Interreg CENTRAL EUROPE
European Union
European Regional Development Fund

Transfarm4.0

POINT-ZERO REPORT OF CE DEMANDS OF INNOVATION IN AGRICULTURE

D.T.1.3.2/1.3.4 Version 14

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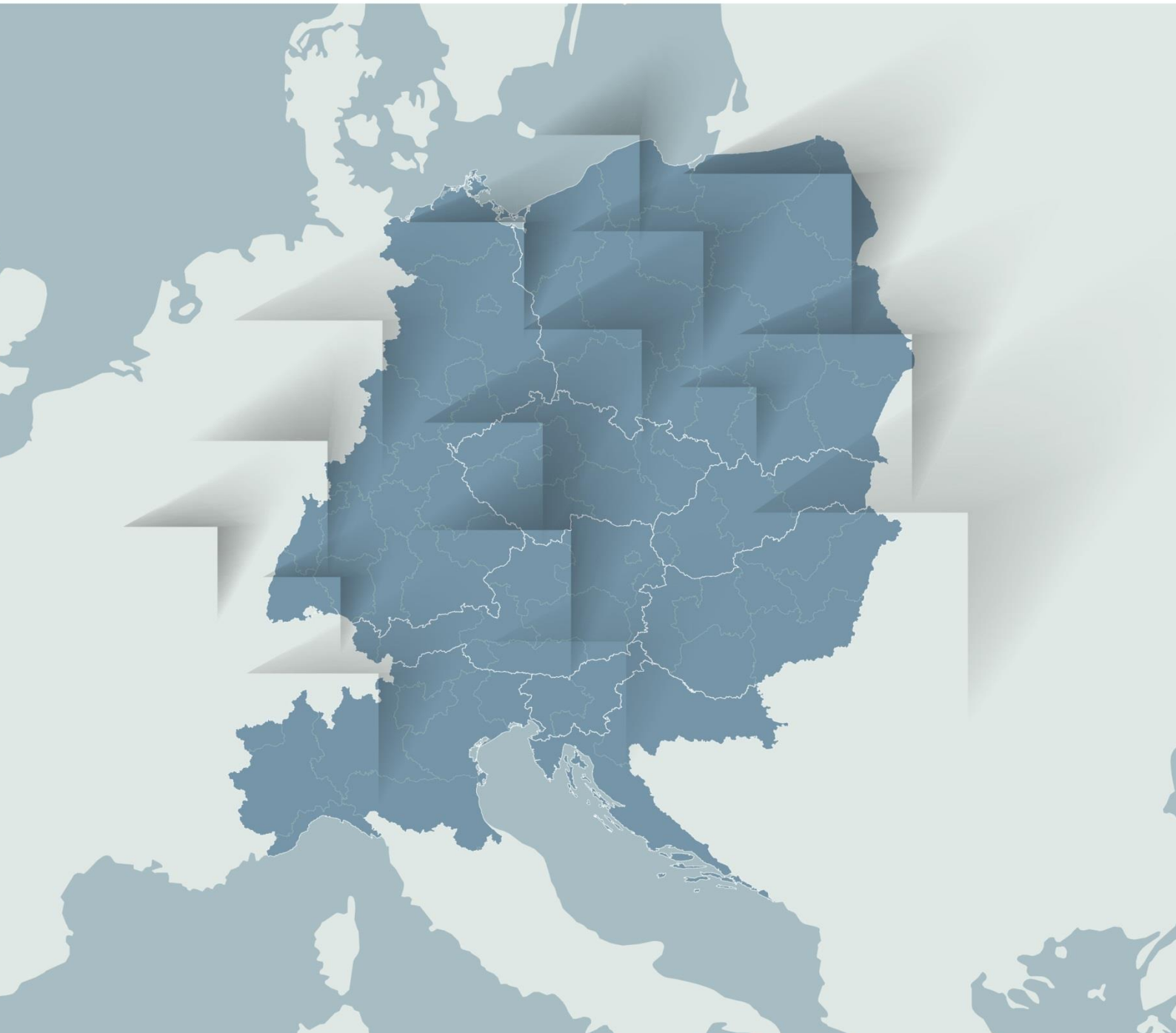

Contents

A. Introduction

This point-zero report of Central Europe demand of innovation in agriculture is based on the results of the previous AT.1.3. deliverables

- D.T1.3.1: Survey on CE farmers requirements in technological innovation
- D.T1.3.2: SWOT analysis to highlight criticals & asset in PF uptake

B. Results - Survey on CE farmers requirements in technological innovation

1. Introduction

1.1. General

Ten partners from 5 European countries (Italy, Poland, Hungary, Slovenia and Austria) started the Transfarm4.0 project in April 2019. During a period of three years the objective of Transfarm4.0 is to promote the uptake of precision agriculture in five respective Central European (CE) countries (IT, PL, HU, SLO and AT). The overall improvement of innovation value chains between technology providers and users should also be analysed.

The project intends to address the issue of technology transfer towards farming businesses in Central European regions. Therefore different degrees of technology intensity in their agricultural practices were characterised. For this purpose, six experimental pilot projects will be launched, focusing on ISOBUS applications, sensing technologies and the use of big data. The experimental activities will start in 2020.

As part of the Transfarm4.0[1] project a Precision Farming (PF) online survey among farmers was launched by Francisco Josephinum[2] Wieselburg (FJ) in 2019.

The Survey on CE farmers was launched online via online-survey-Link at end of July 2019. The online-survey was open for request from July 2019 until at least the end of November 2019 (4 month). The survey was created from FJ in Austria. Each project partner translated the survey afterwards in his own language and FJ created for each area (Italy, Poland, Hungary, Slovenia and Austria) an appropriate online-survey and a web-link for their farmers.

The result of the survey comprises 236 responses from farmers in total of all five CE countries. All farmers answered sixteen questions regarding the topic of "Precision Farming". The aim of the PF survey was to collect and state the requirements and needs of farmers in the respective Central European countries (IT, PL, HU, SLO and AT) for possible future technological innovations.

Furthermore the results of the online survey provide inter alia an insight into the question, in which of the PF applications (e.g. Tracking systems (GPS), use of robots or drones, etc.) the farmers see a

[1] Website: https://www.interreg-central.eu/Content.Node/Transfarm4.0.html;

[2] Reinhard Streimelweger, Jürgen Karner, Christian Rechberger: FJ-BLT / Josephinum Research, Rottenhauser Street 1, 3250 Wieselburg, Tel.: +43 7416 52175 0; E-Mail: r.streimelweger(at)josephinum.at; juergen.karner(at)josephinum.at; christian.rechberger(at)josephinum.at;

benefit or an opportunity, rather than a disadvantage or a risk, when applied for their farm. A SWOT analysis also was carried out for each of the five CE countries based on the online survey results.

In the first part of the survey, general information about the farmers and their farms was raised. This information was important to take into account social factors (esp. gender, age, education) as well as farm factors (esp. farm size, farm type, etc.).

In order to identify which PF innovations or improvements are favoured by the interviewed farmers, the survey served five open questions in the sectors of I) ISOBUS applications, II) remote and proximal sensing and III) big & smart data management applications. These questions tried to catch the needs of the farmers in a realistic manner.

This Precision Farming survey enabled new insights in the requirements and needs of famers in Central Europe and was evaluated in conjunction with CREA for Italy, University of Maribor for Slovenia, Szent István University for Hungary and KIRG for Poland.

1.2. Explanation of Terms

In order that every farmer understands the same thing under the term Precision Farming (short: PF), a definition was developed by FJ Wieselburg. Accordingly, PF is understood to mean the following:

> "Precision Farming (PF) summarizes methods which take account of local differences within arable land as conditions, state and their capacity. These include applications as fertilization, plant protection, or site-specific soil cultivation. In most cases, this requires the use of high-precision GPS systems and application technologies to manage the areas in a location-specific and targeted manner." (Streimelweger, R. from Josephinum Research)
>
> Precision Livestock Farming (PLF) concerns the processing and analysis of animal data to optimize feeding, work processes, husbandry, animal health and animal welfare." (Streimelweger, R. from Josephinum Research)

In case of questions which are marked as multiple-choice questions, only one answer is eligible. For multiple-response (or multiple answers possible) questions various answer options are possible.

1.3. Overview Survey Questions

The Survey on CE farmers was divided into three main parts. First part of the questionnaire was about the general information of the farmers and their farms. The second part of the survey contains eleven closed questions and five open questions to the farmers. The third and last part of the survey was the evaluation of the online-survey by the farmers.

1.3.1. General Information

The questionnaire in the general information of the farmers contained 9 main topics (see figure 1):

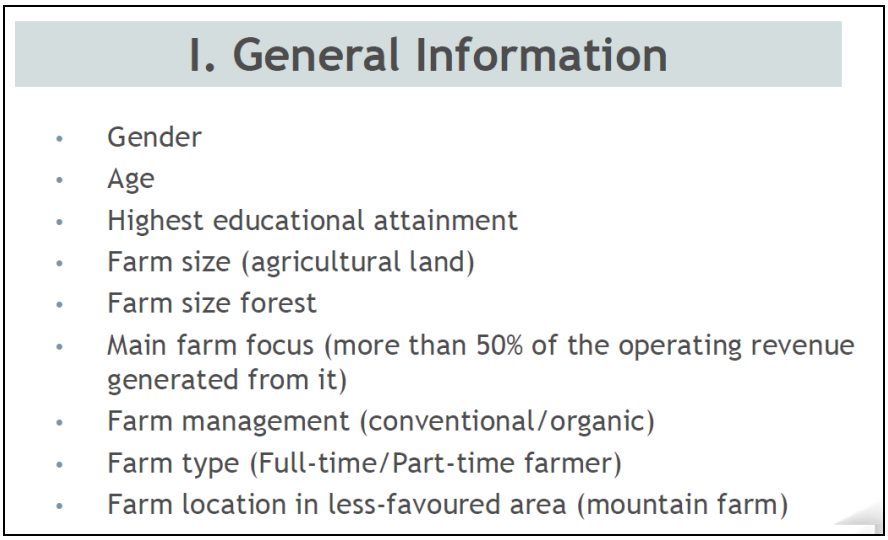

Figure 1: Survey – Overview General Information topics

The possible answer options are shown in an overview below.

Gender ❑ **Male** ❑ **Female** *(multiple choice)*

Age (in Years) _____

Highest educational attainment *(multiple choice)*

- ❑ **Primary school**
- ❑ **Skilled worker certificate, higher school certificate**
- ❑ **High-school education**
- ❑ **University education (university degree, Bachelor, Master, PhD)**
- ❑ **Other: _____**

Farm size (agricultural land) _____ **(hectare)**

Farm size forest ☐ **(hectare)**

Main farm focus (more than 50% of the operating revenue generated from it) *(multiple choice)*

- ❑ **Forage production livestock farm (cattle, sheep, goats)**
- ❑ **Processing or fattening farm (pigs, poultry)**
- ❑ **Forest**
- ❑ **Cash crop farm (cereals-, oil-, protein crops; root crops such as potatoes, sugar beet, etc.)**
- ❑ **Permanent crop farms (fruit and viticulture)**
- ❑ **Vegetable farm**
- ❑ **Mixed farm type (no specialization, respective operating class below 50% of operating revenue)**

Farm management *(multiple choice)*

❑ **Conventional** ❑ **Organic**

Farm type *(multiple choice)*

- ❑ **Full-time farmer (farm manager couple working more than 50% of the total working time on the farm)**
- ❑ **Part-time farmer**

Farm location in less-favoured area (mountain farm) *(multiple choice)*

❑ **Yes** ❑ **No**

1.3.2. Main Survey Questions

The main Survey Questions contains 11 closed questions, with the different possibility to answer the different questions. In case of questions which are marked as multiple-choice questions, only one answer is eligible. For multiple-response (or multiple answers possible) questions various answer options are possible. The last five questions (12-16) of the survey were open questions.

1. How much do you identify with the following statements in connection with Precision

2. How important are Precision Farming applications for your daily practice on your farm?

3. Which statement(s) is (are) correct for you and your farm?

4. What data would you consider most relevant for running your farm?

5. In the following table are some of the existing technologies in agriculture listed. Which of them are already adopted at your farm or is considered to be potentially important to acquire in the coming years?

6. In which of the following PF applications do you see a benefit or an opportunity, or rather a disadvantage or a risk, for running your farm in the future?

7. In which of the following processes do you see a potential through PF applications for your farm? Which statement(s) is (are) correct for you and your farm?

8. How do you rate the following aspects in terms of their impact on better dissemination of PF technologies?

9. For whom do you see more need for action to make PF technologies more widely accepted in practice?

10. In which way do you keep updated about PF and new PF equipment?

11. Who do you currently contact for questions and needs in the field of PF? How do you rate the following aspects in terms of their impact on better dissemination of PF technologies?

Five Open-questions (12-16): "Which PF innovations or improvements do you request in the future for your farm in the area of …

12) … (new) ISOBUS applications?"

13) … remote- & proximal-sensing (satellite, drones, sensors)?"

14) … Big & Smart Data Management applications (IoT, real-time crop data, etc.)?"

15) … field robotics?"

16) … other PF innovations?"

I. Questions

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1) How much do you identify with the following statements in connection with Precision Farming *(multiple choice)*

I am not interested in PF ❑

I do not use PF technologies yet, but I probably will in the near future ❑

I've been using PF applications on my farm recently ❑

I am a beginner in the PF, but I want to become a professional in the field of PF ❑

I am an advanced user of PF applications but not a professional ❑

I am a professional user in the field of PF since years ❑

2) How important are Precision Farming applications for your daily practice on your farm? *(multiple choice)*

Very important ❑

Important ❑

Less important ❑

Not important ❑

3) Which statement(s) is (are) correct for you and your farm?

Multiple answers possible

I would use (reinforced) PF technologies on my farm, if the **cost** would be lower. ❑

I would use (reinforced) PF technologies on my farm, if the **technology** were simpler / more reliable. ❑

I would use (reinforced) PF technologies on my farm, if I would be better **educated** in this area. ❑

4) What data would you consider most relevant for running your farm?

Multiple answers - maximum 3 answers

Field (vegetative stage of plants, soil analysis, etc.) ❑

Weather (forecast, temperature, rainfalls, etc.) ❑

Machinery/equipment (engine, consumption, components aging, etc.) ❑

Production (yield, harvest quality, etc.) ❑

Allocation of production inputs (water quantity, fertilizers, etc.) ❑

Tractor and machinery operators (information about the operator using the tractors or machinery) ❑

Localization (GPS, etc.) ❑

5) In the following table are some of the existing technologies in agriculture listed. Which of them are already adopted at your farm or is considered to be potentially important to acquire in the coming years? *(Multiple-choice)*

Check one answer for each technology

	Technology already acquired and in use in the farm	Technology I will buy safely in a short time manner	Considering to acquire this technology in the coming years	No interest to acquire this technology
Agro-weather stations	❑	❑	❑	❑
APP´s (weather, used machines, market information)	❑	❑	❑	❑
Agro-APP´s for crop farming (specific providers of products or machinery e.g. Bayer, New Holland, plant protection, etc.)	❑	❑	❑	❑
Agro-APP´s for livestock farming (PLF, as stall reports, etc.)	❑	❑	❑	❑
GPS (as equipment for precision farming, for example for site-specific management and	❑	❑	❑	❑

parallel driving)				
Sensors for crop farming (monitoring of plants characteristics, etc.)	❑	❑	❑	❑
Yield modeling systems (based on soil samples, satellite data, etc.)	❑	❑	❑	❑
Drones (to monitor crops, or operate accurately on specific areas or even single plants)	❑	❑	❑	❑
Precision irrigation systems	❑	❑	❑	❑
Technology for site-specific fertilization	❑	❑	❑	❑
Technology for site-specific tillage and sowing	❑	❑	❑	❑
Technology for site-specific chemical plant protection	❑	❑	❑	❑
Augmented reality (for instance Google Glass, as to have specific devices for visual representation and information of the surrounding reality)	❑	❑	❑	❑
Farmmanagement- and Informationsystems *(FMIS):* Software for documentation of work processes, decision support, etc.	❑	❑	❑	❑

6) In which of the following PF applications do you see a benefit or an opportunity, or rather a disadvantage or a risk, for your running your farm in the future?

multiple choice

	benefit / opportunity	disadvantage / risk
Tracking systems (GPS)	❑	❑
Mobile-APPS	❑	❑
Satellite data	❑	❑
Soil samples Services	❑	❑
Use of robots	❑	❑
Use of drones	❑	❑
Site-specific fertilization	❑	❑
Site-specific tillage and sowing	❑	❑
Site-specific plant protection	❑	❑
Adequate irrigation	❑	❑
Real-time farm-, machinery-, and devices data (IoT, Digitization, Big & Smart Data Management)	❑	❑
Records for the fulfilment of documentation obligations	❑	❑
Records for supporting farm business decisions	❑	❑

7) In which of the following processes do you see a potential through PF applications for your farm?

Multiple Choice

	very high potential	high potential	low potential	no potential
Site-specific organic fertilization (liquid manure, dung)	❑	❑	❑	❑
Site-specific mineral Fertilization (NPK, etc.)	❑	❑	❑	❑
Site-specific tillage	❑	❑	❑	❑
Site-specific sowing	❑	❑	❑	❑
Site-specific chemical plant protection	❑	❑	❑	❑
Site-specific mechanical plant protection	❑	❑	❑	❑
Adequate irrigation	❑	❑	❑	❑

8) How do you rate the following aspects in terms of their impact on better dissemination of PF technologies?

(Check one impact for each aspect - multiple choice)

aspects / impact	strongly inhibiting	slightly inhibiting	undecided	slightly promotional	strongly promoting
Initial investment	❑	❑	❑	❑	❑
Compatibility of different systems	❑	❑	❑	❑	❑
Operation costs	❑	❑	❑	❑	❑
Manufacturer service	❑	❑	❑	❑	❑
User-friendliness	❑	❑	❑	❑	❑
Reliability of the systems	❑	❑	❑	❑	❑
Data handling	❑	❑	❑	❑	❑
Traceability of working processes	❑	❑	❑	❑	❑
Facilitation of documents	❑	❑	❑	❑	❑
Improving the quality of work	❑	❑	❑	❑	❑
Reduced workload	❑	❑	❑	❑	❑

9) For whom do you see more need for action to make PF technologies more widely accepted in practice? *(Multiple answers possible)*

Farmers ❑

Research & development ❑

Industry ❑

Political instruments (financial subsidy, general law framework, etc.) ❑

Education and consulting ❑

Other (specify):_____

10) In which way do you keep updated about PF and new PF equipment? *(Multiple answers possible)*

- ❑ Fairs
- ❑ Field days
- ❑ Contact with other farmers
- ❑ Contact with contractors
- ❑ Farmer associations
- ❑ Directly from the supplier/seller of the PF technology (industry, warehouse, etc.)
- ❑ Newspaper (farmer´s newspaper, agricultural technology newspaper, etc.)
- ❑ Internet
- ❑ other:_____

11) Who do you currently contact for questions and needs in the field of PF? *(Multiple answers possible)*

- ❑ Other farmers
- ❑ Contractors
- ❑ Farmer associations
- ❑ Directly the supplier/seller of the PF technology (industry, warehouse, etc.)
- ❑ Internet (Internet forum, etc.)
- ❑ Other: _____

12) Which PF innovations or improvements do you request in the future for your farm in the area of (new) ISOBUS applications? (optional, max. 200 words)

Short description (optional, max. 200 words):

13) Which PF innovations or improvements do you request in the future for your farm in the area of remote- & proximal-sensing (satellite, drohnes, sensors)? (optional, max. 200 words)

Short description (optional, max. 200 words):

14) Which PF innovations or improvements do you request in the future for your farm in the area of Big & Smart Data Management applications (IoT, real-time crop data, etc.)? (optional, max. 200 words)

Short description (optional, max. 200 words):

15) Which PF innovations or improvements do you request in the future for your farm in the area of field robotics? (optional, max. 200 words)

Short description (optional, max. 200 words):

16) Which others PF innovations or improvements do you request in the future for your farm (optional, max. 200 words)

Short description (optional, max. 200 words):

1.3.3 Evaluation of the survey

To get a feedback from the farmers to the survey, there was in the end of the survey the possibility to evaluate the quality of the survey in total.

V) Evaluation of the online survey - Please rate this online survey (multiple-choice)

very good	(5 stars)	❑
well	(4 stars)	❑
in order	(3 stars)	❑
less well	(2 stars)	❑
bad	(1 star)	❑

2. Survey Results – General Information

In the following figure 2 the results of the responses in total and for each country is shown. This structure is for all figures as overview the same. In total we received 236 answers from farmers in CE. These 236 responses are broken down among countries as follows: Italy (40), Hungary (49), Slovenia (40), Poland (30) and Austria (77).

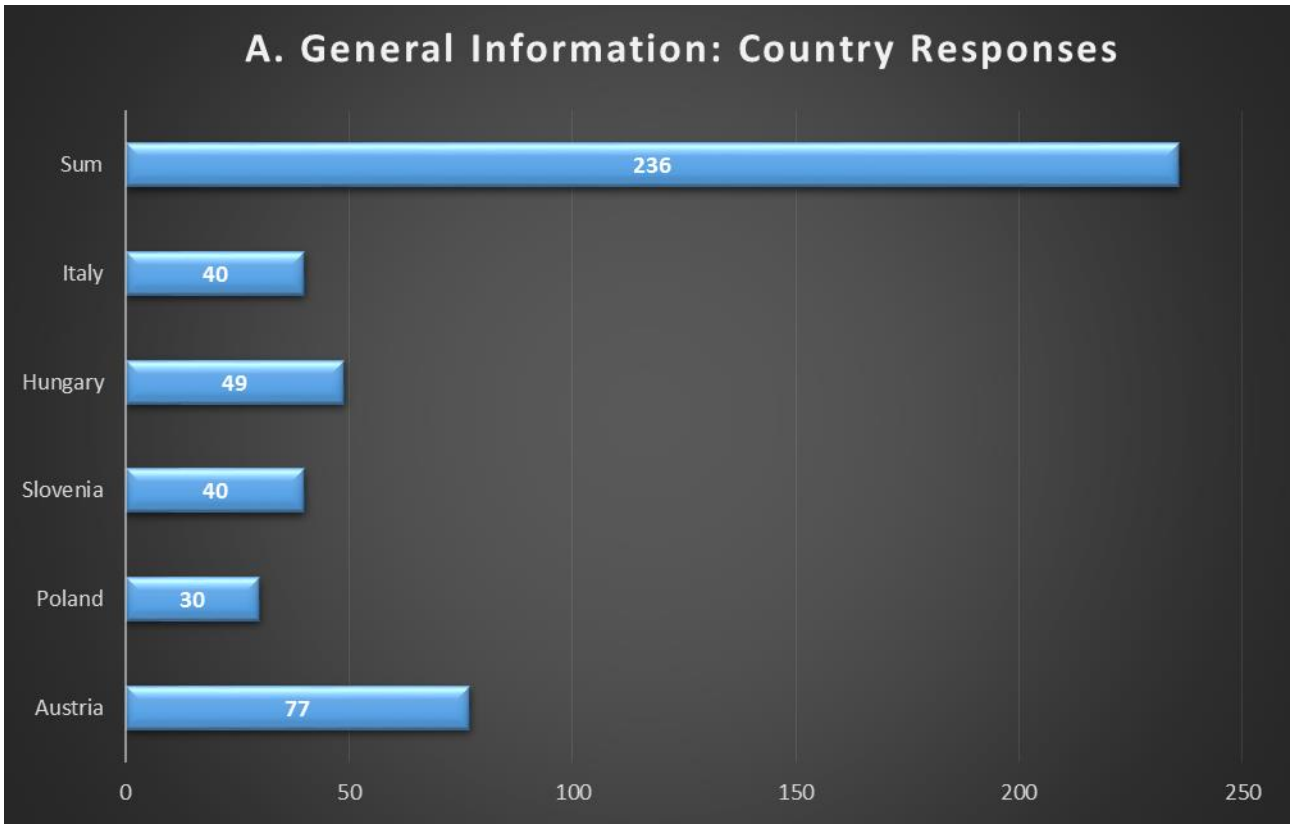


Figure 2: Survey total country responses

2.1. Gender

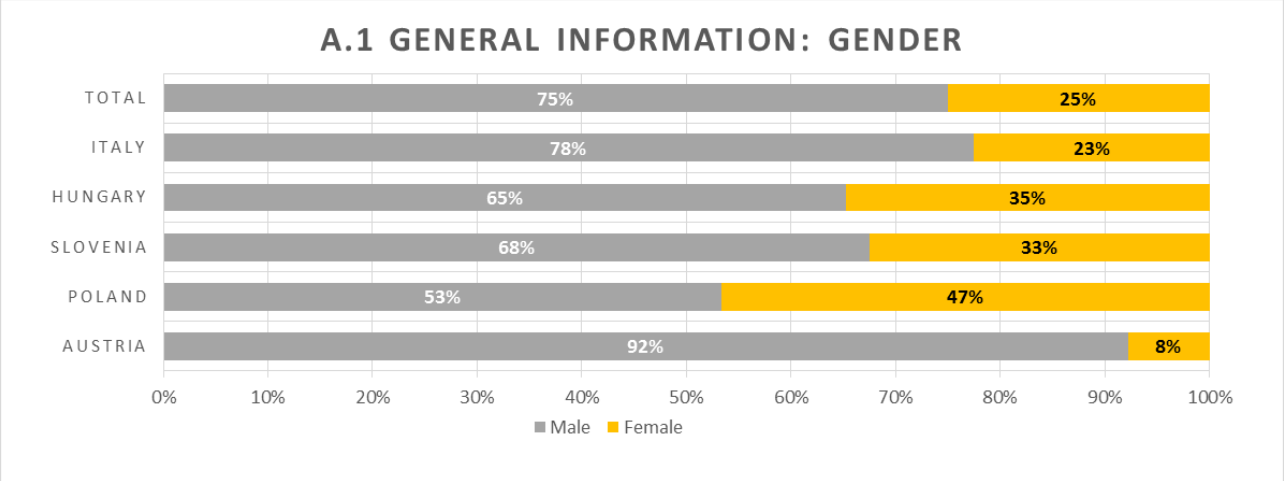


Figure 3: Gender

2.2. Age

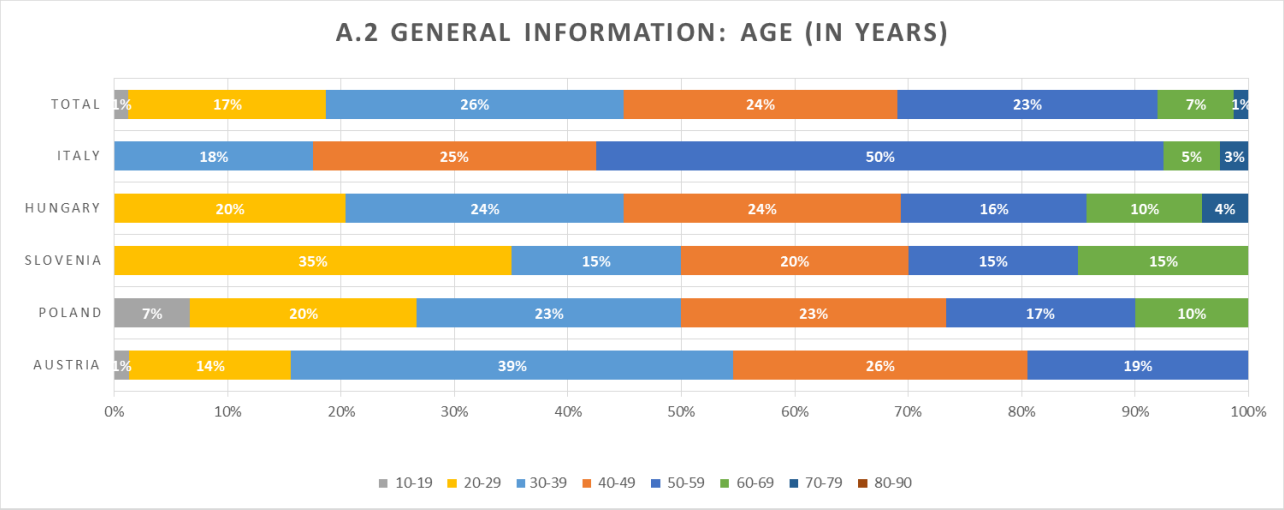


Figure 4: Age

2.3. Highest educational attainment

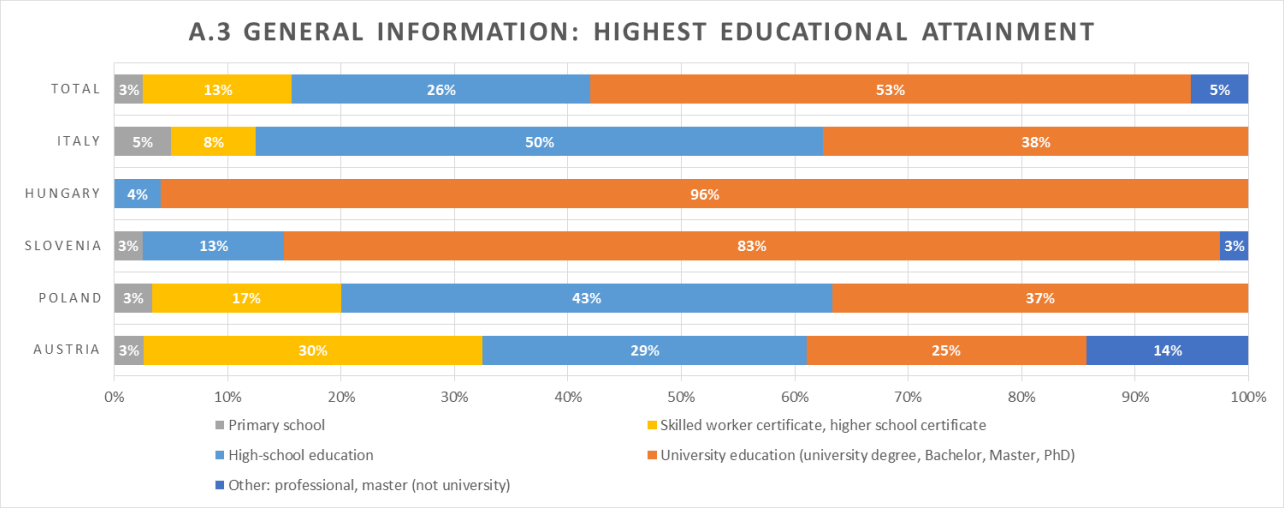


Figure 5: Highest educational attainment

2.4. Farm size (agricultural land)

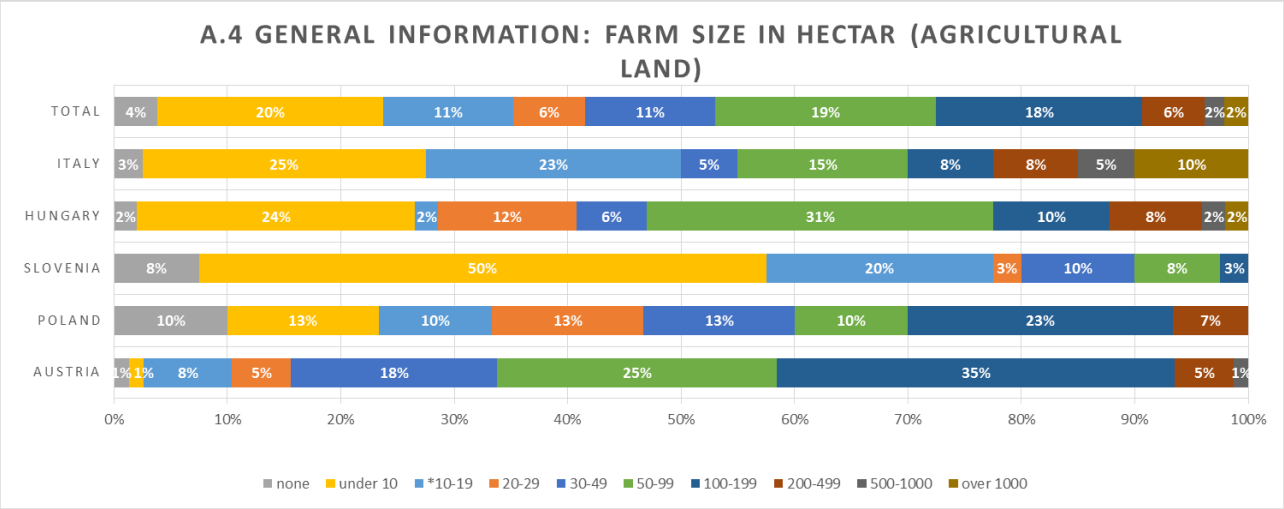


Figure 6: Farm size (agricultural land)

2.5. Farm size forest

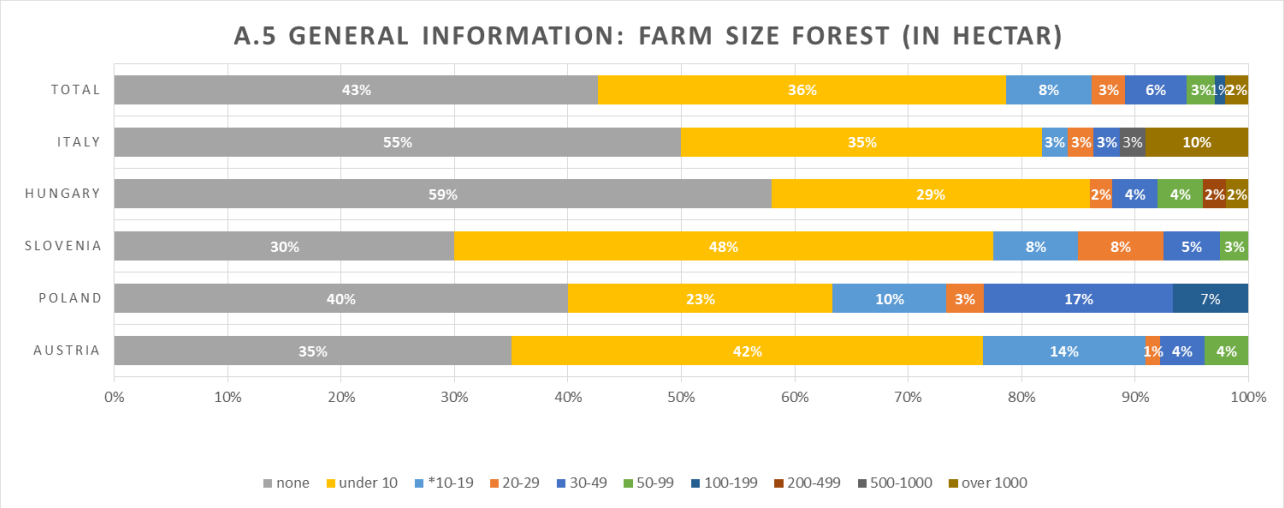


Figure 7: Farm size forest

2.6. Main farm focus (more than 50% of the operating revenue generated from it)

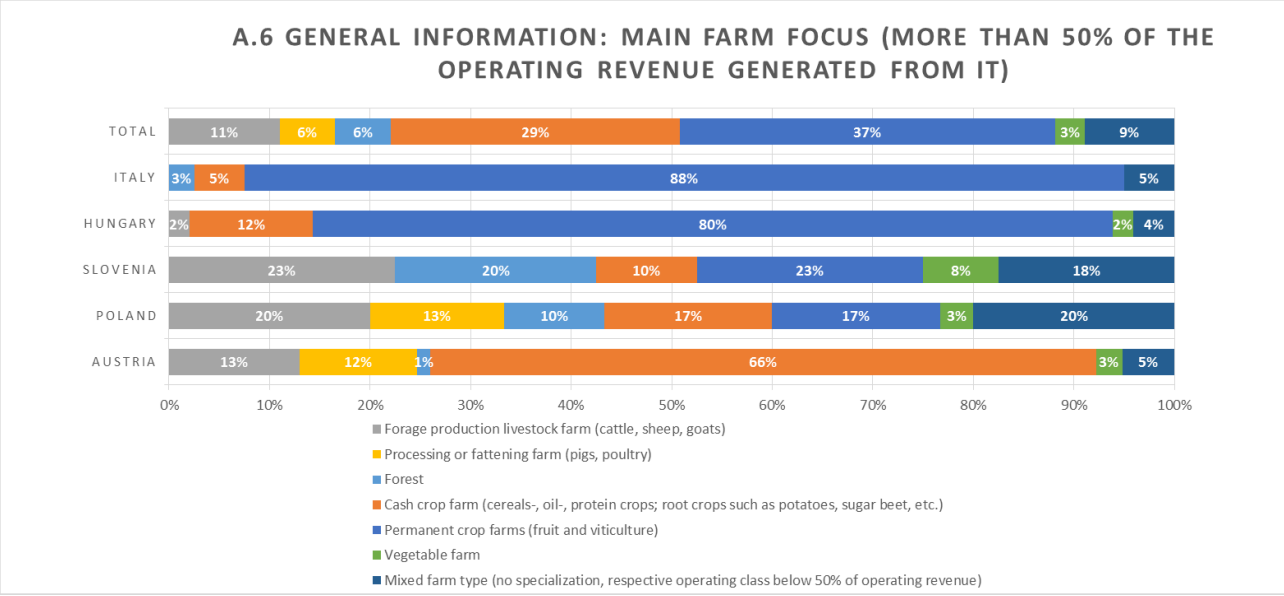


Figure 8: Main farm focus (more than 50% of the operating revenue generated from it)

2.7. Farm management (conventional/organic)

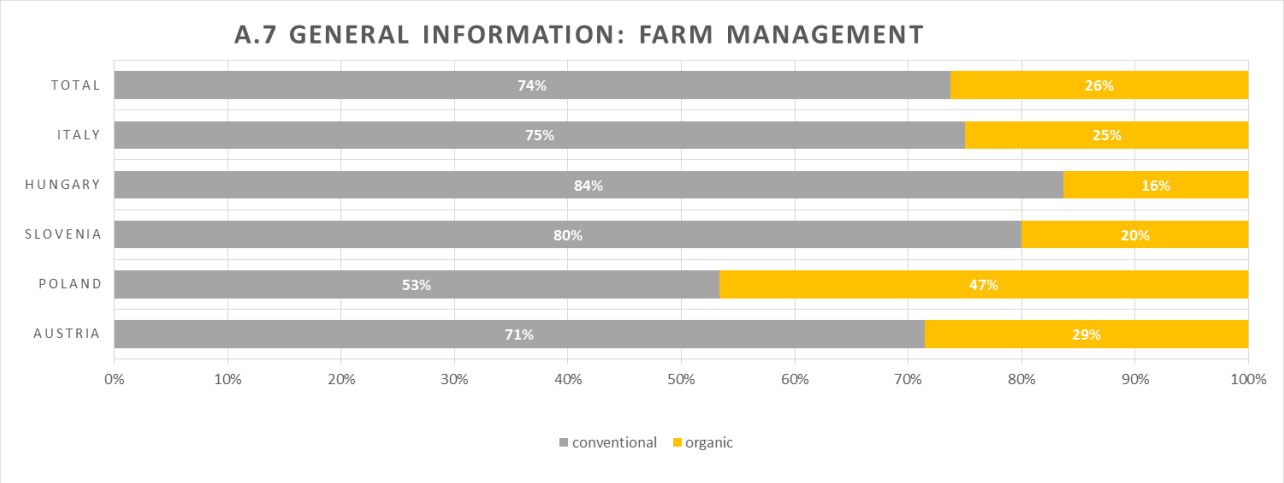


Figure 9: Farm management (conventional/organic)

2.8. Farm type (Full-time/Part-time farmer)

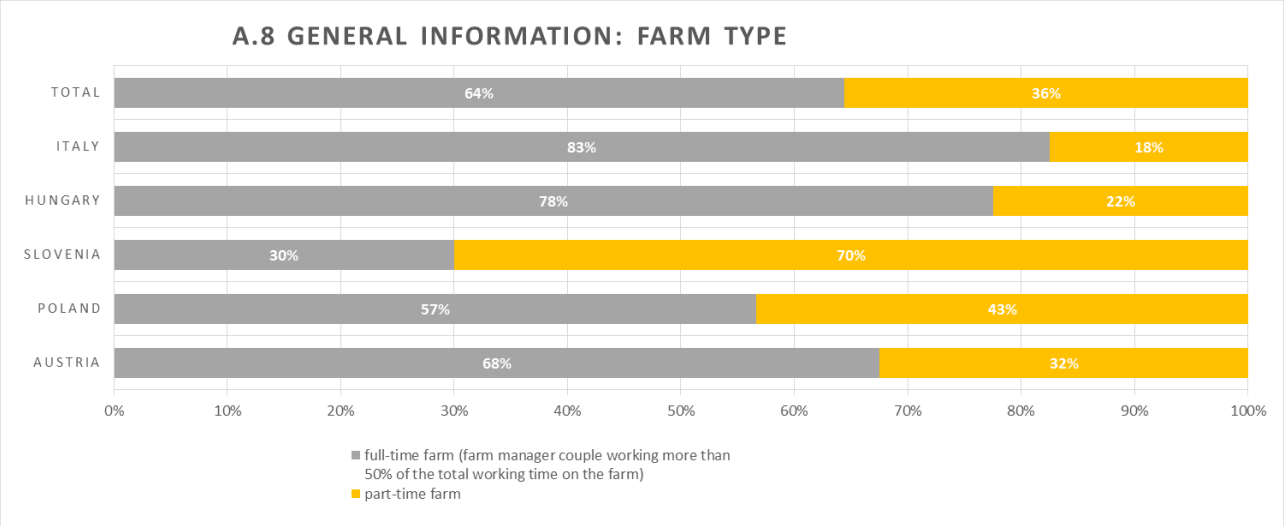


Figure 10: Farm type (Full-time/Part-time farmer)

2.9. Farm location in less-favoured area (mountain farm)

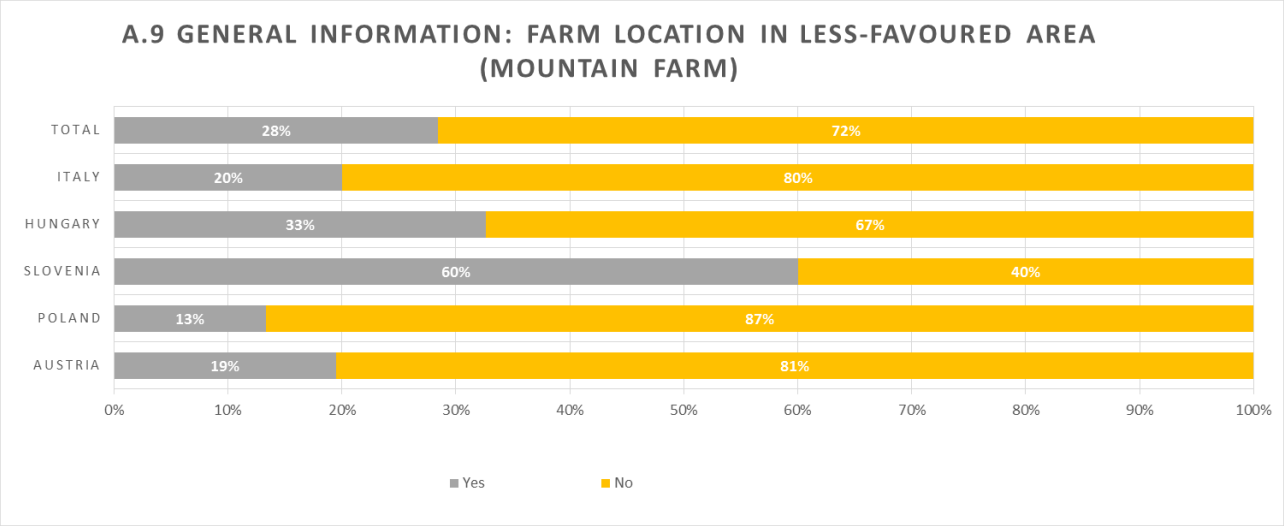


Figure 11: Farm location in less-favoured area (mountain farm)

3. Survey Results - Main Questions

3.1. Question 1

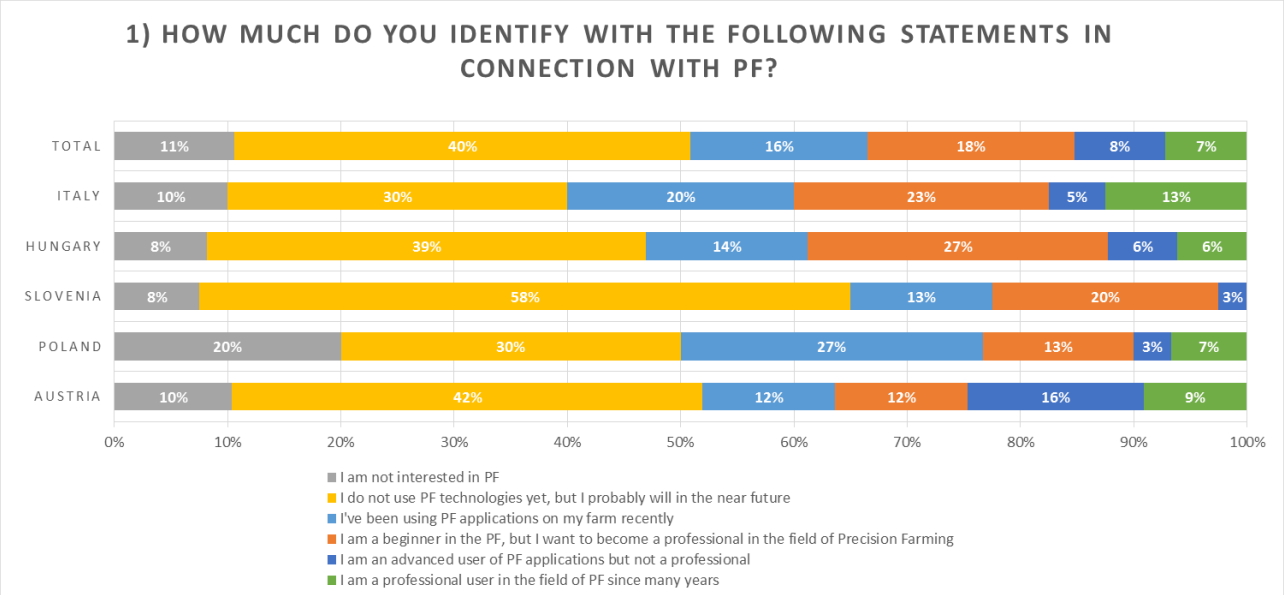


Figure 12: Question 1

3.1.1. Question 1: Detail from PF professionals - Overview

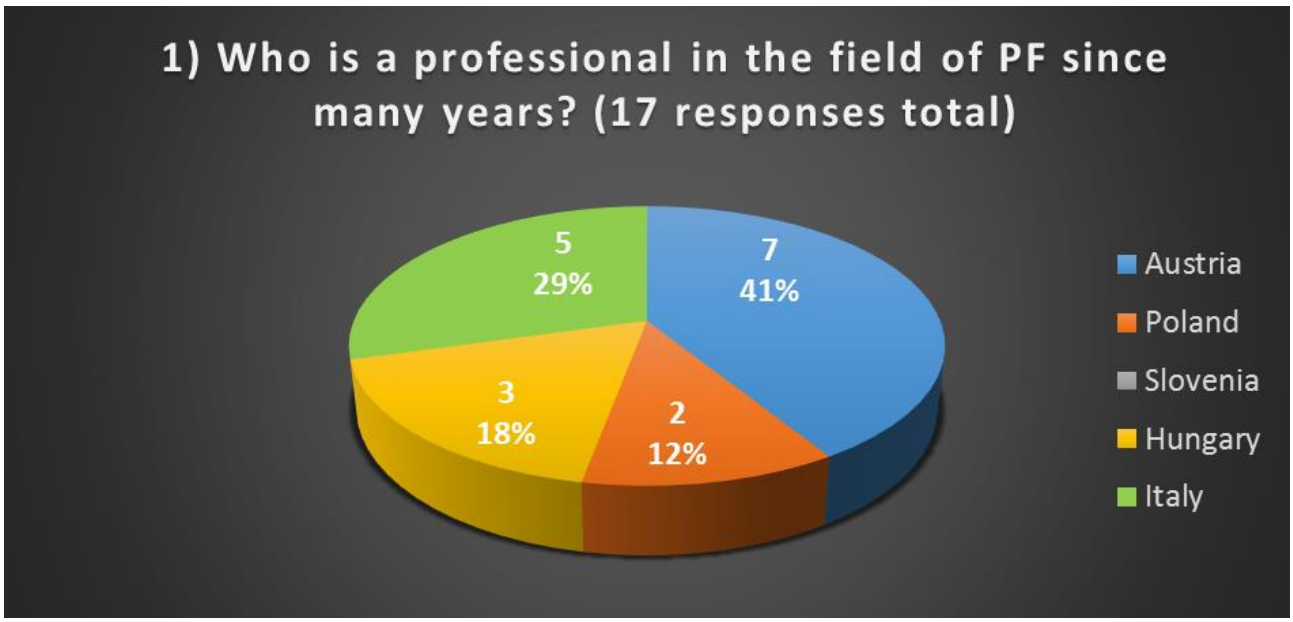


Figure 13: Question 1: Detail PF professionals - Overview

3.1.2. Question 1: Detail from PF professionals - Gender

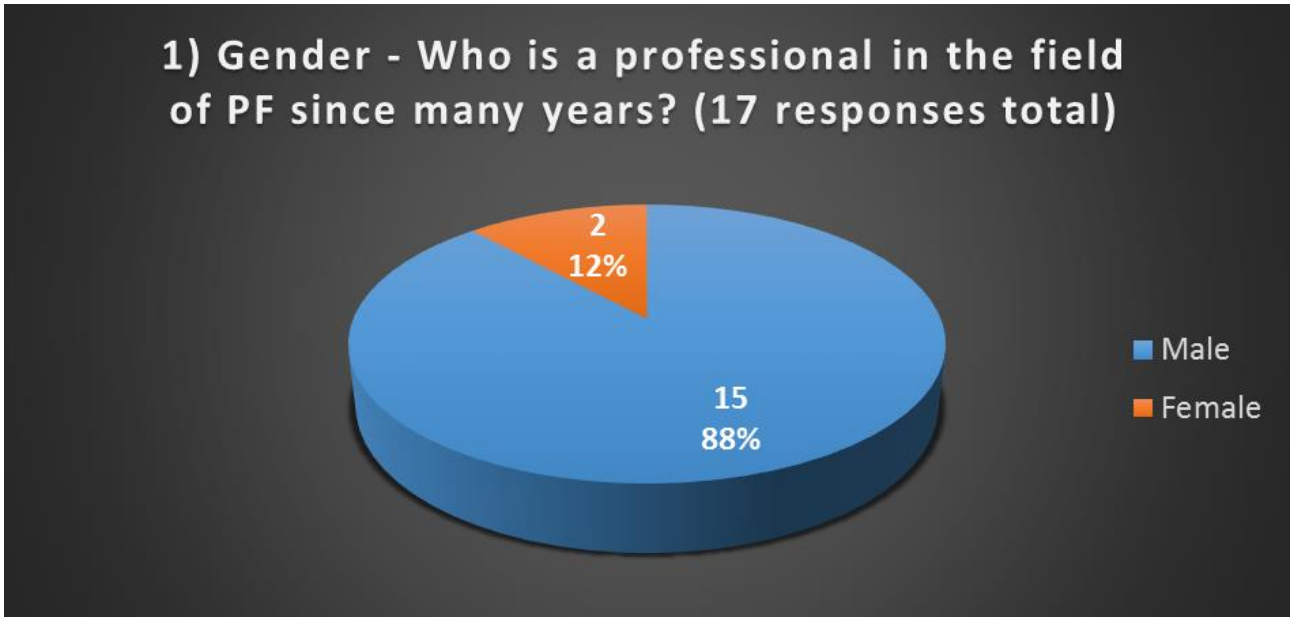


Figure 14: Question 1: Detail PF professionals - Gender

3.1.3. Question 1: Detail from PF professionals – Age in Years

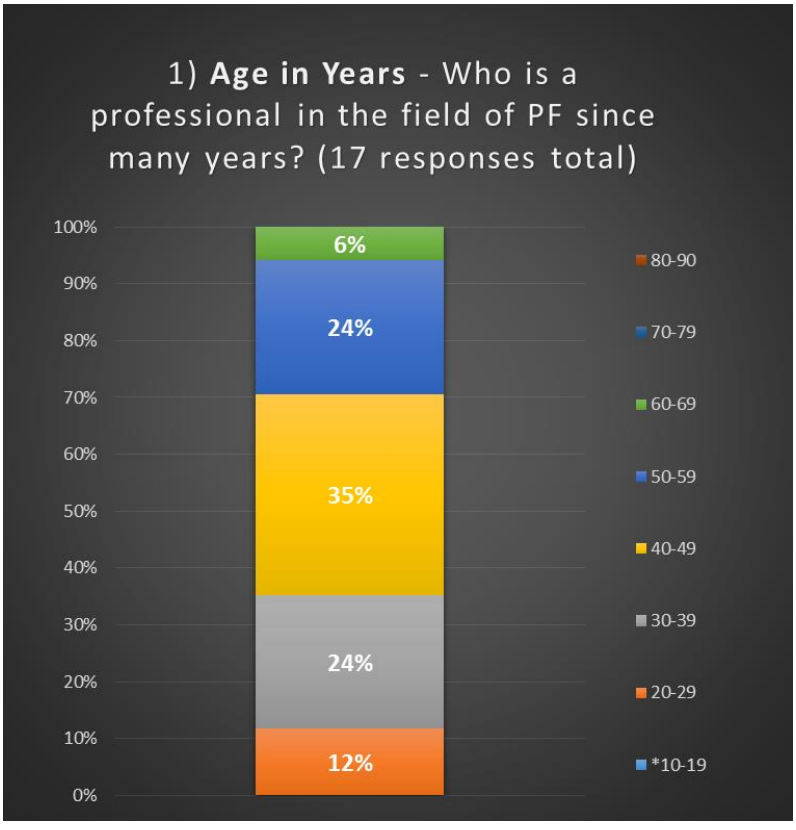


Figure 15: Question 1: Detail PF professionals - Age in Years

3.1.4. Question 1: Detail from PF professionals – Highest educational attainment

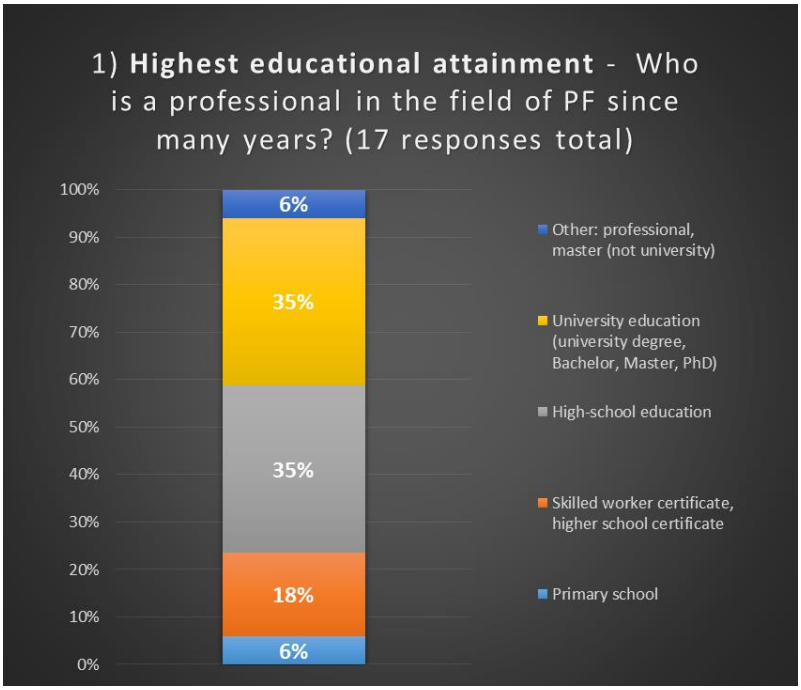


Figure 16: Question 1: Detail PF professionals – Highest educational attainment

3.1.5. Question 1: Detail from PF professionals – Farm size in hectar (agricultural land)

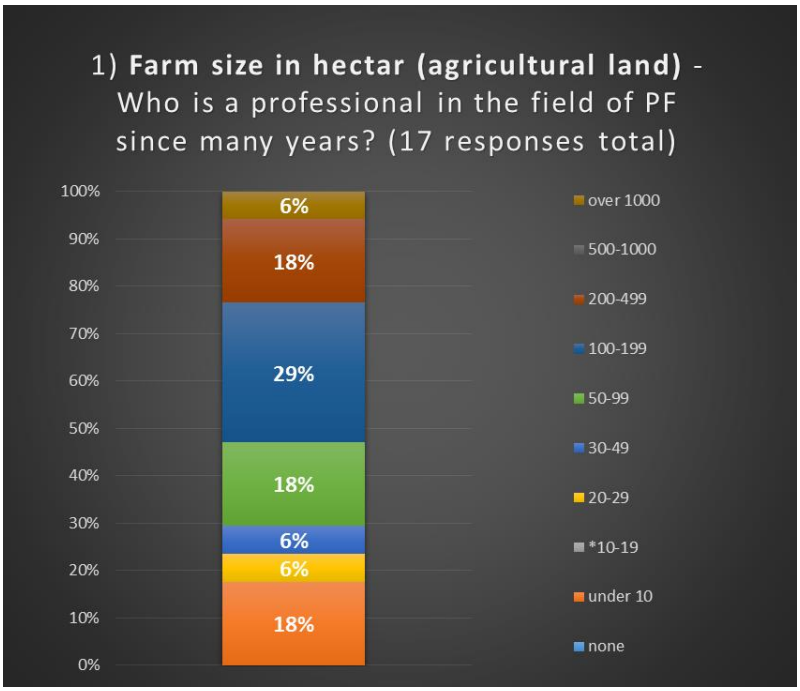


Figure 17: Question 1: Detail PF professionals – Farm size in hectar (agricultural land)

3.1.6. Question 1: Detail from PF professionals – Main farm focus

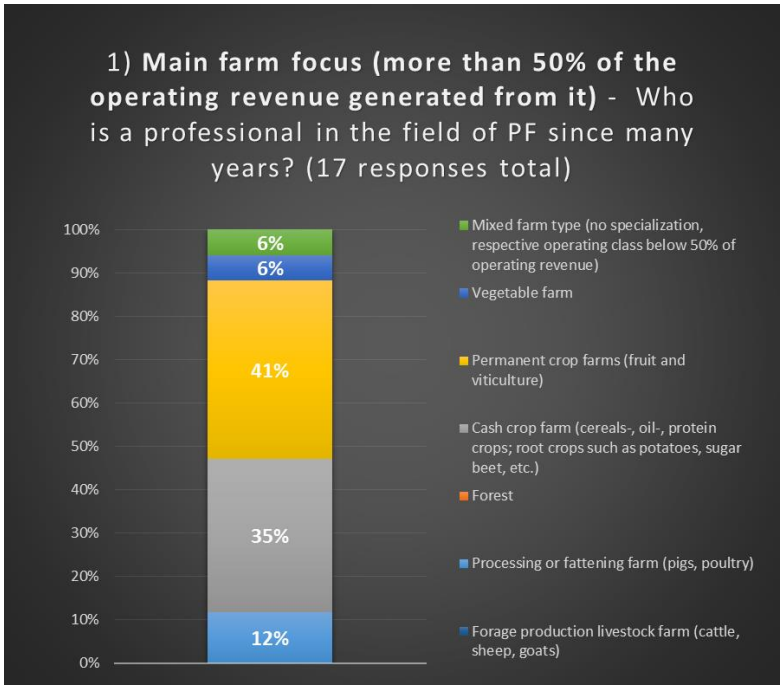


Figure 18: Question 1: Detail PF professionals – Main farm focus

3.1.7. Question 1: Detail from PF professionals – Farm management

Figure 19: Question 1: Detail PF professionals – Farm Management

3.1.8. Question 1: Detail from PF professionals – Farm type

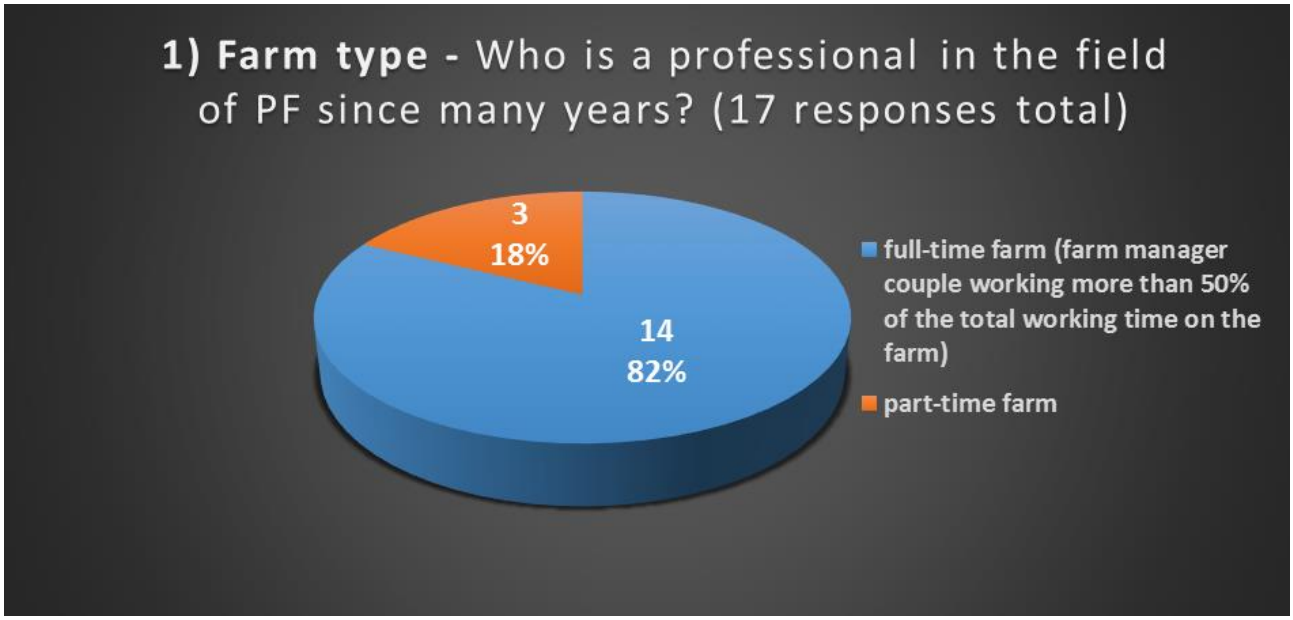


Figure 20: Question 1: Detail PF professionals – Farm Type

3.1.9. Question 1: Detail from PF professionals – Farm location

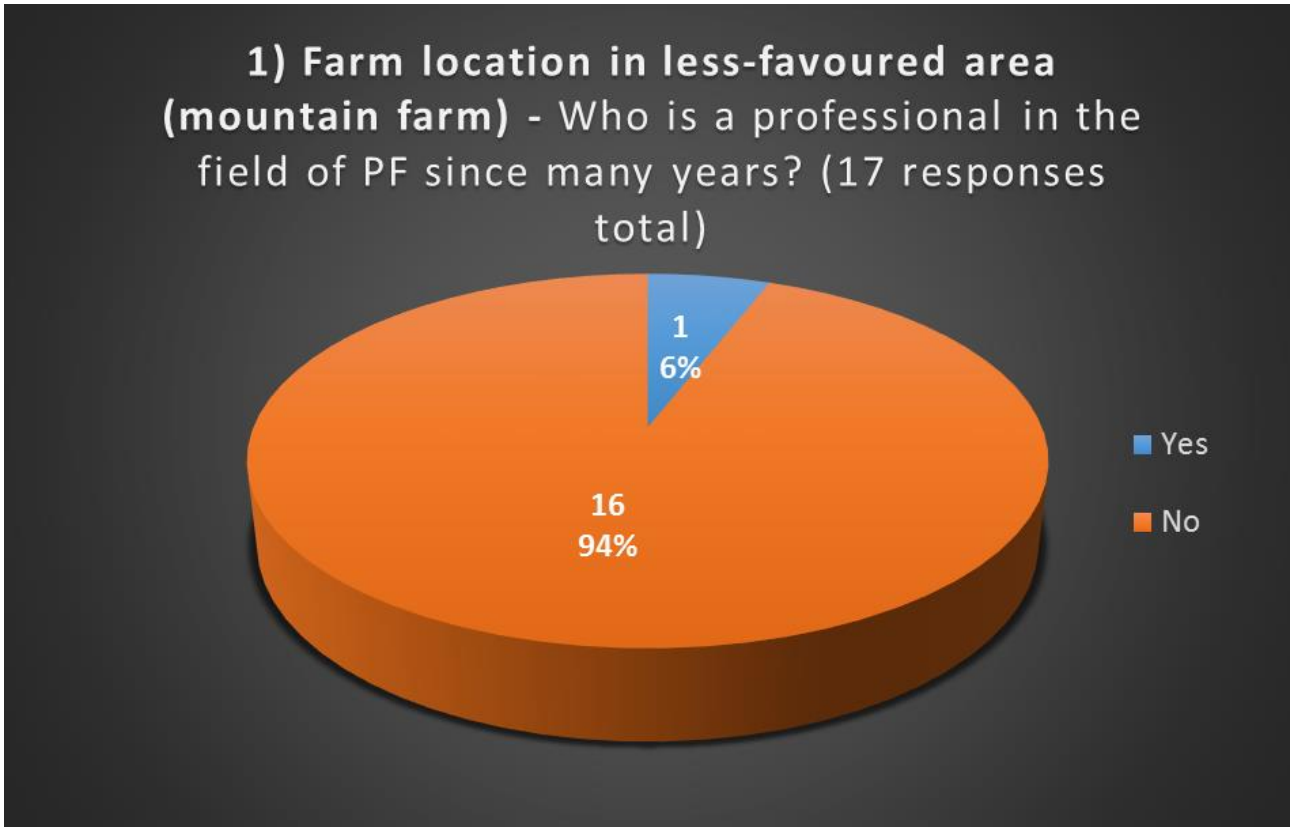


Figure 21: Question 1: Detail PF professionals – Farm location

3.1.10. Question 1: Detail from all statements – Age (number of responses)

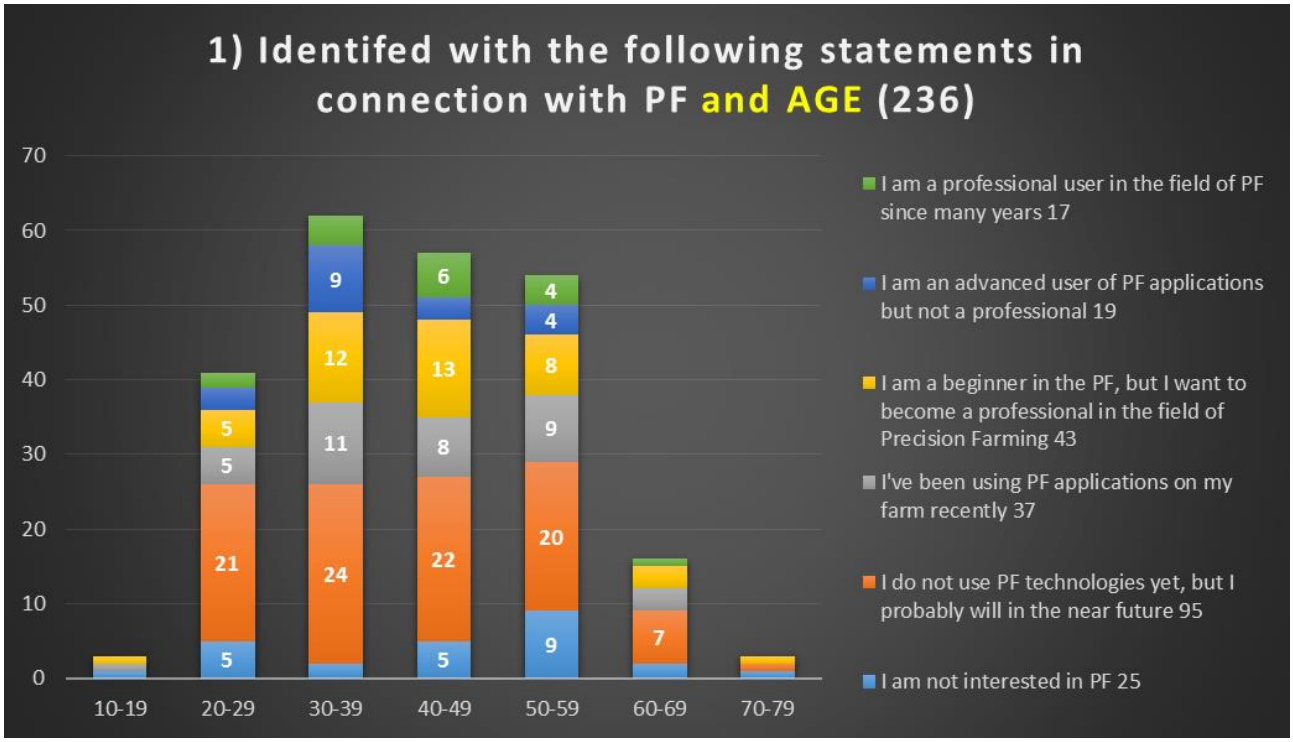


Figure 22: Question 1: Detail from all statements – Age (number of responses)

3.1.11. Question 1: Detail from all statements – Age (in percent)

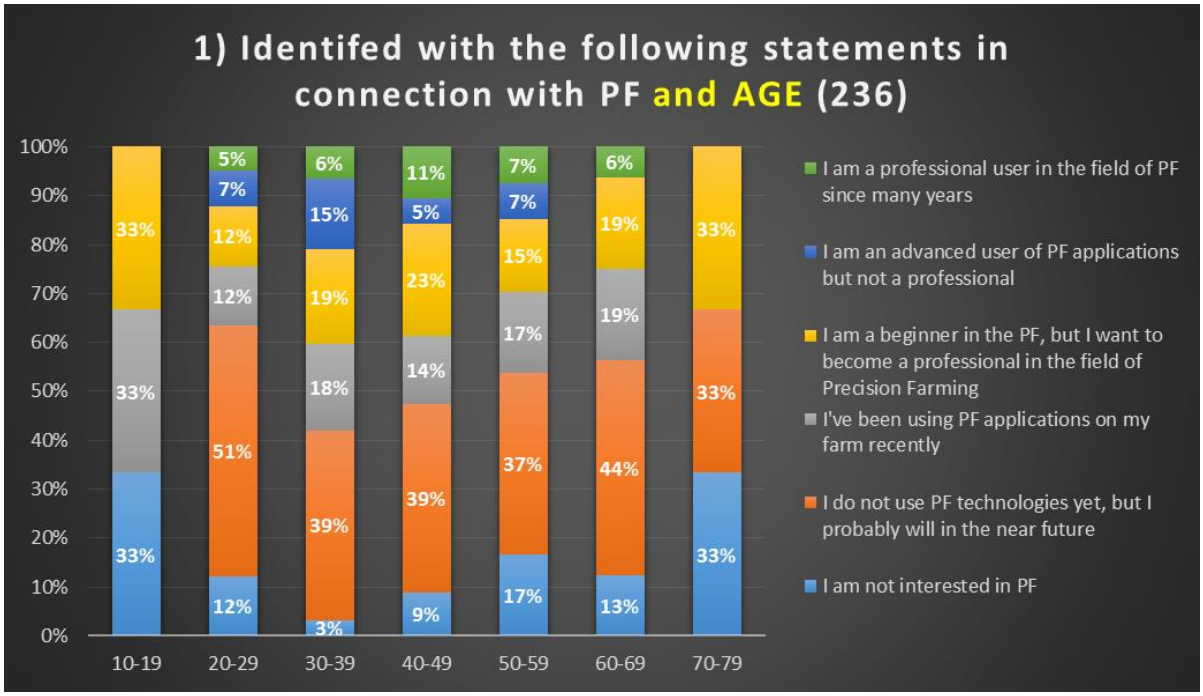


Figure 23: Question 1: Detail from all statements – Age (in percent)

3.1.12. Question 1: Detail from all statements – Education (number of responses)

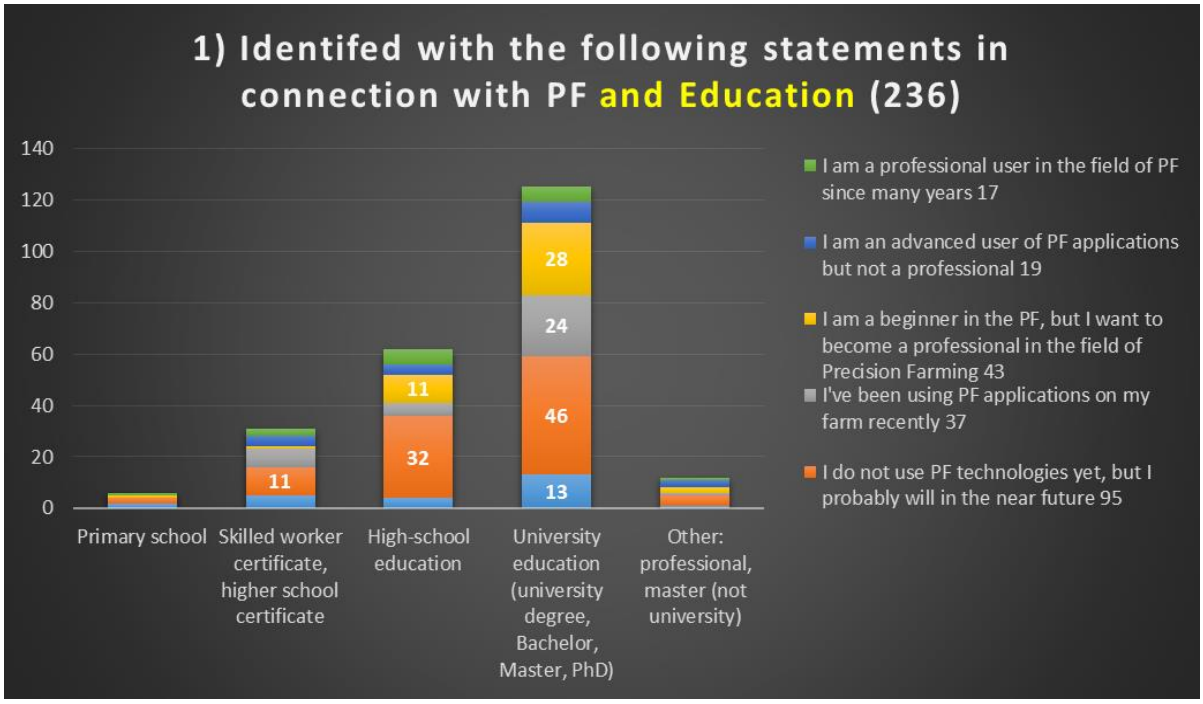


Figure 24: Question 1: Detail from all statements – Education (number of responses)

3.1.13. Question 1: Detail from all statements – Education (in percent)

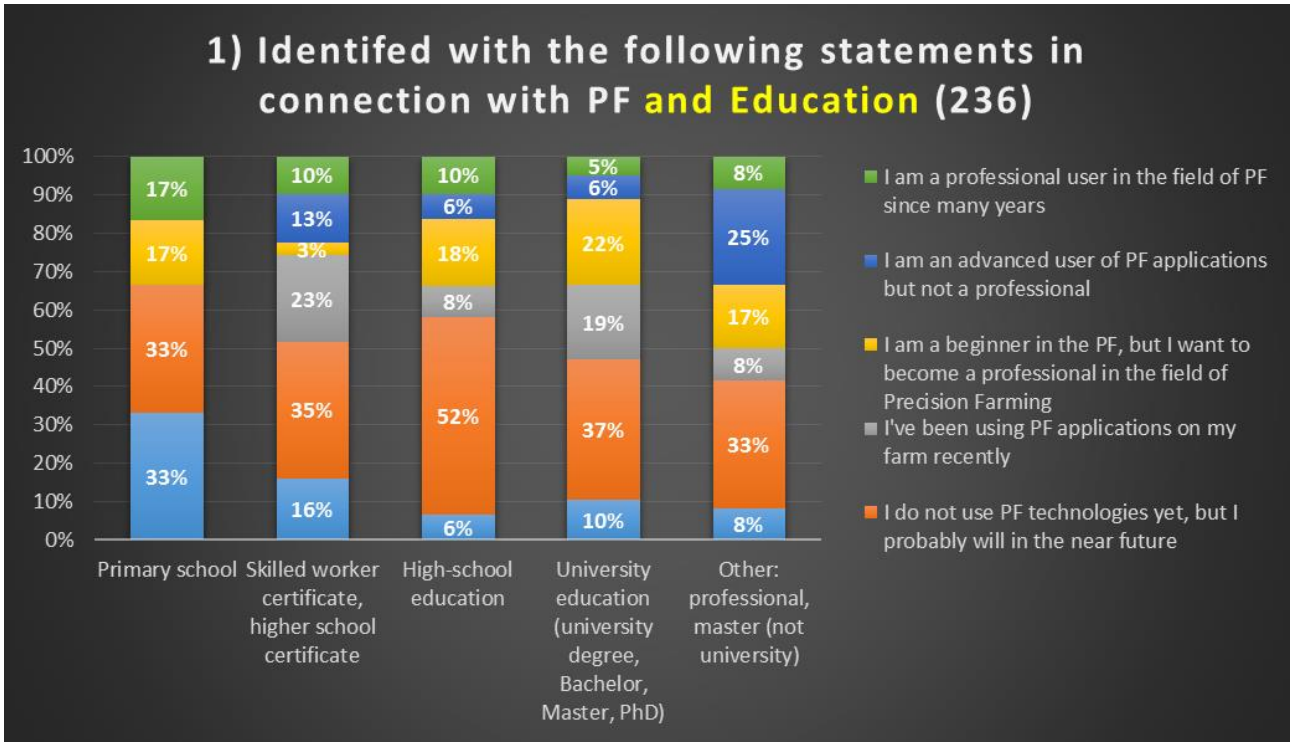


Figure 25: Question 1: Detail from all statements – Education (in percent)

3.1.14. Question 1: Detail from all statements – Farm size (number of responses)

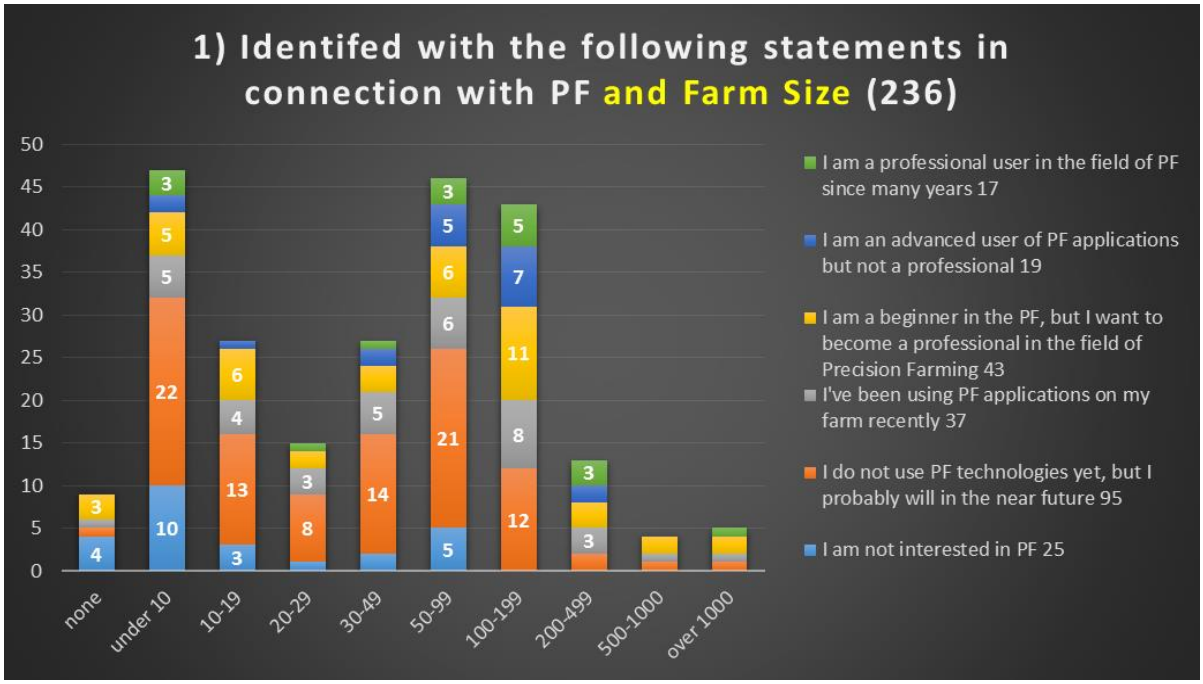


Figure 26: Question 1: Detail from all statements – Farm size (number of responses)

3.1.15. Question 1: Detail from all statements – Farm size (in percent)

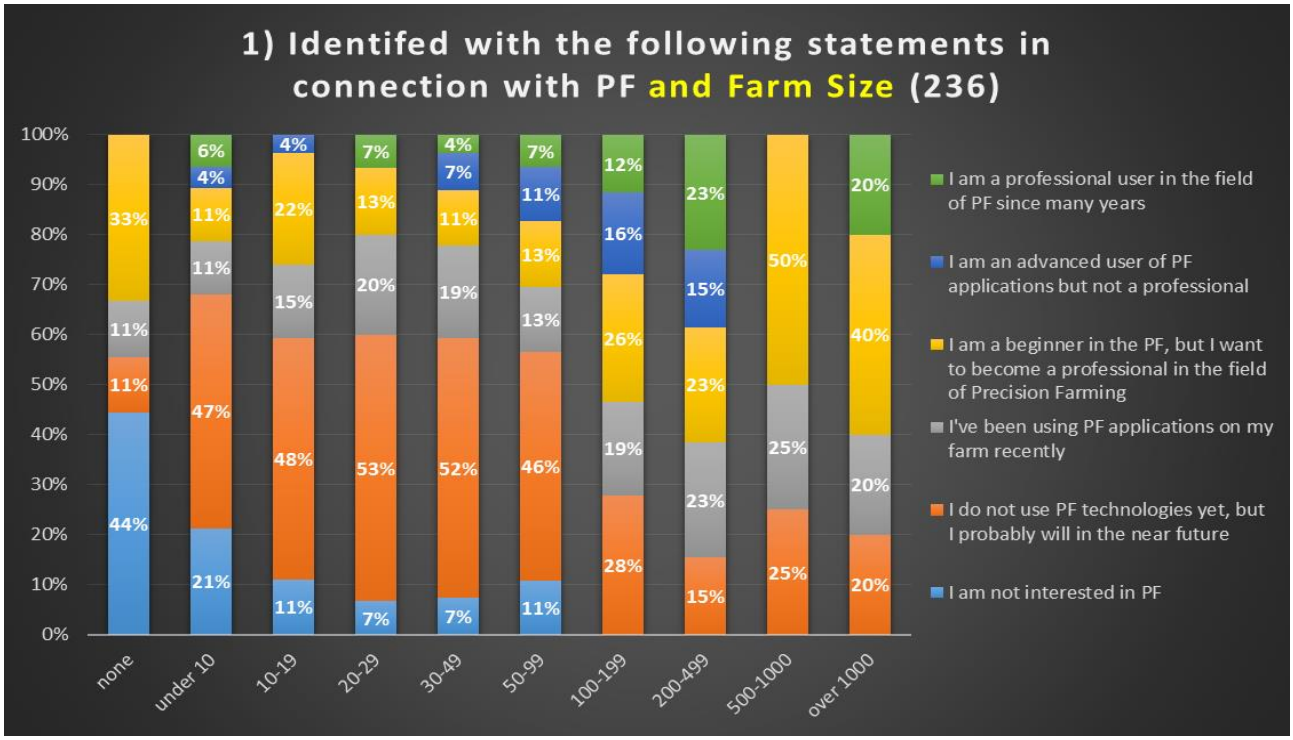


Figure 27: Question 1: Detail from all statements – Farm size (in percent)

3.2. Question 2

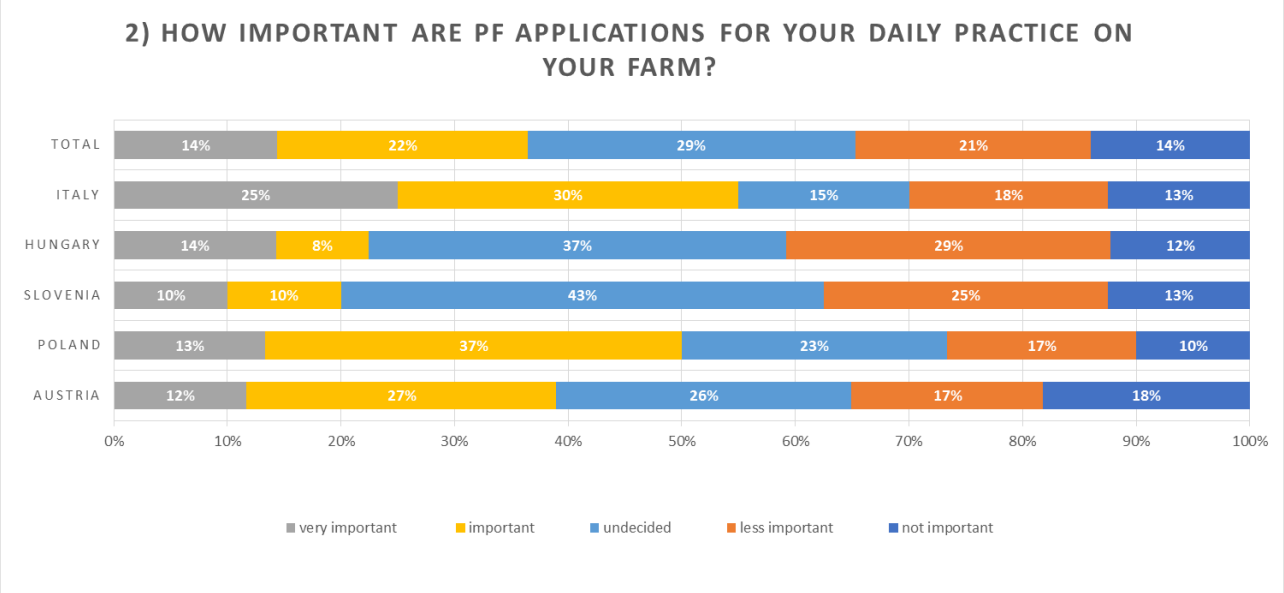


Figure 28: Question 2

3.2.1. Question 2: Detail from all statements - Gender (Female responses)

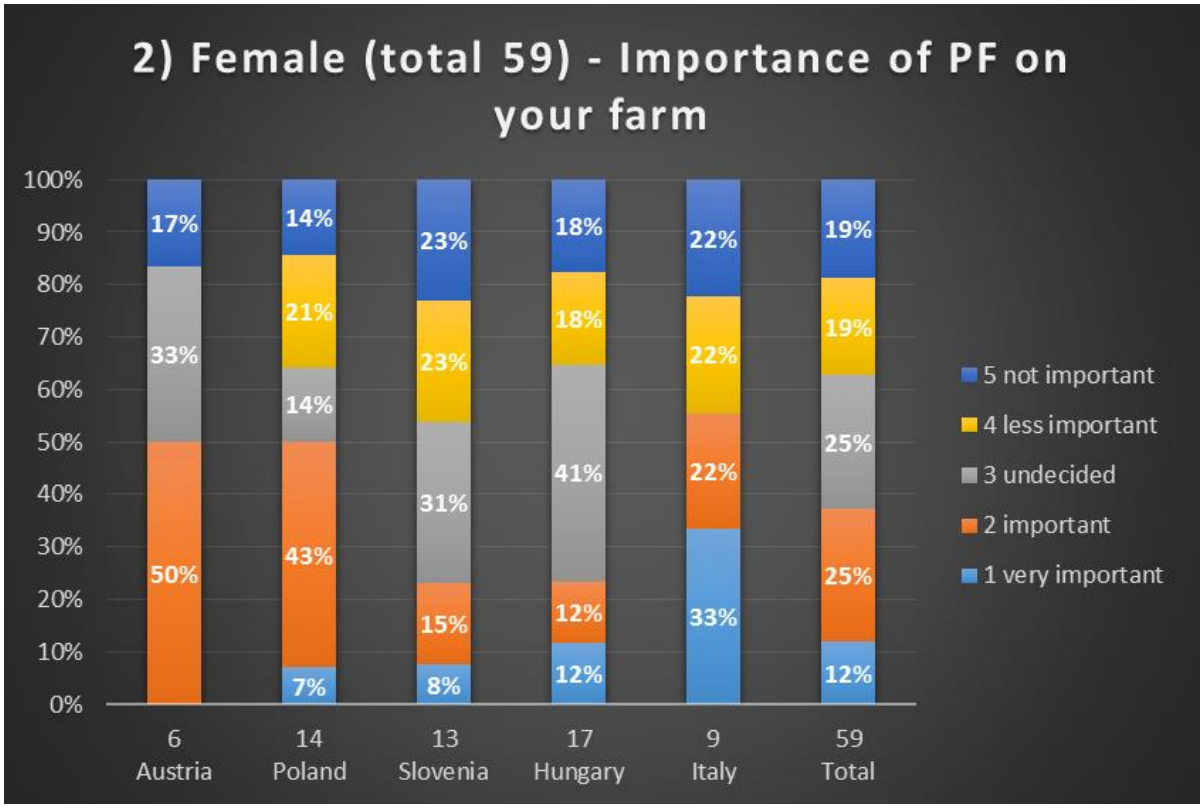


Figure 29: Question 2: Detail from all statements – Gender (Female responses)

3.2.2. Question 2: Detail from all statements – Gender (Male responses)

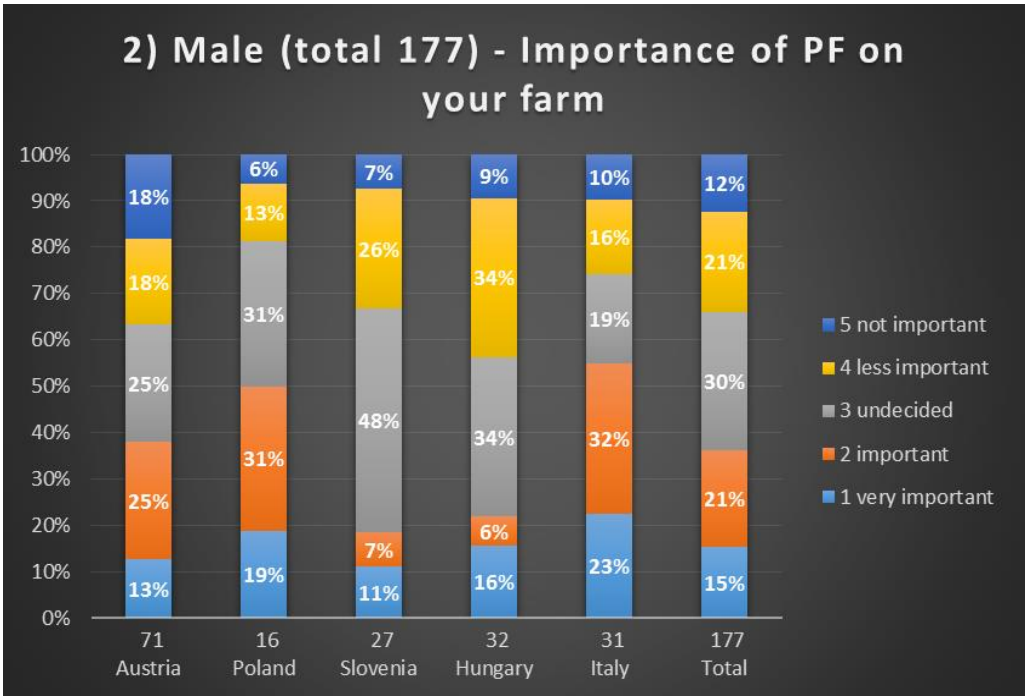


Figure 30: Question 2: Detail from all statements – Gender (Male responses)

3.2.3. Question 2: Detail from all statements – Gender (Male responses)

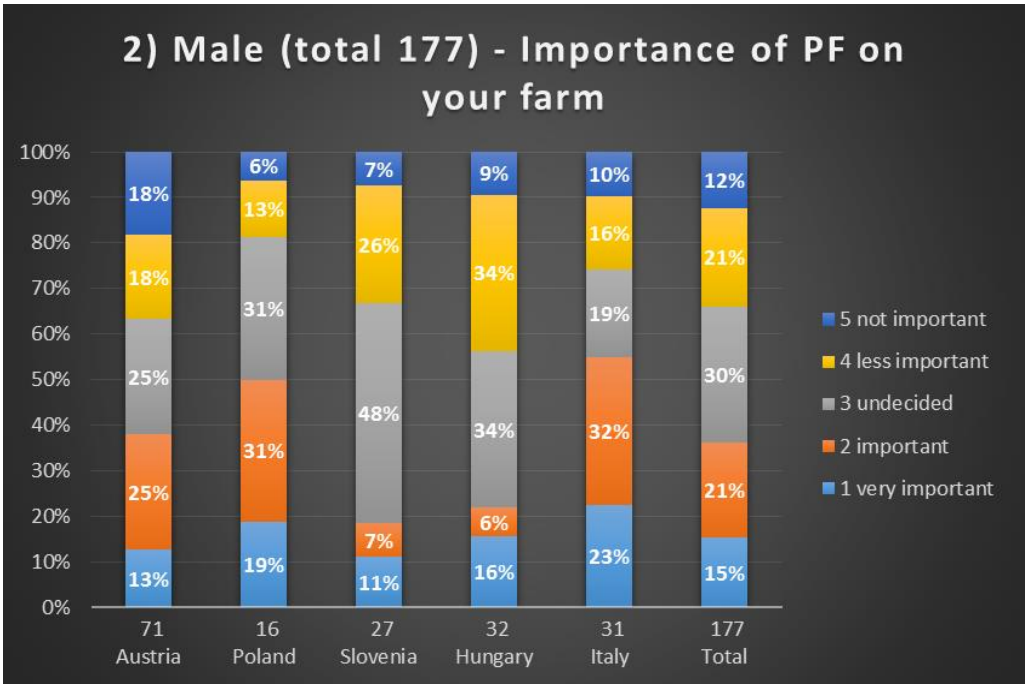


Figure 31: Question 2: Detail from all statements – Gender (Male responses)

3.2.4. Question 2: Detail from all statements – Age

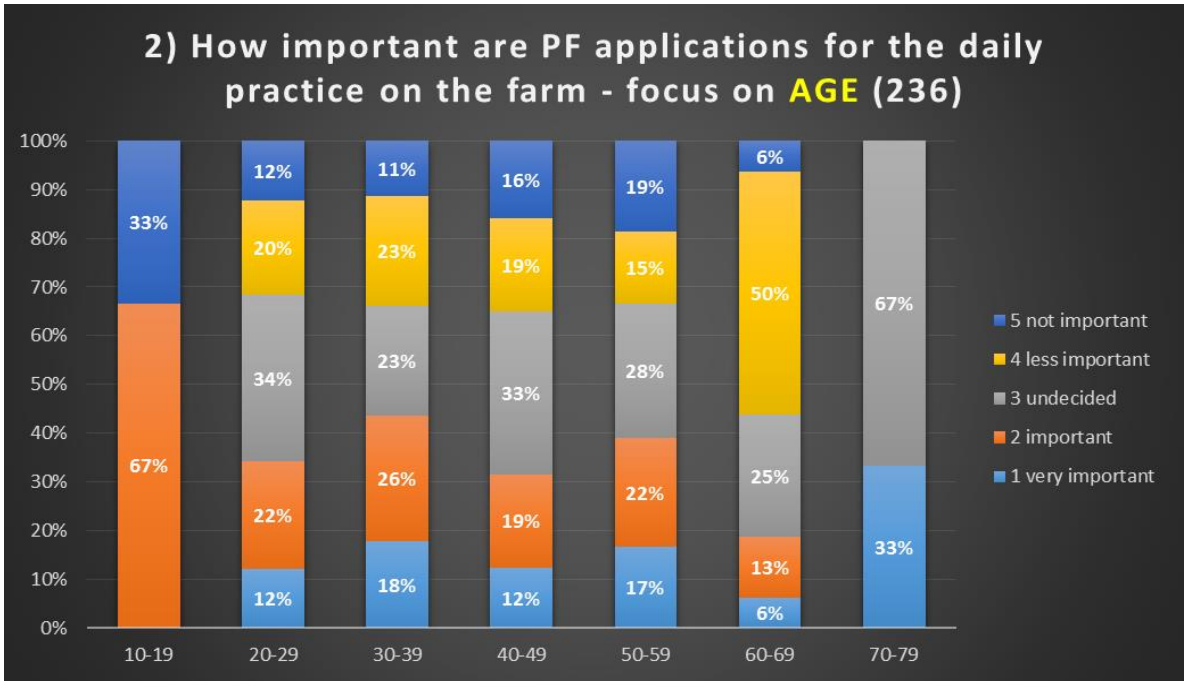


Figure 32: Question 2: Detail from all statements – Age

3.2.5. Question 2: Detail from all statements – Education

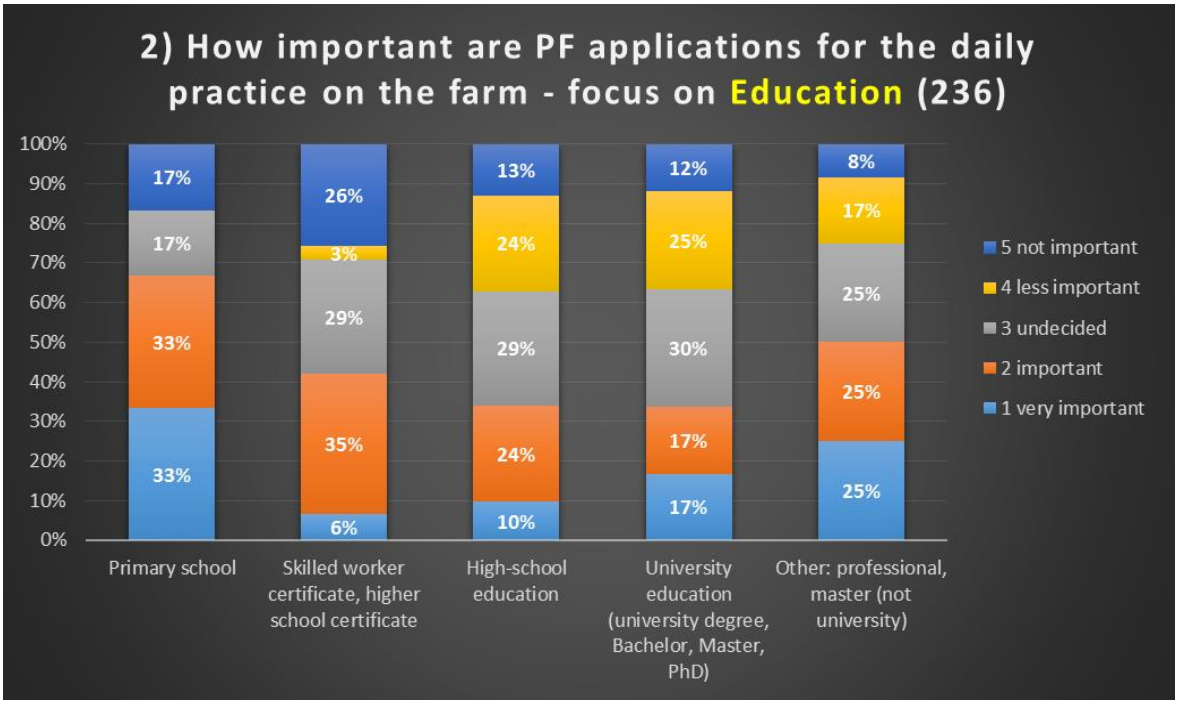


Figure 33: Question 2: Detail from all statements – Education

3.2.6. Question 2: Detail from all statements – Farm size

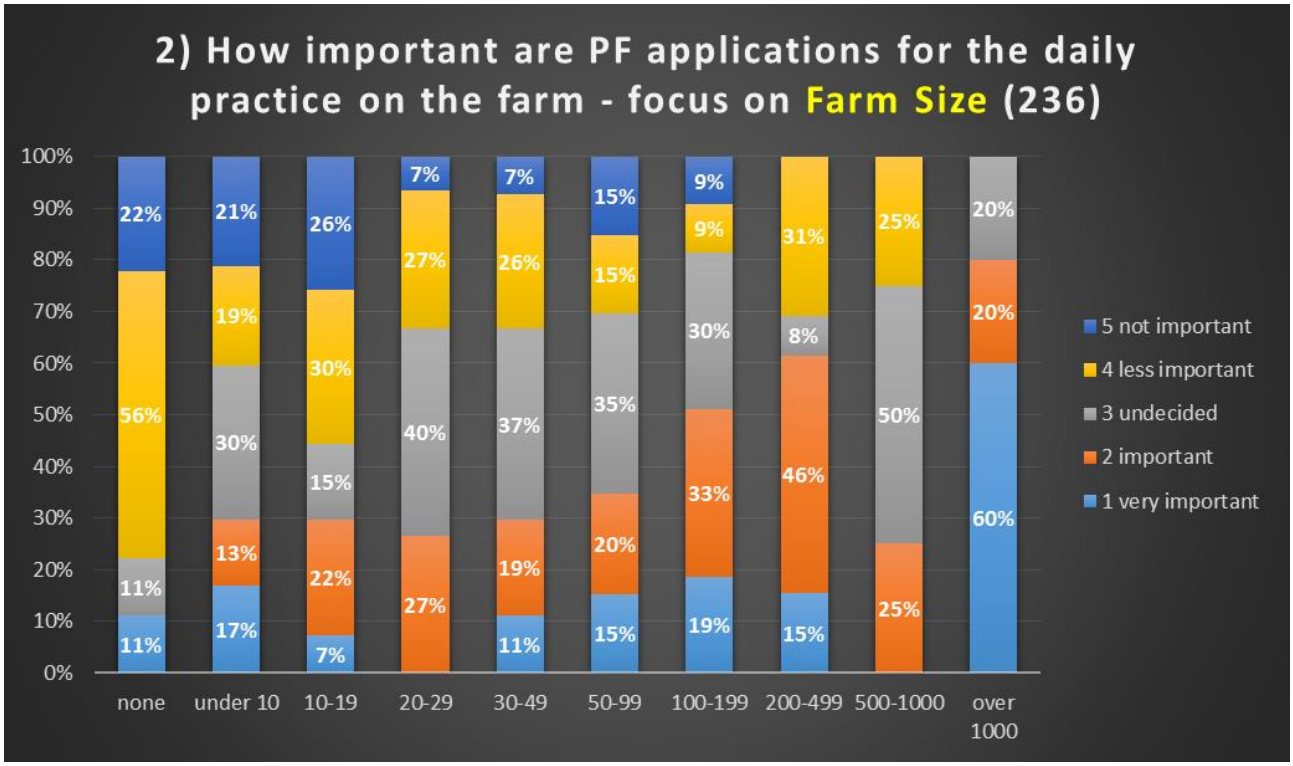


Figure 34: Question 2: Detail from all statements – Farm size

3.3. Question 3

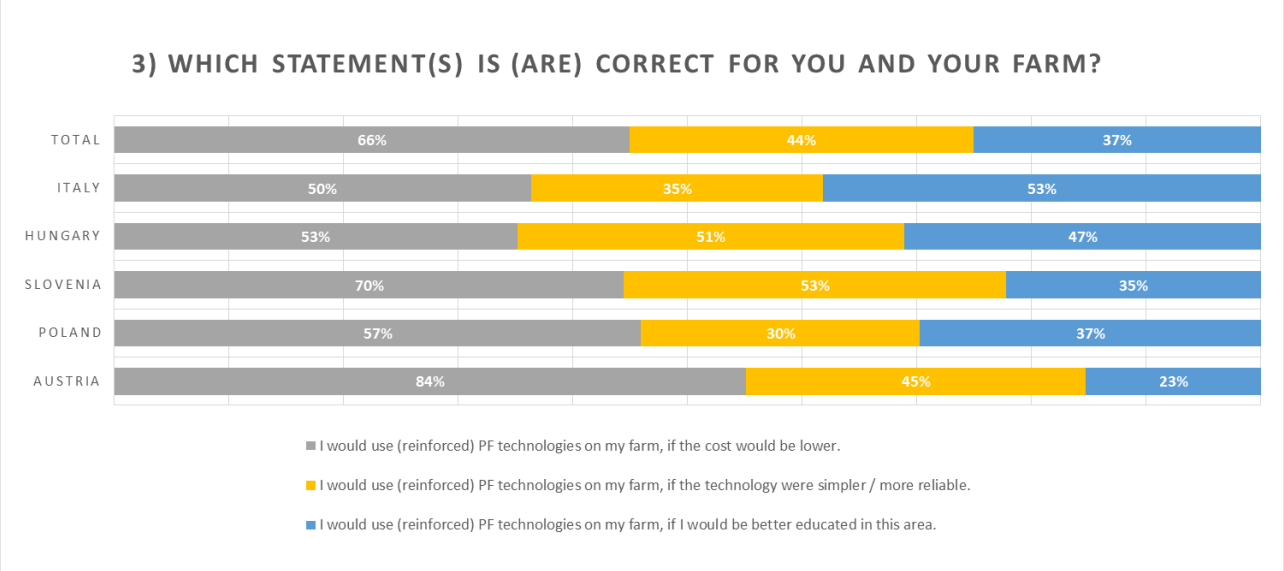


Figure 35: Question 3

3.3.1. Question 3: Focus on multiple response – overview per country

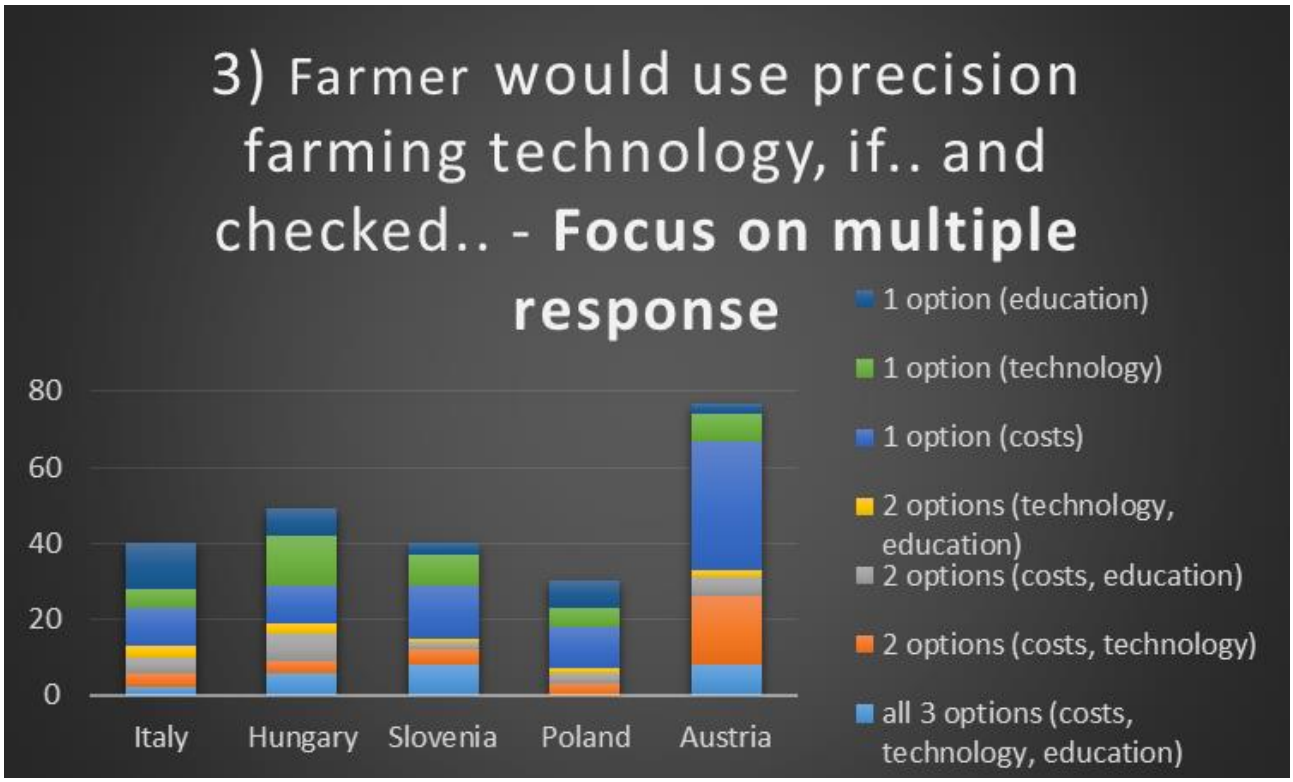


Figure 36: Question 3: Focus on multiple response – overview per country

3.3.2. Question 3: Focus on multiple response – overview for Austria

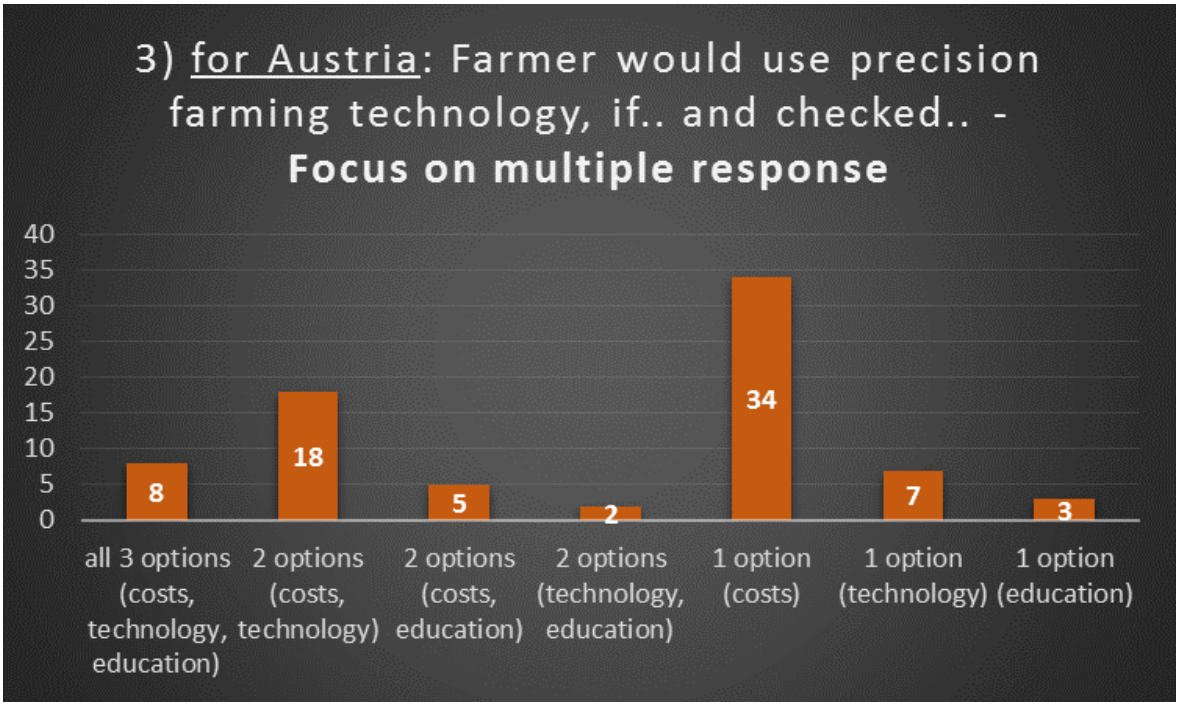


Figure 37: Question 3: Focus on multiple response – overview for Austria

3.3.3. Question 3: Focus on multiple response – overview for Italy

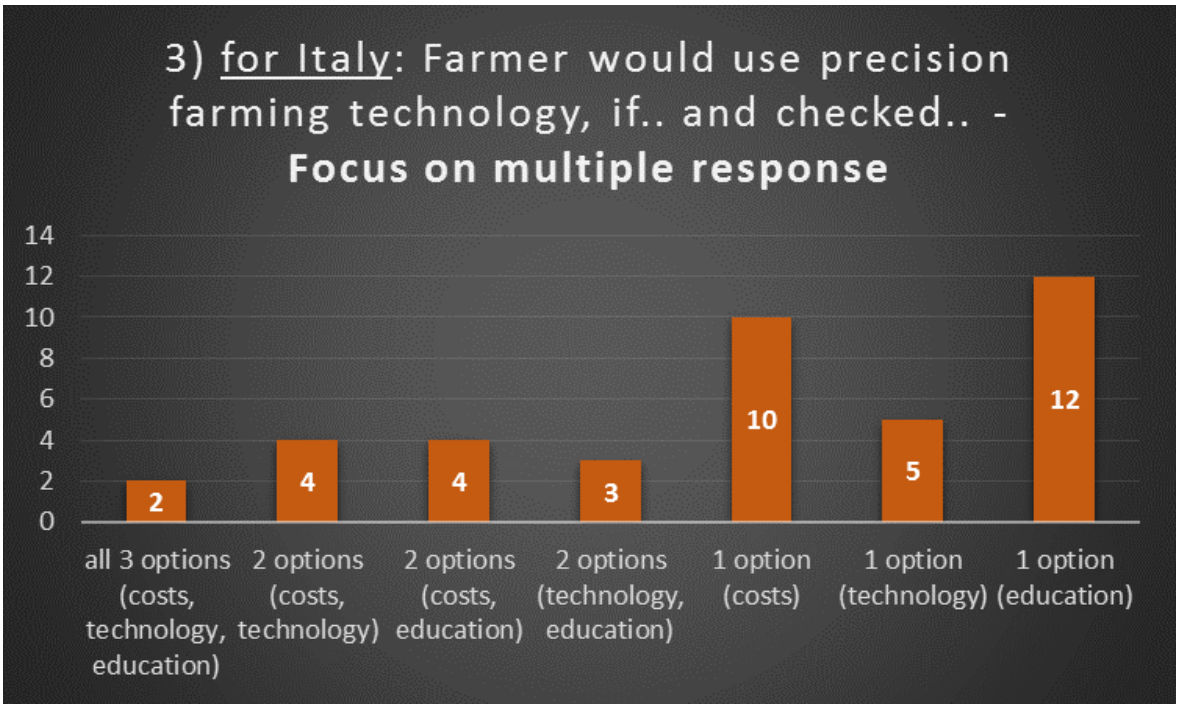


Figure 38: Question 3: Focus on multiple response – overview for Italy

3.3.4. Question 3: Focus on multiple response - overview for Hungary

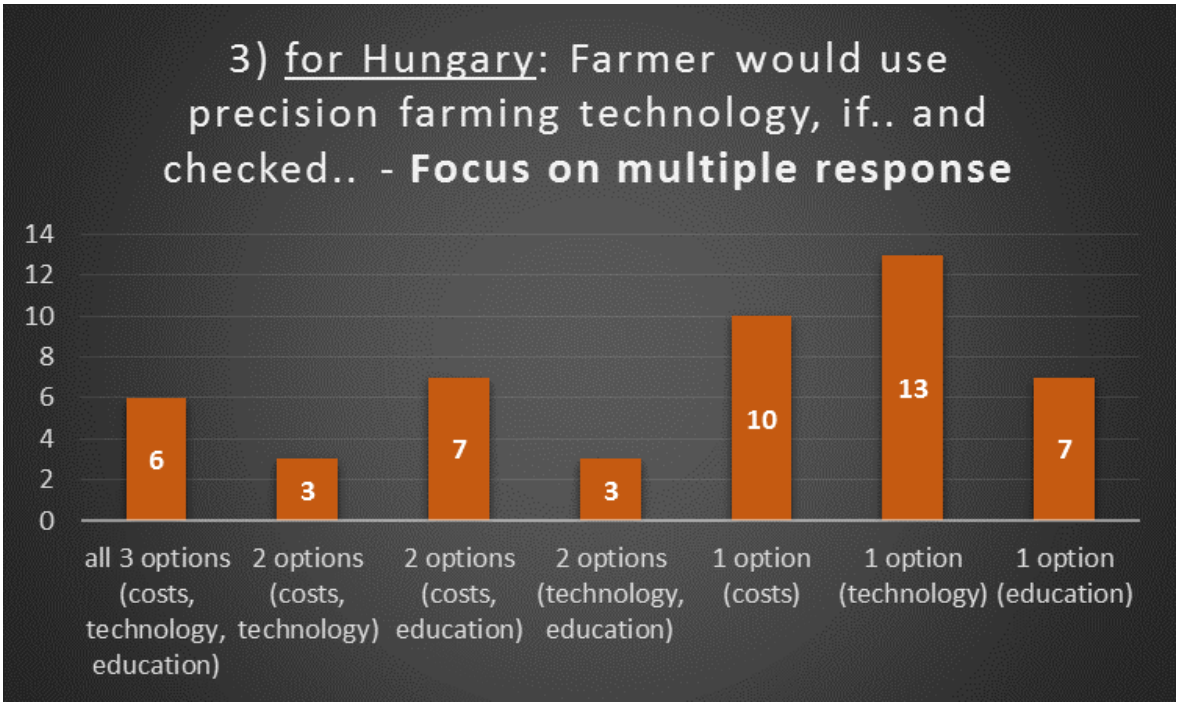


Figure 39: Question 3: Focus on multiple response – overview for Hungary

3.3.5. Question 3: Focus on multiple response - overview for Slovenia

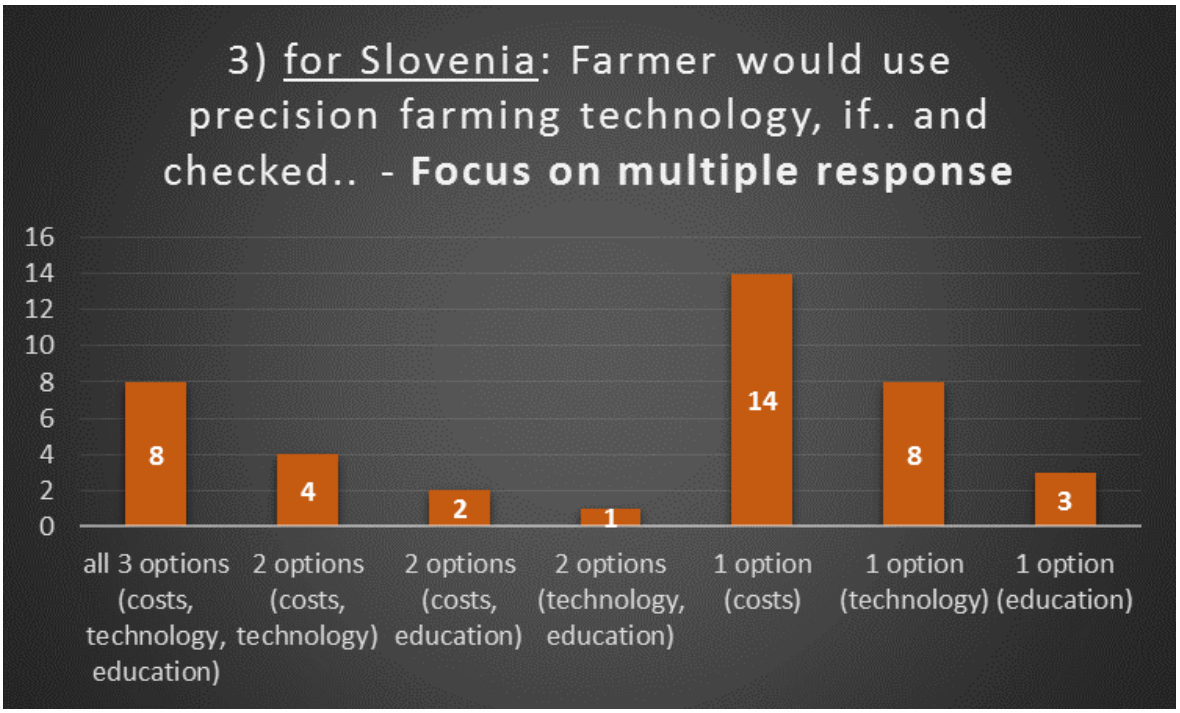


Figure 40: Question 3: Focus on multiple response – overview for Slovenia

3.3.6. Question 3: Focus on multiple response – overview for Poland

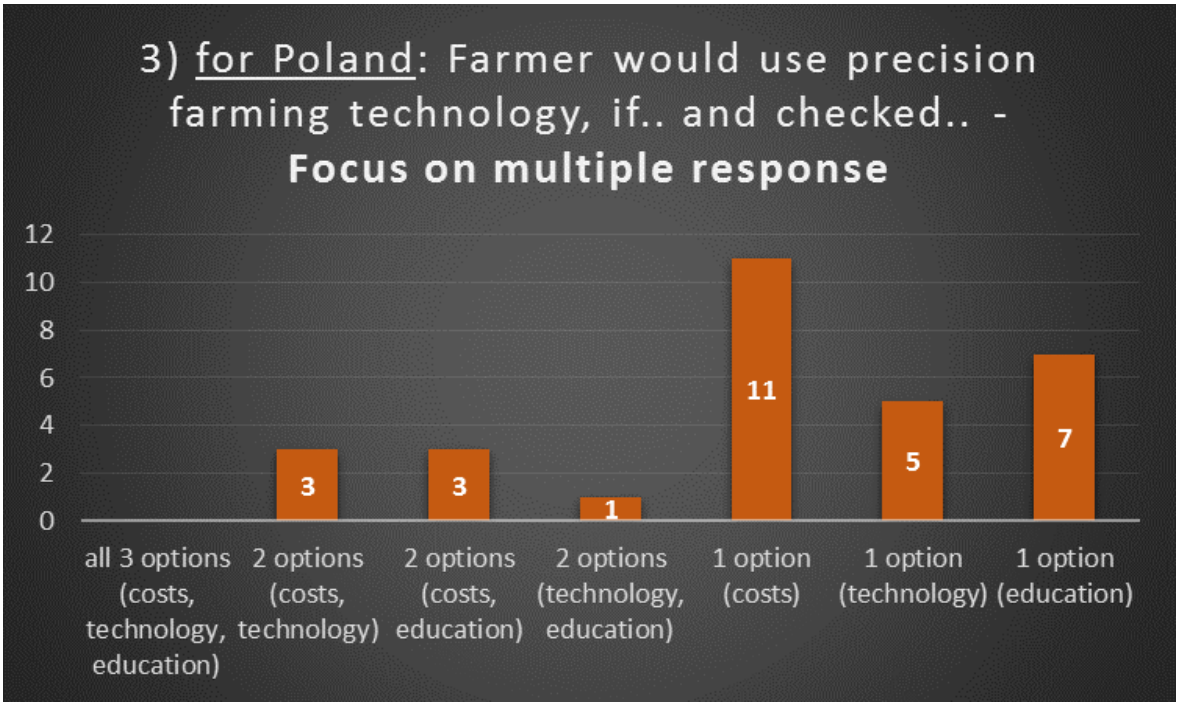


Figure 41: Question 3: Focus on multiple response – overview for Poland

3.3.7. Question 3: Focus on multiple response – overview in total (236)

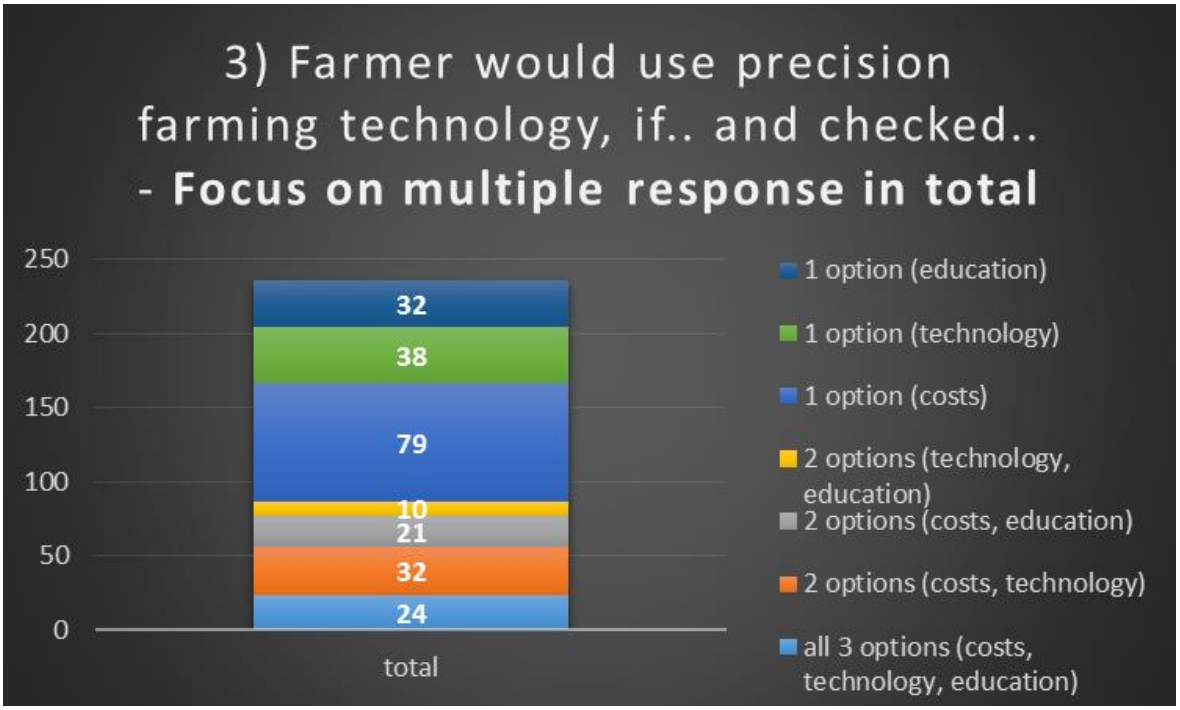


Figure 42: Question 3: Focus on multiple response – overview in total (236)

3.3.8. Question 3: Focus on multiple response – overview in total (in percent)

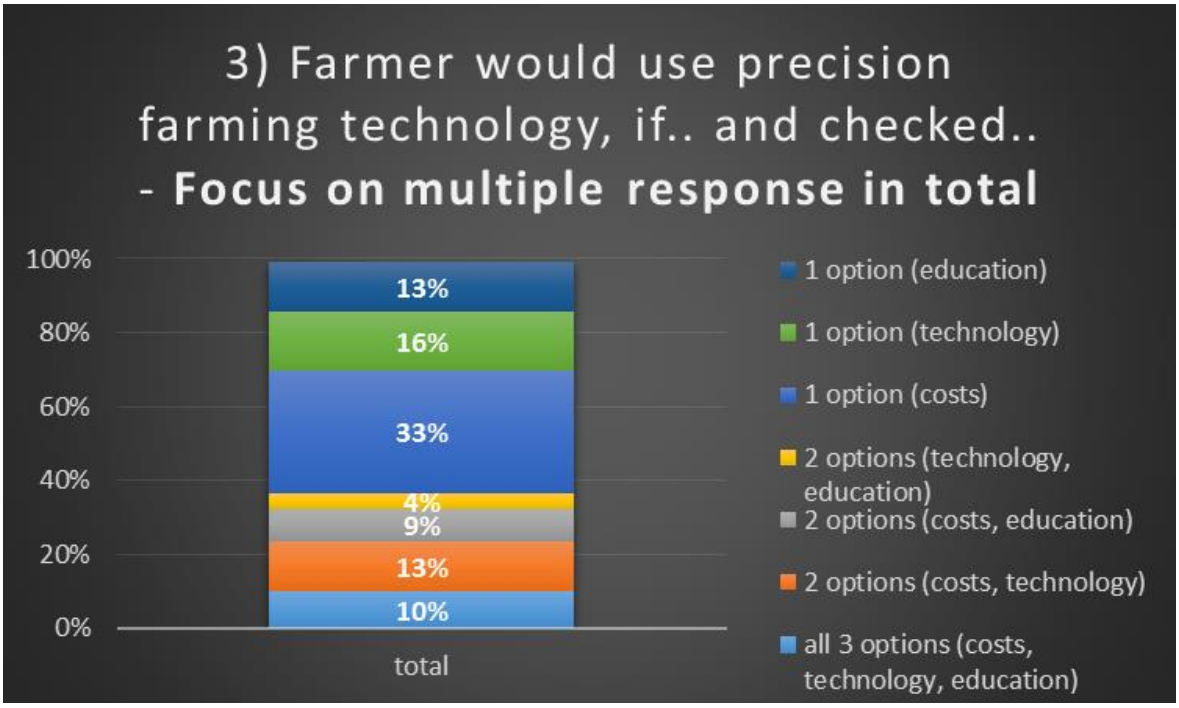


Figure 43: Question 3: Focus on multiple response – overview in total (in percent)

3.3.9. Question 3: Focus on category in total

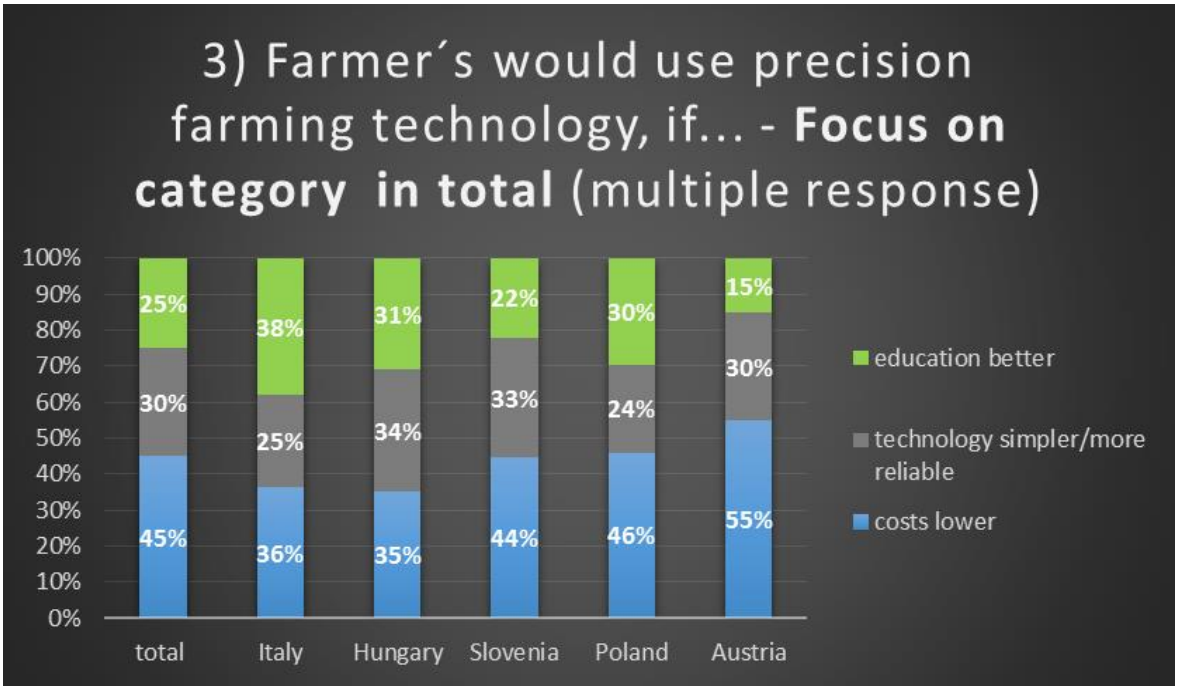


Figure 44: Question 3: Focus on category in total

3.3.10. Question 3: Focus on category and age

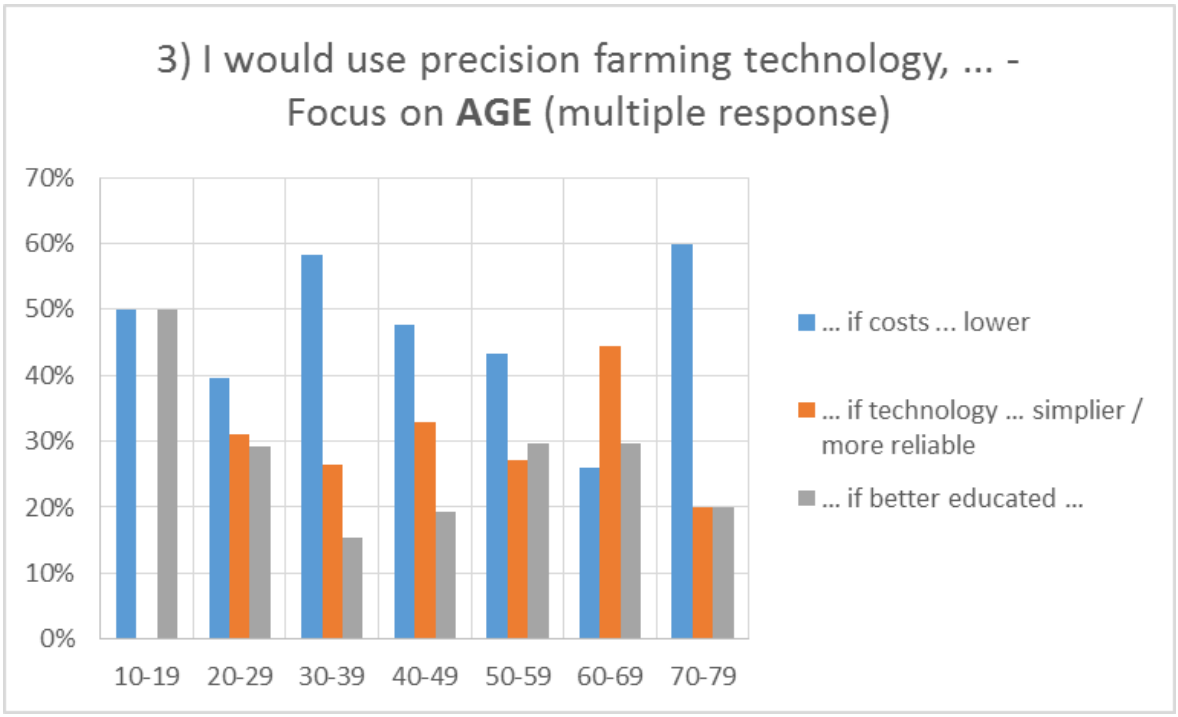


Figure 45: Question 3: Focus on category and age

3.3.11. Question 3: Focus on category and education

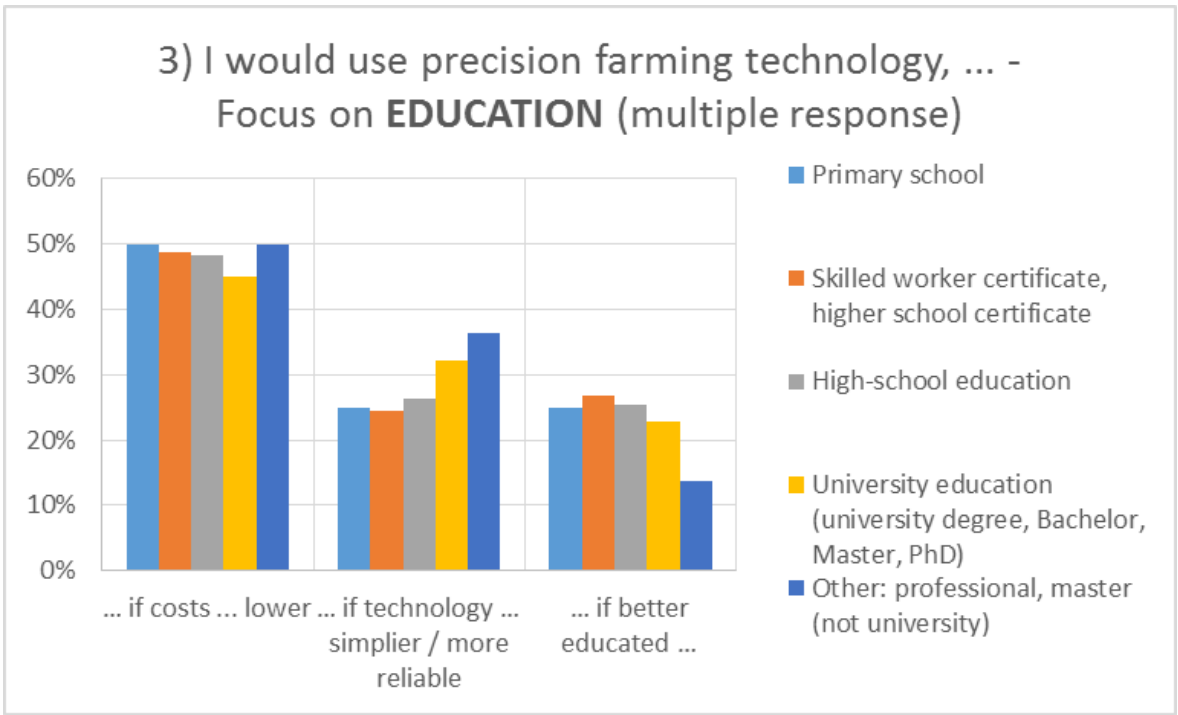


Figure 46: Question 3: Focus on category and education

3.3.12. Question 3: Focus on category and farm size (in hectar)

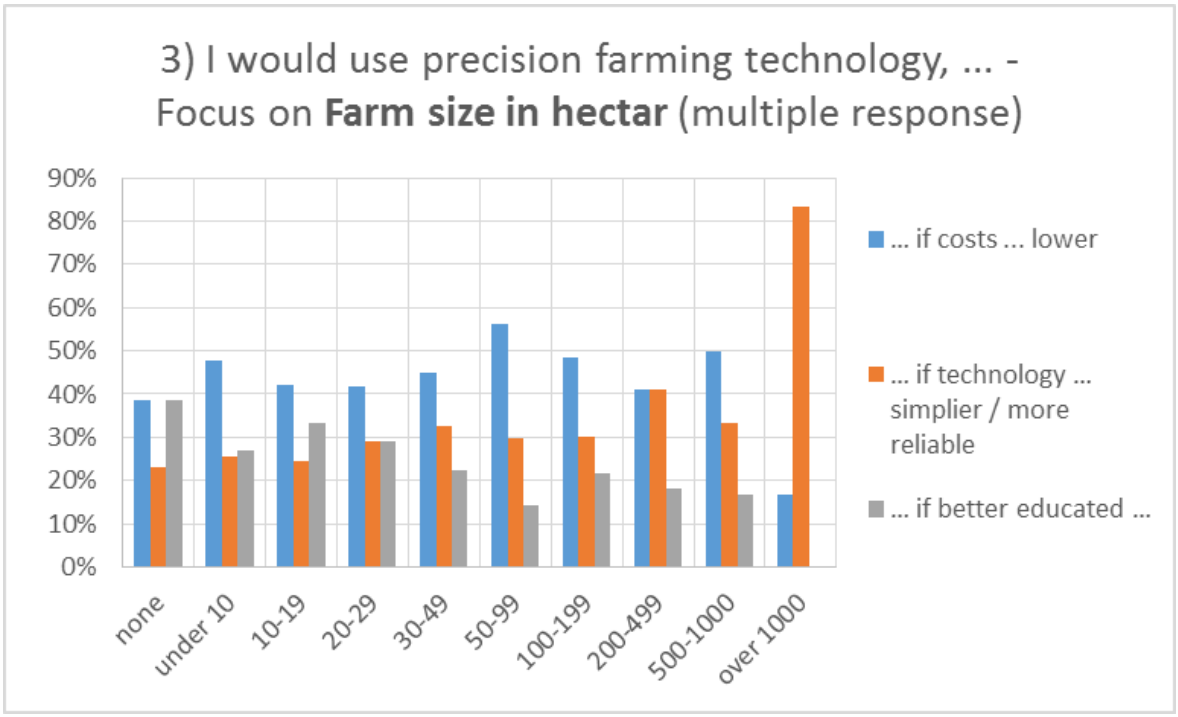


Figure 47: Question 3: Focus on category and farm size (in hectar)

3.4. Question 4

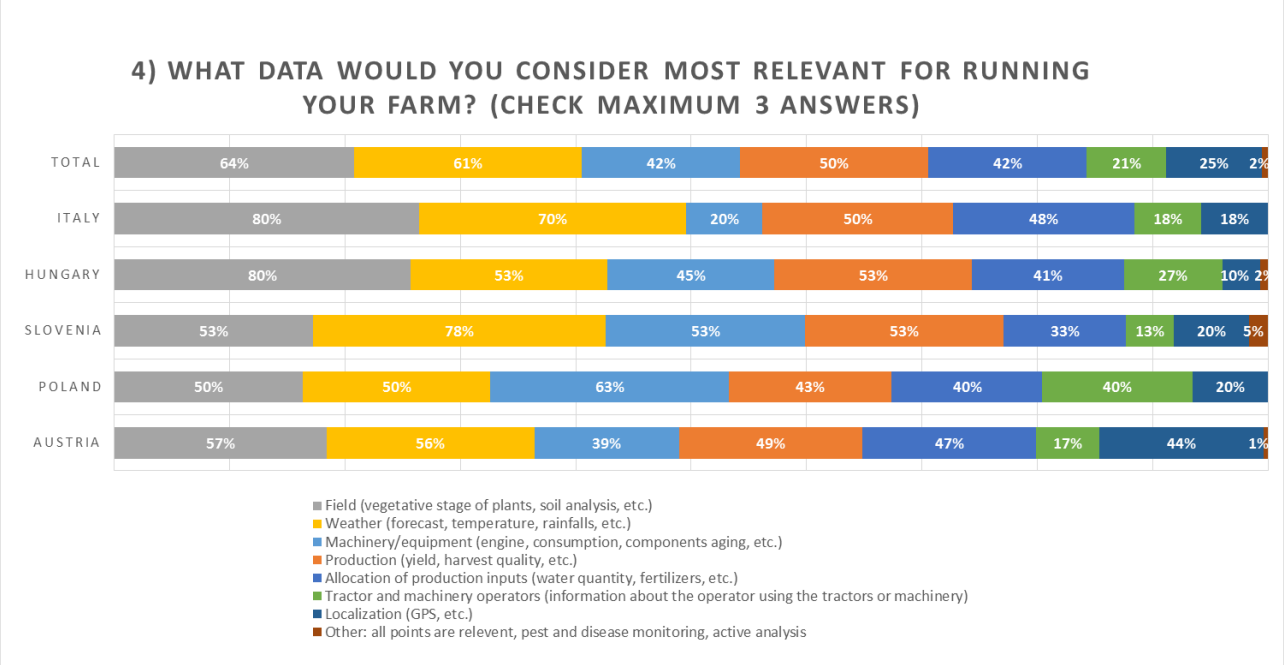


Figure 48: Question 4

3.4.1. Question 4: Focus on answer options and age

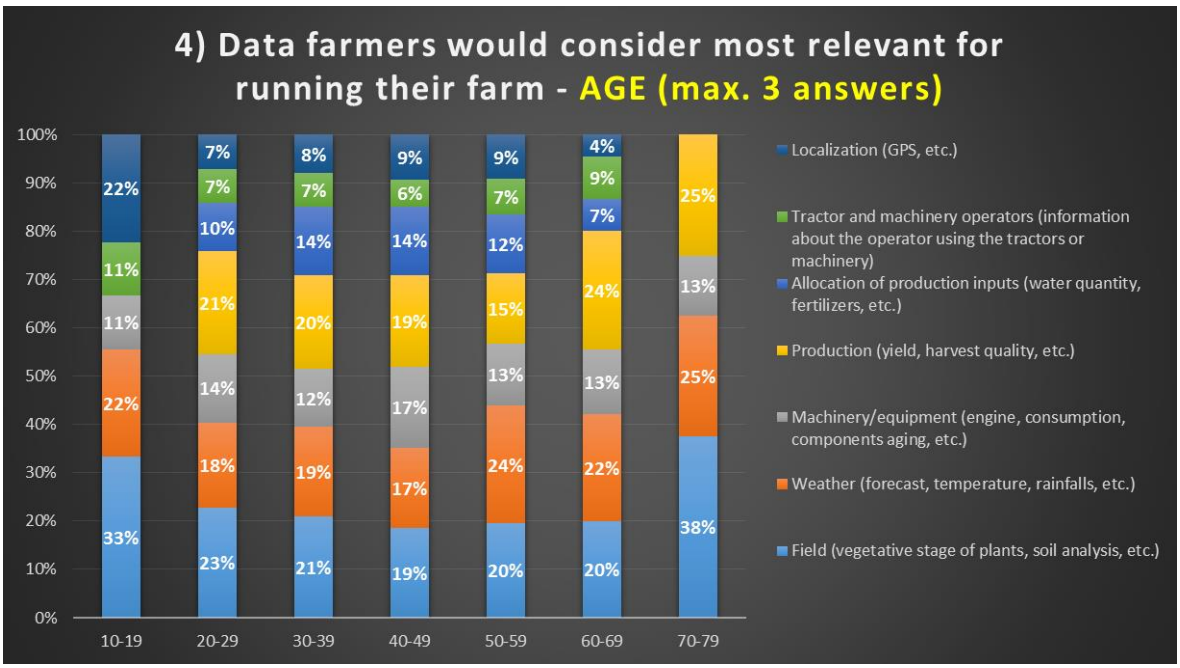


Figure 49: Question 4: Focus on answer options and age

3.4.2. Question 4: Focus on answer options and education

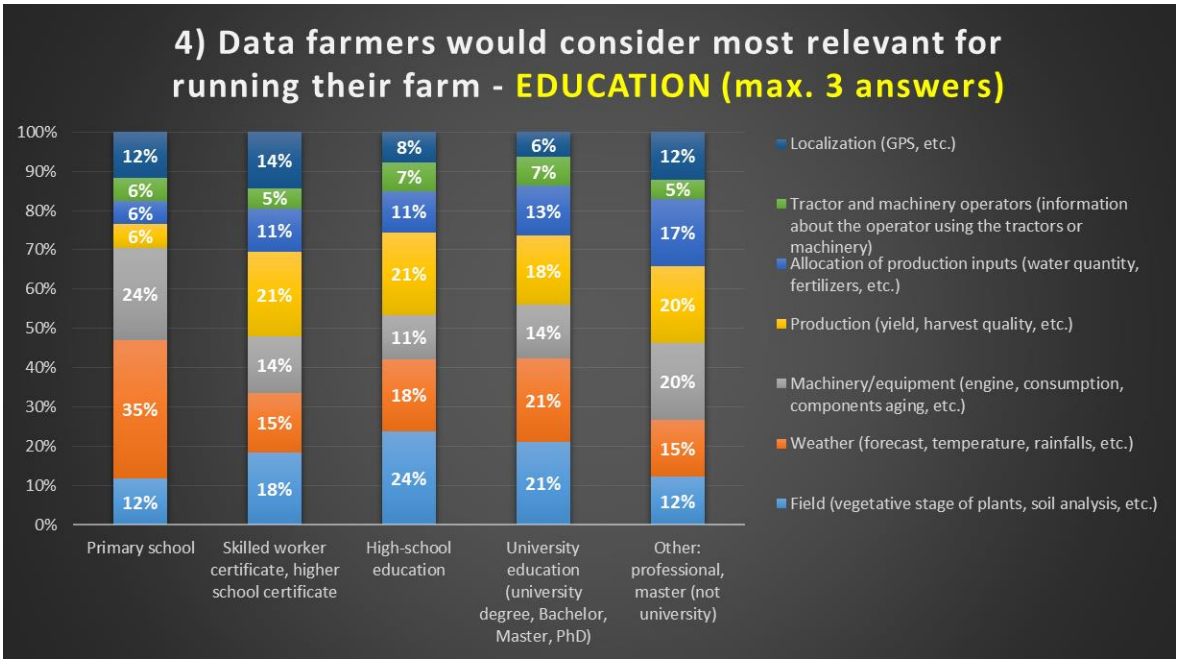


Figure 50: Question 4: Focus on answer options and education

3.4.3. Question 4: Focus on answer options and farm size (in hectar)

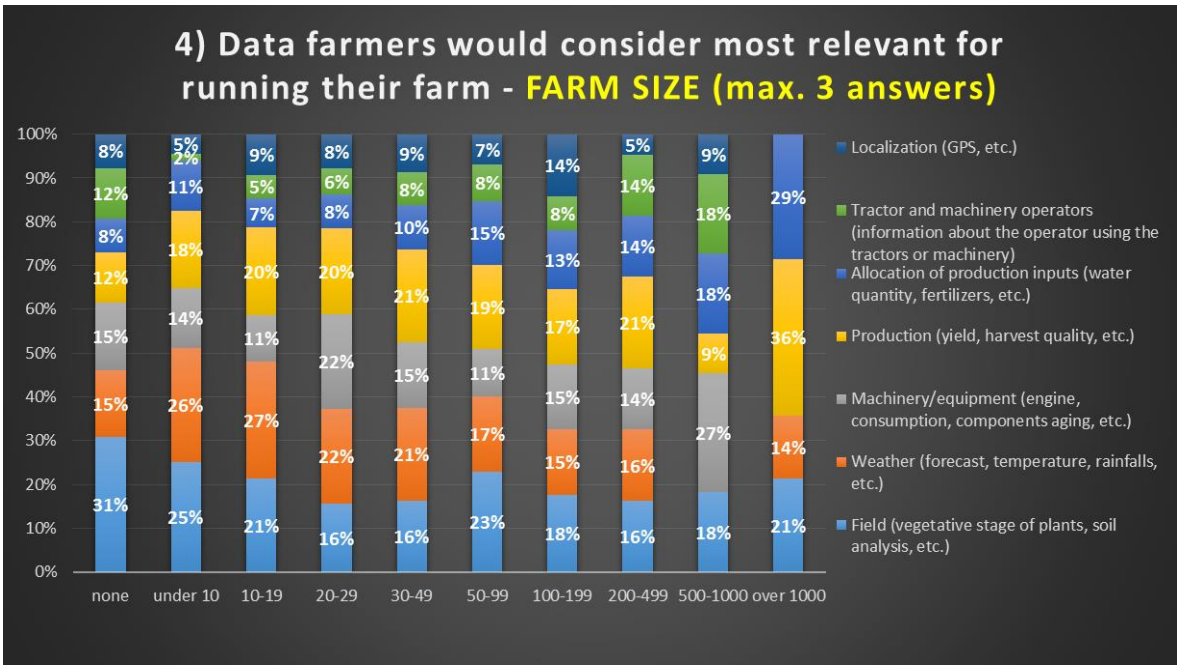


Figure 51: Question 4: Focus on answer options and farm size (in hectar)

3.5. Question 5

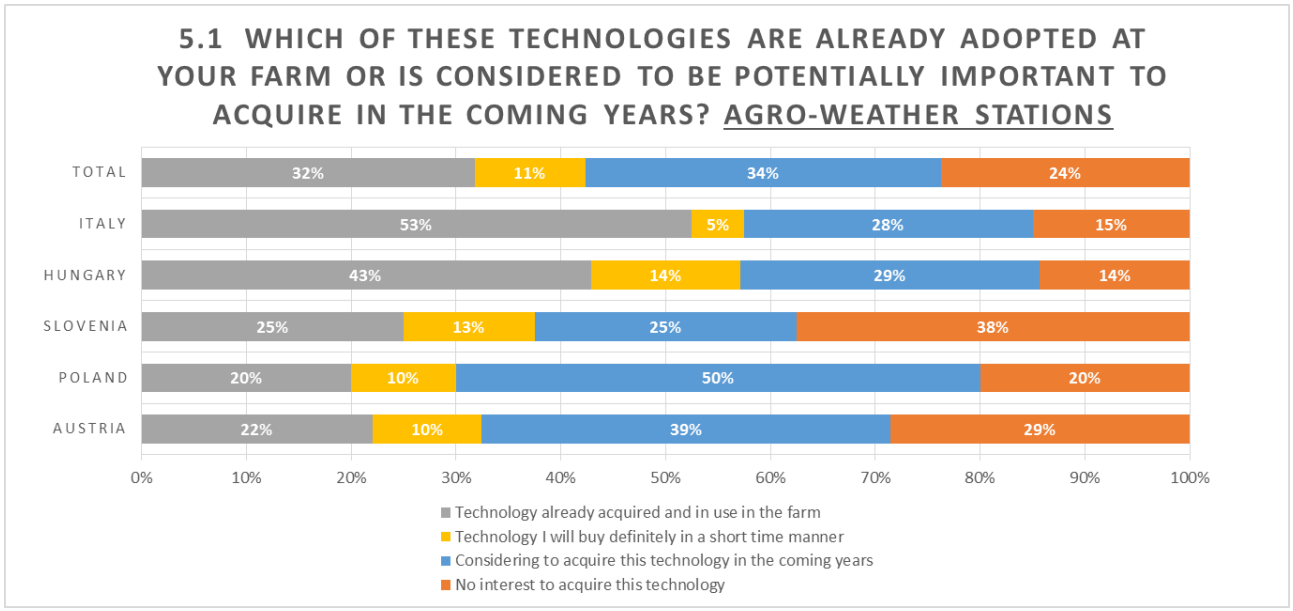


Figure 52: Question 5.1

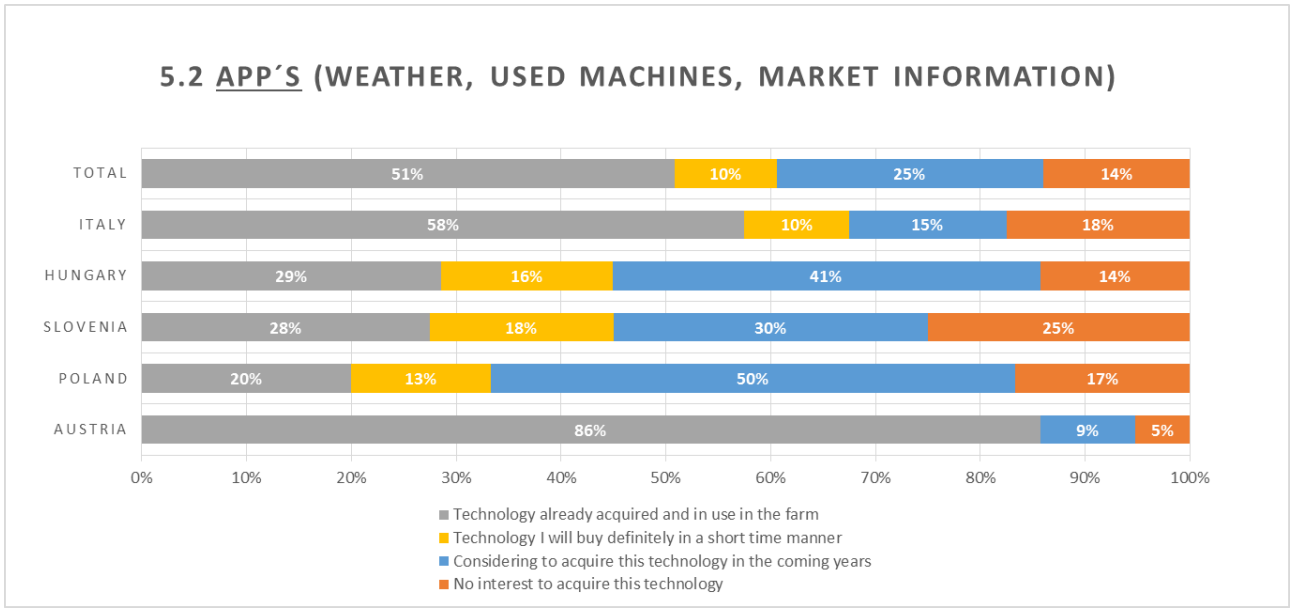


Figure 53: Question 5.2

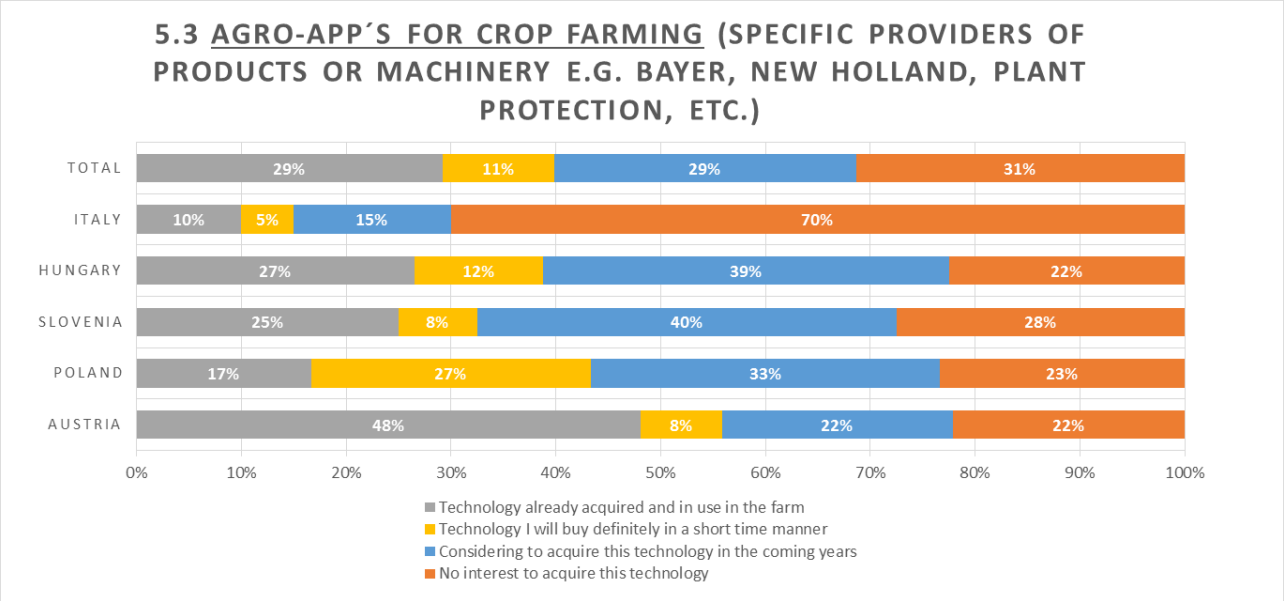


Figure 54: Question 5.3

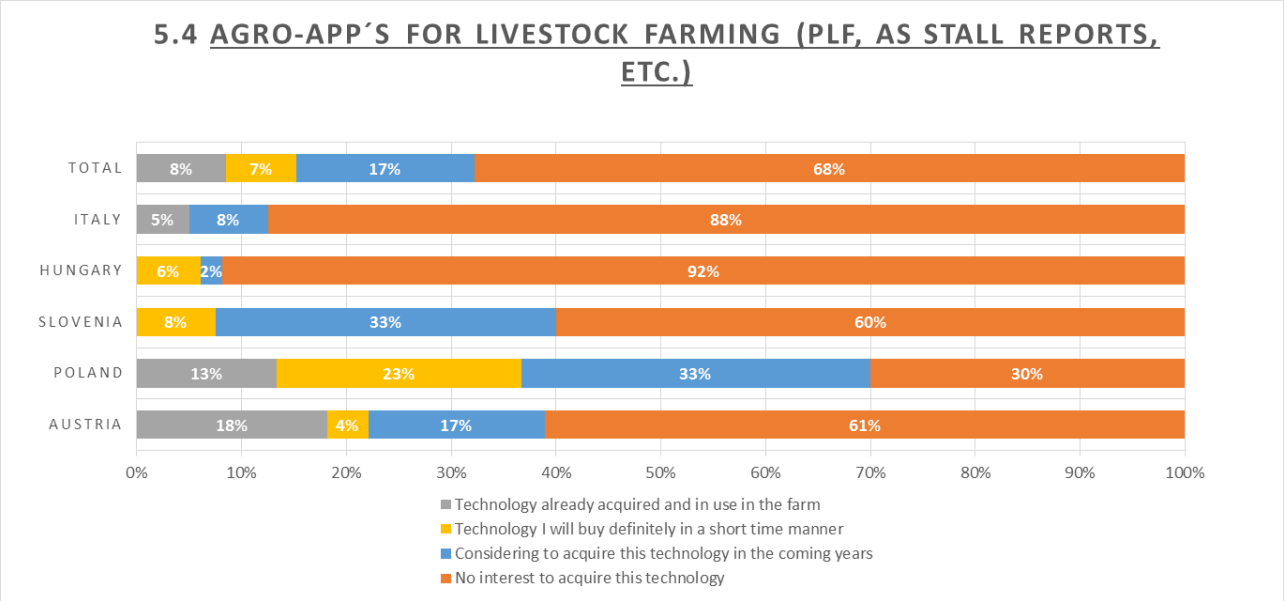


Figure 55: Question 5.4

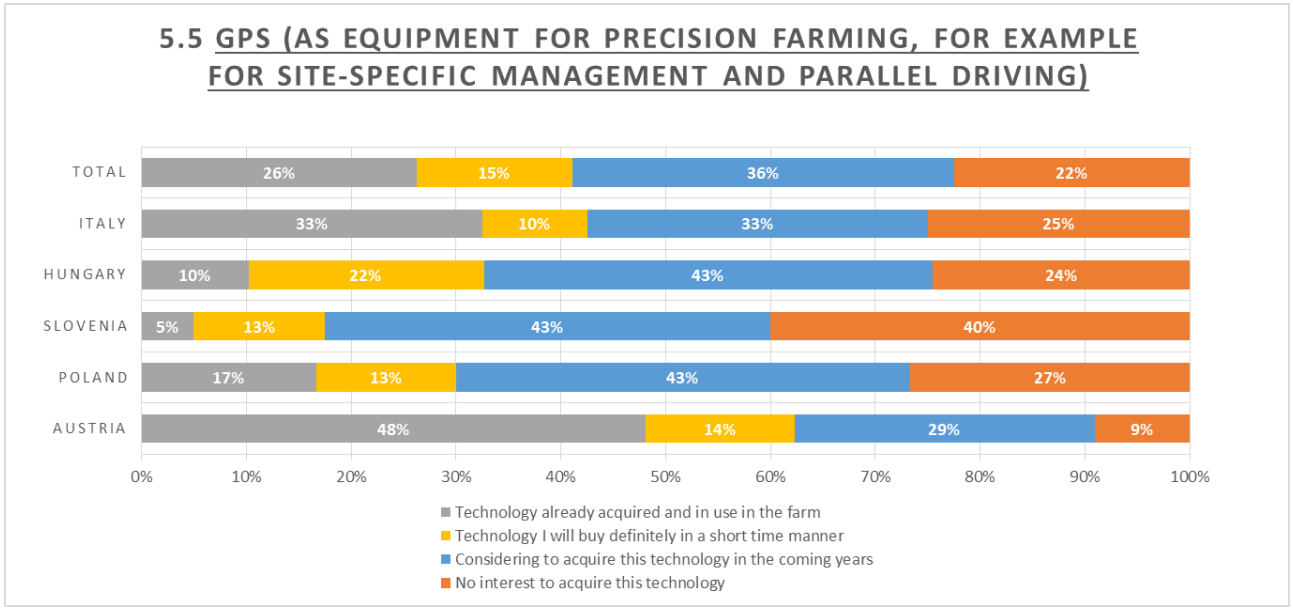


Figure 56: Question 5.5

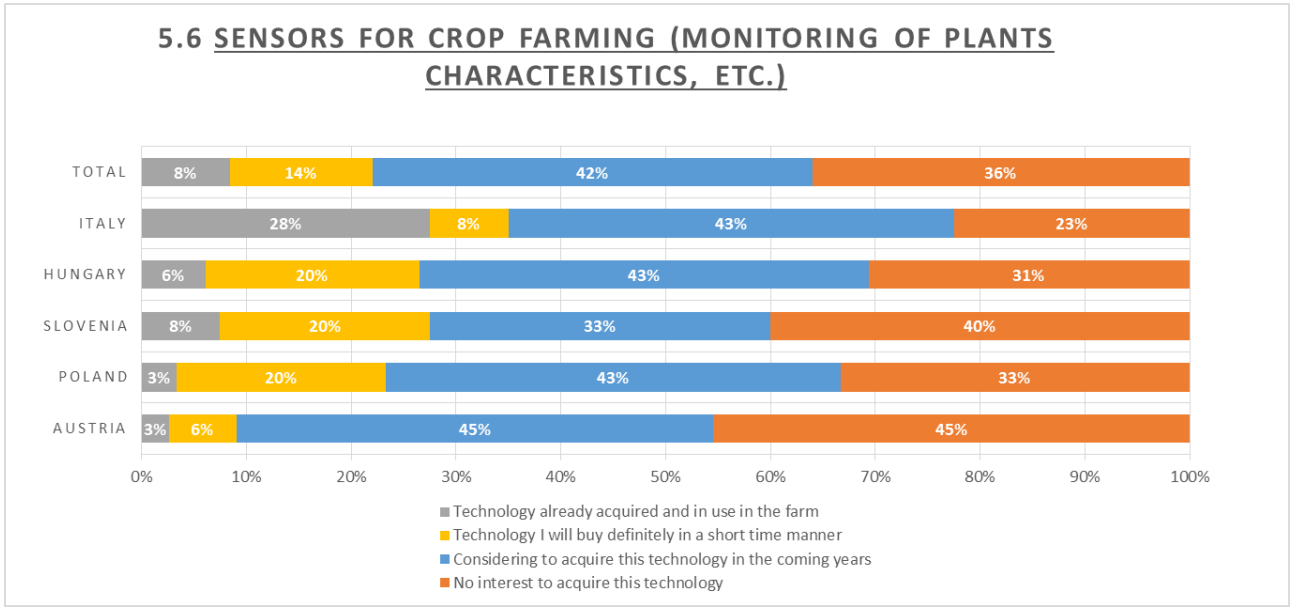


Figure 57: Question 5.6

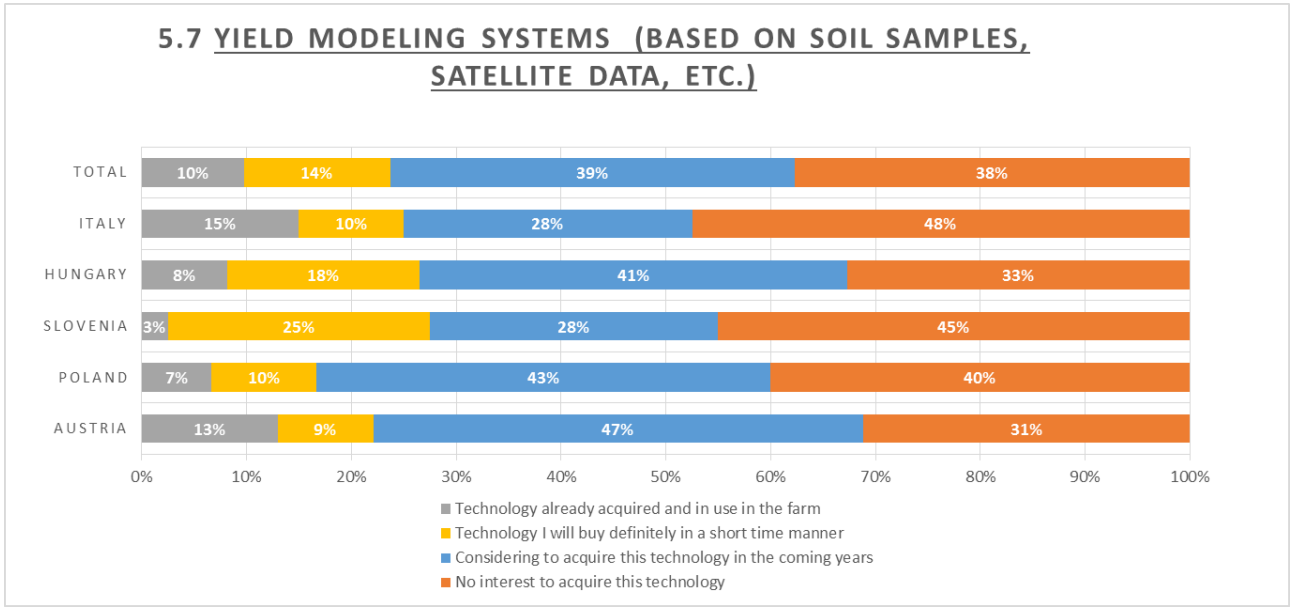


Figure 58: Question 5.7

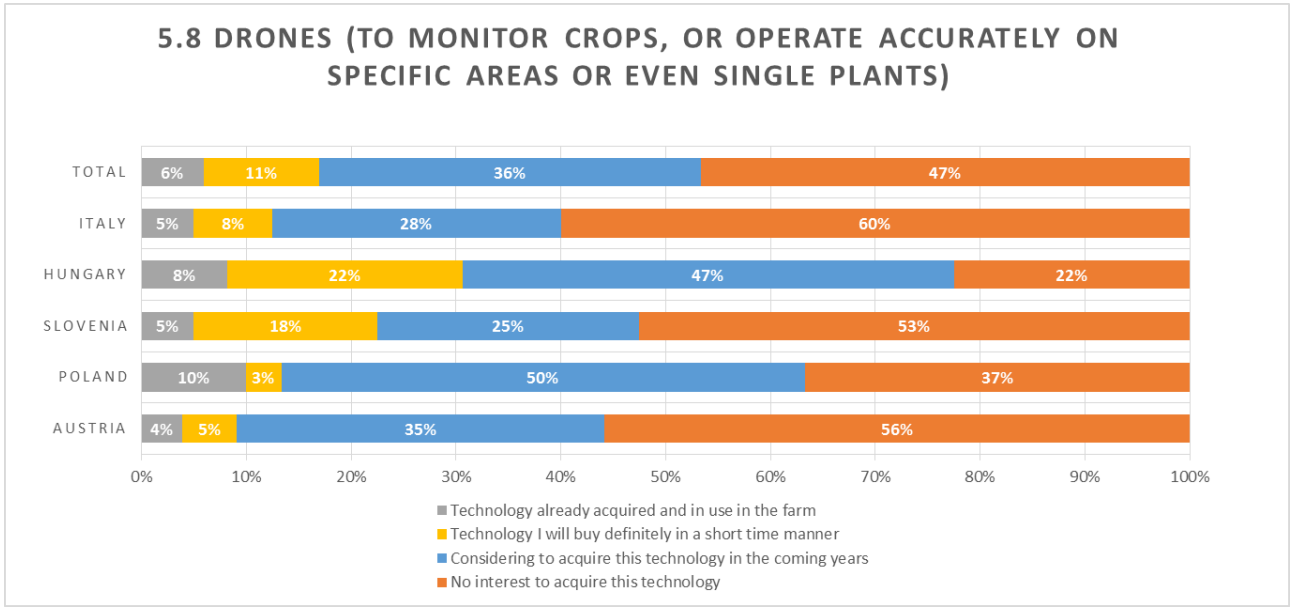


Figure 59: Question 5.8

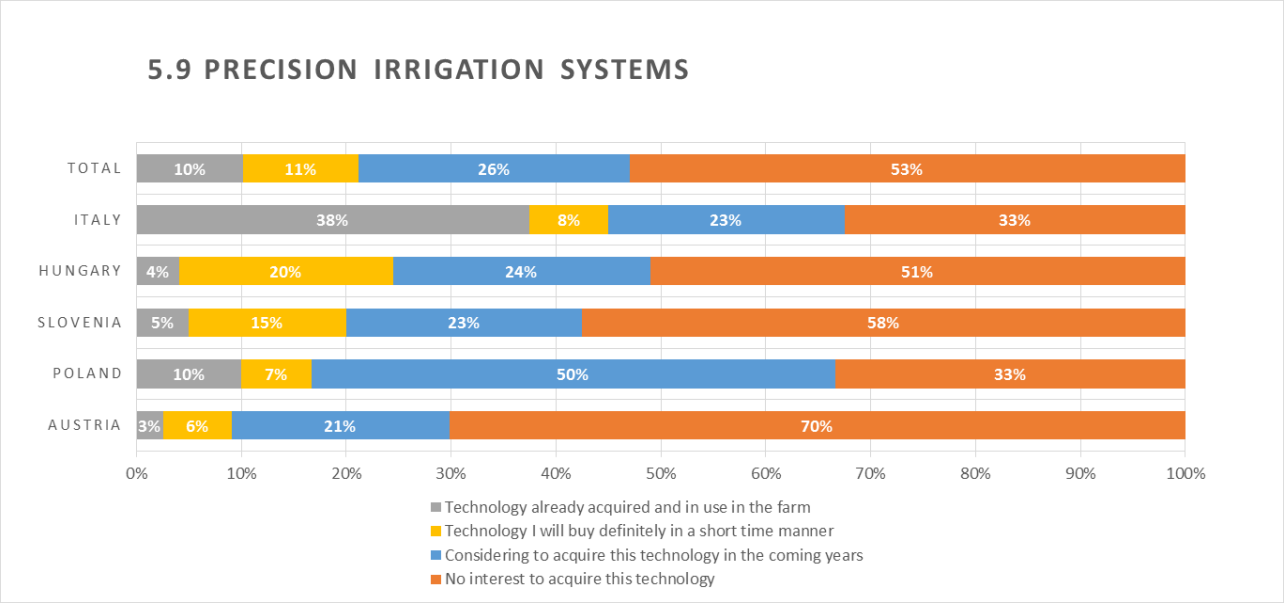


Figure 60: Question 5.9

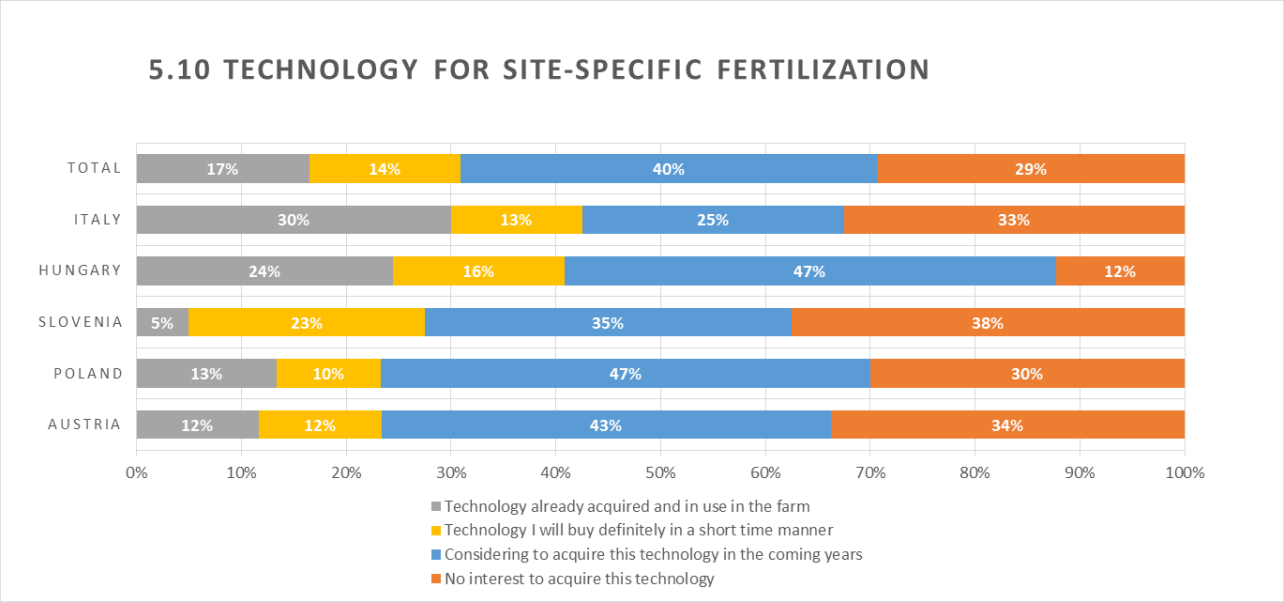


Figure 61: Question 5.10

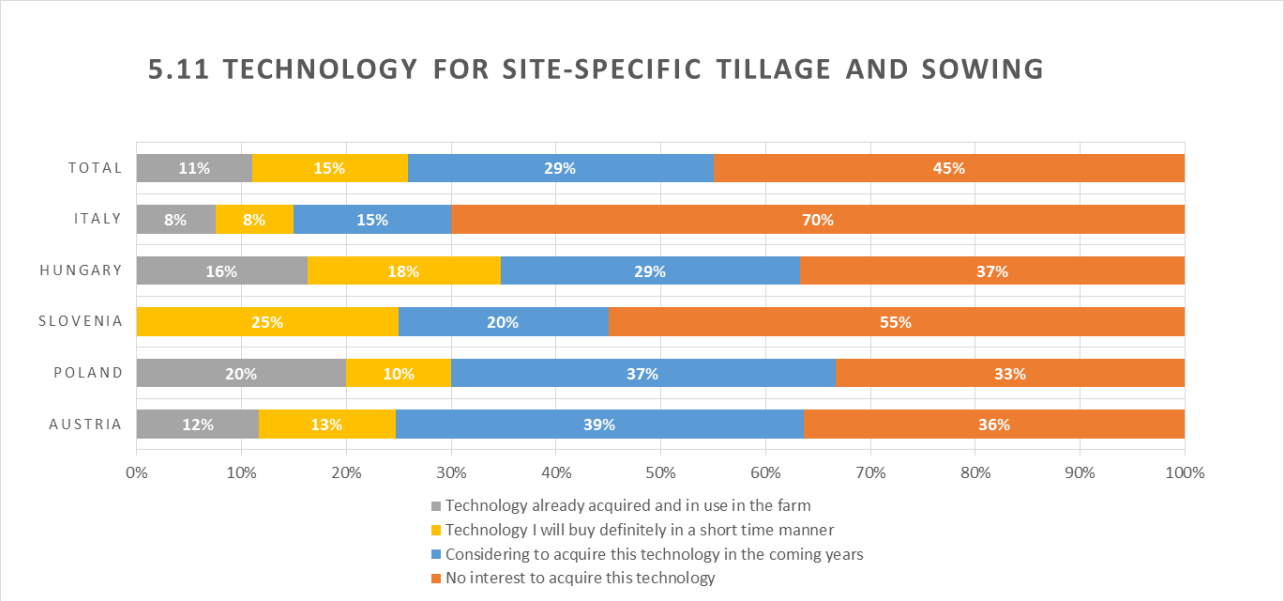


Figure 62: Question 5.11

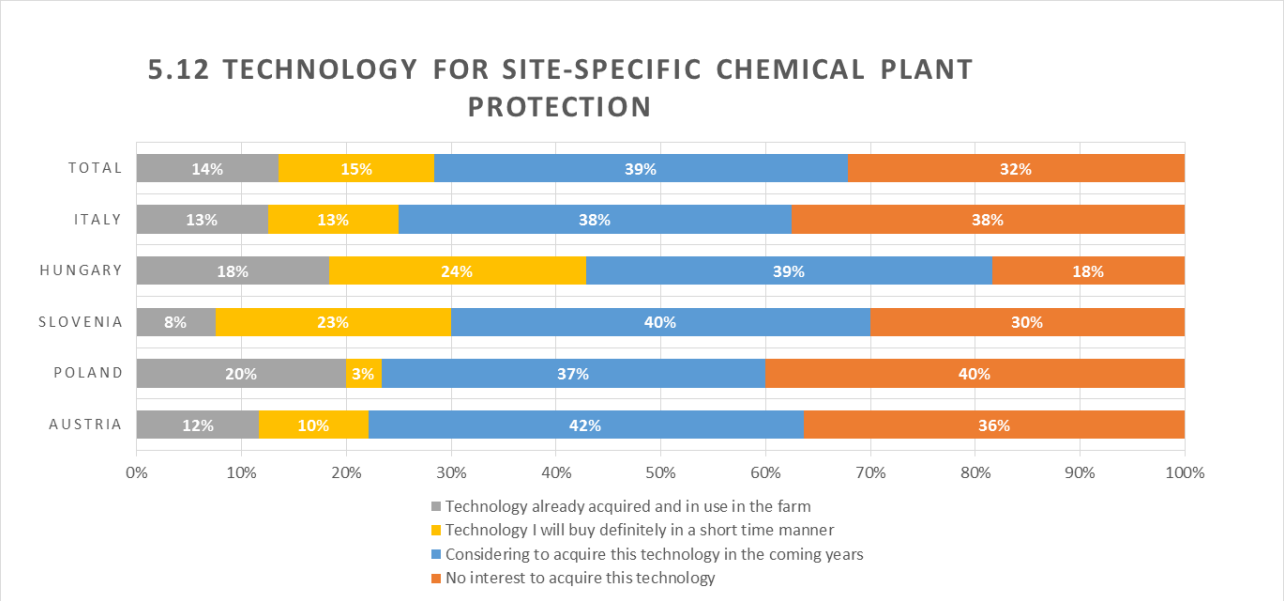


Figure 63: Question 5.12

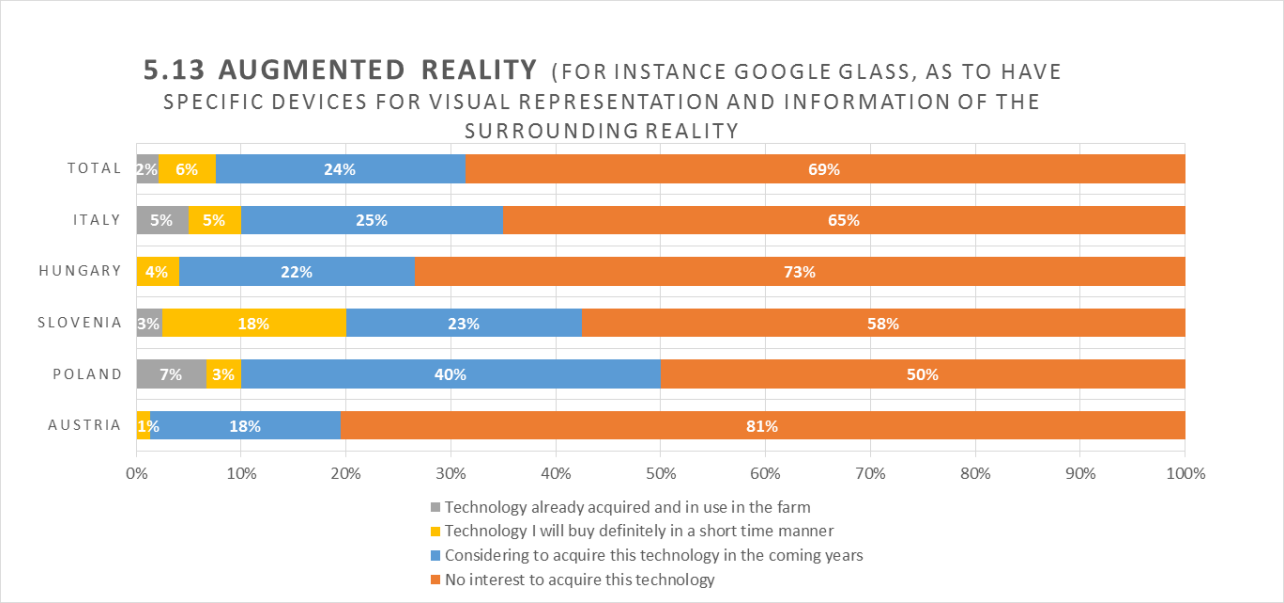


Figure 64: Question 5.13

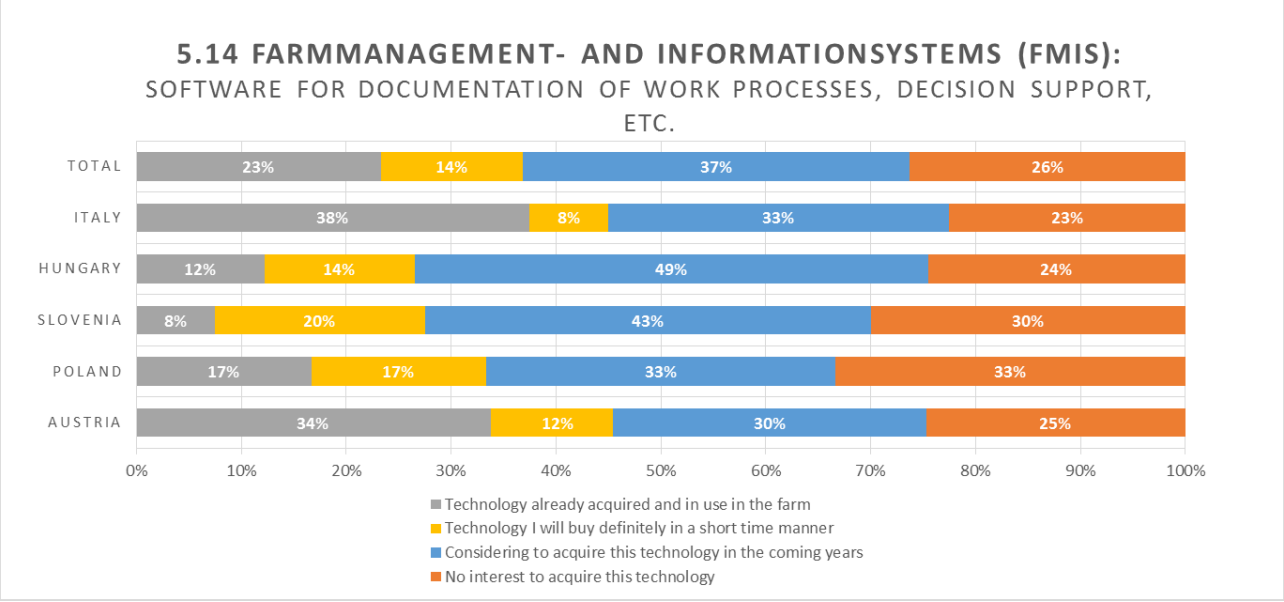


Figure 65: Question 5.14

3.6. Question 6

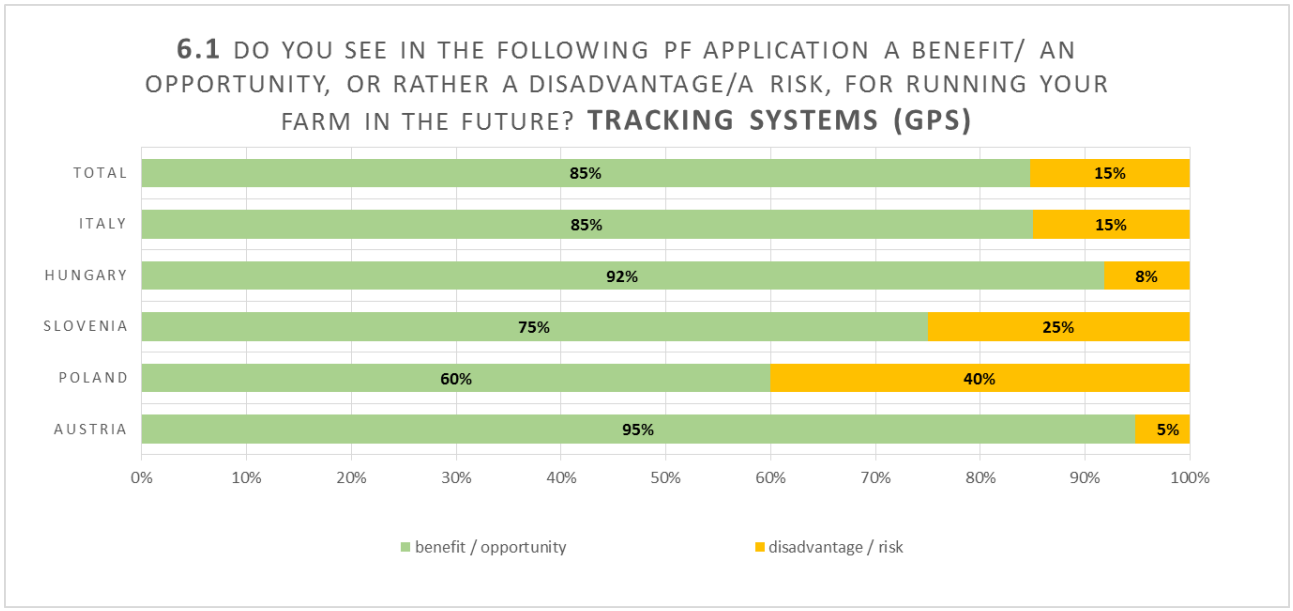


Figure 66: Question 6.1

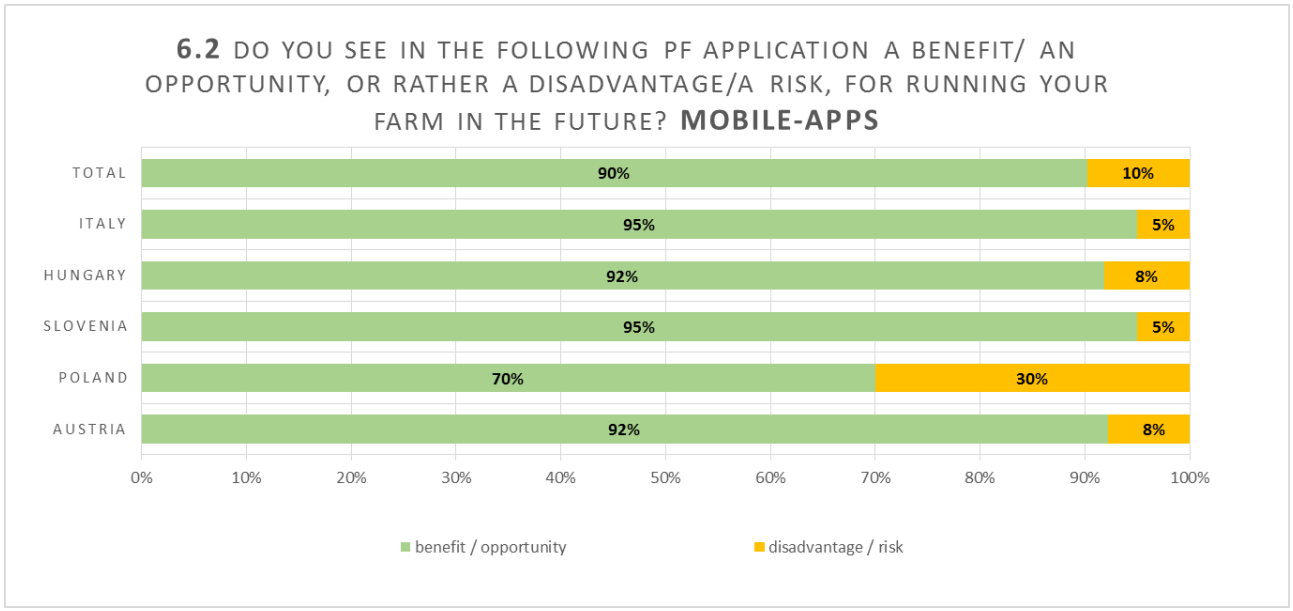


Figure 67: Question 6.2

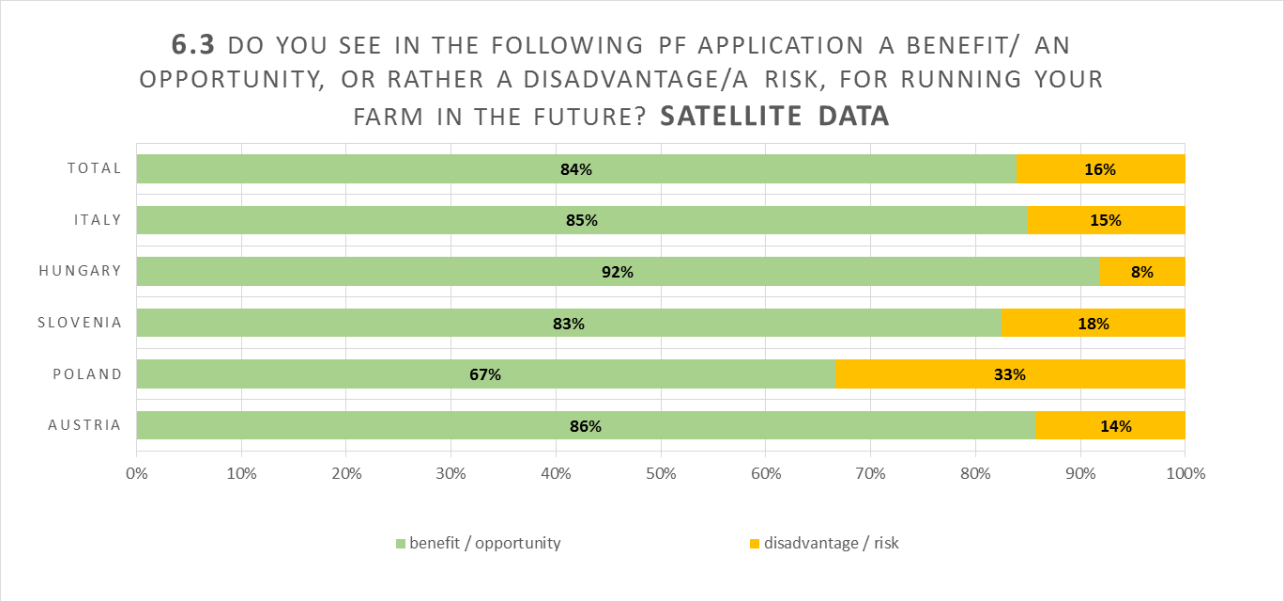


Figure 68: Question 6.3

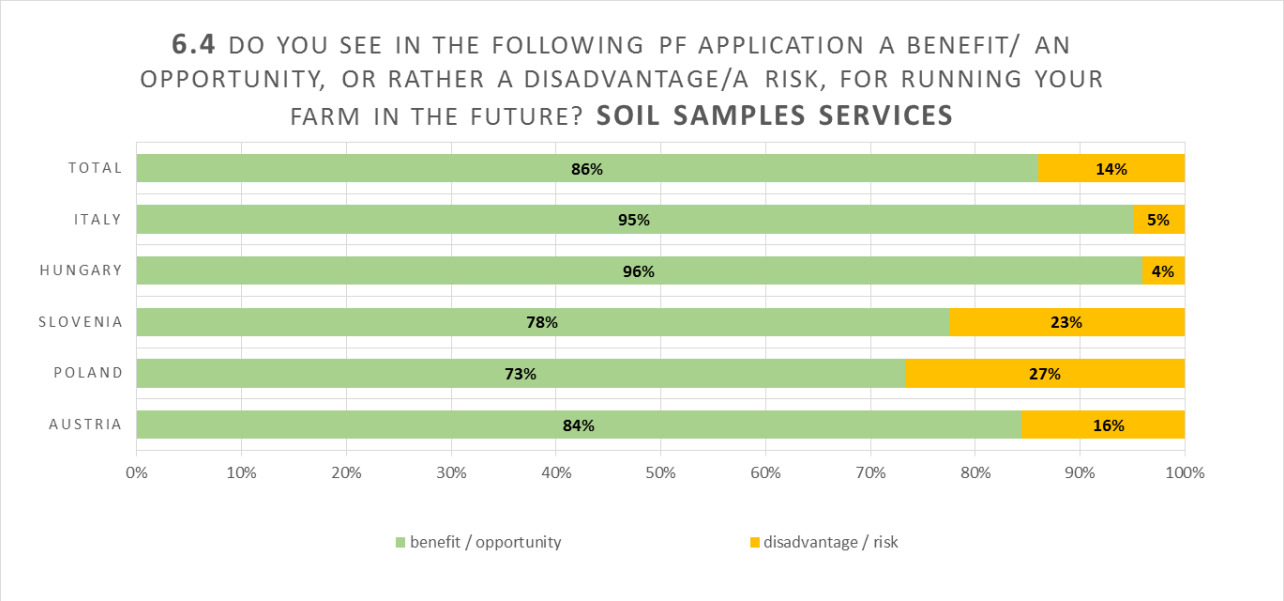


Figure 69: Question 6.4

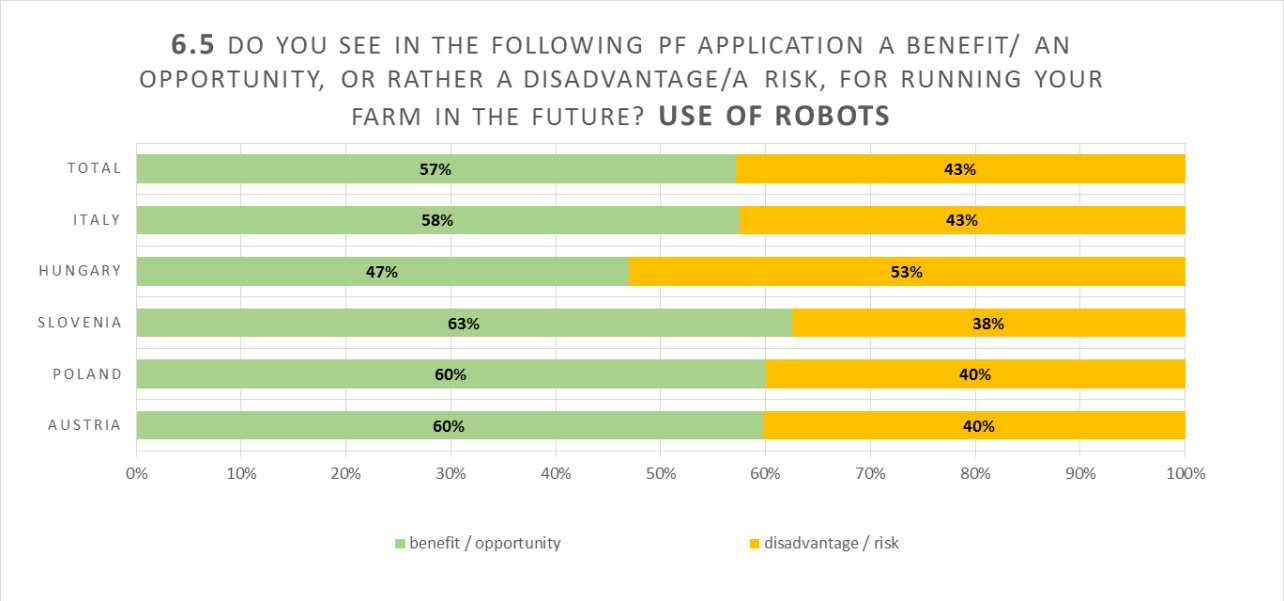


Figure 70: Question 6.5

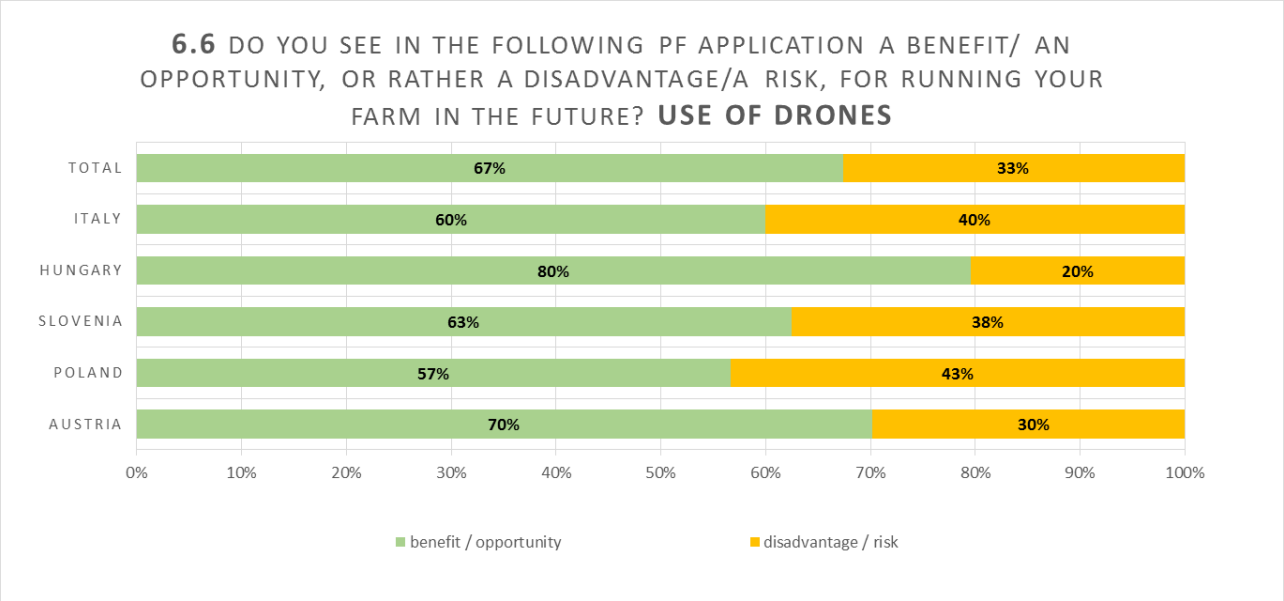


Figure 71: Question 6.6

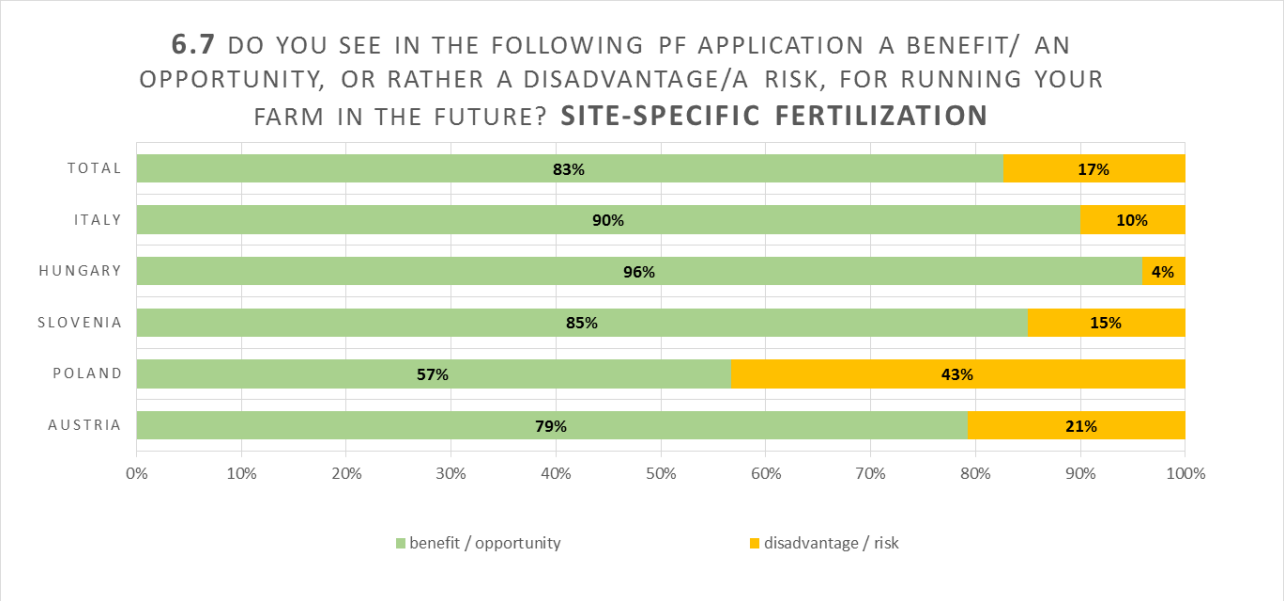


Figure 72: Question 6.7

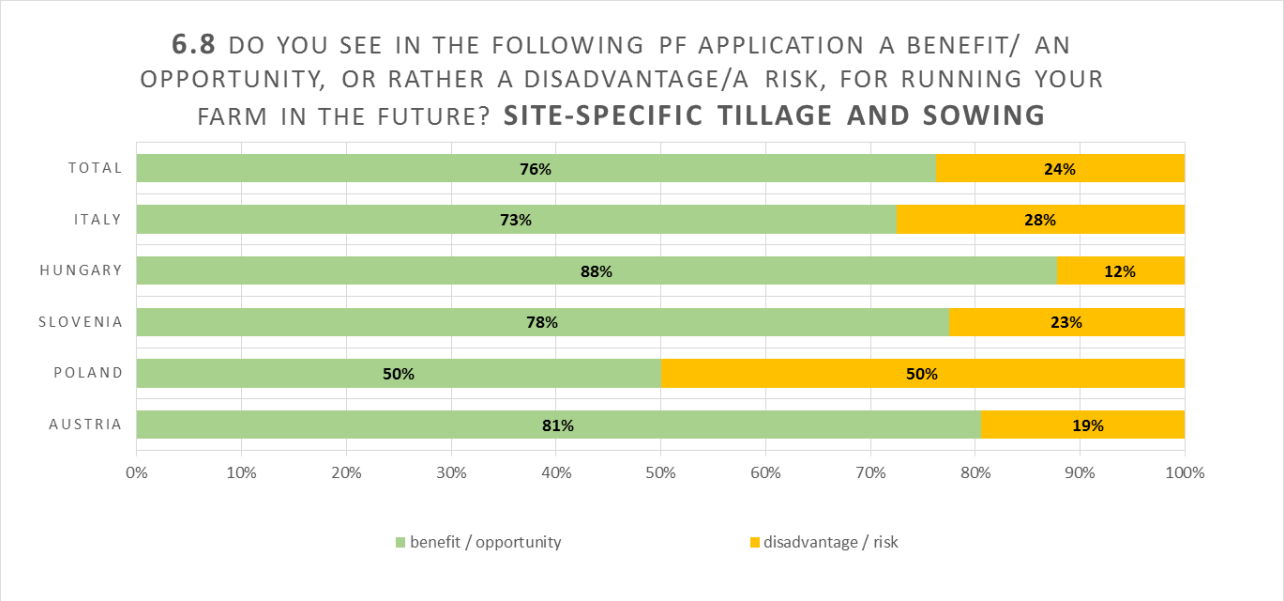


Figure 73: Question 6.8

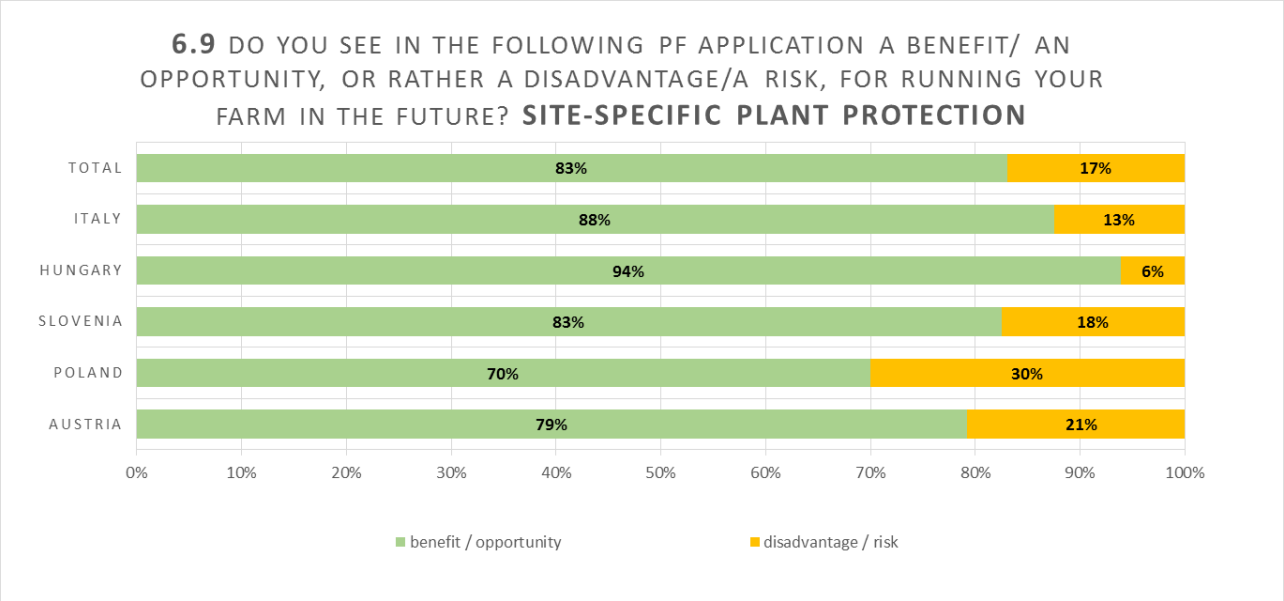


Figure 74: Question 6.9

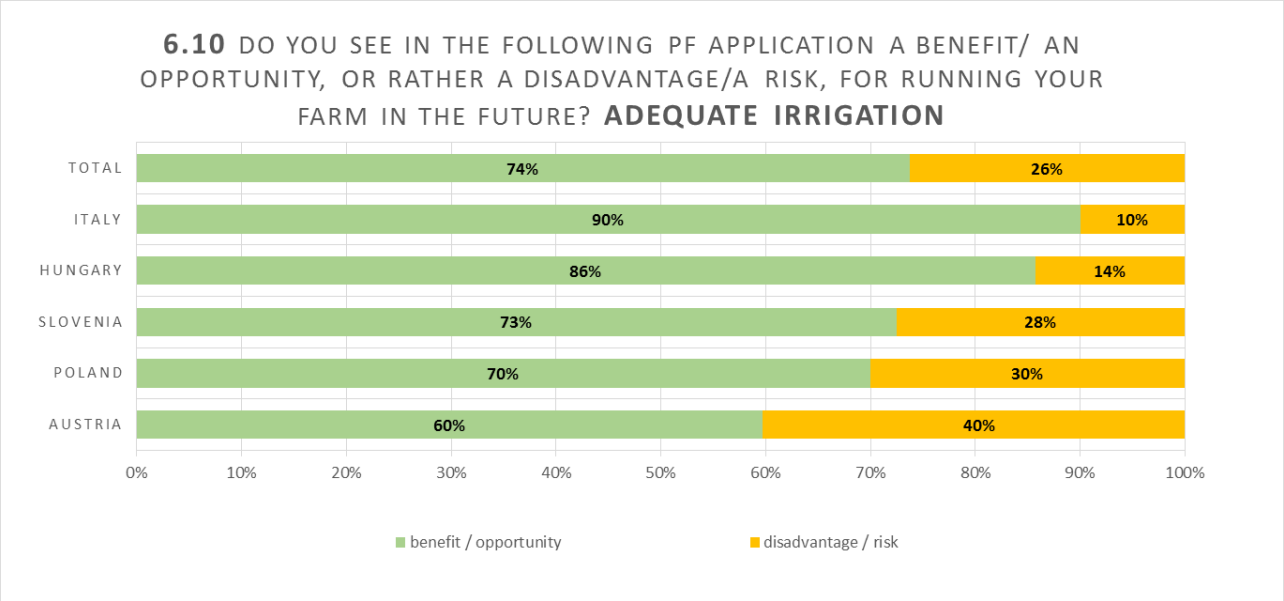


Figure 75: Question 6.10

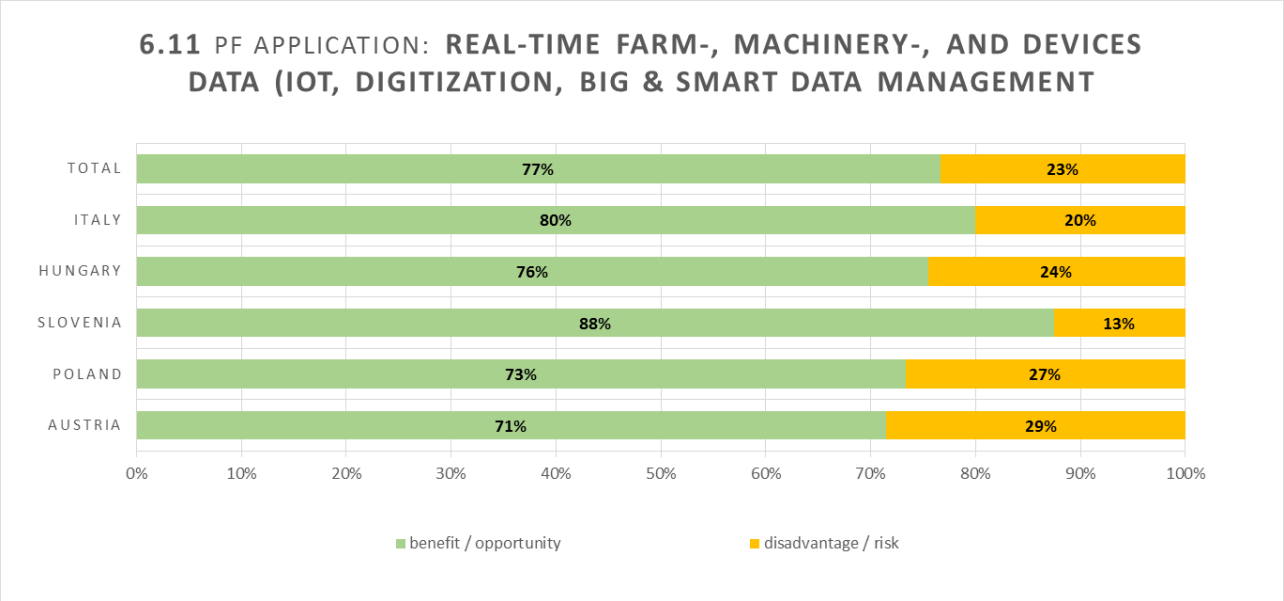


Figure 76: Question 6.11

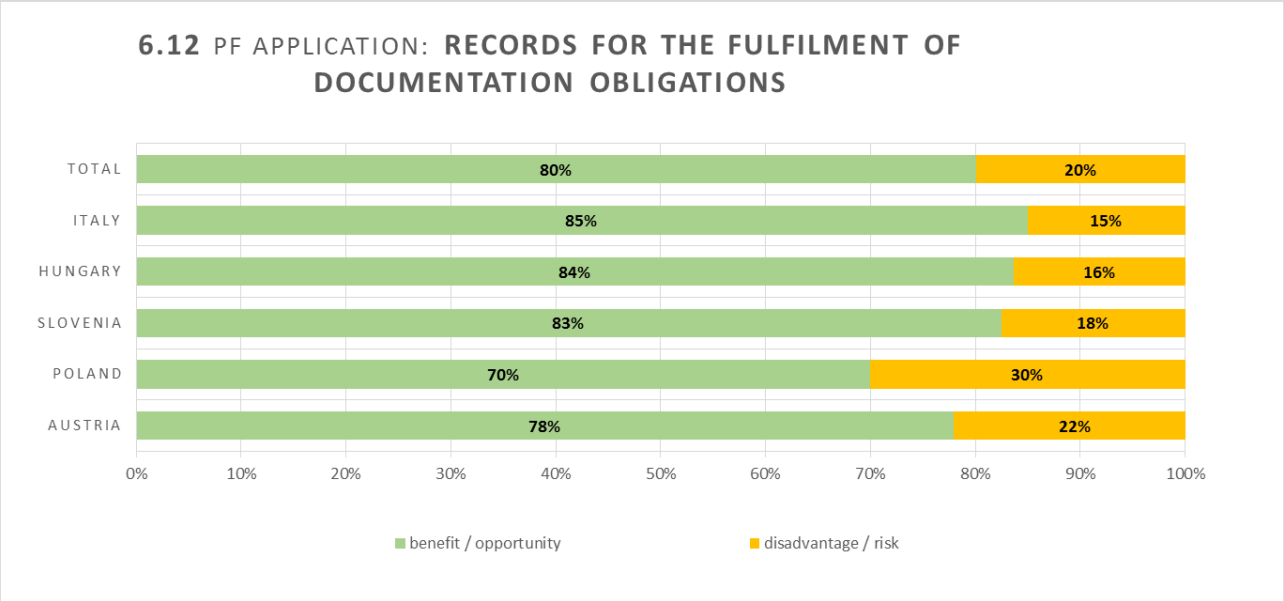


Figure 77: Question 6.12

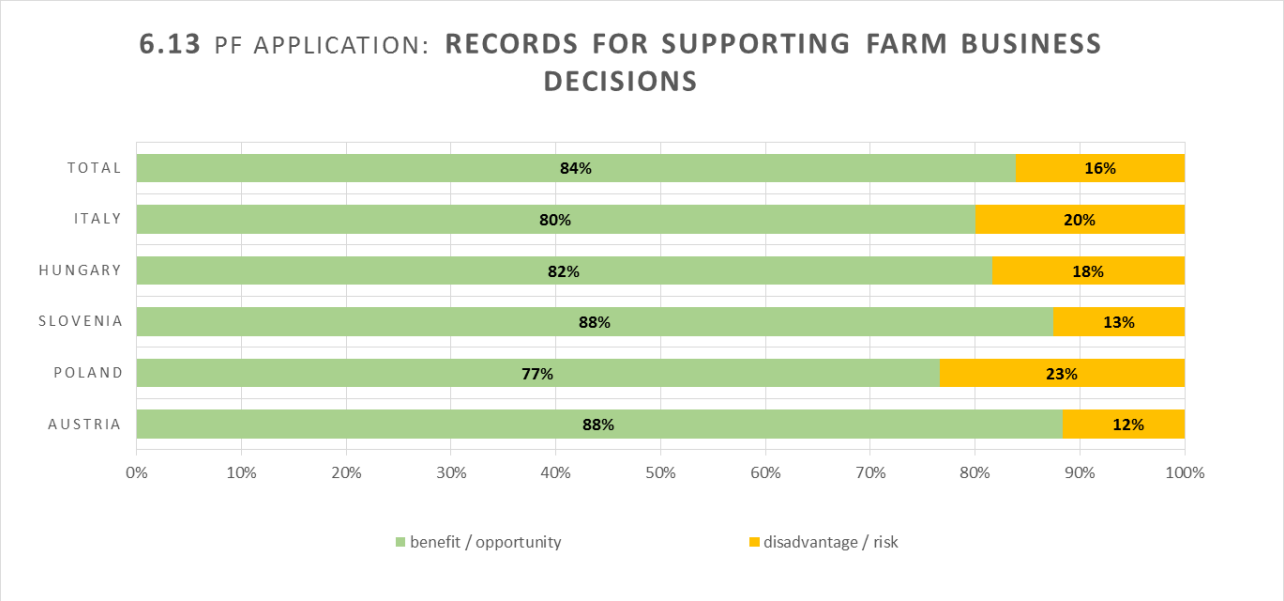


Figure 78: Question 6.13

3.7. Question 7

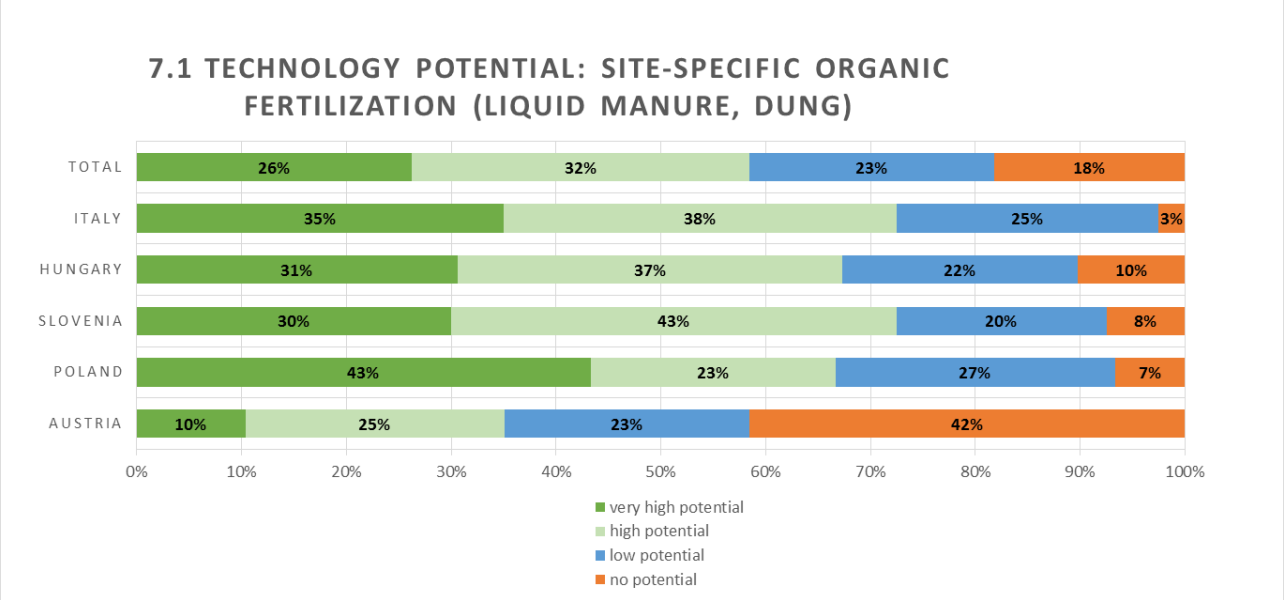


Figure 79: Question 7.1

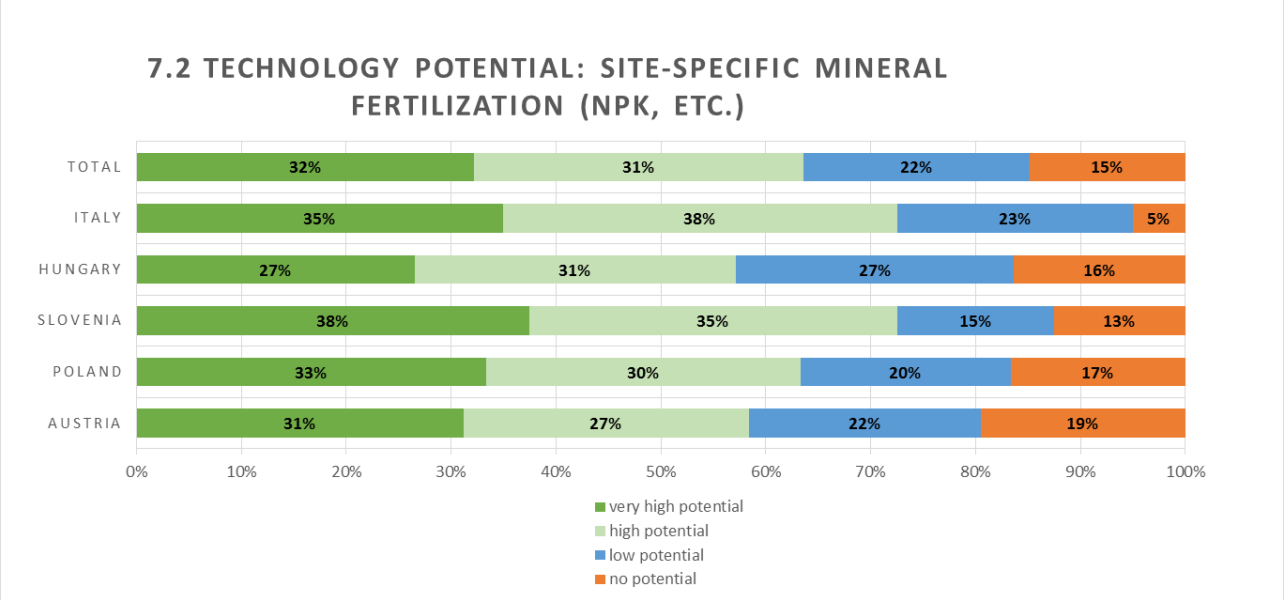


Figure 80: Question 7.2

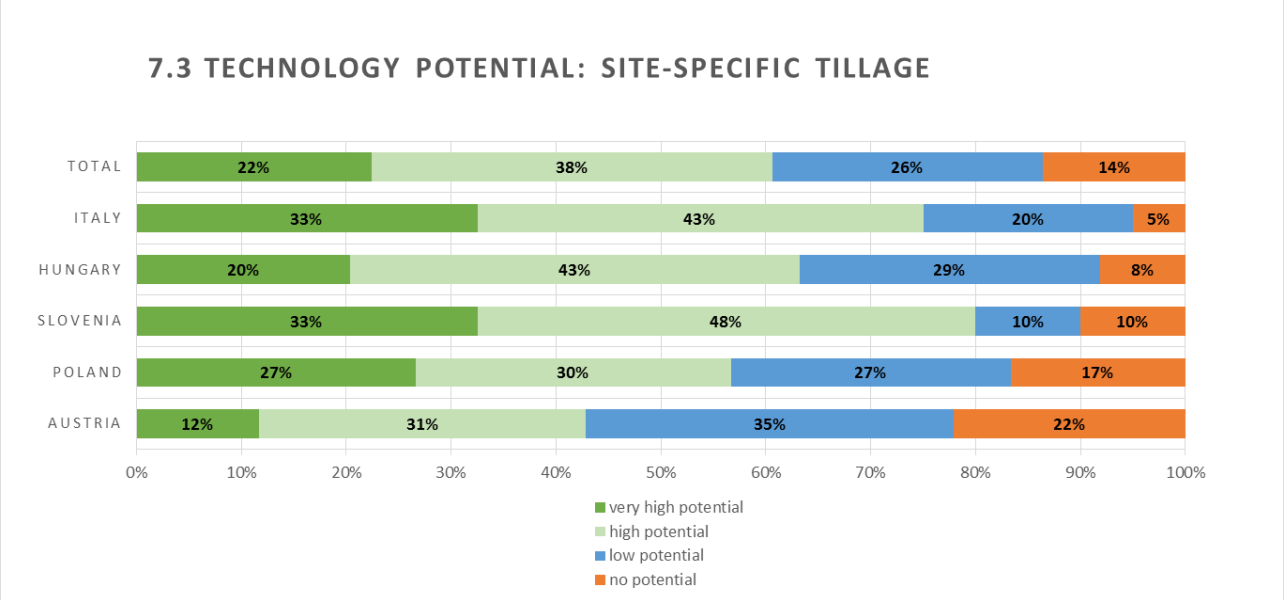


Figure 81: Question 7.3

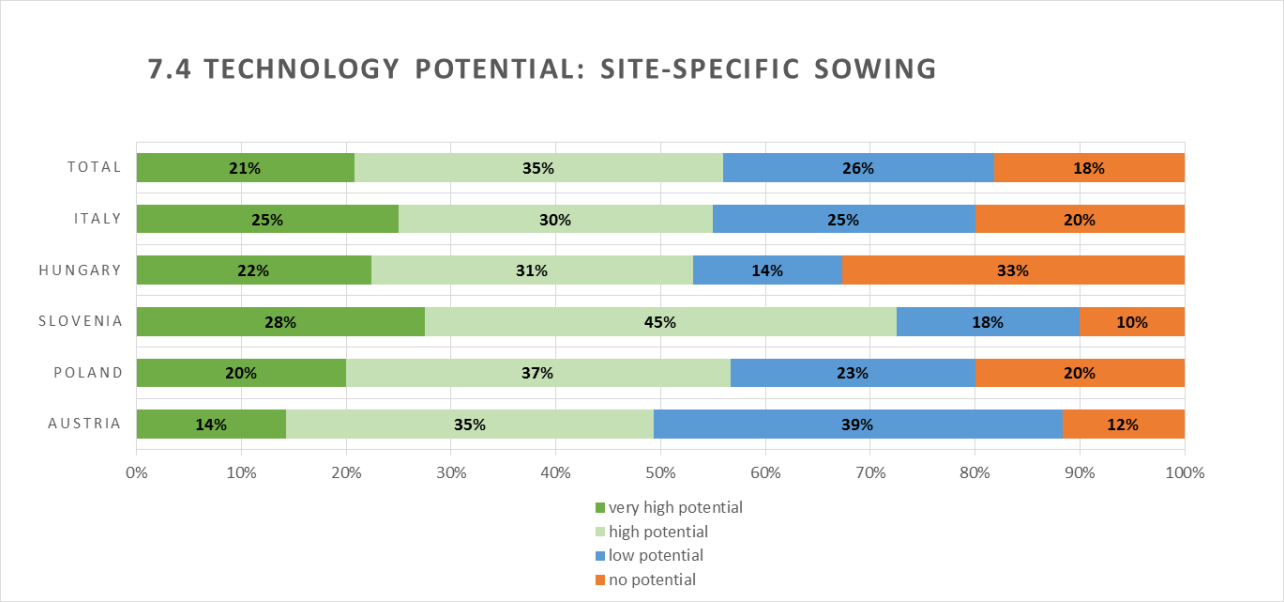


Figure 82: Question 7.4

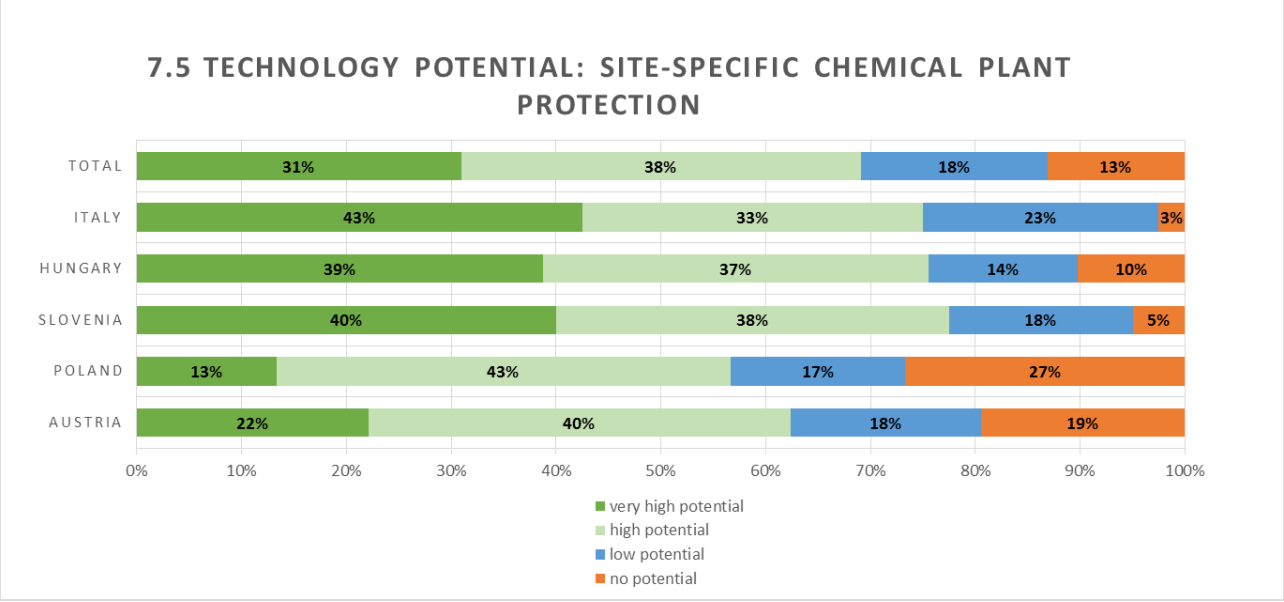


Figure 83: Question 7.5

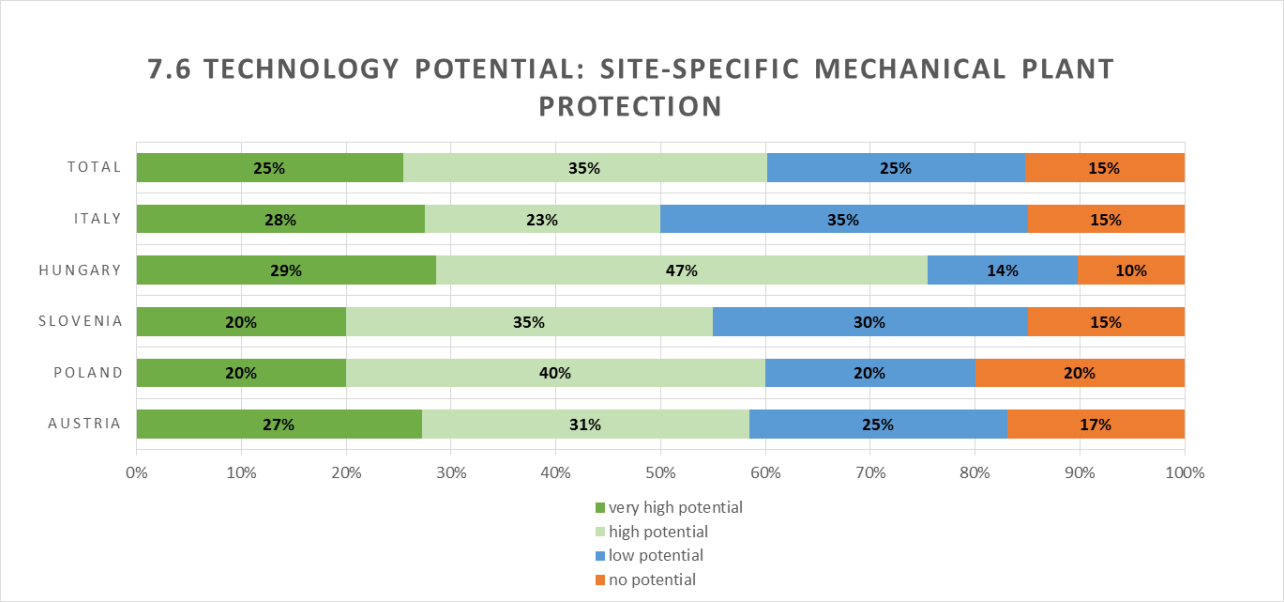


Figure 84: Question 7.6

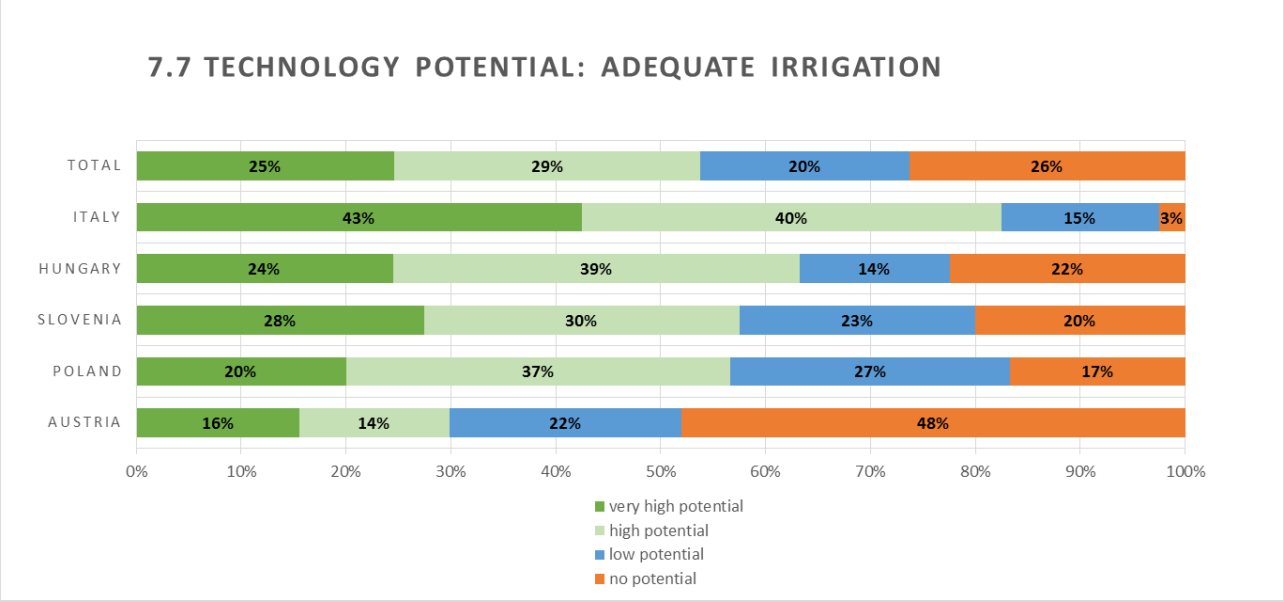


Figure 85: Question 7.7

3.8. Question 8

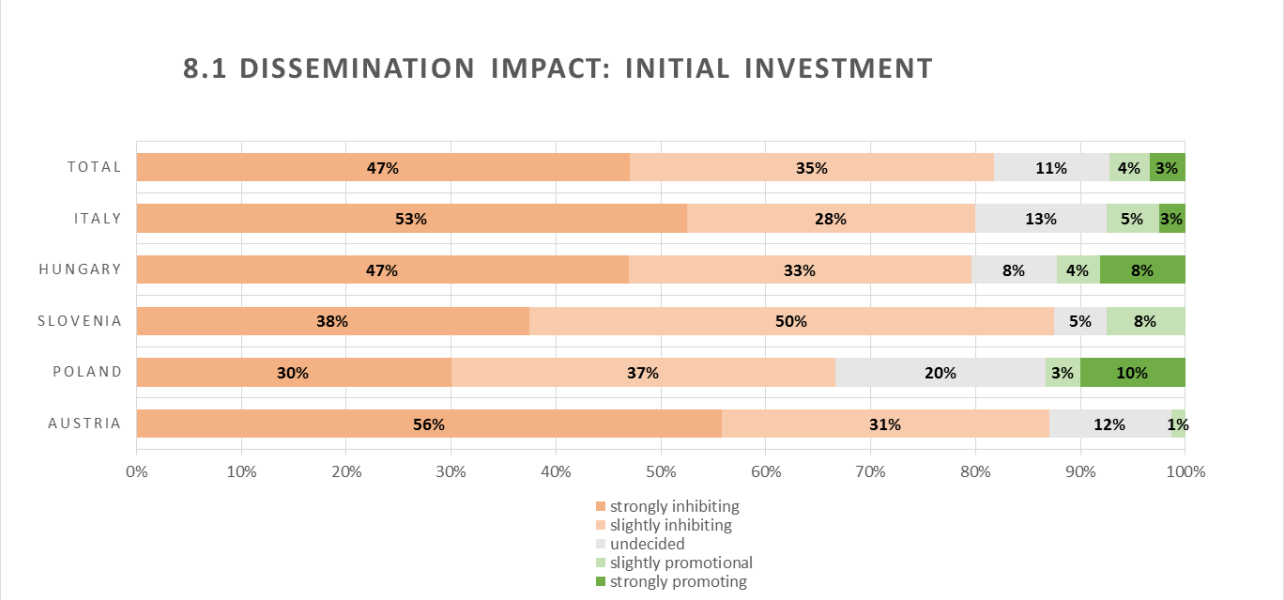


Figure 86: Question 8.1

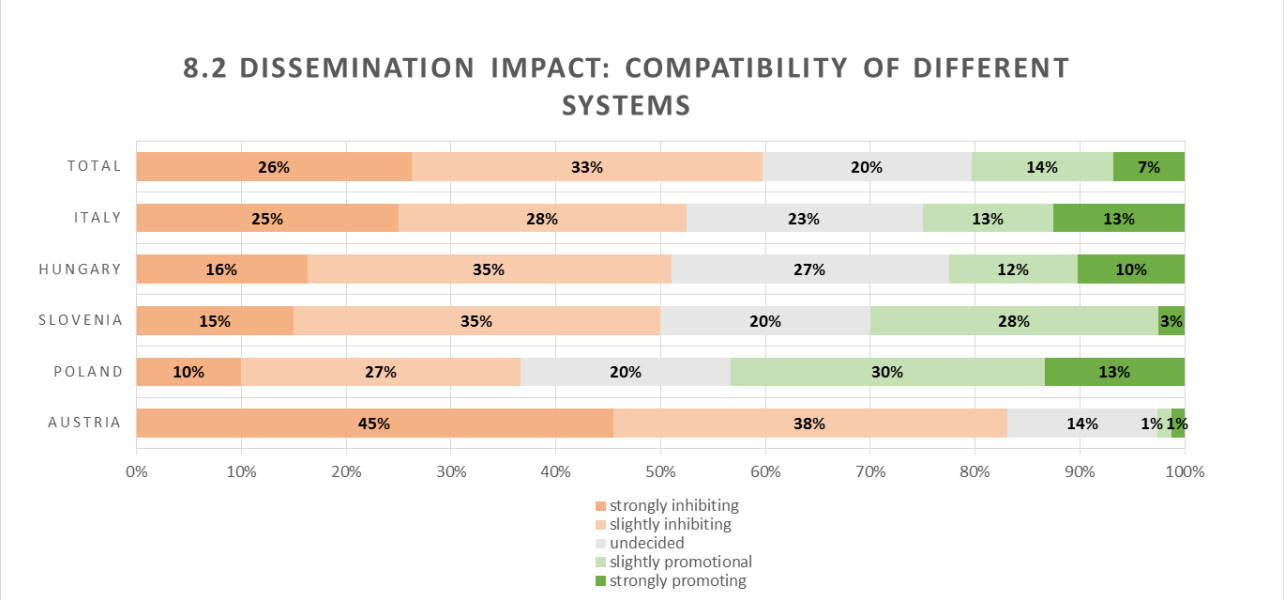


Figure 87: Question 8.2

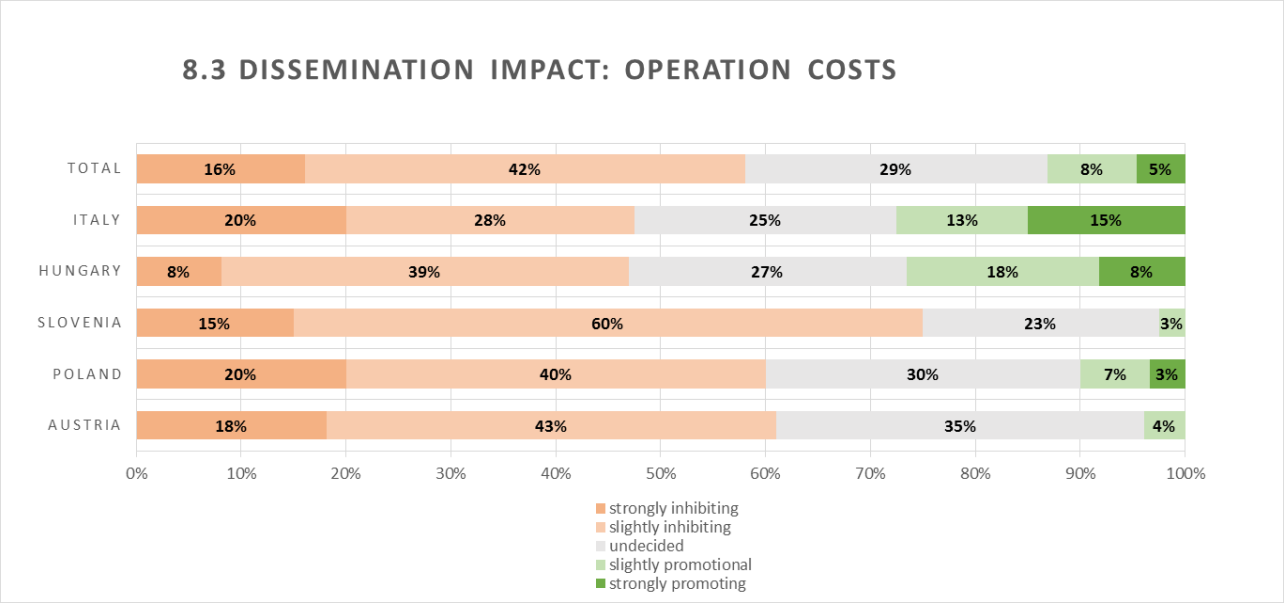


Figure 88: Question 8.3

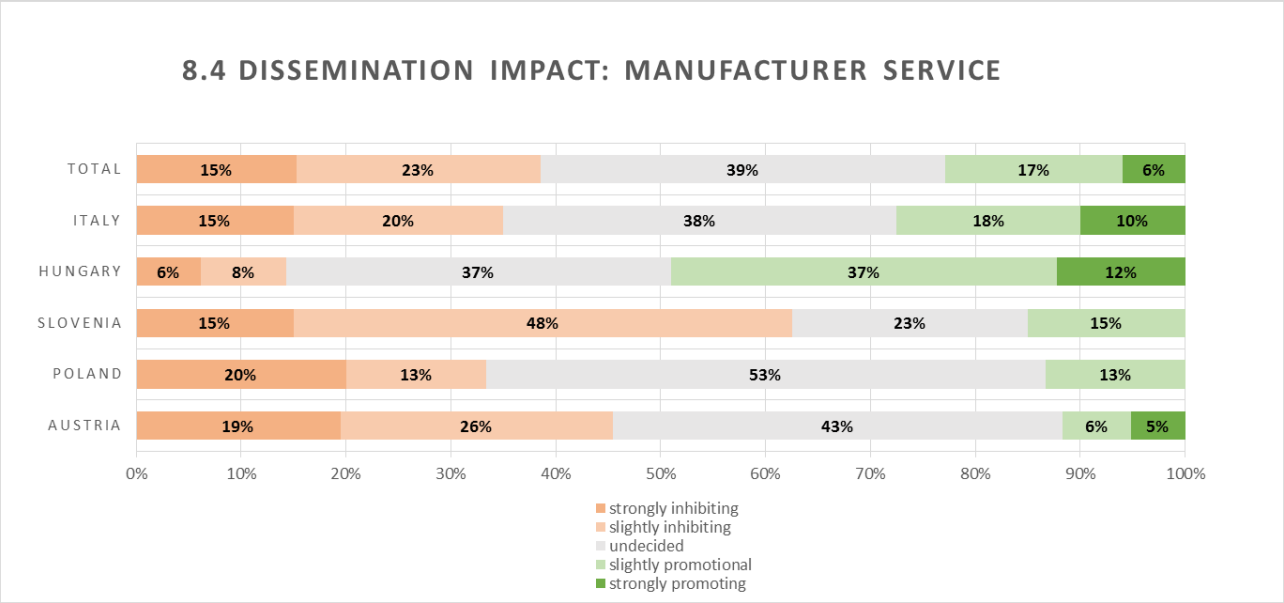


Figure 89: Question 8.4

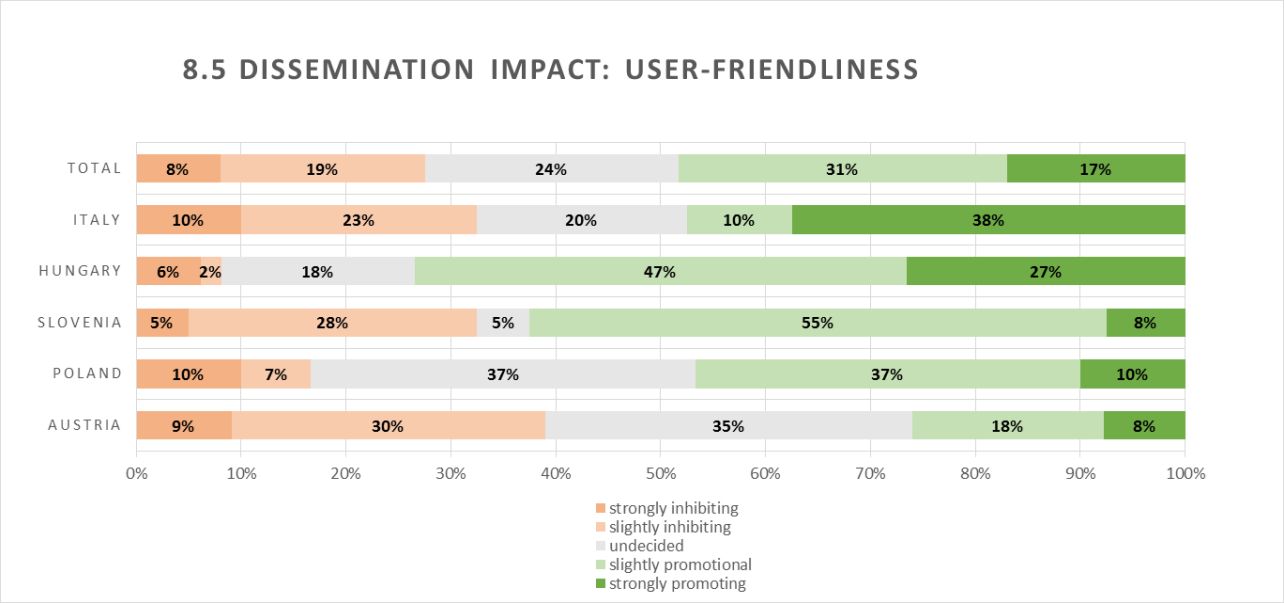


Figure 90: Question 8.5

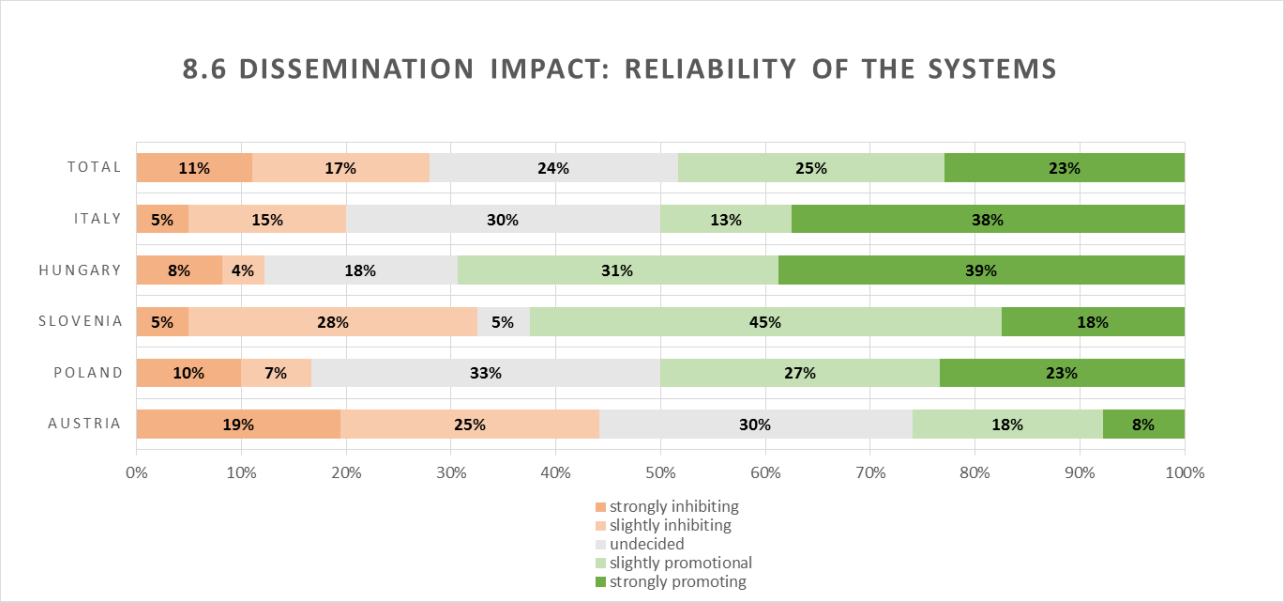


Figure 91: Question 8.6

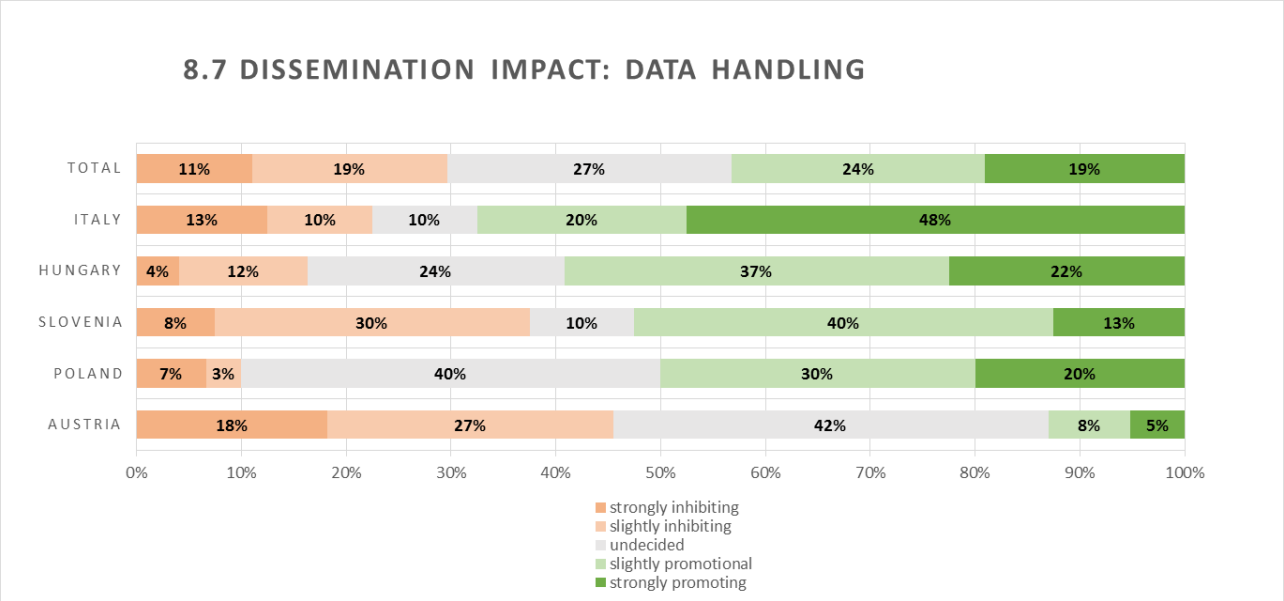


Figure 92: Question 8.7

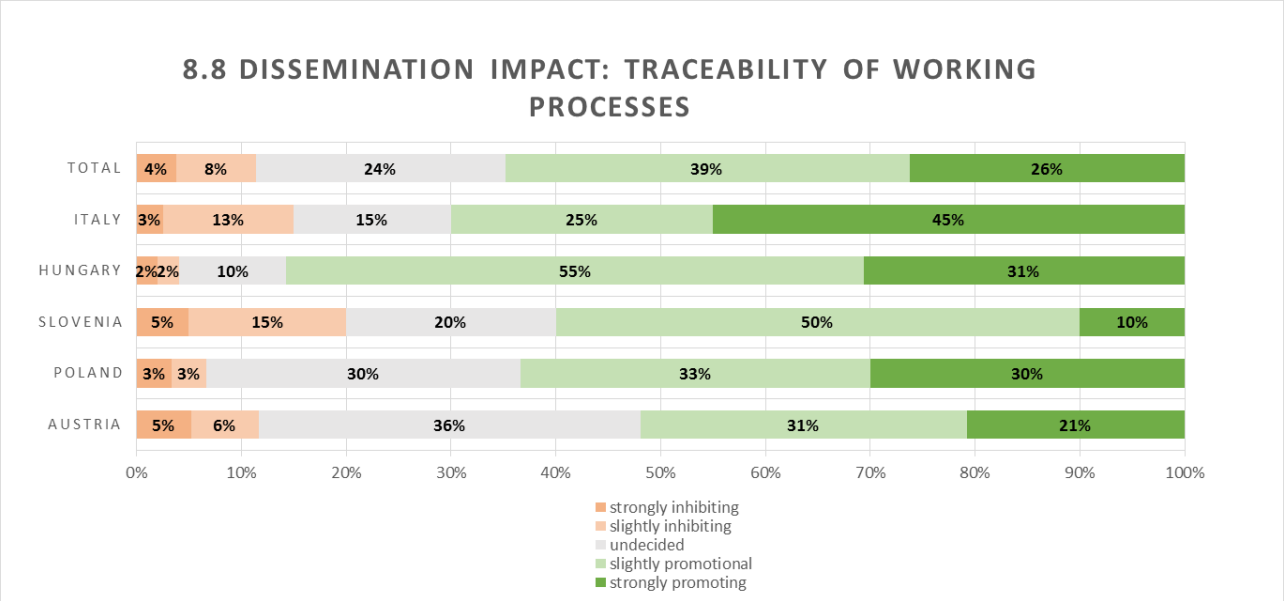


Figure 93: Question 8.8

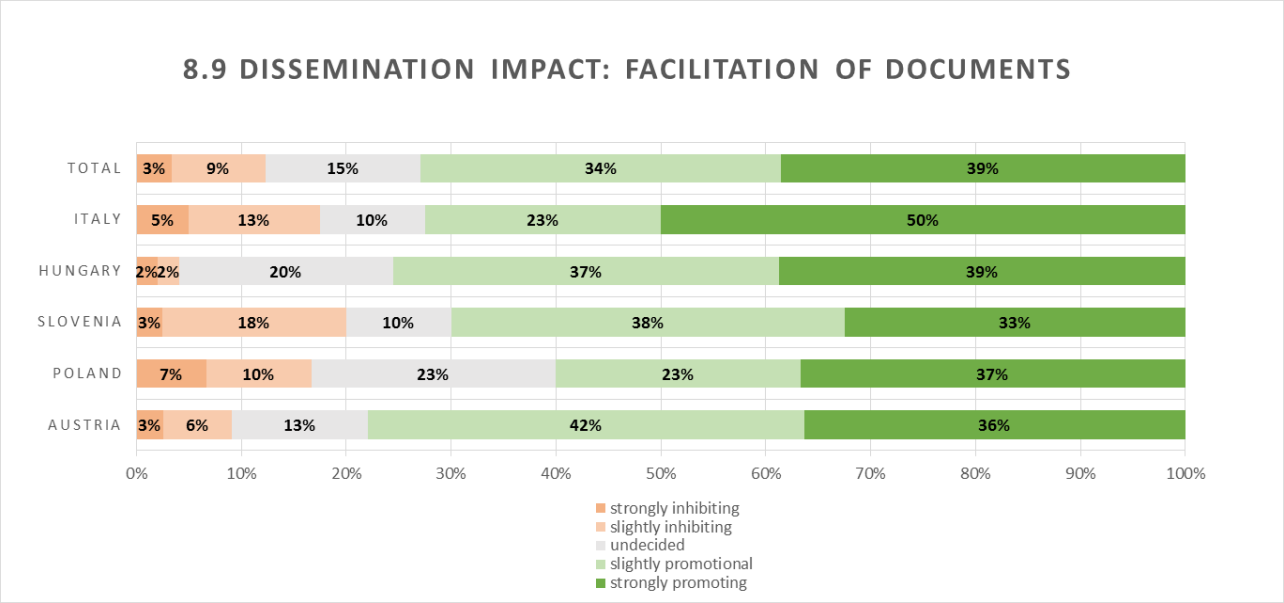


Figure 94: Question 8.9

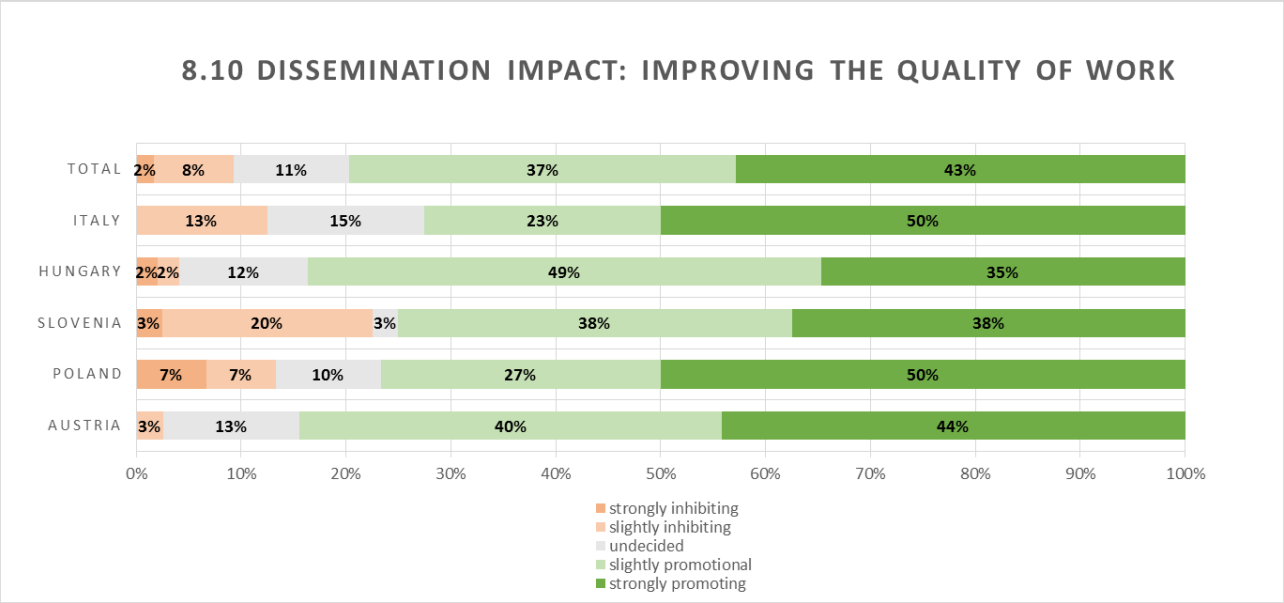


Figure 95: Question 8.10

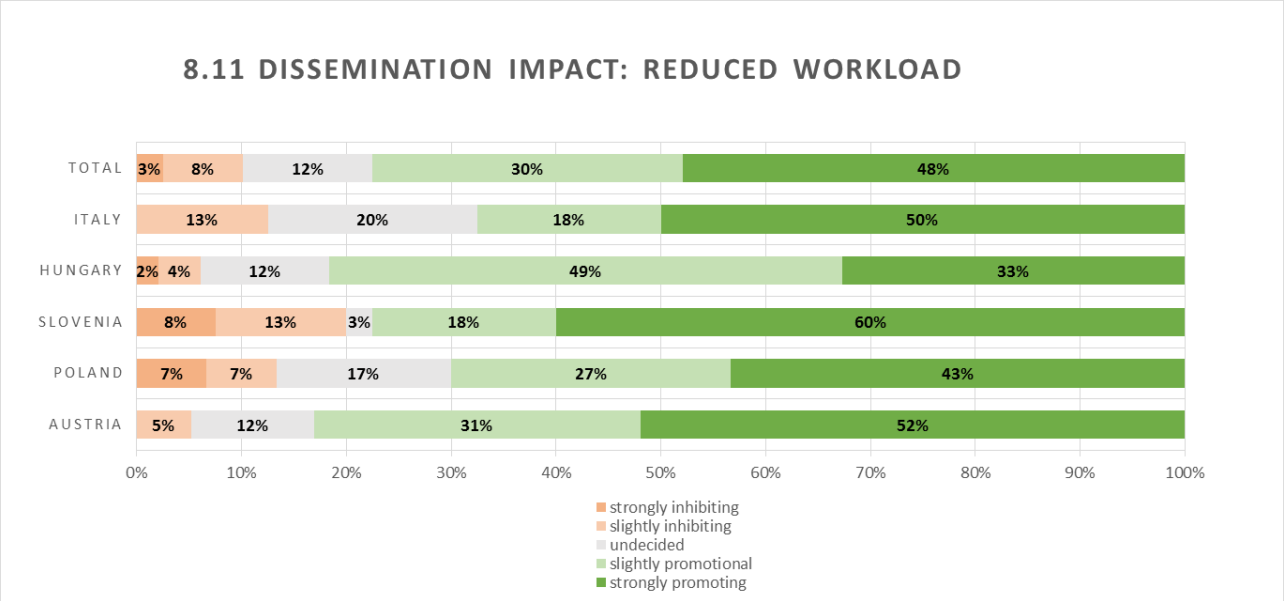


Figure 96: Question 8.11

3.9. Question 9

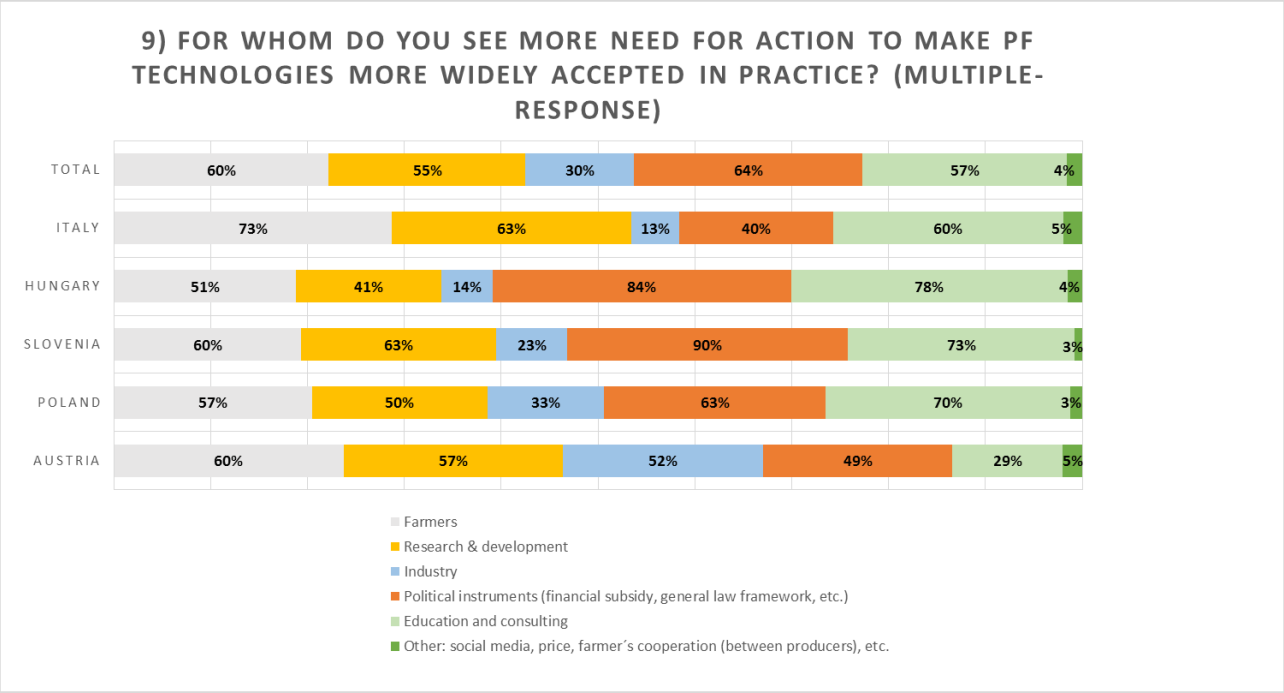


Figure 97: Question 9

3.10. Question 10

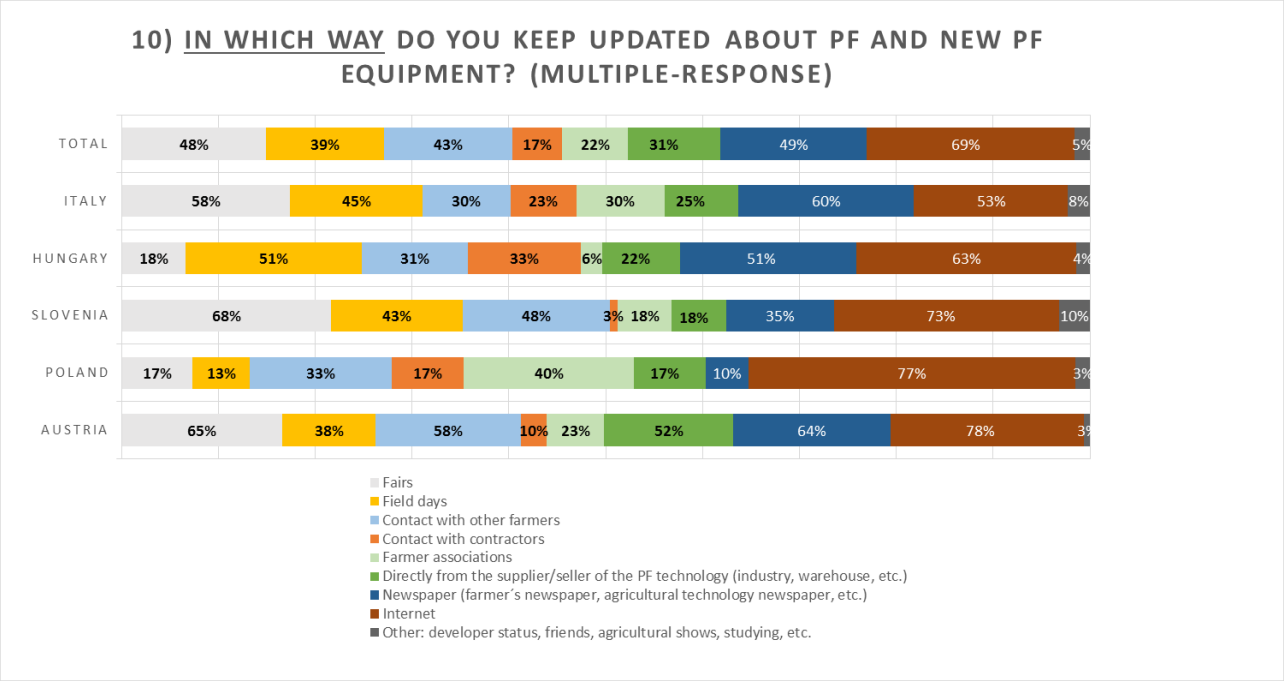


Figure 98: Question 10

3.11. Question 11

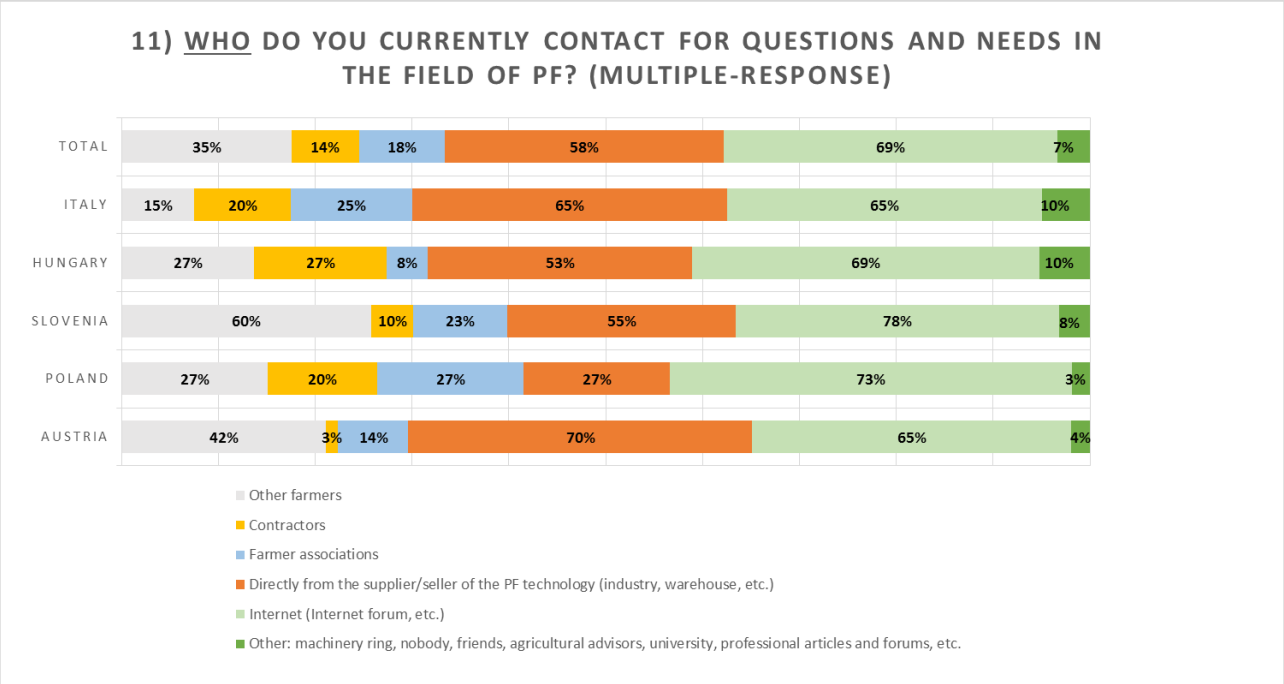


Figure 99: Question 11

3.12. Open-Question 12:

Which PF innovations or improvements do you request in the future for your farm in the area of (new) ISOBUS applications?

3.12.1. Responses Italy

Simplify in machinery utilisation
To advert breaks of the machinery
Compatibility among the different machineries
I don't know
Flexibility during the utilisation of the ISOBUS, adaptation for the current machineries
Contemporary machineries for haymaking
I own a viticulture farm in a hilly area and precision farming is not very applicable
less costs, easier utilisations
Grape harvester with yield mapping system and NIR system that can measure the main parameter of the product. From the data gained, precision fertilisation will be applied
More integration between the tractor and the equipment
Nothing
More compatibility among the different systems

3.12.2. Responses Hungary

use not intended
don’t know
use not intended
GPS based fertilizer application, sprayer support (segmentation, application). GPS based driving of tractors.
don’t know
depending on economical situation and price
optimization of in-row soil management
use not intended
fertilizer and pesticide application
insufficient knowledge
not relevant
Intended purchase of cereal sowing machines for precision sowing (regulated, individual seed application). Combine harvester with yield sensor.
spraying machine

3.12.3. Responses Slovenia

Grass cutting and mulching
Improving marketing
- monitoring soil sampling for soil analysis, GPS detection, - monitoring the location of grape sampling to monitor grape ripening, sensory perception of grape ripening, processing, access to data for the general public, - remote sensing of forest bumps in forests for the purpose of rapid response and also protection in drone forests, - sensory monitoring of the nutritional status of plants (vines, orchards, other crops) for the purpose of rapid point-based action
Documenting farm events, processing and accurate decision making (calves, claims, cycles, sowing, rotation, …)
Improvements in plant protection, precision fertilization and row cultivation of crop and vegetable plants, mowing and planting. Mulching grass in rows in permanent crops.

3.12.4. Responses Poland

lack of knowledge
I'm not going to have a farm
Cosmic wave level measurement
I do not know
I do not know
One terminal for operating all machines in the ISOBUS system
Full documentation of individual stages of production
lack
Basic-terminal
I do not know
isobus terminals
Isobus terminals
sensors
retrofitting tractors

3.12.5. Responses Austria

"improved compatibility of manufacturers, separate applications tractor / Device control (not a monitor), Android interfaces (on the monitor) for apps as standard "

Compatibility, simplification of use even for untrained users
Seeding Technology
Technology must be compatible (cross-manufacturer)
Isobus standard
The implementation has to be simplified considerably. How should someone who does not manage to submit the AMA application online, do PF? Farmers often do not even know what potential their machines already have. You have to train farmers far more in PF. The technology is available, but it is often far too complicated to implement.
cheaper
Compatibility of the systems, general and simple transfer of the AMA-GIS data
more simply a directive
Lower price No maintenance fees from manufacturers, more compatibility
Devices should also cope with older updates
1 terminal for all devices and the same control
I do not have it yet. Would require that all agricultural equipment manufacturers work on the same easily compatible system
Complete compatibility - Each manufacturer partially cooks its own soup.
Store planting and irrigation of the plants with GPS data
None
Existing good machines should be able to be retrofitted at low cost.
easy to use machines and automatic simple documentation
That the systems simply really work together, compatibility of the entire machine;
ONE standard for everything
Affordability of the investment
Functional reliability, falling prices.
The ISOBUS becomes uniform and you do not need the original operating part for every implement.
Improving compatibility with older systems, upgrading existing tractors (including old ones)
Cost reduction, functionality increase, simple operation and installation
Better cooperation between individual companies and models. Easier and cheaper retrofitting of ISOBUS with existing machines.

3.13. Open-Question 13

Which PF innovations or improvements do you request in the future for your farm in the area of remote- & proximal-sensing (satellite, drones, sensors)?

3.13.1. Responses Italy

The possibility to use drones in vineyards/orchards
Sensors that allow to measure the natural movement of the soil
I would like to have a weather station that could be recognized by the insurance companies. The ARPAV one is far and not useful for our farm, because it is 2 km far in a place where is not possible to measure the wind blow
Crop monitoring
Less price and higher precision
sensors
Control of the health status of vineyards trough sensors and variable applications based on the sensor measurement
"Satellites and sensors in the tractors, it is important the timing and the 14/5000 ease of use"
Sensors
Monitoring of new crop diseases, and check the stress status of the plants, e.g. Flavescence dorée
Weather station with automatic control of irrigation
Higher precision in the mid-term weather forecasts
Development of Sentinel Satellites with weekly vigour maps and indication of the water stress variability
Easy to use real time data from satellites
The indexes measured from the field have to be more applicable in the field, instead of ask to external companies for the data managements
Nothing
Sensors

3.13.2. Responses Hungary

meteorological stations and sensors, drones
don’t know
use not intended
public satellite data sources needed
Use of drones in plant health surveys and spray applications. Meteorological data collection, updating of forecast systems and cooperation with decision support systems (e.g. disease forecast softwares).
don’t know
use not intended

use of drones
sensors
satellite and drone
plant protection, yield estimation
drone
Soil and plant sensors for irrigation scheduling support.
Use of drones depending on prices.
not relevant
Drone. N sensor for real-time control of fertilizer application.
drone

3.13.3. Responses Slovenia

Satellite or autonomous robot management and control.
drones, remote sensing
smart irrigation, fertilization
remote controlled machines (cutters) for cultivating steep farmland
sensors
Use on hilly farms with limited factors. The satellite image is very useful, the opportunity is to use a 3d computer model for the farm (along with GOOGLE EARTH).
In addition to multispectral cameras on the drone, there are security systems for unwanted animals (wolves, foxes ...) in the field, pastures.
Starting new companies that would offer these services because of the small size of the farms, our farmers cannot afford.
Self-propelled no till tracked planters.
drone
GPS support
sensors

3.13.4. Responses Poland

drones
sensors
Above.
I would gladly launch a satellite
any
drones
I am not determined
sensors

GPS, drones
satellites and drones
sensors and satellites
sensors
sensors
sensors - yield mapping

3.13.5. Responses Austria

comprehensive soil water measurements, forecast models for Different cultures with regard to climate and culture specific to location
Real time satellite images with low cost
Function in an FMIS
Plant development, better soil analysis
Simplify drone approval
easy and free access
Fieldround" by car should go through satellites and drones be made easier and improved since the areas can be inspected more precisely in a shorter time.
Absolute data sovereignty over my data.
Detection of the maturity of the plants
no
Better usability and higher reliability with prescription (application) maps
K. A.
Spatial resolution 1m, multispectral sensor
affordable sensors
reasonable satellite images at an affordable price that is affordable even for small businesses;
Current free data from the satellite and from all in-house machines
No
data security
Controls of various organizations will lead to problems for agriculture
Easy handling
Cheaper satellite data, better algorithms for evaluating the data, especially for the "real-time data"
Link to multiple application areas (in Austria “Mehrfachantrag Flächen”)

current, readily available and high-resolution satellite images

3.14. Open-Question 14

Which PF innovations or improvements do you request in the future for your farm in the area of Big & Smart Data Management applications (IoT, real-time crop data, etc.)?

3.14.1. Responses Italy

Have more information about the development of crop diseases ad spread of pests
I don't know
Simplification of farm management
Simplicity
I don't know
App for the vineyard management
Have the possibility to monitor crops with and historical database
Teach and inform more the farmers
Control of the miling
According to my knowledge, data are available only if you own a subscription or if you own a weather station. I would make more open usable data.
Simplicity in database access
An integrated system of the different data types able to provide indications for prescription maps
Management system that is available for every user
Management platforms with the possibility to integrate the harvest and the elaboration of the data
The index measured have to be more applicable in the field, instead to ask for external services
nothing
Development of the software

3.14.2. Responses Hungary

Data evaluation and decision supporting systems.
use of drones in field survey
use of drones in field survey
don’t know
use not intended
Wider knowledge needed before introduction of innovations.
don’t know

use not intended
Option working in part (plant surveys via camera system)
use not intended
real-time plant survey
Use of drones with thermo- and multispectral camera in plant surveys.
in daily use
Software for management of data for precision farming, set of machines and vehicles, and also useful in designing of application schedules of chemicals.

3.14.3. Responses Slovenia

Shared database, traceability of work processes.
Machine learning.
crop data
weather station application - to predict disease onset

3.14.4. Responses Poland

real-time crop data
Above.
I would put a nice boy in the field, once she would watch if it grows and two, it could be moved from time to time
any
I didn't make a decision
real-time crop data
flight
soil moisture sensors
drones
flight
real-time crop data

3.14.5. Responses Austria

Preferably none. The operating data is working capital and I do not want to share it and record it online.
Dokumentation
Function in an FMIS
If so, then as in 13).
no
K.A.
must be outsourced, service provider
Many system providers, but what if I change providers? What happens to the data? Who owns the data? Data synchronization when changing providers.
Self-generation of the data by the machines (tractor, fertilizer spreader, etc.), so only more control and sharing of data is needed.
No
Data security, greater advantage, better price situation
Better cross-system collaboration, “Agrirouter” is a good approach but only if everyone joins in.

3.15. Open-Question 15

Which PF innovations or improvements do you request in the future for your farm in the area of field robotics?

3.15.1. Responses Italy

Improve the performance of the vineyards robo-mowers
Development of robot able to work in high slopes
I don't know
I don't believe in robotic due to the low realiability
Use of robot for the weeding and the canopy management in the vineyard
Small robot, high performances and with electrical alimentation, management of the row and sub-row in the vineyard
I don't know
Tractors with autonomous guidance
They have to allow the operator to relieve from driver-setting operations and it can be more

focused in the control of the works
I would like to understand how robotic can help in the field operations, e.g. pruining, fertilisation
Automatic milking
Make the disease control automatic
Electrical robot for vineyards with high autonomy
interesting
I would like to have available implements to make automatic operations
Pesticides application that has to be rational and technological
nothing

3.15.2. Responses Hungary

use not intended
use not intended
don't know
use not intended
lawn-mower robot
Robot developments aiming at reducing manpower demand of e.g. canopy management in vineyards or harvest. Safe autonomous driving of tractors.
don't know
use not intended
under planning
use not intended
use of drones in spraying
use not intended
use not intended
use not intended
autonomous driving, soil scanner

3.15.3. Responses Slovenia

Medium sized mowing and mulching robots in permanent crops.
Robotic sprayers
Weed and pest control on organic farm, row cultivation, ...
Use on steep pitches. Weed detection and more accurate application of plant protection products.
When using plant protection products.

For precise pruning of cultivated plants (vegetables, arable crops) for other farms involved.

3.15.4. Responses Poland

Machines enabling work to reduce the number of employees.
Above.
Pretty boy in the field
Mechanization of agriculture, reduction of labor input, automation.
I do not know
better engines
monitoring of plants characteristic
drones
preferably everything, because I plan to expand my farm

3.15.5. Responses Austria

Chopping robots for all cultures, including swarm technology
Ease of cultivation, chopping, cultivation by small robots and targeted crop protection using drones
Weed control, irrigation
Very valuable for organic cultivation. Manual workers can no longer be mobilized.
weed control
practicality
Relief with chopping technology
No need, there is far too much fuss about it, everything is still in its infancy.
Weed control in a row - autonomous
Cheaper prices
Legally clear framework conditions for use, more reliable technology
K. A.
Practical weed removal
good, cheap robotic robots for organic root crops (pumpkin, corn, soy) and good cheap robotic

lawnmowers for vineyards under floor
No
Affordable, autonomous and functionally perfect technology
regional field days with demonstrations

3.16. Open-Question 16

Which others PF innovations or improvements do you request in the future for your farm?

3.16.1. Responses Italy

Improve the feeler sensors of the vineyards implements to avoid the damage of small grapes along the row
Use more sustainable and less pollutant materials
New sensors able to measure the main diseases e.g. Esca disease, Flavescence doree
Reduction of costs
All the improvements and innovations that will allow to manage the farm and to control the crop status
Bring the innovation in the field, reliability of the technology, simplicity in the machinery reparations, too much technology could slow the work than improve them, no too much sophisticated technology
haymaking control
measurement of the soil characteristics for the fertilisation program
more flexibility for the hiring of workers
more instruction towards young people to prepare them for the precision farming
an implement able to reduce the environmental impacts of the farming operations
more biotechnologies and research for the pests diseases
nothing
reduction of pesticides and fertilizers

3.16.2. Responses Hungary

WineData complex management software
WineData complex management software
don’t know
use not intended
Comprehensive developments of precision machinery, with data logging for adequate fertilization, plant protection and tillage, and traceability of expenses.

don’t know
decision after considering demands and opportunities
under planning
consultations needed
use not intended
Precision irrigation in the long-term

3.16.3. Responses Slovenia

More PA in the forestry sector.
More electrically driven machines.
Environmentally friendly tillage and mulching.
Fruit and olive farms need very good monitoring of diseases and pests - knowledge of this, and the conditions which are regulated by law (we have very big problems because less is allowed than in neighbour country Italy.) This is not even a PA, but a basis urgent and we do not have it yet.
Farm and culture. What is meant by agriculture in landscape culture and in art.

3.16.4. Responses Poland

remote and automatic data processing systems adapted to the type of farm
mobile applications, soil testing services
Better machines and get to know a more efficient cultivation system.
Above.
any
Full automation, individual selection of plant protection products and fertilizers.
Drones, robots and applications
Modern solutions in beef cattle breeding, topics related to the organization of the feed base, prevention of metabolic disorders.
I wonder
measuring station, precise irrigation system
mapping system, applications
devices that control weather conditions
applications of all kinds, GPS
remote control of combine harvesters

more applications
soil mapping

3.16.5. Responses Austria

Easy handling of the currently available technology and reliability, including data backup and data security.
sustainable forms of irrigation
After purchasing free service or updates.
data protection
K. A.
Uniform data format of the manufacturers. Data processing on the PC.
no
That the different providers could be linked!
Reading field data must improve (Inveko-Gis compatibility), Price has to go down, programming has to be easier to adapt.
Access to economic systems at reasonable prices; DATA SECURITY - greatest challenge; What data is relevant for the company - no production of data cemeteries!
simple, easily accessible online tools for small businesses

4. Evaluation of the online survey

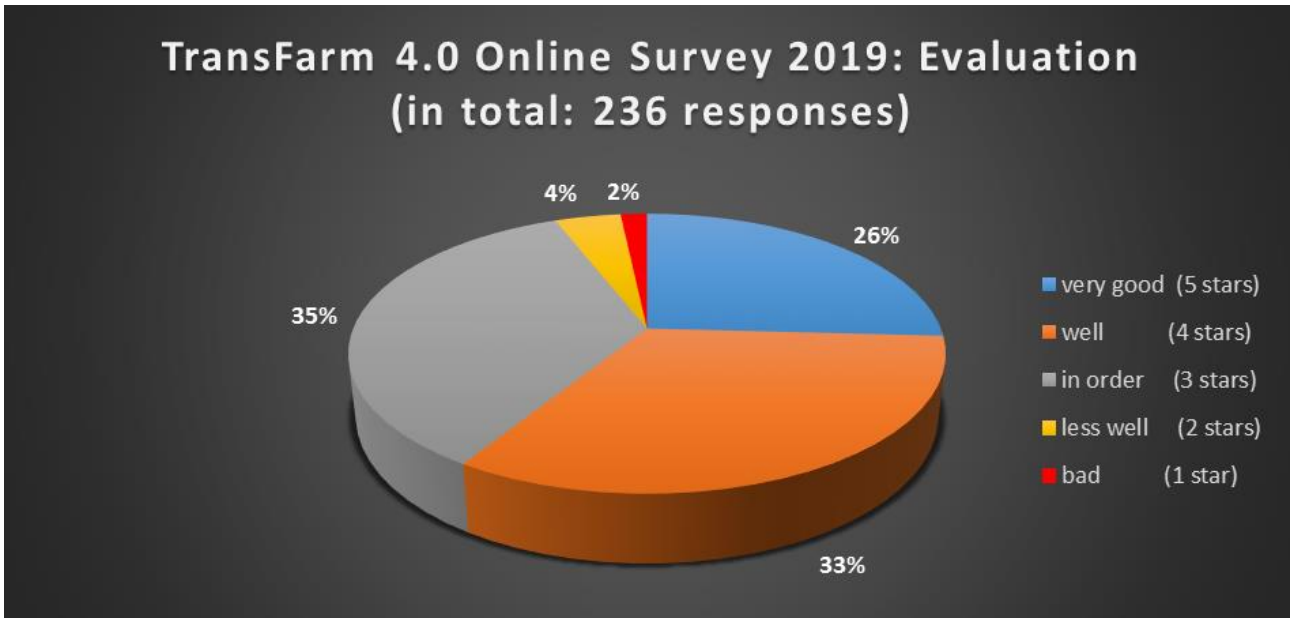


Figure 100: Evaluation Survey

C. SWOT analysis to highlight criticals & asset in PF uptake (D.T1.3.2)

1. Introduction

The results of the SWOT analysis are based on the elaborations by CREA for Italy, University of Maribor for Slovenia, Szent István University for Hungary, KIRG for Poland and HBLFA Francisco Josephinum and LCM for Austria.

2. SWOT analysis – Italy (Veneto Region)[3]

2.1. General information

Veneto agricultural sector, despite many difficulties faced each day, is characterizes by one of the highest revenues-generator in Europe. This is due principally by the high specialized farming that is of this region. In fact, Veneto region is characterized by the cultivation of about 77.800 ha of vineyards, 22.500 ha of orchards, 17.000 ha of vegetables and 450.000 ha of extensive crops.

Additionally, the quality of the products is appreciated abroad and imitated all over the world, with a constantly increasing turnover over the last years, capable of creating authentic symbols of the region, such as Prosecco or the renowned Veneto cheeses. Moreover, the Veneto agriculture boasts the best practices, real growth paths within the agricultural sector, intended as producers of foodstuffs and as protagonists in the protection of the environment and promotion of the territory (Statistical report of Veneto Region, 2014).

Future steps will consider the improvement of the agricultural process in the region thanks to the promotion of new technologies able to reduce the production costs and the environmental footprint. These technologies will come from different fields, such as genetic or new production technics thanks to the introduction of precision farming. With this last regard, the following document will provide a Strengths Weaknesses Opportunities Threats (S.W.O.T.) to highlight criticalities and asset in precision farming uptake.

2.2. Strenghts

In Veneto region, several agricultural equipment manufacturers and dealers are present. The network is great, and latest technologies are available to the farms. This high presence of stakeholders could generate a positive competition in favour to the development and spread of new technologies.

Farmers generally are interested in new technologies due to their high inclination towards innovations able to increase the sustainability of their farm and improve its management (e.g. facilitation of the

[3] provided from: CREA – Researcher *Davide Boscaro*, *Diego Tomasi* (2020)

bureaucracy, reduction of pesticides utilisation). This is supported especially for the speciality-crops (e.g. vineyards, orchards), which deal with higher profitable cultivation and where the impact of the production costs is generally higher. Moreover, Precision farming can be useful in this context due to the possibility of increasing the control and the quality of the production process.

The presence of Agricultural University (Padua) and of well-known research centres in the region is another important factor that favour the educational system towards the teaching of PF practises. In surplus, agricultural fairs, exhibitions and workshops on precision farming are generally performed in several events from these institutions, trying to make more familiar these new practices.

Another important factor is also the current trends about the food production, which sees the demand from the consumers of more safety food with a certain origin. This scenario can favour the adoption of PF thanks to the recent development of traceability solutions (e.g. blockchain), able to track the "cycle-life of the product".

2.3. Weaknesses

Despite Veneto region is a high-tech farming region, the overall size of the farms is generally small, with a high network of small farms. This aspect is effectively not favourable for the spread of PF, because generally the costs of these technologies is too high respect the return of a small-medium enterprise. In addition, some farming areas are in hilly zones, where most of the labour can be performed only by hand, limiting, de facto, the possibility to mechanize the process.

Consider the EIP measures adopted in the region for the CAP 2014-2020, we state that no direct measured were proposed to the farmers for the utilisation of PF practises. The scenario is also unfavoured by the high average age of farmers, which influence negatively their willingness to learn new production techniques.

2.4. Opportunities

Future scenarios for the Veneto farming see several opportunities in case of a higher adaptation of PF. As matter of fact, there are an increase of young farmers which start a new company in this business with

the potential inclination towards the use of PF. This Is due also because of new farming entrepreneur generally has a background in agricultural sciences. In addition, today there is a new trend in the rising of start-ups companies that deal with PF, highly interested to test their solutions with these "new farmers".

Considering also the manufacturing sector, the inclusion of PF solution in the production of implements can increase the content of technology of the products with the possibility to open new markets creating new opportunities for the manufacturing enterprises. This possibility is also favoured by the several research projects that have been conducted by Universities and research centres with the aim of increasing the technological contents of the farming sector, which have tested the application of PF practices.

In addition, climate changes are affecting negatively the production of the region, PF is proved as a tool to mitigate the negative agronomic effects caused by adverse weather conditions.

2.5. Threats

Threats in PF uptake considers the possibility that farmers are linked to their traditional methods, which make difficult to ask them for a change in innovation. This aspect is strengthened by the size of the farms, generally not conduced as main activity by the owner, which "favor" a traditional method with a low input of technology, because it is the simplex and the faster adoptable.

All this scenario makes also difficult for the manufactures to invest in the development of new machineries able to comply with the requirement of PF due to the uncertainty of the market. In fact, this aspect has generally unfavored the development of "local technologies" by local manufactures promoting the importing of technologies from abroad, especially from outside EU countries.

With the PF data about farms can be more accessible: this technological revolution has to be controlled because of the possibility of spread of sensible data linked to the farmers.

STRENGTHS	WEAKNESSES
▪ several agricultural equipment manufacturers and dealers are present ▪ latest technologies are available to the farms ▪ high occurrence of stakeholders could generate a good competition in favour to the development and spread of new technologies ▪ largest farmers generally are interested in new technologies due to their high affinity towards innovations to increase their farm's sustainability and improve its management (e.g. simplifying bureaucracy, lowering pesticide use, etc.) ▪ educational system teaching PF practices ▪ reduction of environmental footprint ▪ rising of start-up companies dealing with PF services ▪ agricultural fairs, exhibitions and workshops on precision farming	▪ overall size of farms is generally small ▪ high average age of farmers ▪ cost of PF technologies is too high for small-medium enterprises, not favouring the spread of PF ▪ limited availability of PF sensors' data for the farmers ▪ high GPRS prices ▪ in hilly zones, with high hand labour demand, mechanization is limited ▪ restricted availability and high price of satellite and GIS data, maps for farmers ▪ farmers are linked to their traditional methods ▪ low salaries, weak education level and missing skilled manpower ▪ missing competence in response to EU calls
OPPORTUNITIES	**THREATS**
▪ increase of young farmers with higher education level ▪ rising of start-up companies dealing with PF ▪ research projects conducted by universities and research centres ▪ reduction of environmental footprint ▪ mitigation of negative agronomic effects of climate change ▪ lower use of input materials ▪ less work consuming processes ▪ demand from the consumers of more safety food with a certain origin ▪ support of free availability of satellite and GIS data, maps for farmers ▪ marketing advances of higher food safety (inland and abroad) ▪ water saving irrigation technologies ▪ developments and innovation in IT ▪ rising of start-up companies dealing with PF services	▪ resistance to PF innovation ▪ uncontrolled failure of field sensors ▪ critical security level of field equipment (sensors, data loggers, solar panels, cables, etc.) ▪ low GPRS performance, communication failures ▪ unexpected data losses ▪ internet attacks ▪ enhancement and extremes of climate change ▪ uncertainty of the market ▪ unwanted spread of sensible data linked to the farmers ▪ crucial changes in policy ▪ missing competence in response to EU calls ▪ cutback in EU sources and diminution of project calls

3. SWOT analysis – Hungary[4]

3.1. General Information/Overview

SWOT ANALYSIS TO HIGHLIGHT CRITICALITIES AND ASSETS IN PRECISION FARMING RECEPTION IN HUNGARY

3.2. Strenghts

Several agricultural equipment manufacturers and dealers are present, latest technologies are available to the farms in Hungary, and high occurrence of stakeholders could generate a good competition in favour to the development and spread of new technologies.

Generally the largest farmers are interested in new technologies due to their high affinity towards innovations to increase their farm's sustainability and improve its management (e.g. simplifying bureaucracy, lowering pesticide use, etc.).

We have educational system teaching PF practices, rising of start-up companies dealing with PF services, frequent agricultural fairs, exhibitions and workshops on precision farming.

Adopters of precision farming in Hungary are primarily younger than 40 years old, have higher education and cultivate more than 300 hectares of land, which is consistent with international experiences.

About 44 per cent of farmers use GPS, and among farmers under the age of 40 years this share can reach 48 per cent. Site-specific soil sampling, the use of guidance systems and, increasingly, automatic steering can be considered to be standard management practices. More than half of the precision farmers use guidance systems, and around 30 per cent of them use autopilot, followed by machine control, VRT seeding and fertiliser applications (25 per cent).

[4] provided from: Szent Istvan University (SZIU) – Researcher Prof. *Dr. Borbala Balo*, et.al (2020)

3.3. Weaknesses

Precision farms emerged in Hungary in the last 15 years, but for many people it is still an unknown concept. Only half of the crop producers have heard about it, but this percentage depends on the farm size. Most of the farmers that believe that PA does not fit to their farm size have fewer than 200 hectares of land, and 83.6 per cent of the respondents that emphasized the lack of financing opportunities are traditional small-scale producers.

The most important hindering factor for the penetration of precision farming in Hungary among arable farms is the high investment costs. Economic considerations appeared to be an important aspect in the decision to adopt, as can be documented by ranking factors that were taken into consideration. Fifty-two per cent of the respondents indicated the excess investment cost as the main barrier to widespread adoption of PA. Fifteen per cent of the respondents indicated that the technology cannot work effectively for their farm size, and according to 12 per cent of the respondents, there are no adequate financial possibilities for the additional expenditures.

The applications of sensors for pest control, drones and precision irrigation are still at the inception phase: the rate of their application is only around 5 per cent.

In order to lower the additional investment costs of PA, technologies are usually introduced sequentially. However, this approach to adoption may seem inefficient and time consuming compared to adoption of complete, possibly complementary technologies.

Restricted availability and high price of satellite and GIS data, maps for farmers and, sometimes missing competence in response to EU calls may also represent some weakness.

Although profitability is critical to the adoption decision by farmers, several studies only estimate changes in input use and yield, and the reported data are sometimes rather variable. For example, automatic machine guidance is expected to result in a 10-25 per cent decrease in fuel consumption, weed detection can reduce the herbicide use by 6-81 per cent, and precision irrigation typically enables 25 per cent water savings. For site specific nitrogen management the input use saving ranges from 6 to 46 per cent, and the yield increase from 1 to 10 per cent.

Most scholars have approached the expected economic effect of PA from decreasing input costs. A recent survey, 51.1 per cent of the farmers reported a decrease in variable costs. The increase of input use can be explained by the low initial level of fertiliser use, quite common among arable farms in Hungary. However, the amount of fertiliser itself is not the issue that really matters. The real question is how the efficiency of use changes. Therefore, the yield level and associated nutrients need to be studied.

Main barriers to the adoption of PA according to the farmers (in decreasing order of importance) are excessive investment cost, not suited to the farm size, lack of appropriate financing, lack of appropriate knowledge, lack of experience of using PA, distrust of new technology, lack of services, lack of time to adopt PA, lack of advisory services.

3.4. Opportunities

Adopters of precision farming are primarily younger than 40 years old, have higher education and cultivate more than 300 hectares of land, which is consistent with international experiences.

The profitability of PA technology adoption increases with the years after adopting the technology.

Beyond the economic benefits, lower environmental impact (reduction of residual nitrogen in soils by 30 to 50 per cent) is also mentioned.

The introduction of precision fertilisation and pest management applications would cause a decrease in the input use.

Precision farming in case of the main arable crops (winter wheat, maize, oilseed rape, sunflower) increases yield, with cost and profitability benefits compared to current conventional agronomy practices.

The exact input application results in a more efficient nutrient utilisation and less negative environmental impact. And even if input use and production costs increase under PA, yields can grow enough to increase profit.

The impact of adoption is initially small but during this period knowledge and skills are gained and important data are collected. Then, once sufficient data and skills are present, the gains from adoption of

PA technology could grow quickly to a point where the benefits are largely realised and further gains are limited.

PA technologies can be applied successfully also in medium sized or in small farms, partly based on own equipment and partly through common machinery usage (i.e. machinery rings), as well as of course by services.

Main drivers of PA adoption according to the farmers (in decreasing order of significance) are higher profitability, more and/or more detailed information, would be part of an area-based subsidy, would be a measure in a RDP (rural development program), compatibility among technologies, higher market price (e.g. by certification), support of machinery used by farmers' group, would be part of a 'greening' payment, would be part of an AEP (agri-environmental policy) subsidy, availability of data recording mobile apps.

3.5. Threats

It is widely accepted that the economic potential or profitability of PA depends on the farm size, heterogeneity of agricultural land cultivated by the farm, the applied technology mix (both PA and non-PA), the cultivated crops, and the experiences and ICT skills of the farmers.

Owing to the many complex factors, profitability cannot be demonstrated in all cases. A significant increase in profitability could be confirmed only in those farms that apply PA for at least three years. Accordingly, 62.2 per cent of the respondents reported some increase in profitability, while 17.8 per cent realised a fall in crop income. The fact that many farmers have not realised/perceived any direct increase in their profitability is a real barrier to the wider adoption of PA. That higher profitability would be the main driver for PA was reported by 28.2 per cent of the respondents.

More than half of the respondents indicated the high investment cost as the main barrier to adoption. A lack of appropriate financing was listed in third place among the barriers; at the same time the need for subsidies appears in third place among the drivers. Our view is that precision crop production can be one of the means of enhancing the green component, as an environmentally-friendly farming practice,

drafted within the direct subsidy system of the EU's Common Agricultural Policy proposed for the 2020-2027 planning period.

Low salaries, weak education level and missing skilled manpower may also represent a real threat.

4. SWOT analysis – Slovenia[5]

4.1. General Information

In the framework of the Interreg Transfarm 4.0 project, SWOT analysis was made and four aspects - strengths, weaknesses, opportunities and dangers - ware take into account. The purpose of the analysis is to make the necessary strategic decisions, precisly where to focus precision agriculture, which areas of precision agriculture need to be strengthened. First we delineated the strengths/weaknesses and opportunities/dangers of precision agriculture. The first two aspects are related to internal factors, the other two to external factors. The main difference is that in the internal factors we have an impact that we can adapt, develop or otherwise act. In internal factors, we are in the area of our own influence. Opportunities / dangers refer to external factors that are unaffected and cannot directly do anything on our own, other than to adjust internal properties.

The SWOT analysis was conducted on the basis of a survey of 40 respondents (27 males, 13 females, with age structure: 20-29 years, 13 respondents; 30-39 years, 3 respondents; 40-49 years, 5 respondents; 50-59 years, 6 respondents; education: 5 respondents-high school, 35 respondents-university education). According to the Slovenian regions there are 28 respondents from the Podravska region, 3 from the Savinjska region, 1 from the Primorje-Notranjska region, 2 from the Obalno-kraška region, 1 from the Southeast region and 4 from the Goriška region. 87% of the respondents described the survey as appropriate (25%), good (25%) or excellent (37.5%). 80% of respondents believe that more effort should

[5] provided from University of Maribor: Peter Berk, Damijan Kelc, Miran Lakota, Jurij Rakun, Denis Stajnko, Peter Vindiš and AG-ROBO.net: Peter Lepej, Peter Polič.

be put into promoting PK at the national level (Agricultural Policy Instruments, followed by Education and Counseling with 70% and R&D with 62.5%).

Positive	Negative
Strengths	Weaknesses
- product quality (upgrade of existing PA technologies), - savings (fuel, seeds, reduced consumption of pesticides...), - simplification of work process documentation, - relieving the user (less workload for operators, better work quality, better traceability of work processes), - awareness of the potential of PA technologies in the near future.	- lack of knowledge and skills (potentially too complex or too reliable technology), - poor access to PA information (farm users lack PA skills and knowledge), - the current price of PA products on the market, - maintenance costs, - the Common Agricultural Policy of the PRP 2014-2020 does not indirectly subsidize the sustainable development of the PA.
Opportunities	Threats
- opening new markets for PA (purchase of PA technologies), - changes in government policy, - new sales channels, - new PA services (use of satellite data, selective fertilization and spraying technology and support for farmer data management), - development of PA in agricultural sectors (forestry, fruit-growing, viticulture, vegetable production), - education and counseling in different areas of PA (workshops), - new opportunities for different fields of application of PA applications on agricultural holdings.	- reliability of PA technologies (risk of using robots or drones in agriculture), - excessive initial investment in the use of PA according to the size of agricultural holdings (the proportion of respondents who consider PA irrelevant to their farm or who care about them is relatively high), - compatibility of different PA systems, - availability of PA services that will be available in the Slovenia, - current offer and services in PA, - beneficiaries in the PA, see only the source of income in terms of the use of subsidies.

4.2. Strenghts

Positive features are reflected in successful brands and new PK prototypes. Great opportunities lie in the higher quality of products that will be enhanced by the upgrading of existing PK technologies. With the using new technologies users save fuel and seeds. The use of pesticides is reduced, which makes a lower risk to the environment.There will also be very big savings in the working time, that means more time for other activities and education. Administration will be greatly reduced as work documentation will be simplified. Workers and users will be relieved, because they will experience less stress. Less workload for operators of work processes will lead to better quality work and better guidance of work processes. There is also great potential in acceptance the potential of PK technology in the near future.

4.3. Weaknesses

Weaknesses are mainly due to the lack of knowledge and skills of our farmers and users on one hand and to potentially too complex and not reliable technology on the other. Poor access to PK information is also present. Farm users do not have enough skills and knowledge in the field of agriculture, which should be obtained in training in the near future. The current price of PK products on the market is high and, as a result, the products are not readily available to customers. The cost of maintaining advanced technology is high, especially if smart devices are used with the lack of knowledge. The weakness is reflected in the

common agricultural policy of the RDP 2014-2020, which does not indirectly subsidize the sustainable development of the PK.

4.4. Opportunities

There are many opportunities for good PA involvement and overall success for users and service providers. The greatest potential is in the opening of new markets for PK and the extension of new PK technologies. Changes in government policy and the realization that these are technologies of the future are very likely to occur in the future. New sales channels and new PK services are being opened, using satellite data, selective fertilization and spraying technologies, and support for agricultural data management. The development of PK in the forestry, fruit-growing, viticulture and vegetable industries has only just begun and will become increasingly important. There will be a great deal of training in various areas of PK, including in the form of workshops and practical demonstrations. In many areas, new opportunities are opening for different areas of PA use on farms.

4.5. Threats

Possible dangers are present in many factors that can affect success. Problems may be reflected in the reliability of PK technologies and the associated risks of using robots or drones in agriculture. The start-up investment for the use of PKs in relation to the size of agricultural holdings is high. The proportion of respondents who say that PK does not find it important or not interested in their farm is relatively large. There are also some uncertainties and questions about the compatibility of the various PK systems. The availability of PK services in the Republic of Slovenia is relatively small and the existing network has not yet been established. Current offerings and services in PK are small and users do not yet know about them. Certain users in the PK see only a source of income in terms of the bonuses they could receive.

5. SWOT analysis – Poland[6]

5.1. General Information

According to Evenson and Pingala, around 1% of innovations come from the agricultural sector, while more than 80% of agricultural patents are supplied by other sectors, such as chemical, pharmaceutical or machinery. This is due to the specificity of manufacturing processes, the type of materials used and technology. Industry working for agriculture (e.g. production of new plant varieties, plant protection products and livestock breeds) participates in around 45% of agricultural R&D.

In 2017, out of over 1.4 million farms in Poland, only 15,470, i.e. only about 1% of all, were certified organic farms, and a further 4,787 farms were at that time in the transition to ecological activities19. These farms covered an area of over 380,000 hectares20, which is only about 2.6% of the total agricultural area. It should also be emphasized that the number of farms of this type has been decreasing for several years, which may indicate the existence of barriers to discouraging organic farming

High financial costs associated with the purchase of special equipment. In addition, farmers who undertake to implement these modern methods must constantly improve their knowledge in order to fully utilize the potential of precision farming. Precision farming in Poland is unfortunately still rare. This is connected not only with the garden of investments that need to be carried out, but also with the structure of Polish agriculture. In our country, crushing of farms is dominant, and precision farming is used in large-scale farms.

Innovative activity in Polish agriculture faces many barriers, including a fragmented agrarian structure, insufficient transfer of knowledge to farmers or low resource supply. Until now, most Polish farms have adopted a strategy of imitation (adaptation) of various types of innovation.

Supporters of precision farming are primarily less than 40 years old, have a university degree and cultivate over 200 hectares of land, and the provisions of national law changed in 2018, limiting the purchase of land by private individuals, foreign buyers, which causes a continuous increase in the area of farms.

[6] Provided from KIRG: Pawel Materka et.al. (2020)

5.2. Strengths

The most important strengths supporting the use of PA for Polish agriculture are:

- relatively favorable age structure of rural population - a high percentage of young people, - large concentrations of people in rural areas despite migration to cities
- low degree of specialization giving high flexibility in changing production direction
- relatively good soil condition in Poland
- progressive modernization of the processing sector and a large processing raw material base
- proximity of sales markets and the market of Eastern countries, the single European market, as well as experience gained in obtaining funds from structural funds and subsidies for agriculture.

An important form of educating farmers about PF are frequent agricultural fairs, exhibitions and workshops on precision farming.

Poland is in third place in Europe due to the share of agricultural area in the total area of the country. The countries ahead of Poland are France and Spain. This area is 18 608 thousand hectares, i.e. 56% of the entire country. Such a large surface area allows the land to be used less intensively as well as the use of environmentally friendly production methods.

Thanks to investments (including those co-financed from EU funds), the Polish food industry is one of the most modern in Europe, and companies can successfully compete with producers from other EU countries

One of the most advanced precision farming technologies is the possibility of applying variable doses of mineral fertilizers tailored to the soil conditions of a given field zone and plant nutritional requirements.

In connection with positioning by means of a satellite signal, application of a variable dose of pesticides based on application maps has become possible. Yield maps are also used to create fertilizer, seed and pesticide application maps.

5.3. Weaknesses

Weaknesses of Polish agriculture are also a whole group of brokers of agricultural products and PA technologies delivered to the Polish market.

In Poland, the concept of precision farming is not often used, while young farmers are increasingly using new solutions. However, the agri-food sector is considered a sector with little innovation.

Statistically speaking, about 1.2 million farms (i.e. about 80% of the total farms with an area of more than 1 ha) do not have the capacity to restore and modernize their production potential, and so:

- The low quality of the education system is not conducive to the implementation of PF practice and the establishment of start-ups dealing with PF

- Currently, when competition in the market intensifies, innovation generation processes may prove to be a more effective strategy. They are more effective in the conditions of growing volatility of the environment, when market demand becomes more and more uncertain and competitors' actions more and more unpredictable. Research by Józwiak et al. 20 showed that about 38% of domestic farms with a size of 2 and more ESU has at their disposal permanent or periodic means for implementing various types of innovations. However, taking into account the total number of farms in the country with an area of 1 ha and more, this share is only 18-19%. Potential innovators should be seen among these farms.

Direct payments are the most common type of support for agriculture in Poland. Every year, around 1.4 million farmers use them, 87% of farms over 1 ha use this form of assistance.

A large part of agricultural imports are products that are not cultivated in the country, and imported to supply the domestic market and for processing in the food industry and re-export as processed products. However, this does not apply to animal products, especially pigs and pork.

An important weakness of Polish agriculture is also the poor vertical and horizontal integration in the agri-food sector and low inclinations to joint actions, as well as the growing income disparities between small and large-scale farms

There are also not many producers and sellers of agricultural equipment, the latest technologies for farms in Poland are available, and a large number of interested parties could generate good competition in favor of the development and dissemination of new technologies.

5.4. Opportunities

The main development opportunities of PF in Poland include:

- extending Polish agriculture to the Common Agricultural Policy (CAP) and structural funds, guarantees a departure from supporting production intensification and increasing the freedom to make production decisions
- development of non-agricultural activities in rural areas, support from structural funds for this type of activities, diversification of agricultural activities, a large internal market for
- rural areas associated with the potential increase in purchasing power,
- a large single EU market,
- changing the expectations of the population in the EU regarding the social functions of agriculture in favor of multifunctional agriculture,
- changing consumer expectations regarding production methods in favor of extensive, environmentally friendly, animal health and welfare
- preferences of Polish consumers towards Polish food
- gradual adaptation of EU technologies and management methods
- transfer of economic activity to rural areas
- opening of the JRE for Polish producers of organic, traditional and regional food.

The profitability of applying PA technology increases with the passage of years after the adoption of the technology and this is beginning to be noticed by farmers who, thanks to EU subsidies, are increasingly willing to equip themselves with PF technologies.

The combination of direct payments and cross compliance requirements means that this form of support can fulfill a key role in providing basic public goods through sustainable management of agricultural land (preservation of landscape values, biodiversity, water availability, climate stabilization and air quality) or unrelated public goods with the environment (active in rural areas)

In addition to economic benefits, technologies are gaining popularity, including due to lower environmental impact and performance, and:

- limited to the necessary minimum of concentrated fertilizers and plant protection products
- increasing plant yielding by introducing precision fertilization
- reduction of environmental contamination by means of sustainable development
- lower financial outlays for agrotechnical operations and improvement of the efficiency of using the means of production
- faster and more efficient field work and increased productivity of people and machines
- the possibility of carrying out agro-technical procedures not depending on the weather conditions
- preparing accurate data on the size and quality of crops
- the possibility of saving the cropland's efficiency and profitability in an easy way
- easier and more effective management of the farm
- improving management and working conditions on the farm
- reduction of production costs
- optimization of agricultural produce quality

• reduction of environmental pollution

• improving the degree of sustainability of the cultivation system, i.e. selection of the dose of the means of production to the spatially diverse demand for it

5.5. Threats

Open competition on the world market, which is a manifestation of globalization, brings more threats to Polish agriculture than development opportunities. These threats are, of course, neutralized by integration with the EU, but EU agriculture is also unlikely to face open competition on the world market

In Poland, almost only the largest farmers are interested in new technologies due to their high affinity for innovations that increase the sustainability of farms and improve management (eg simplifying bureaucracy, reducing the use of pesticides, etc.).

Low professional mobility of inhabitants of rural areas, regional diversification regarding farm fragmentation in one part of Poland, and sufficient for the application of PF technology in other regions of the country.

Insufficient awareness of agricultural producers regarding climate change. One of the threats that farmers see is global warming, which causes instability in weather conditions and their unpredictability, including for lack of rainfall, natural disasters

An important threat is also the divergence of rural development priorities and agricultural policy between developed EU countries and Poland, and a reduction in support for European agriculture as a result of WTO negotiations

The diverse level of education and qualifications of the rural population, including farmers, with a large group of people with low qualifications and skills, is a limited opportunity to improve the education of the rural population. As a result of low farmers' awareness and poor social infrastructure, only most young farmers are aware of education and education, as well as the need for continuous improvement and innovation.

Rapid development of agricultural production in countries with low production costs, it is necessary to incur large expenses in a short time to adapt to EU standards

6. SWOT analysis - Austria[7]

6.1. General Information

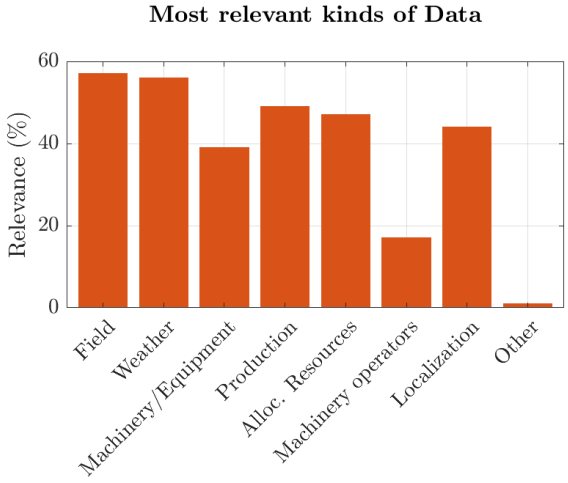
Of all the Austrian farmers who answered the questionaire, 49 % have already been using Precision Farming (PF) technology. Another 16 % considered themselves "advanced user", and 9 % are professionally using PF for many years.

While for 39 % PF is important (incl. 12 % very important), 26 % are undecided, for 17% PF is less important and for 18 %, PF appears not important at all.

Farmers would use (reinforced) PF technologies on their farm, if the cost would be lower (84 %), if techology would be simper and/or more reliable (45 %), and if they would be better instructed how to use it (23 %). From these results, there is a clear demand for cheaper products and benefit-oriented marketing/product information. Moreover, the products should be obviously reliable and easy-to-use (high quality-of-user-experience).

The following figure provides an overview on which kinds of data are considered relevant (please see also figure 48 - question 4 from the survey). Aside from weather information, field condition monitoring appears to be most relevant to Austrian farmers, followed by production data, the allocation of resources and localization.

[7] provided from: Linz Center of Mechatronics – Researcher DI(FH), Dr. *Martin Scherhäufl*, Dr. Florian Hammer (2020) and HBLFA Francisco Josephinum (FJ) – Researcher DI.Dr. *Jürgen Karner*, DI *Reinhard Streimelweger* LL.M. (WU), DI *Christian Rechberger* (2020)



Farmers assign a high amount of benefit to the use of tracking systems (GPS, 95 % of the farmers), Mobie-apps (92 %), records for supporting farm business decisions (88 %), satellite data (86 %) and soil samples services (84 %).

In addition, site-specific-focussed applications such as tillage and sowing (81 %), fertilization (79 %) and plant protection (79 %) are considered highly beneficial. The use of drones (70 %) and robots (60 %) have a tendency of being perceived as a benefit rather than a risk.

While, e.g., the initial investment, compatibility issues, data handling and system reliability tend to inhibit the use of Precision Farming, the traceability of the working processes, the facilitation of documents, reduced workload and an improvement of the quality of work are factors that appear to promote its use.

Essentially, the farmers try to keep themselves informed using five channels:

- The Internet,
- fairs,
- magazines,
- discussions with other farmers and
- agricultural associations.

In case of questions, they are consulting suppliers and vendors or the Internet.

In the following describes the analysis of the online questionaire with regard to the strengths, weaknesses, opportunities and threats of employing Precision Farming in Austria's farms.

6.2. Strengths

Summarizing the potential strengths of Precision Farming, Austrian farmers identify an increase of resource efficiency and quality of work (less work intensity and better working quality). The documentation of working processes would be easier and would be traceable. In addition, some working processes could be automated.

6.3. Weaknesses

The weaknesses related to PF are manifold, but there are some major core issues to be improved.

The first issue is about *costs*. The initial investments (incl. upgrades of existing machines) and maintenence costs appear to be too high. Up-to-date, high resolution satellite images that are easily available would be a nice-to-have but do not seem to be affordable.

Another core issue is related to the *compatibility* of the systems of different vendors which appears to be quite small regarding ISOBUS technology and the exchange of data. Easy-to-handle and cost-efficient upgrades for ISOBUS on existing machinery do not seem possible.

The *usability* of the systems appears to be weak and needs to be improved as to enable their use to untrained users. Systems also appear not to be sufficiently *reliable* to the users.

Regarding the topic „data“, security and sovereignity are not clearly defined. Algorithms for data analysis are missing, especially with regard to data from real-time applications.

Field robot technology appears to be still in its infancy and requires high initial investments. Root crops robots that exist on the market do not serve all cultures (missing for organic root crops such as pumpkin, corn and soy), and good and affordable robots that mow below vine stocks are missing as well as proper swarm technologies. Clear legal guidelines are missing for their operation. Drones seem difficult to use for cultivation, fertilization, and targeted plant protection.

Farm Management and Information Systems (FMIS) do not sufficiently provide short-range and remote sensing functionality. When changing the FMIS-provider, the systems lack possibilities for synchronization.

Regionwide soil water measurements and forecast models are missing for different cultures regarding location-specific climate and development. PF Technology is rather economically useful for larger farms than for smaller ones.

6.4. Opportunities

The following applications are perceived by farmers rather as a *benefit/opportunity* than a disadvantage/risk for running their farm:

- Tracking sytems (GPS),
- mobile Apps,
- satellite data,
- soil samples services,
- use of robots and drones,
- site-specific fertilization,
- site-specific tillage and sowing,
- site-specific plant protection,
- adequate irrigation,
- big & smart data management,
- records for the fulfilment of document obligations, and
- records for supporting farm business decisions.

One of the major opportunities --- and challenge for the manufacturers/vendors --- is the costs. Farmers would be willing to use PF technology if the costs would be reduced (84 %). This may especially be important for upgrades of existing gear/machinery.

The willingness to incorporate PF would also be increased, if the products would be more reliable and easier to use (45%). While, generally, more extensive product quality tests may address the first issue, Quality-of-User-Experience tests including naive test users may help increasing system usability and user satisfaction.

Another important opportunity results from the current weakness of products not being compatible with procucts from other manufacturers. If all vendors would cooporate in this respect, the use of PF could significantly be increased.

PF is especially interesting for cash crop and permanent crop plants. Field robots will be very useful for organic farming, as manual workforce will hardly be mobilisable. Moreover, additional functionalities, such as the easy Integration of AMA-GIS-Data or Integration of GPS-data, would provide increased attractivenes of PF to the farmers.

Farm operations theoretically will get economically and ecologically more efficient with increasing use of PF.

In order to establish a broad acceptance of PF, especially the following institutions need to act accordingly:

- 1. Research & Development,
- 2. Industry,
- 3. Political framework (funding, legal framework, etc.).

6.5. Threats

Precision Farming is associated with the following threats/risks.

- Data security and data sovereignty is not regulated.
- PF technology providers obviously do not take into account that their products need to be compatible with those of other vendors and need to be easily usable, especially taking the increasing age of the agricultural works managers into consideration.

- The prices and charges for equipment/gear and services appear not to be affordable for smaller farms/businesses.

This is in fact in line with the trend that the number of full-time farmers is decreasing. While part-time farming is currently increasing, the total amount of farmers will steadily decrease.

D. List of figures