. They…															
Q9h	… provide information in a real time manner.	1%	3%	4%	7%	25%	59%	269	4.32±1.06	4.48±0.92	4.09±1.23	3.89±1.24	0.08	0.00	0.06
Q9g	… provide reliable information.	1%	3%	1%	19%	39%	37%	269	4.04±1.00	4.19±0.90	3.82±1.11	3.61±1.10	0.04	0.01	0.18
Q11b	…are easy to operate.	4%	2%	14%	30%	22%	29%	269	3.49±1.30	3.82±1.09	2.98±1.53	2.69±1.26	<0.001	<0.001	0.02
Q11d	…operate in a reliable manner.	6%	4%	11%	25%	28%	26%	269	3.42±1.42	3.69±1.21	3.13±1.66	2.53±1.52	0.01	<0.001	0.01
Q11a	…can be maintained at a reasonable cost.	9%	5%	19%	29%	28%	10%	269	2.93±1.37	3.20±1.27	2.61±1.45	2.08±1.27	0.09	<0.001	0.21
Q11e	...are secure in terms of data management.	17%	5%	6%	31%	30%	12%	269	2.88±1.59	2.98±1.54	2.91±1.68	2.31±1.60	0.87	0.18	0.34
Q11c	…can be connected well with other equipment/software.	17%	5%	15%	28%	23%	12%	269	2.72±1.58	2.93±1.52	2.41±1.72	2.22±1.46	0.33	0.10	0.52
Availability of PLF technologies.															
Q10a	PLF technologies are easily accessible on the market.	4%	5%	12%	22%	20%	37%	269	3.59±1.43	3.95±1.24	3.21±1.52	2.42±1.42	0.00	<0.001	0.18
Q10c	It is easy to get information on smart technologies and distributors.	3%	10%	17%	22%	19%	29%	269	3.32±1.46	3.55±1.38	3.18±1.53	2.39±1.38	0.26	<0.001	0.05
Q10d	It is easy to get technical assistance for smart technologies.	6%	12%	20%	23%	23%	16%	269	2.91±1.46	3.15±1.40	2.84±1.52	1.89±1.17	0.16	<0.001	0.01
Q10e	Proper education is available for using smart technologies.	7%	13%	25%	19%	16%	21%	269	2.88±1.53	3.10±1.50	2.66±1.63	2.11±1.24	0.32	<0.001	0.08
Q10b	PLF technologies can be purchased at an affordable price.	6%	15%	24%	31%	20%	4%	269	2.58±1.25	2.81±1.19	2.43±1.26	1.69±1.04	0.03	<0.001	0.14

0: Did not know; 1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly agree

3.2. Application practices and satisfaction with PLF technologies

Respondents were able to select whether they were using, planning to use, or not using (and not even planning to use) different smart technologies listed in the survey. The results of the responds indicated that the most commonly used technology was the monitoring of buildings and animals by sensors and/or cameras, both in case of poultry (81%) and pig (64%) farms, as well as the monitoring of microclimate (temperature, humidity) and air quality (CO_2, NH_3 and dust concentration) within the barns (77% and 55%) by fixed or portable sensors. Other frequently used technologies of responding poultry farmers were weight measuring devices by using bird scales or cameras (71%) and lightning control in commercial egg production (57%). The same holds true for the use of robots (for cleaning or feeding or monitoring) in case of pig farmers (42%). The least-used technologies were infrared cameras (for oestrus monitoring) by pig farmers (11%) and radio frequency identification (RFID) by poultry farmers (0%), just like portable Near Infrared (NIR) instrument for nutrient analysis for feed and feed ingredients by both, poultry and pig farmers (7% and 14%), respectively (Figure 3).

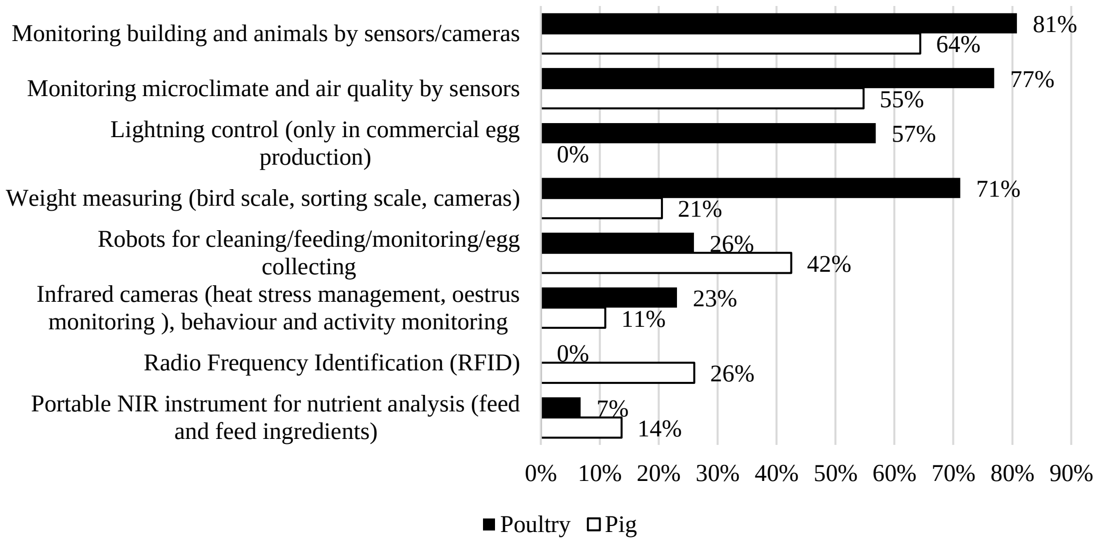

Figure 3: Frequency of applied smart technologies by responding pig and poultry farms

To explore the satisfaction of respondents with frequently used smart technologies, they were asked again to score the listed technologies according to the level of satisfaction on a scale of 1-5 (1: very dissatisfied,… 5: very satisfied). Based on the results of responses (Table 4), it can be established that the mean score of each technology was above 3.6, that means that respondents were generally satisfied with all the listed technologies. The highest level of satisfaction (4.19) was found in case of technologies monitoring building climate and air quality. Standard deviation was low (0.85), which indicated homogenic opinion. Pig farmers showed a little bit higher satisfaction (4.26±0.68) than poultry farmers (4.16±0.93). The same holds true for animal weighing, where the mean score of pig farmers was 4.15 (±0.99) and poultry farmers 3.74 (±1.20). Behaviour and animal health monitoring technologies reached the lowest level of satisfaction (3.67±1.01), though users were still satisfied with them in general, especially poultry farmers (3.73±0.94) who indicated similar level of satisfaction to that of animal weighing. Average score of pig farmers was far lower (3.58) compared to the previous technologies, accompanied by high standard deviation (1.14) showing that their level of satisfaction was more heterogeneous.

Table 4: Statistical results of survey answers for questions regarding users' satisfaction with different smart technologies

Smart technologies	Very dis-satisfied	Dis-satisfied	Neu-tral	Satis-fied	Very satis-fied	Respon-ses (N)	Total	Pig farms	Poultry farms
Building climate/air quality monitoring	1%	3%	15%	38%	42%	120	4,19±0,85	4,26±0,68	4,16±0,93
Animal weighing	4%	10%	20%	27%	35%	89	3,80±1,18	4,15±0,99	3,74±1,20
Behaviour and animal health monitoring	2%	4%	11%	22%	12%	134	3,67±1,01	3,58±1,14	3,73±0,94

To establish the main reasons of dissatisfaction, respondents were asked to choose from a list. Out of PLF-user respondents, 97% chose at least one issue. The top reason of dissatisfaction which was marked by 57% of the user respondents, was that *'Because of less human care, some problems remain hidden inside the herd'*. Besides this, all other issues were on much lower level of importance, which means that at most 31% of the user respondents marked them, respectively, as shown in Table 5.

Table 5: Statistical results on the frequencies of the marked reasons of dissatisfaction

Reasons of dissatisfaction	Responses (N)	Pig farms	Poultry farms	Total
Because of less human care, some problems remain hidden inside the herd.	177	25%	32%	57%
Proper operation of the device needs better quality internet connection.	177	14%	17%	31%
Farm staff's skills are lacking in data analysis.	177	13%	17%	30%
I don't get enough technical assistance.	177	10%	16%	27%
It's impossible to establish a connection between different devices.	177	12%	14%	26%
Too many malfunctions.	177	11%	15%	26%
Maintenance fee is too high.	177	12%	12%	25%
The device/technology is not compatible with the current structure of the buildings/barns.	177	13%	10%	23%
Extension service is not available.	177	10%	12%	23%
Needs too much time to work with the data (more than expected).	177	10%	11%	21%
The device needs too much care.	177	9%	11%	20%
Unable to see the value brought by the devices.	177	7%	12%	19%
The software is too complicated to use.	177	8%	10%	18%
Unreliable data (data cleaning lacks).	177	7%	9%	16%
I don't receive the information in a real-time manner, but later.	177	7%	6%	13%

4. Discussion

The survey indicated that the automatization, the age, and the infrastructure, including internet accessibility, of pig and poultry farms are important preconditions of the successful operation of PLF systems. This is in accordance with several literature (Akinyemi et al., 2023; Guarino et al., 2017; Nääs et al., 2022; Neethirajan and Kemp, 2021) that highlighted that the obstacles of PLF-technology adoption are internet connectivity and the design of existing farm buildings, especially the older ones, where the barns are rarely able to accommodate PLF technology.

The respondents of this survey, regardless of whether or not they used smart technologies, confirmed the well-known benefits of applying these new solutions, such as improving of production effectiveness and transparency, by continuously monitoring and providing information about the performance and the environment of the animals, enabling early problem detecting and fostering decision making (Akinyemi et al., 2023; T. M. Banhazi et al., 2012; Hartung et al., 2017; Krampe et al., 2021; Schillings et al., 2021). Similarly, it was agreed by the respondents that ICTs provide reliable information in a real time manner which, according to Guarino et al. (2017) is core to PLF and makes it different from other technological solutions, since this ensures immediate warning as mentioned above. In contrast, easiness and reliability of the operation of PLF systems was not approved consensually, only by the users, while potential users and non-users remain unsure in this regard. The simplicity and ease of use was identified by Borchers and Bewley (2015) as an important purchase criteria of precision farming technologies. Users of the technology would like to apply not just easy to operate devices, but receive the data in an easy to read, comprehensible format (Akinyemi et al., 2023). The fear of unreliable operation paired with slow or difficultly available maintenance service expressed by the respondent does not seem unfounded, as several studies reported similar experiences (Hartung et al., 2017; Maselyne et al., 2022; Tikász et al., 2022; Tuyttens et al., 2022), since these systems may be subject to a many hardware and software failures. Obtaining technical assistance to innovative technologies appeared to be especially challenging for non-users as established in this survey. For successful implementation and application of PLF technologies in livestock farms, proper training and education is necessary (Cosby et al., 2022), as technical knowledge associated with PLF systems is usually missing. However, the lack of training in digital skills is a problem in general within the pig and poultry industries as indicated by Maselyne et al. (2022) and Nääs et al. (2022) and was also reflected by the respondents, especially those representing the non-users group.

Though a lot of PLF solutions are available on the market (as stated in the beginning of this article), accessing smart technologies and getting information on them and their distributors appeared to be particularly difficult for non-users, being much less familiar with the sources of information than users. Besides, the purchase price of these technologies was found to be too high. This is in line with the experiences of Boothby and White (2021) and Nääs et al. (2022) who pointed out that the reason for the relative high technology setup costs is that on most farms, the installation costs of reliable internet connections and sometimes the costs of improvement of electrical network must be added to ensure the successful operation of the advanced technologies. Moreover, respondents agreed only in part that the costs of maintenance of PLF systems would be reasonable. This might be explained by the lack of knowledge, especially among non-users, of what kind of expenses are covered by the maintenance cost. According to Farooq et al., (2022), the operating cost, beyond ensuring the sound operation of the equipment, covers the expense of IoT systems in order to facilitate the data processing, knowledge exchange, as well as the data sharing among cloud servers, IoT devices, and gateways. These three perceptions – i.e., difficulties in accessing ICTs on the market, high price and maintenance costs – together are mutually reinforcing barriers of technology uptake. To eliminate this hinderance, according to Borchers and Bewley, (2015) the return of investment regarding such systems should be proved urgently along with a more intensive knowledge-sharing activity.

In relation to the applied technologies by the respondents of this survey, the results indicated that the most commonly used technologies were non-invasive biometric sensors. This was the case for both poultry and pig farms, with the aim of monitoring the health and wellbeing of animals in the barns without increased contact time as demonstrated by Neethirajan and Kemp (2021) which more specifically means the continuous monitoring of buildings and animals, as well as the microclimate and air quality conditions. In general, the respondents expressed satisfaction with the technologies. Dissatisfaction was most frequently indicated in relation with less attention to animals by humans, which may cause hidden problems in the herd, similarly to the findings of Krampe et al. (2021); Schillings et al. (2021) and Tuyttens et al. (2022). Internet connection deficiencies were recognized as the second biggest problem, as reported by many studies (Banhazi et al., 2022a; Nääs et al., 2022; Piñeiro et al., 2019), which makes clear that the quality of internet connectivity is similarly important as the existence of communication infrastructure on the farm.

5. Conclusions

This study investigated the readiness, expectations and experiences of pig and poultry (chicken meat and commercial egg producing) farmers towards PLF technologies by using quantitative surveying methodology. The results highlighted that current automatization of farms, the age of infrastructure, the on-farm internet connectivity and the network availability within the livestock buildings are important limiting factors for the adoption of smart technologies. Besides these, farmers' attitude especially their perceiving regarding the operation and availability of smart solutions is an important determining factor. Key issues are the easiness and reliability of operation, the cost of maintenance, the access to technologies as well as to technical assistance on the market, the high implementation price of the technologies and the fear that because of less human care, some problems remain hidden inside the herd. For this reason, most frequently used applications were the least expensive solutions which provide the most obvious information, such as live pictures about the buildings and the animals, and real time data on the climate and air quality within the livestock buildings.

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