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Regenerative Agriculture. An innovative approach towards mitigation of climate change through multi-tier learning

The REGINA project (No. 2021-1-HU01-KA220-HED-000027629) was funded by the European Commission. The content of this publication does not necessarily reflect the views of the European Commission.

Call 2021, KA2

KA220-HED – Cooperation Partnerships for Higher Education

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REGINA National Report

Hungary

Regenerative agriculture.
An innovative approach towards mitigation
of climate change through multi-tier learning.

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1. Overview of RA uptake and prospects in Hungary

1.1. Introduction

At the moment, there is no available representative national survey or analysis on regenerative agriculture, consequently, it is difficult to show where Hungarian farmers exactly stand regarding this topic. Preferably, it is worth reviewing the situation of agriculture on a whole and its development over the past ten years, which can be seen in detail from the Hungarian Statistical Office (HCSO).

1.2. An overview of the situation of Hungarian agriculture

The present situation of Hungarian agriculture as processed by HCSO (https://www.ksh.hu/docs/hun/xftp/idoszaki/mezo/2020/index.html):

- In June 2020, the country's agricultural land amounted to 4 million 922 thousand hectares, which accounted for almost 53% of the total area of the country. 82% of this was used as arable land, 15% as grassland. Furthermore, vineyards and orchards together covered about 3% of the above-mentioned agricultural area.
- On the basis of the most up-to-date data, in 2021, 293 597 hectares were used for organic farming, which is interesting because it is maybe the closest approximation to the principles and recommendations found in regenerative agriculture. Notwithstanding, it should be noted that the vast majority of these 293 597 hectares, that is, 179 586 hectares are used as grassland, on 91 278 hectares they produce arable crops, the remainder is used as plantations, is fallow land and as green manure areas.
- The number of holdings has fallen by two thirds, down to 234 000 since 2010.
- Two thirds of holdings mainly dealt with crop production, which is a significant change compared to 2010, when the ratio of livestock farming to crop production was 46-41%. In parallel, the proportion of farms with a mixed profile has fallen and specialisation has increased.

- The concentration of holdings has elevated, that is, the amount of land per holding has increased for all types of farming.
- The age of holding leaders has increased because the proportion of farmers under 65 years of age has decreased from 73% down to 65%.
- It can definitely be considered as a positive change that the proportion of farmers possessing agricultural qualifications has increased since 2010. A higher proportion of younger holding leaders have some type of relevant (agricultural) qualifications than older farmers.
- Most farmers do not know or have not thought about what will happen to their farm in the upcoming years. This is particularly interesting in the case of farmers older than 65 years of age since 27% of them only want to run the farm for only 1-5 more years, while 51% of them do not know or have not even thought about how long they will lead their farm. Nonetheless, 9.2% of young farmers also said they would like to hand the leadership of their farm over to somebody else within 5 years.
- The use and application of any digital tools is most widespread among younger leaders. The most commonly used tool related to precision farming is crop health monitoring. 5.3% of the farms use their own equipment or make use of services and the majority of them plan to use it for this purpose.
- 15% of farms employs agricultural consultants, advisors, younger leaders employ them more often than the average (22%).
- The higher the level of qualification in agriculture, the higher the proportion of farmers who seek information from companies and agricultural consultants, advisors.

1.2.1 The role of Hungarian agriculture in the EU

According to the analysis of the HCSO again, the role of Hungarian agriculture in the EU evolved in the past period of time as follows:

According to the preliminary data, Hungary produced 2.1% of the EU's agricultural output in 2020. In 2020, Hungary produced 4.9% of EU’s cereals output and 11% of maize output. Hungary produced 5.8% of the EU's industrial crops output, mainly oilseeds. Our poultry production amounted to 4.4% of the total EU output.

Of the countries with significant output, typically in Central and Eastern European, furthermore, Southern European countries, including Greece, Romania and Hungary have the largest proportion of agriculture in gross value-added production, with a share of over 4%. By contrast, Germany and Belgium it is less than 1%. The fact that Germany and France together give one third of the EU's output clearly indicates the different economic structure as well, however, agriculture makes only a small contribution to the economic performance of these countries.

The volume of agricultural output (at comparable prices) has risen by almost a third overall since 2010. Output from crop production has grown even more, while that of livestock-related activities has grown more moderately. The volume of most of the main crops proved to be significantly higher at the end of the decade; the output of industrial crops, animal feed crops, wine and cereals rose the most. Potato production, on the other hand, declined, falling by a quarter in volume.

Among the main animal and livestock products, the largest increases could be seen in poultry and cattle output, while pig output remained stable during the decade. Egg output fell behind of the output of 2010, and the yearly production stabilized at a lower level.

Regarding international comparisons, domestic labour productivity is one of the lowest among the EU countries with major outputs. The domestic value (€11,000/AWU) is just a little more than half of the average of the 27 Member States, and a quarter of the average of Germany and France. The value of the indicator is influenced by several factors, including the structure of output (intensive or extensive production), the level of inputs or the development of production technologies.

1.3. Stakeholder interviews

We have also interviewed professional agricultural organisations playing a significant role in Hungary in the field of regenerative agriculture. Their answers have shown that, apart from a few nuanced differences, they share the same views on the subject. There were 14 questions in the interviews, taken the most relevant ones and combined with the answers given to them: we get the the following picture of the views of the decision-makers:

Regarding the **awareness of RA** and whether **the farmers** who belong to them **make use of it**, we got the following answer: They know the term, although not nearly as often used as organic farming or (ecologically) sustainable agriculture. Not the same, though partly “synonym” with

these terms or farming systems, they think that the term is not at all that well known in the 'industry public awareness'. We do not have registered members in this sense, but in practice many use its elements.

Their view on **the feasibility of RA**, based on the responses received, is that nothing new like this can be introduced in a sector in the short term. It requires several years of mindset formation. Because of the economic crisis, there is particularly little attention that farmers can pay to this at the moment, since many of them are struggling to survive. But if we want it to be a known concept in 4-5 years' time, furthermore, to be understood and accepted by everyone and we want them to start using it, moreover, to be in general use in 5-10 years' time, we definitely need to start transferring knowledge now.

In addition to training and awareness-raising, support also has an important role. In other words, at least initially, extra support should be given to start using these tools or as many elements of the toolbox as possible. But it is also important that the farmer should understand why he is doing it, and not just that he is getting extra money for it (subsidies can often have this 'thoughts-simplifying' or 'message-destroying' effect). Regenerative agriculture is described in terms of soil health principles, which indirectly affect crop production, productivity and economic efficiency. In many cases, the given methods are site-specific to a particular production area and are not generally adaptable tools.

The **obstacles to the application of RA** are perceived as follows: The ecological production systems which belong to the concept of regenerative agriculture, unambiguously push Hungary’s agriculture towards extensification. The scientific data published on the yield differences of organic production systems compared to conventional systems are quite frightening. If we take into account that in conventional farming, depending on the season, pests cause a 30% yield loss in an average year, this figure can exceed 70% in the absence of reasonable chemical crop protection, and we have not even mentioned other abiotic factors or yield losses due to the absence of fertilisers. Though fertilisation does not put chemicals into the soil that are not already there. It contains the same important nutrients that soil and organic fertilisers provide. So, if applied correctly, fertilisation has minimal chance of polluting the environment. In fact, if they are actually used to make up for soil deficiencies or correct soil deficiencies (correcting nutrient ratios and imbalances, moderating excessive acidity or alkalinity, etc.), they can result in healthier soil, soil life, vegetation, animal and human communities on previously infertile lands. Of course, there are useful and adaptable parts in the

toolbox of regenerative agriculture, which mean soil cover or minimal soil disturbance the no-till and min-till systems.

Regarding **the benefits for the farmers, the environment and the society**, the following opinion was expressed: Since regenerative agriculture involves multidisciplinary parts, it is difficult to assess it as a complex whole. There are benefits, such as improved soil structure in minimum tillage systems, improved soil air-water management and increased soil organic matter but weed control or the use of additional herbicides in no-tillage cover crops cannot be considered as a clear positive effect. The social acceptance of regenerative agriculture is a strongly propagated topic, which is intended to demonstrate the positive aspects of the raw materials produced this way. There are undoubtedly a number of benefits if we look at each of the solutions in the toolbox of regenerative agriculture one by one. Nonetheless, practice and reality are not based on visions and must be treated as a complex whole, with all its advantages and disadvantages. One of the most significant drawbacks is the uncertain production level and yield outcomes. When assessing the benefits, we should approach each practice not only from an environmental perspective, but also from an economic efficiency perspective as well.

We also asked them about **the likelihood of more farmers applying RA**. Respondents believe that some of the elements are already being used by the farmers, which create real added value and are positive for their farming. They reduce crop losses due to weather anomalies and provide them with more efficient production.

However, if we look at all regenerative farming techniques, which are similar to ambitious green measures (organic farming, no use of pesticide, limiting the use of fertilisers), their use leads to reduced yield and losses. In this case, the European Union, including Hungary, will produce less agricultural products, which will mean further losses on international markets. Furthermore, from regions with a typically conventional agriculture, from third countries where production is not subject to restrictions, a lot of food will arrive, often of a quality that does not meet our expectations. These objectives are neither good for the consumers, the society nor for the environment.

We also asked **under what conditions the representatives of the organisations think farmers would start or even try RA farming**. According to them, there are two important keys: (1) knowledge transfer and awareness raising and (2) direct/normative additional supports. They also mentioned that the land structure in our country makes it extremely difficult for farmers to make predictable investments, as a large part of their land is not independent

property. This could be an obstacle to a transition which would bring along machinery replacement or would not give them tangible, physical results or benefits.

As to whether and how they would be willing to **support** such efforts among farmers, they replied that they would support farmers in obtaining professionally sound information from credible sources. The aim is to ensure that economically and ecologically sound, real and evidence-based technologies are presented to their members.

We asked whether they expect the government to provide financial support to farmers for RA. Based on their answers, on the one hand, the government should be asked about this and, on the other hand, the CAP Strategic Plan for 2023-2027 has been prepared and has already been accepted by the EU. There are elements in it that promote and support environmental sustainability. They can be further strengthened (and have to be for the period after 2027), but the framework is already given for 2023-2027.

In terms of RA-related training, organisations either consider that they themselves can and are willing to provide training to farmers or, if they do not have the capacity, they consider that trainers, teachers and professors from secondary and tertiary (college or university) agricultural education institutions are suitable.

We wanted to know their **overall assessment of the chances of RA spreading among Hungarian farmers**. According to respondents:

In the short term (within 5 years) a very modest spreading can be expected. If there is intensive awareness-raising in the next 2-4 years, in 5-10 years it could be a reality that a few or all of the elements of regenerative agriculture will be applied on some tens of percent of the farmland. Some aspects of regenerative agriculture are already being implemented in domestic agricultural practice. However, when evaluating its practices individually, it is possible that the use of certain technological elements and production systems (organic farming, no pesticide use, no fertiliser use) would create serious food supply problems. In addition, the production of less food raw material would set in motion a process that would run against to the whole movement, that is, new areas would have to be taken in to supply the growing population with food of sufficient quantity and quality. It is exactly by intensifying agriculture and using more precise inputs that we can achieve a greater output per unit of land. In this way, we can reduce the taking of natural vegetation (forests, grassland, etc.) into agriculture.

Finally, we also asked whether **they think that RA is an issue that should be decided by the country, whether it should be encouraged or promoted (or not), or whether it is an issue that concerns the EU as a whole and that European policy and action is needed**.

As national and, in particular, agronomic conditions vary in many areas of the EU, it is up to the country concerned to define incentives at national level.

1.4. Conclusion

On the basis of the most up-to-date data, in 2021, 293 597 hectares were used for organic farming, which is interesting because it is maybe the closest approximation to the principles and recommendations found in regenerative agriculture. Notwithstanding, it should be noted that the vast majority of these 293 597 hectares, that is, 179 586 hectares are used as grassland, on 91 278 hectares they produce arable crops, the remainder is used as plantations, is fallow land and as green manure areas.

The volume of agricultural output (at comparable prices) has risen by almost a third overall since 2010. Output from crop production has grown even more, while that of livestock-related activities has grown more moderately. The volume of most of the main crops proved to be significantly higher at the end of the decade; the output of industrial crops, animal feed crops, wine and cereals rose the most. Potato production, on the other hand, declined, falling by a quarter in volume.

The stakeholder's view on the feasibility of RA, based on the responses received, is that nothing new like this can be introduced in a sector in the short term. It requires several years of mindset formation. Because of the economic crisis, there is particularly little attention that farmers can pay to this at the moment, since many of them are struggling to survive. But if we want it to be a known concept in 4-5 years' time, furthermore, to be understood and accepted by everyone and we want them to start using it, moreover, to be in general use in 5-10 years' time, we definitely need to start transferring knowledge now.

In addition to training and awareness-raising, support also has an important role. In other words, at least initially, extra support should be given to start using these tools or as many elements of the toolbox as possible.

The obstacles to the application of RA are perceived as follows: The ecological production systems which belong to the concept of regenerative agriculture, unambiguously push Hungary's agriculture towards extensification. The scientific data published on the yield differences of organic production systems compared to conventional systems are quite frightening. If we take into account that in conventional farming, depending on the season, pests cause a 30% yield loss in an average year, this figure can exceed 70% in the absence of reasonable chemical crop protection, and we have not even mentioned other abiotic factors or yield losses due to the absence of fertilisers. There are benefits, such as improved soil structure in minimum tillage systems, improved soil air-water management and increased soil organic matter but weed control or the use of additional herbicides in no-tillage cover crops cannot be considered as a clear positive effect. The social acceptance of regenerative agriculture is a strongly propagated topic, which is intended to demonstrate the positive aspects of the raw materials produced this way. We also asked under what conditions the representatives of the organisations think farmers would start or even try RA farming. According to them, there are two important keys: (1) knowledge transfer and awareness raising and (2) direct/normative additional supports. In the short term (within 5 years) a very modest spreading can be expected. If there is intensive awareness-raising in the next 2-4 years, in 5-10 years it could be a reality that a few or all of the elements of regenerative agriculture will be applied on some tens of percent of the farmland. Some aspects of regenerative agriculture are already being implemented in domestic agricultural practice. However, when evaluating its practices individually, it is possible that the use of certain technological elements and production systems (organic farming, no pesticide use, no fertiliser use) would create serious food supply problems.

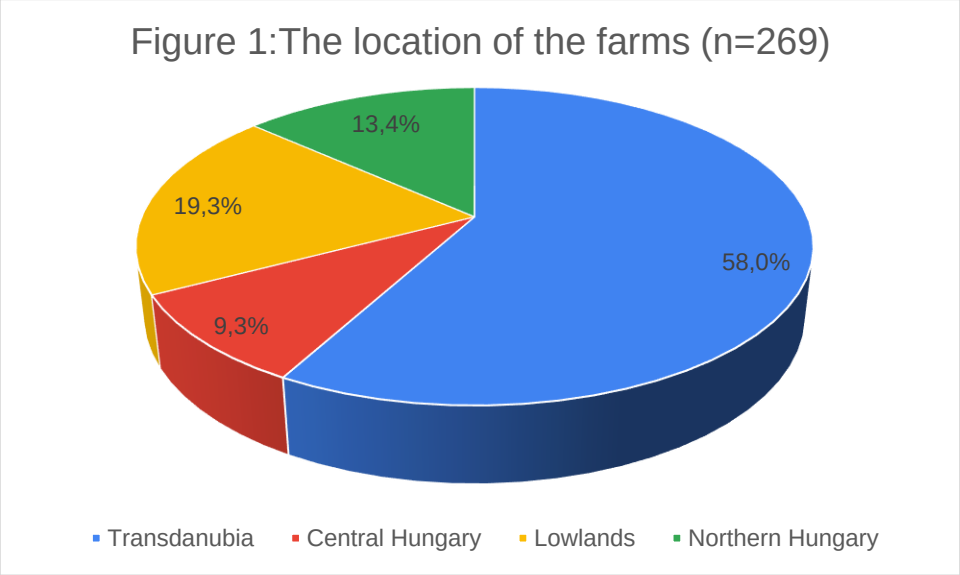
2. The farmers online survay

2.1. Introductin

The survey started with a translation of the internationally standardised English questionnaire into Hungarian. The survey was able to collect data from 269 farmers.

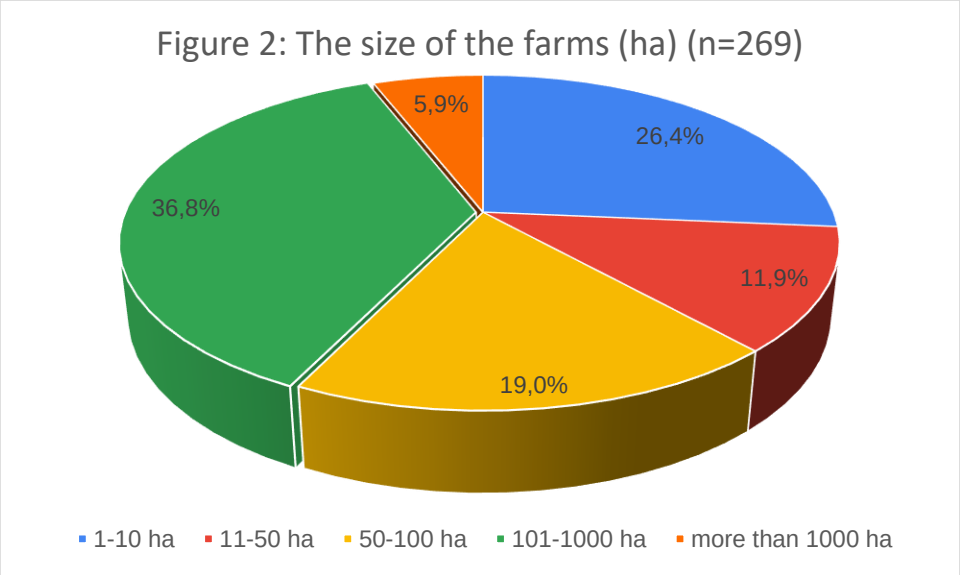
2.2. Evaluation of the questionnaire survey

The survey started with a translation of the internationally standardised English questionnaire into Hungarian. The survey was able to collect data from 269 farmers. Figure 1 shows the agricultural areas in Hungary covered by the survey. More than half of the farmers surveyed are located in the Transdanubian region, while the second largest group (19%) is located in the Great Plain.

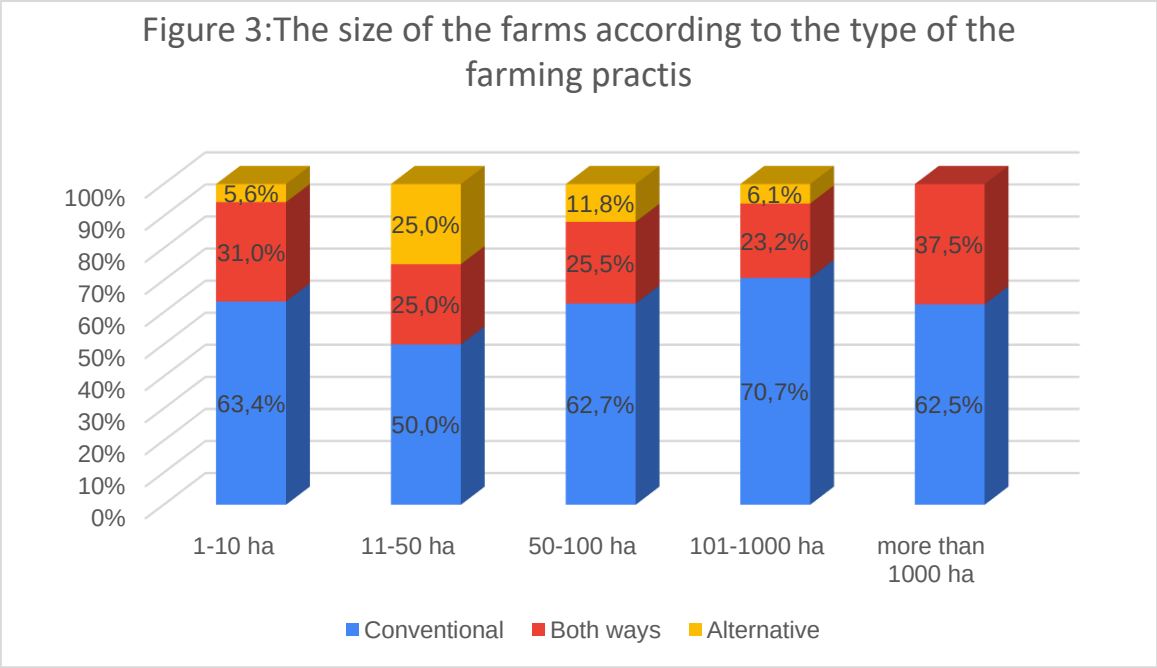


An analysis of the amount of land cultivated by farmers was also included in the study and is illustrated in Figure 2. Farmers with land in all the size categories indicated were included in the data collection. In the primary survey, the largest proportion (36.8%) of farmers with land between 100 and 1,000 ha participated. While farmers with farm sizes between 1 - 10 ha

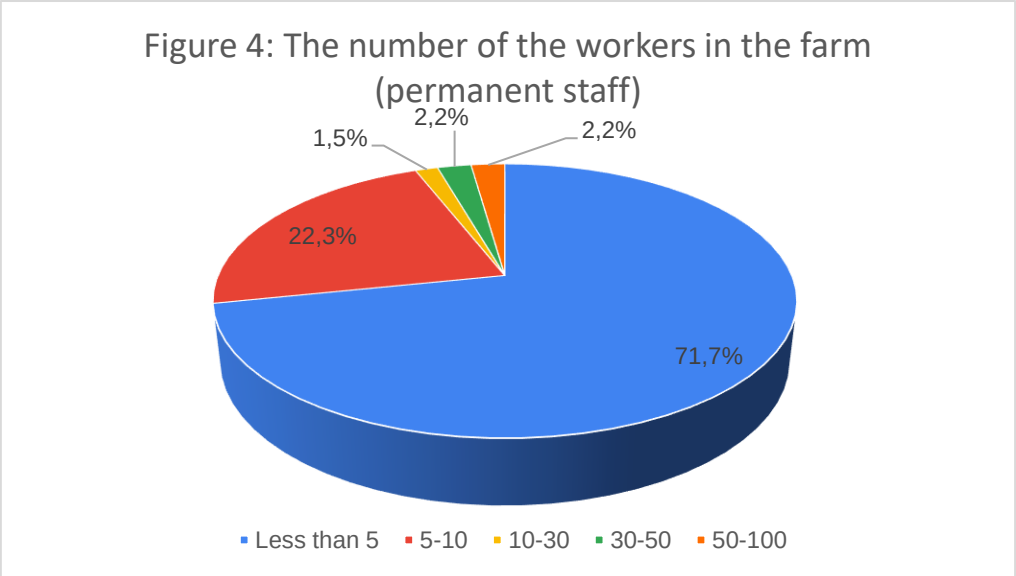
(26.4%) and 50 - 100 ha (19%) completed our questionnaire in almost similar proportions. The lowest number of farmers over 1,000 ha (5.9%) participated.



In the case of the size of area owned by the farms surveyed, it was considered important to examine whether, for each size of area, the owners considered themselves to be conventional, alternative or both (Figure 3).As almost two thirds of the total population surveyed said they considered themselves to be conventional, this response option dominated the breakdown by size of area, but not equally so. Farms between 11 - 50 ha had the lowest proportion of conventional responses (50%), while for other sizes the proportion was over 60%. The proportion of alternative producers was almost equally low for farms between 1 - 10 ha and 101 - 1000 ha, and the highest proportion was found for farms between 11 - 50 ha in size. The highest proportion of farms using both technologies is for farms of 1000 ha and above (37.5%), followed by the smallest size category (31%). The proportion of farms using both farming technologies is almost similar for farms between 11 - 50 ha (25%), and between 50 - 100 ha (25.5%) and 101 - 1000 ha (23.2%).

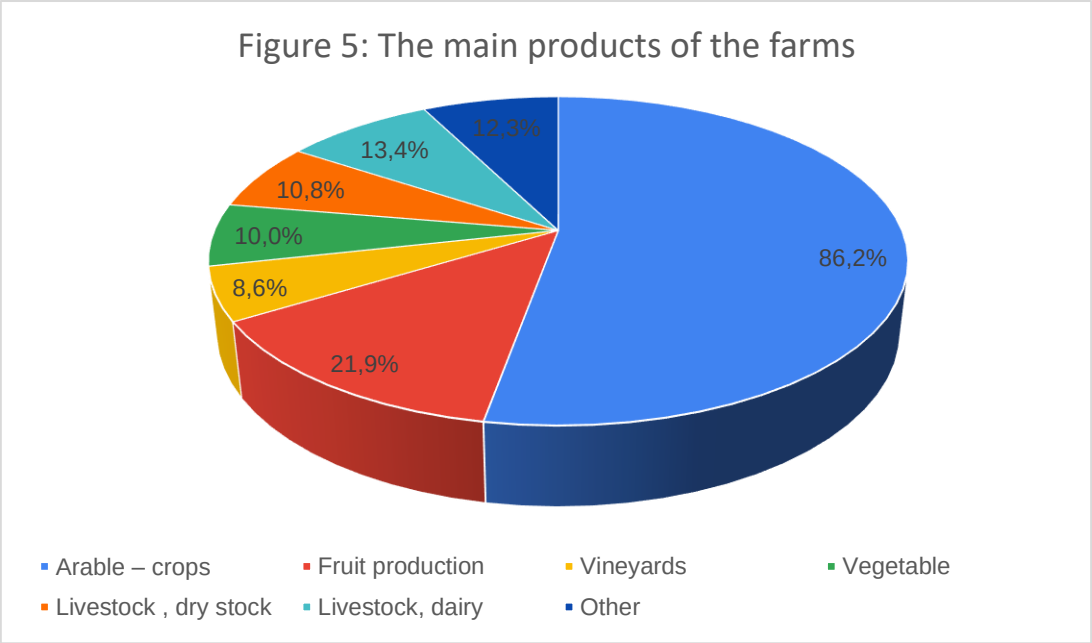


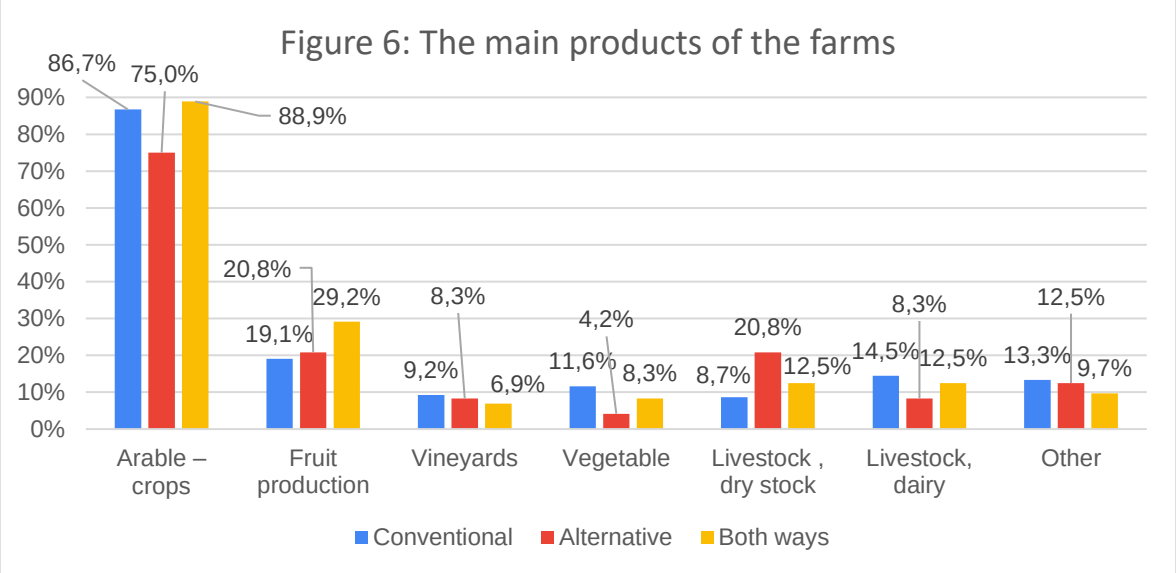
After recording the size of the farms, the questionnaire also asked for the number of persons employed (Figure 4). More than two thirds of the farms surveyed had less than 5 persons regularly employed. The proportion of holdings with between 5 and 10 employees is 22.3%, while only 5.9% of the farmers surveyed with more than 1 000 ha of land have more than 5 000 regular employees. Farms with a surface area of 1 to 10 ha and 11 to 50 ha have only less than 5 employees, while farms with a surface area of 51 to 100 ha have half the number of employees with less than 5 employees and half the number of employees with 5 to 10 employees. This ratio shifts towards farms with less than 5 employees for farms between 101 and 1000 ha, which represents two thirds of the farms in this category.



The next question of the questionnaire was to record the main activity of the holding, where all of the given answer options could be selected, including the other option (Figure 5). This resulted in 136 respondents indicating one main activity, while 133 farms were found to be engaged in more than one, up to 3 or 4 activities. For the whole population surveyed, it can be observed that the majority of agricultural holdings (86.2%) have arable crops as their main activity. The second activity, indicated by the largest number of farmers, is fruit growing, which was indicated for 59 farms, representing one fifth of the holdings surveyed. Grape growing (8.6%) was the least popular activity, and the other options, such as vegetable growing (10%), dairy (13.4%), meat (10.8%) and other (12.3%) were mentioned by almost the same proportion of producers.

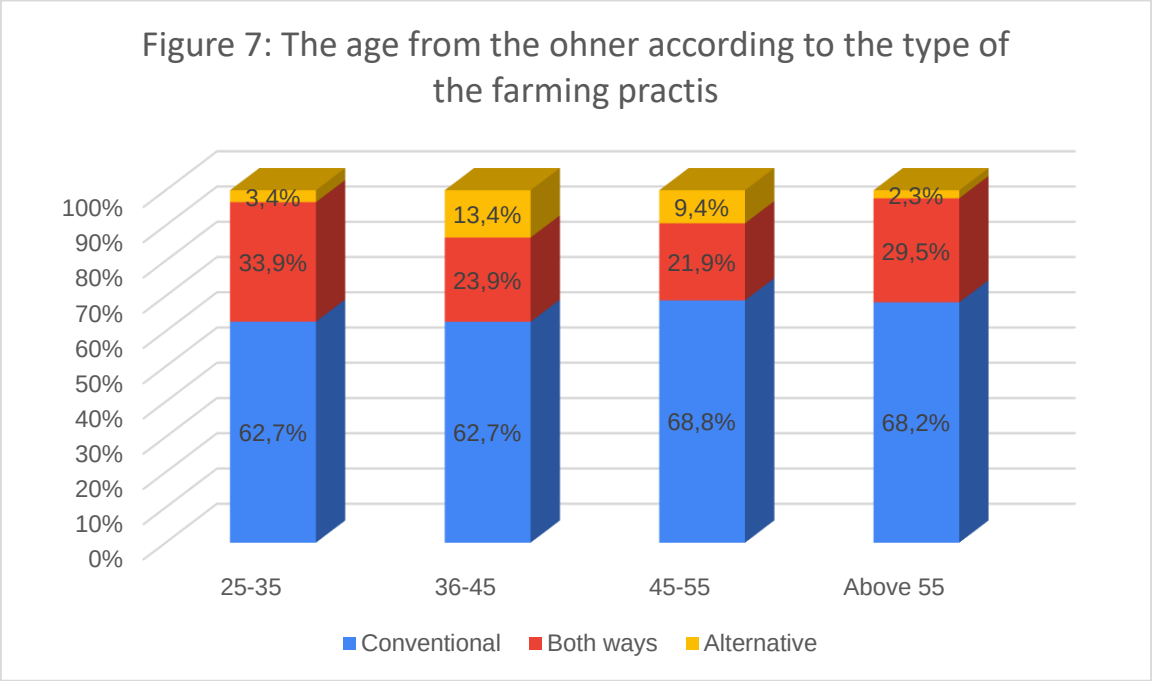
If we further analyse the main activity of the farms in terms of farming type (Figure 6), we find that arable crop production is mostly practised by farmers who either have the characteristics of conventional or both types of production. Fruit growing is more likely to be practised by farms with characteristics of both types of production. There is a further difference between producers in the case of meat livestock, where the proportion of alternative farmers is almost double that of conventional farmers and those combining both types. In the case of vegetable production, it can be observed that the farms using alternative technologies are the least involved in this sector in the surveyed population. No significant differences were found for the other factors studied: vines, dairy farming, other.





Keeping in mind the objective of the study, we compared the age of the grower and the cultivation technology used on the farms, the results of which are presented in Figure 7. Our hypothesis was that younger farmers might be more open and interested in alternative technologies. The results suggest that this is not entirely the case for the population studied, with the youngest farmers aged 25-35 (3.4%) and the oldest farmers aged 55+ (2.3%) having the lowest rates of adoption of alternative technologies. However, this hypothesis proved to be

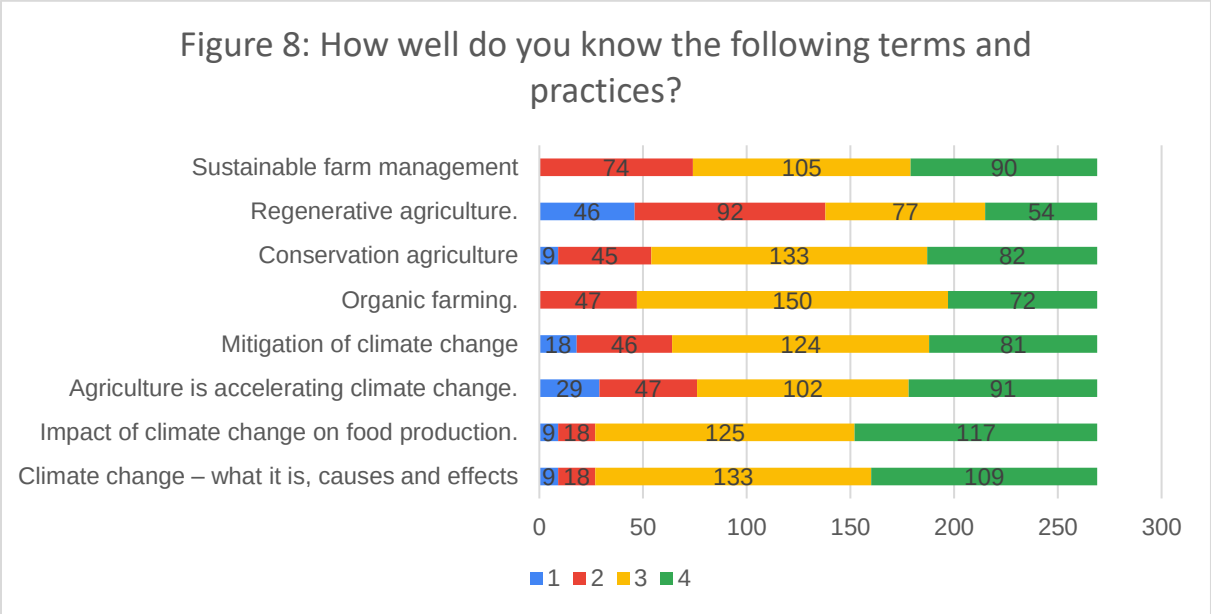
true for farms with characteristics of both types of farming, as the youngest holders, i.e. aged between 25 and 35, had the highest rate (33.9%).



In the next question of the questionnaire, question 8, we asked whether the farmers surveyed had heard about the impact of agricultural production on climate and climate change. For each topic, respondents were asked to rate their views on a scale of 1 to 4, with 1 being never heard of it and 4 feeling very knowledgeable on the topic. Figure 8 shows the aggregated results of the responses of the whole survey population for a total of 8 questions on the following topics:

- Climate change – what it is, causes and effects
- Impact of climate change on food production.
- Agriculture is accelerating climate change.
- Mitigation of climate change
- Organic farming.
- Conservation agriculture
- Regenerative agriculture.
- Sustainable farm management

With the exception of regenerative agriculture, almost two thirds of respondents ticked between 3 and 4, i.e. they feel moderately or fully informed on these topics. Full knowledge (4) was found for the topics "Climate change - what causes it and what are its effects" (109 respondents) and "Impact of climate change on food production" (117 respondents). Regenerative agriculture" is the topic where respondents feel the least informed. Less than half of the farmers feel moderately or more informed on this topic, with 46 saying they have never heard of it, while 92 respondents feel they have only a little knowledge about regenerative agriculture.



It was considered interesting to investigate whether there is a difference in the level of information among owners of farms using different production technologies - conventional, alternative, both. Therefore, we examined the mean (Figure 9), the standard deviation (Figure 10) and the most frequent value, i.e. the mode (Table 1), of the responses filtered by the total population and the three production technologies. Analysing the mean of the responses, it can be said that there is no significant difference between the responses for the whole population and those for each type of cultivation. However, when analysing the variance of the answers, i.e. their uniformity, some differences can be observed, with the exception of "Climate change - what is the cause and what are the effects", "Climate change impacts on food production" and "Agriculture accelerates climate change". In the topics of mitigation options, organic farming, and conservation tillage, the variance in responses from alternative farmers exceeded the total number of respondents. Farmers combining the two farming technologies were more consistent

than the overall population for almost all questions, but this difference in consistency was most pronounced for the topics "Organic farming", "Soil conservation tillage", "Regenerative agriculture" and "Sustainable farming" (Figure 10).

Figure 9: Average of the responses

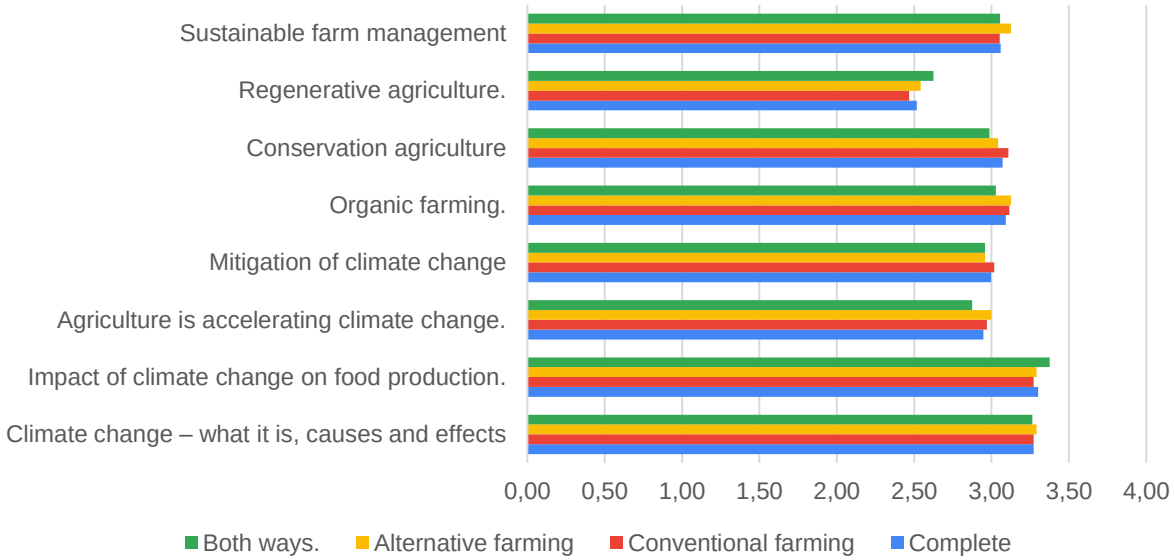


Figure 10: Standard deviation of the responses

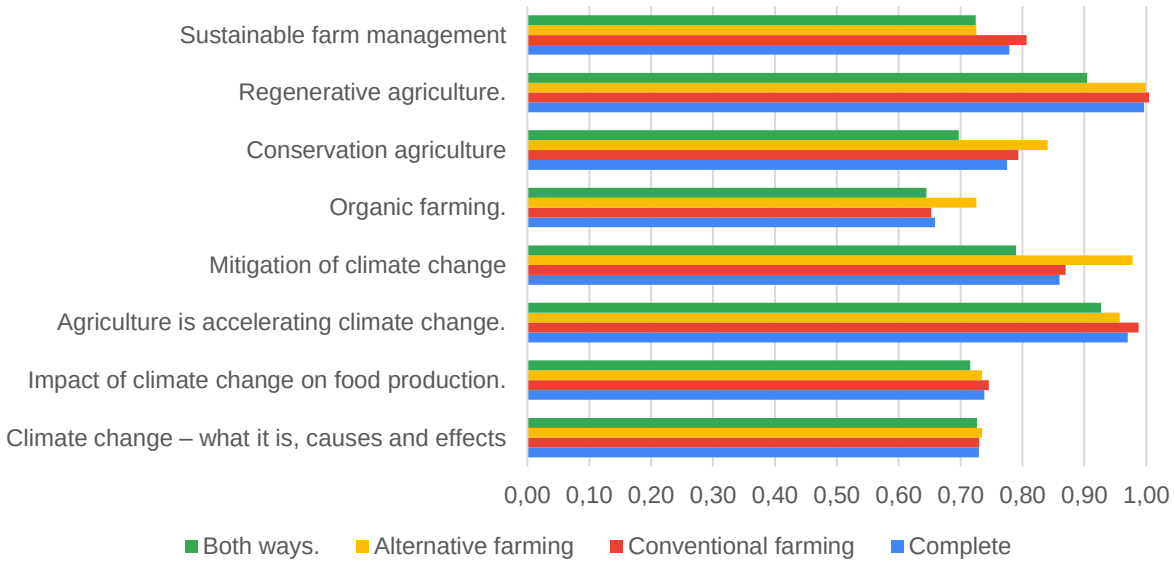


Table 1 shows the numerical values for the most common responses. These show that farmers combining both types of farming are the most informed for "Impact of climate change on food production" and "Regenerative agriculture". For "Agriculture is accelerating climate change", alternative farmers feel the most informed, while for "Sustainable farm management", conventional farmers feel the most informed.

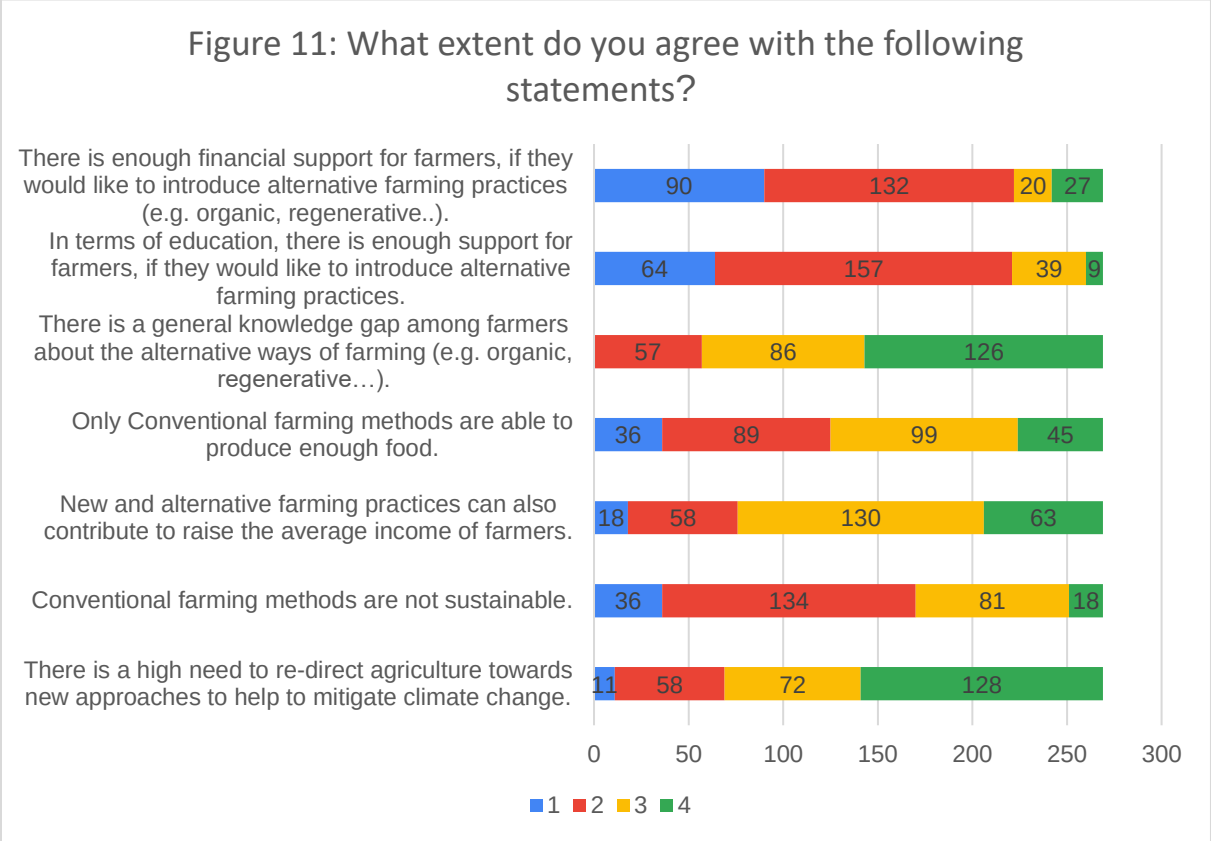
Table 1: Mode of the responses

	Mode			
	Complete	***Conventional farming***	***Alternative farming***	***Both ways.***
Climate change – what it is, causes and effects	3	3	3	3
Impact of climate change on food production	3	3	3	**4**
Agriculture is accelerating climate change	3	3	**4**	3
Mitigation of climate change	3	3	3	3
Organic farming	3	3	3	3
Conservation agriculture	3	3	3	3
Regenerative agriculture	2	2	2	**3**
Sustainable farm management	3	**4**	3	3

Next, we wanted to assess the extent to which respondents agree with the statements listed. For each topic, respondents were asked to rate their opinion on a scale of 1 to 4, with 1 being strongly disagree and 4 being strongly agree. Figure 11 shows the aggregated results of the responses of the whole survey population for a total of 7 questions on the following topics:

- There is a high need to re-direct agriculture towards new approaches to help to mitigate climate change.
- Conventional farming methods are not sustainable.
- New and alternative farming practices can also contribute to raise the average income of farmers.
- Only Conventional farming methods are able to produce enough food.
- There is a general knowledge gap among farmers about the alternative ways of farming (e.g. organic, regenerative…).

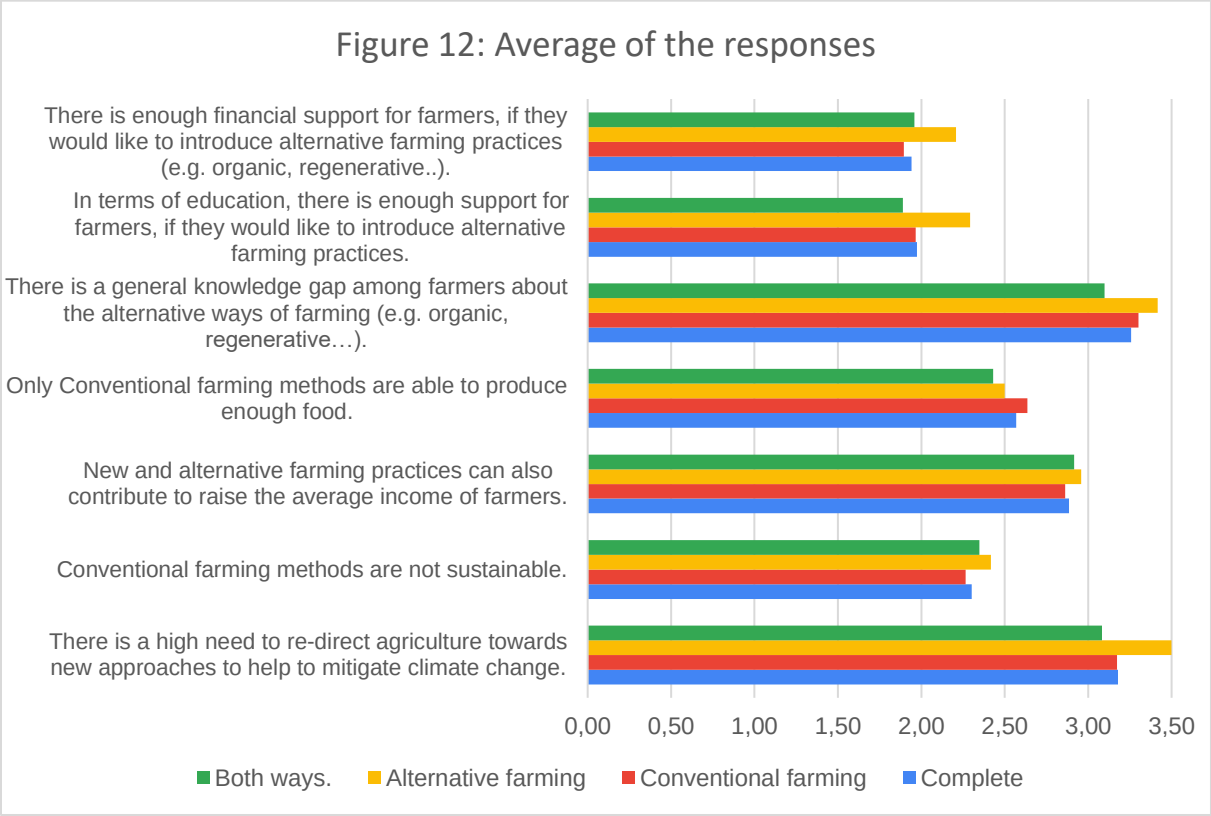
- In terms of education, there is enough support for farmers, if they would like to introduce alternative farming practices.
- There is enough financial support for farmers, if they would like to introduce alternative farming practices (e.g. organic, regenerative..).



Calculating the average value of the answers received for each topic, it can be established that "In terms of education, there is enough support for farmers, if they would like to introduce alternative farming practices" (1.97) and "There is enough financial support for farmers , if they would like to introduce alternative farming practices (e.g. The most important ones are "There is a general knowledge gap among farmers about the alternative ways of farming" (3.26) and "There is a high need to re-direct agriculture towards new approaches to help to mitigate climate change" (3.18) were able to agree with the findings.

As before, we examined whether there were any differences in the opinions of the owners of plants using different - conventional, alternative, or both - production technologies. Therefore, we examined the average (Figure 12), standard deviation (Figure 13) and the most common value (Table 2) of the responses filtered on the basis of the entire population and the three production technologies. Analyzing the averages, it can be concluded that "Only conventional

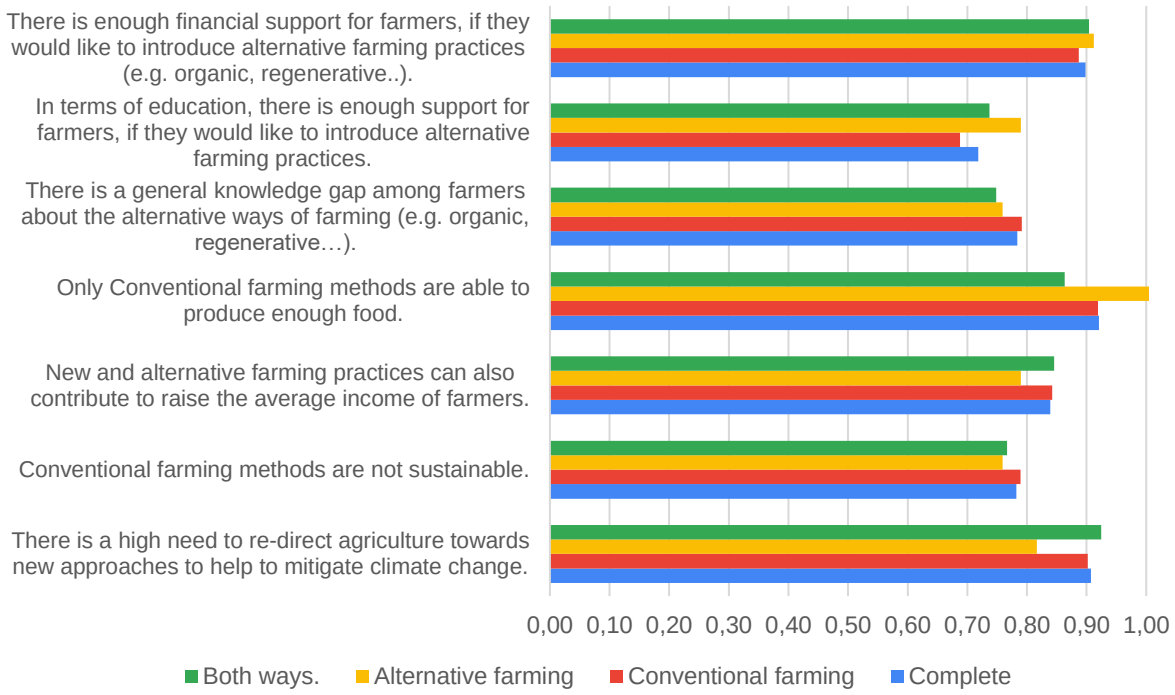
farming methods are able to produce enough food." with the exception of all the other topics raised, those practicing alternative farming agree the most.



The consistency of responses is demonstrated by analysing the comparison of variances.

The unanimity of responses is demonstrated by analyzing the comparison of standard deviations.

Figure 13: Standard deviation of the responses

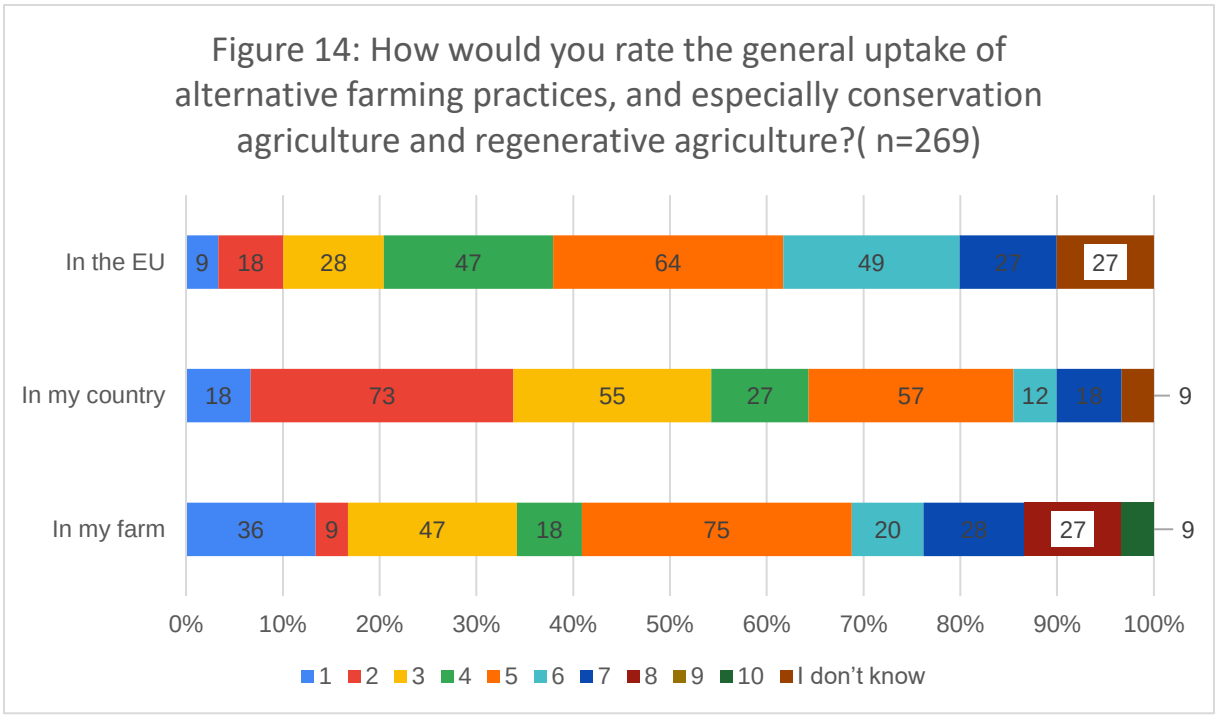


The responses of alternative farmers are the most consistent, for 6 statements, both in relation to the total population and in relation to the other two forms of production. However, for these two statements, "In terms of education, there is enough support for farmers, if they would like to introduce alternative farming practices.." and "Only Conventional farming methods are able to produce enough food", alternative farmers are the least in agreement. When analysing the most frequent responses, no differences were found after grouping by farming technology, except in two cases. The statement "Only Conventional farming methods are able to produce enough food" was less agreed by alternative farmers than the other groups. The statement "There is a general knowledge gap among farmers about the alternative ways of farming" was less agreed with by the owners of farms combining both farming technologies.

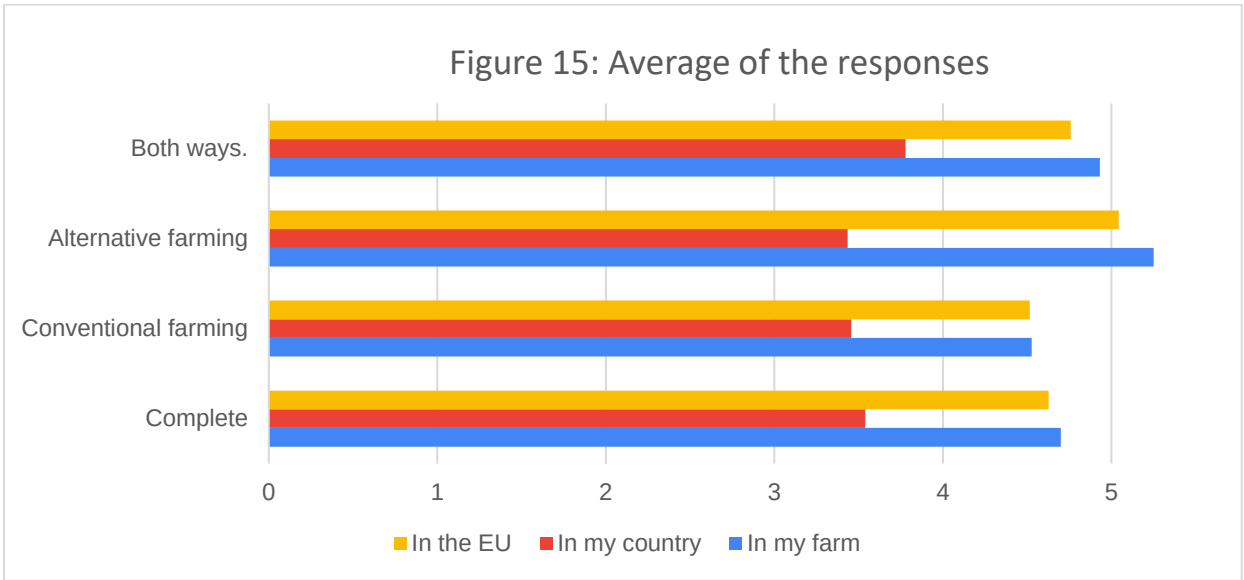
Table 2: Mode of the responses

	Mode			
	Complete	***Conventional farming***	***Alternative farming***	***Both ways***
There is a high need to re-direct agriculture towards new approaches to help to mitigate climate change.	4	4	4	4
Conventional farming methods are not sustainable.	2	2	2	2
New and alternative farming practices can also contribute to raise the average income of farmers.	3	3	3	3
Only Conventional farming methods are able to produce enough food.	3	3	**2**	3
There is a general knowledge gap among farmers about the alternative ways of farming (e.g. organic, regenerative…).	4	4	4	**3**
In terms of education, there is enough support for farmers, if they would like to introduce alternative farming practices.	2	2	2	2
There is enough financial support for farmers, if they would like to introduce alternative farming practices (e.g. organic, regenerative..).	2	2	2	2

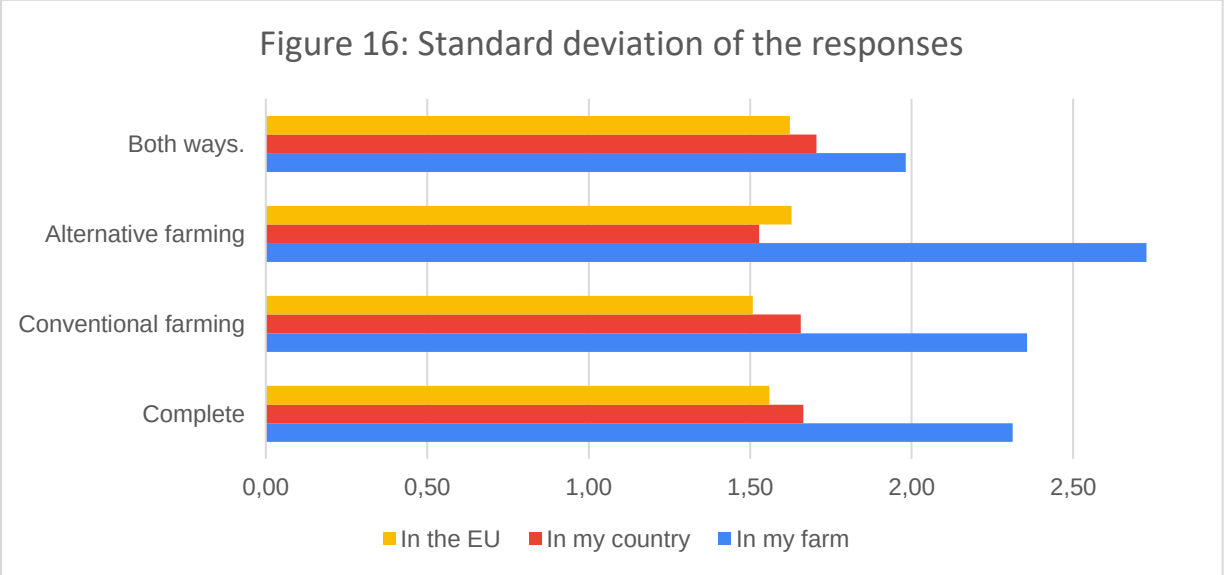
The next question asked respondents to rate the uptake of alternative farming practices in their own economy, in their home country and globally in the European Union (Figure 14). Their answers were given on a scale of 1 to 10, with 1 being not at all widespread and 10 being very widespread. In this case, the scoring method used for previous similar questions was applied and the mean, standard deviation and mode of the responses were compared. Figure 14 shows the responses of the whole population, showing that 27-27 respondents could not assess the situation with regard to the EU and their own economy, while only 9 respondents had difficulties in the case of Hungary.



Domestic farmers have similar perceptions of the uptake of alternative farming practices in all 3 areas surveyed, regardless of the type of production. They consider the uptake of alternative farming practices to be medium both at EU level (4.52 - 5.04) and on their own farm (4.53 - 5.25). However, they consider its uptake in Hungary to be less favourable (3.43 - 3.78).



In terms of consistency of opinion, the largest difference from the average is for the perception of the farm, while the responses for the domestic and EU farms show a much more consistent picture.



When filtering out the most frequent answers, it can be seen (Table 3) that no differences were found for each type of farming for both own farm and EU. For the EU responses, it can be observed that alternative farmers and farmers who combine the characteristics of both types of production are more favourable to the uptake of alternative farming practices compared to both conventional farmers and the overall population.

Table 3: Mode of the responses

	Mode			
	Complete	***Conventional farming***	***Alternative farming***	***Both ways.***
In my farm	5	5	5	5
In my country	2	2	2	2
In the EU	5	5	**6**	**6**

Question 11 asked respondents to indicate which of the 7 techniques/practices listed they know or use:

- Reducing or eliminating mechanical interventions in the soil
- Keeping the upper part of the soil overgrown with vegetation
- Increasing plant biodiversity
- Keeping the roots alive in the soil throughout the year
- Include livestock in farmland to fertilize the soil
- Increasing organic matter in the soil
- Implementing habitat conservation techniques e.g Preserving hedgerows, leaving field margins to grow (17. ábra).

The most frequently selected response option for techniques already in use was "Increasing plant biodiversity" (156 people), followed by "Reducing or eliminating mechanical interventions in the soil" (126 people) and "Implementing habitat conservation techniques" (101 people). Most farmers feel well informed about "Include livestock in farmland to fertilise the soil" (96 people). The highest number of farmers reporting a lack of knowledge (47) was for the second most used practice "Reducing or eliminating mechanical interventions in the soil". Among the techniques planned to be introduced, "Keeping the upper part of the soil overgrown with vegetation" was the one mentioned by the most respondents (108).

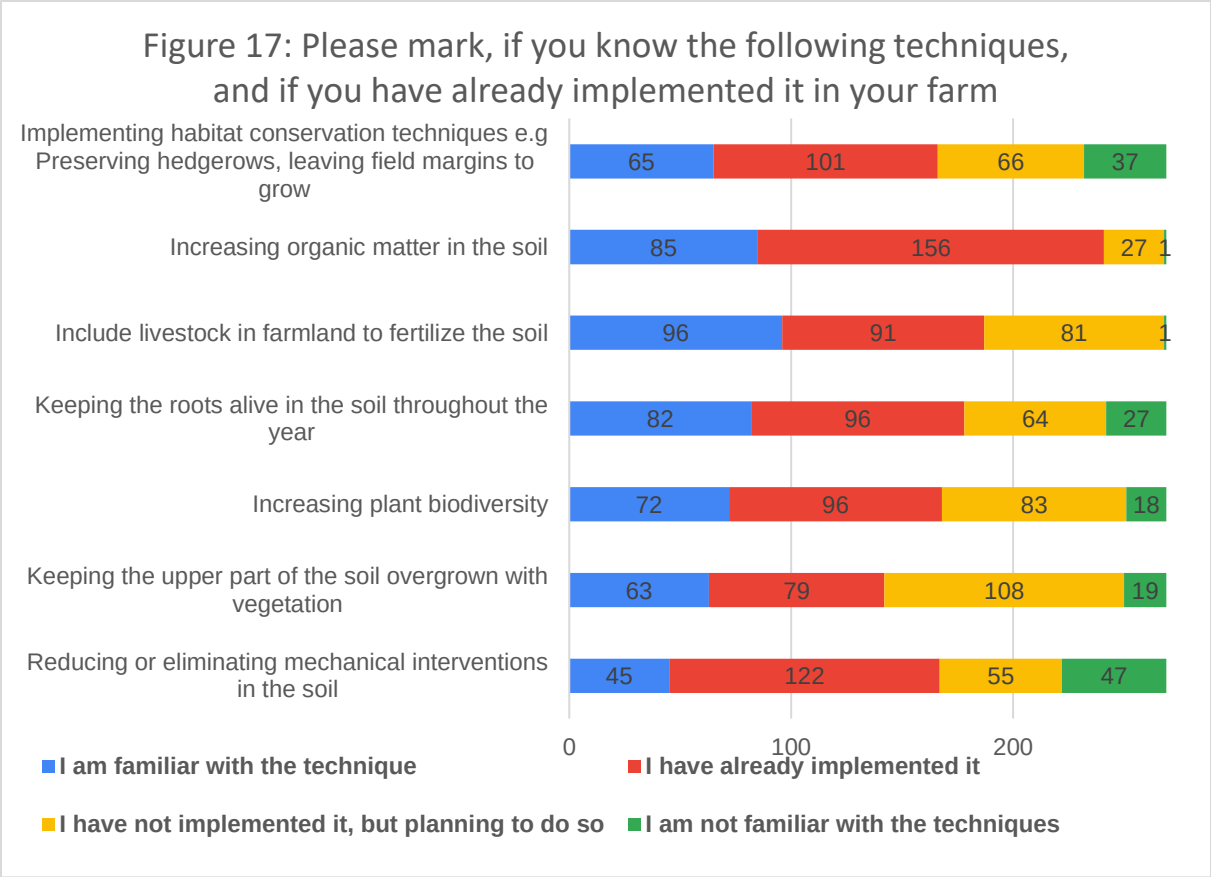


Figure 18 shows the responses for the techniques/practices listed, grouped by the production method used. In the category "I know the technique well", the highest proportion of responses for both conventional and alternative farmers is "Include livestock in farmland to fertilise the soil", while the highest proportion of responses for both production techniques are "Increasing organic matter in the soil" and "Implementing habitat conservation techniques e.g. Preserving hedgerows, leaving field margins to grow". In the "I already use, I use" category, "Increasing organic matter in the soil" is the most common for all three production technologies. In the I plan to introduce category, there were also unanimous responses in all three categories, with the response "Keeping the upper part of the soil overgrown with vegetation". In the do not know group, the highest response rates were found for both conventional and alternative farmers for "Reducing or eliminating mechanical interventions in the soil" and for "Keeping the roots alive in the soil throughout the year" for both production technologies.

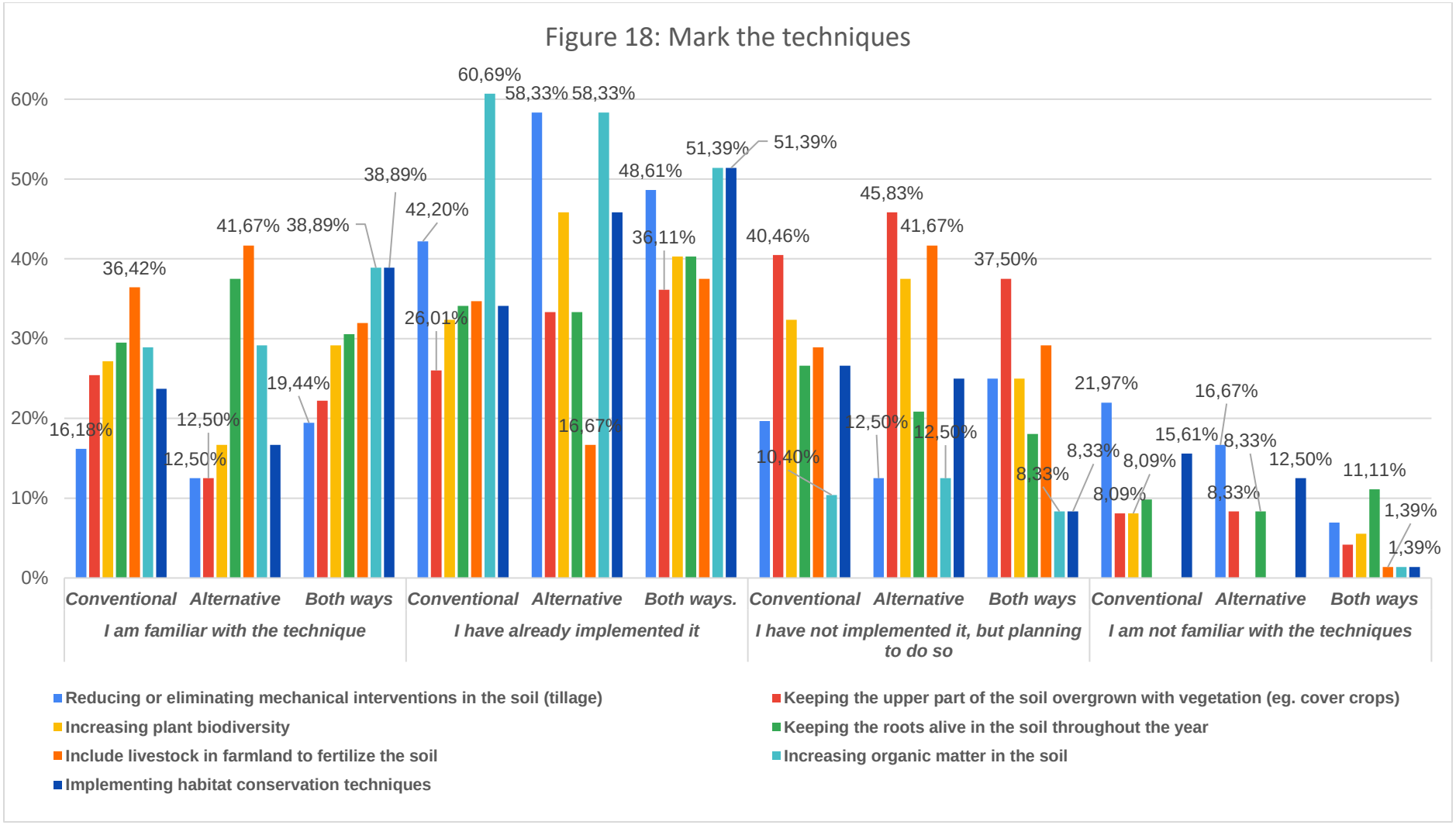
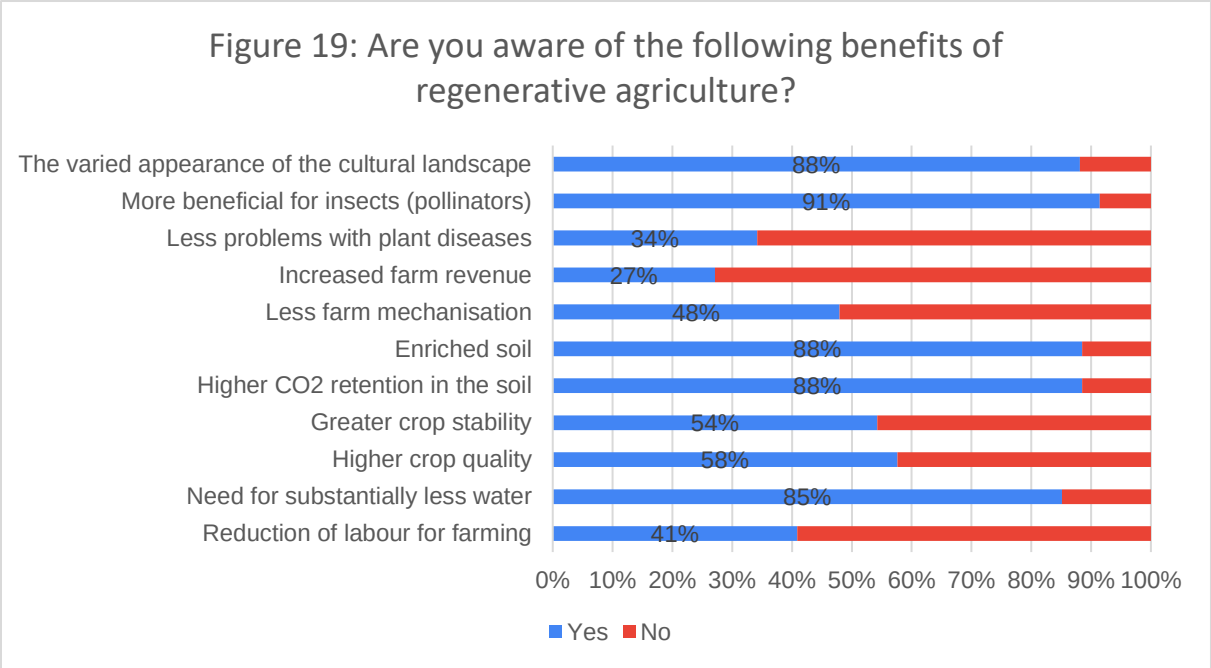
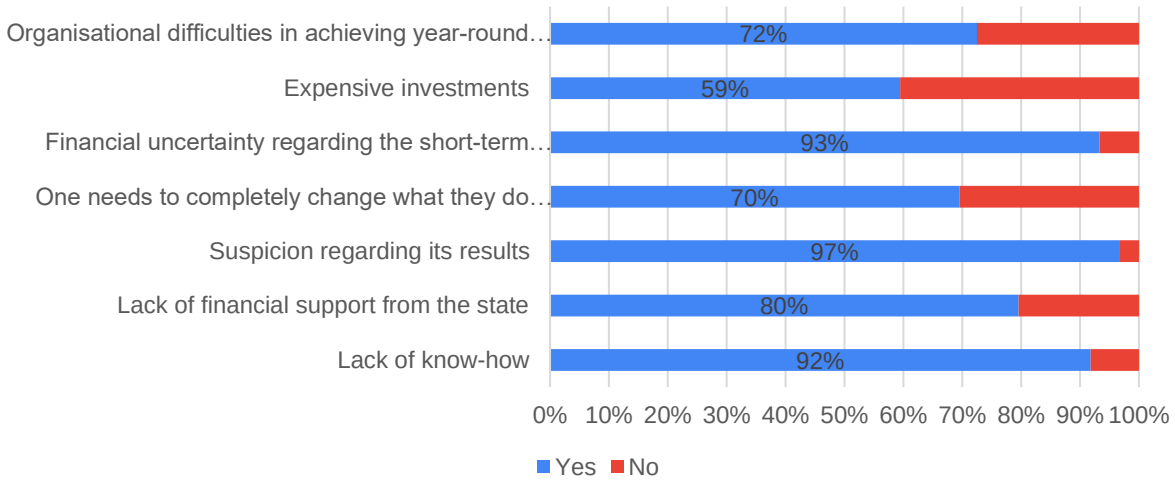


Figure 18: Mark the techniques
60%
50%
40%
30%
20%
10%
0%
16,18%
36,42%
12,50%
12,50%
41,67%
38,89%
19,44%
38,89%
42,20%
26,01%
60,69%
58,33%
16,67%
58,33%
48,61%
36,11%
51,39%
51,39%
40,46%
10,40%
12,50%
45,83%
41,67%
12,50%
37,50%
8,33%
21,97%
8,33%
8,09%
8,09%
15,61%
16,67%
8,33%
8,33%
12,50%
11,11%
1,39%
1,39%
Conventional
Alternative
Both ways
Conventional
Alternative
Both ways.
Conventional
Alternative
Both ways
Conventional
Alternative
Both ways
I am familiar with the technique
I have already implemented it
I have not implemented it, but planning to do so
I am not familiar with the techniques
Reducing or eliminating mechanical interventions in the soil (tillage)
Keeping the upper part of the soil overgrown with vegetation (eg. cover crops)
Increasing plant biodiversity
Keeping the roots alive in the soil throughout the year
Include livestock in farmland to fertilize the soil
Increasing organic matter in the soil
Implementing habitat conservation techniques



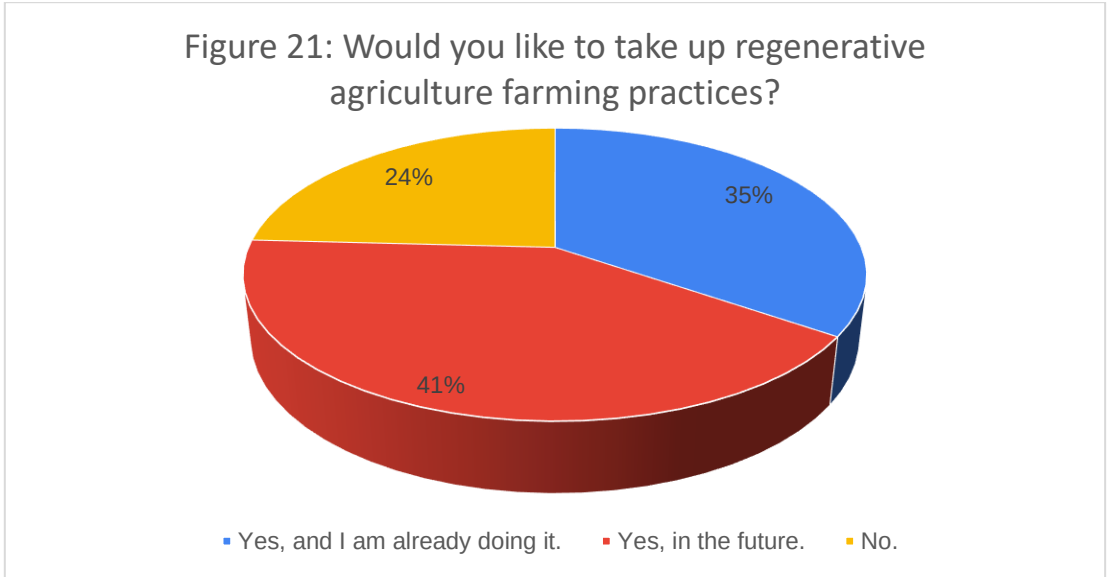
The next question in the questionnaire asked farmers whether they were aware of the benefits of regenerative agriculture (Figure 19). The most frequently identified benefits were "More beneficial for insects (246), "Higher CO2 retention in the soil" and "Enriched soil" (238 - 238), "The varied appearance of the cultural landscape" (237) and "Need for substantially less water" (229). The least identified potential positive benefits of regenerative agriculture were "Increased farm revenue" (73 people) and "Less problems with plant diseases" (92 people). After listing the benefits, the factors that hinder the adoption of regenerative agriculture were identified (Figure 20). 97% of farmers are sceptical about regenerative agriculture due to "Suspicion regarding its results", 251 farmers are concerned about "Financial uncertainty regarding the short-term future" and 247 farmers feel that this form of production is problematic due to "Lack of know-how". Lack of financial support from the state" is also a concern for a significant proportion of respondents (80%). Expensive investments" is the least worrying (59%).

Figure 20: What do you consider the main obstacles for taking up regenerative agriculture?

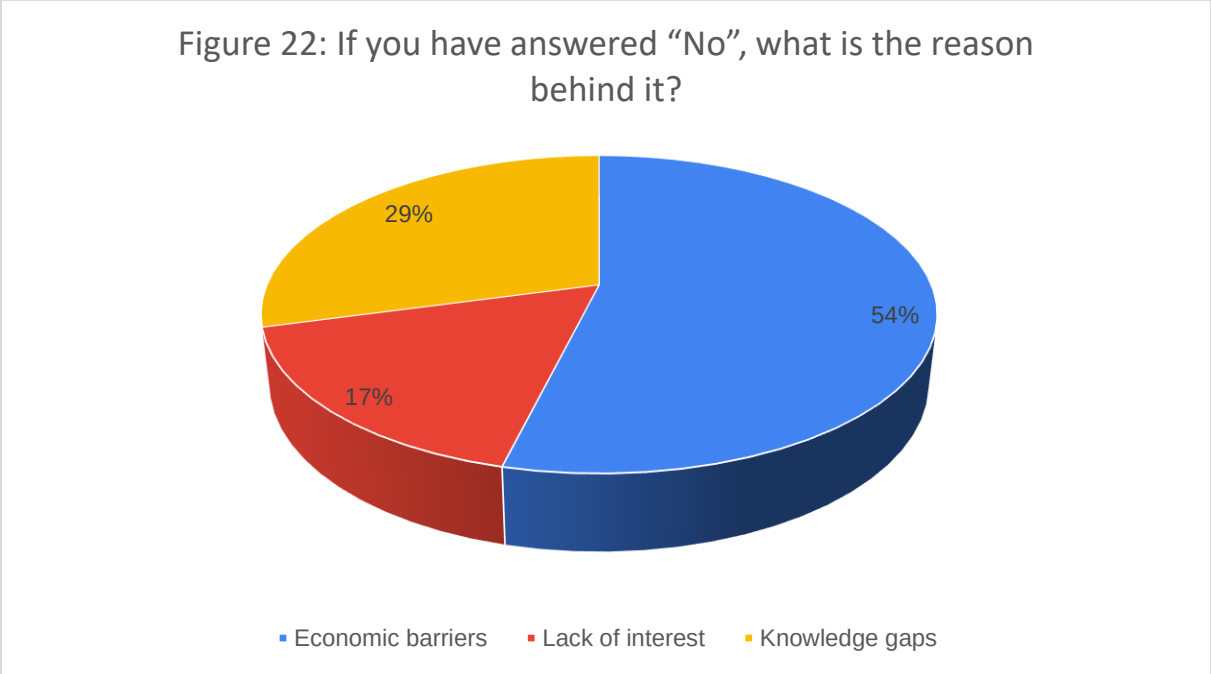


After clarifying the benefits of and concerns about regenerative farming, respondents were asked whether they would like to adopt this production technique (Figure 21). A quarter of the total surveyed population were not interested in adopting this technique, 35% said they were already adopting it and 41% were considering it. A mapping of the reasons for the negative responses is presented below in Figure 22.

Figure 21: Would you like to take up regenerative agriculture farming practices?



Of the 5 reasons listed, more than half of the respondents cited "Economic barriers" as a concern, 29% were concerned about "Knowledge gaps" and the rest cited "Lack of interest" as a reason for not adopting regenerative farming practices at all.

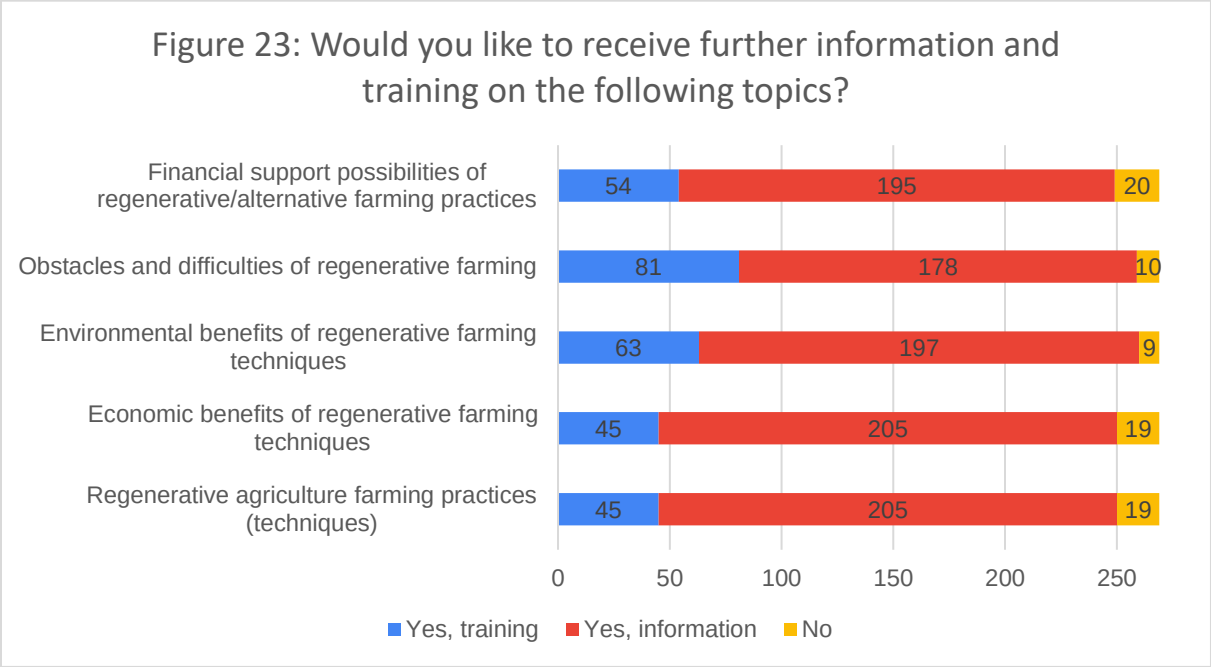


Question 16 asked whether farmers would like to receive further information or possibly receive training on the topics listed in relation to regenerative agriculture practices (Figure 23):

- Regenerative agriculture farming practices (techniques)
- Economic benefits of regenerative farming techniques
- Environmental benefits of regenerative farming techniques
- Obstacles and difficulties of regenerative farming
- Financial support possibilities of regenerative/alternative farming practices in the region..

The percentage of those who refuse to receive further information and to participate in the training is generally below 10%. The lowest rate (3%) is for the topic "Environmental benefits of regenerative farming techniques". For all the topics concerned, more than two thirds of the respondents would be interested in additional information, and for the questions "Regenerative

agricultural farming practices (techniques)" and "Economic benefits of regenerative farming techniques" the percentage of farmers interested is above 75%.



The last closed question of the questionnaire asked for respondents' opinions on measures to promote the adoption of regenerative agricultural practices, on a scale of 1 to 4. A 1 would not increase the likelihood of RA adoption at all and a 4 would increase it a lot. The following factors were rated by farmers:

- More financial support from government or EU,
- More opportunities for training and technical support,
- Good practice sharing among farmers, network,
- Knowledge: lectures, workshops, demonstrations, instructions.

The responses are illustrated in Figure 24, where it can be seen that the factor "More financial support from government or EU" has the highest percentage of responses (72.5%) that would increase a lot. When looking at the average of the responses across the whole population, the average of the responses for the 4 factors examined shows only a slight difference.

More financial support from government or EU: **3,05**

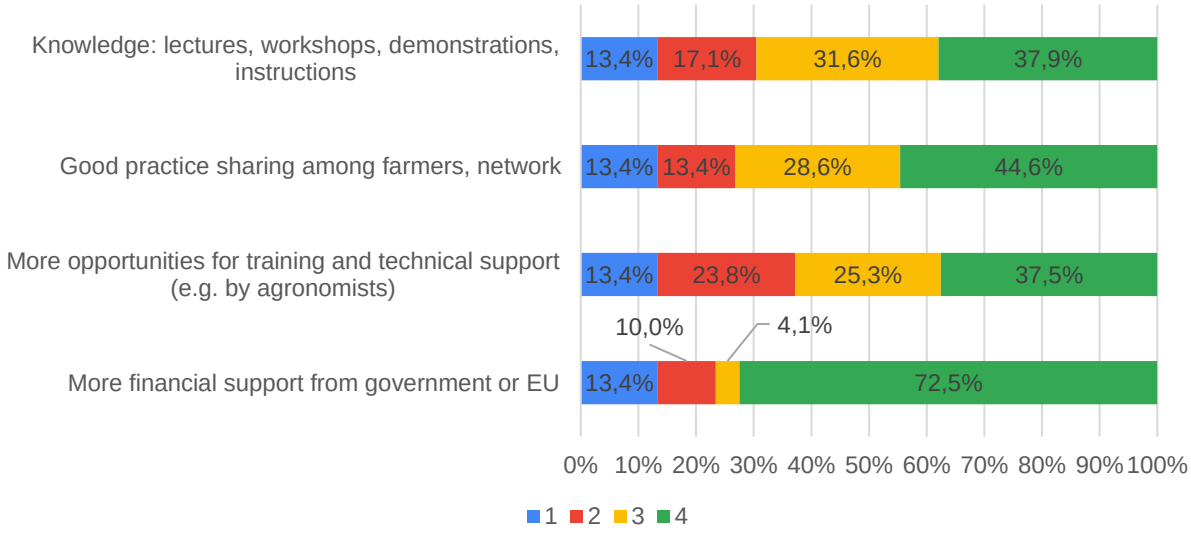
More opportunities for training and technical support: **2,87**

Good practice sharing among farmers, network: **3,04**

Knowledge: lectures, workshops, demonstrations, instructions: **2,94**

However, if it is necessary to prioritise, the factors "More financial support from government or EU" and "Good practice sharing among farmers, network" are considered by the farmers surveyed as the most important for the spread of regenerative agricultural practices.

Figure 24: Which of the following factors could enhance the uptake of regenerative agriculture practices in your farm?



2.3. Conclusion

In the primary survey, the largest proportion (36.8%) of farmers with land between 100 and 1,000 ha participated. The lowest number of farmers over 1,000 ha (5.9%) participated.

As almost two thirds of the total population surveyed said they considered themselves to be conventional.

Farms between 11 - 50 ha had the lowest proportion of conventional responses (50%), while for other sizes the proportion was over 60%. Farms between 11 - 50 ha had the lowest proportion of conventional responses (50%), while for other sizes the proportion was over 60%. The highest proportion alternative producers was found for farms between 11 - 50 ha in size. The highest proportion of farms using both technologies is for farms of 1000 ha and above (37.5%). More than two thirds of the farms surveyed had less than 5 persons regularly employed. The proportion of holdings with between 5 and 10 employees is 22.3%.

The next question of the questionnaire was to record the main activity of the holding. This resulted in 136 respondents indicating one main activity, while 133 farms were found to be engaged in more than one, up to 3 or 4 activities. It can be observed that the majority of agricultural holdings (86.2%) have arable crops as their main activity. That arable crop production is mostly practiced by farmers who either have the characteristics of conventional or both types of production.

Our hypothesis was that younger farmers might be more open and interested in alternative technologies. The results suggest that this is not entirely the case for the population studied, with the youngest farmers aged 25-35 (3.4%) and the oldest farmers aged 55+ (2.3%) having the lowest rates of adoption of alternative technologies. However, this hypothesis proved to be true for farms with characteristics of both types of farming.

In the next question of the questionnaire, question 8, we asked whether the farmers surveyed had heard about the impact of agricultural production on climate and climate change. With the exception of regenerative agriculture, almost two thirds of respondents feel moderately or fully informed on these topics (Climate change – what it is, causes and effects, Impact of climate change on food production, Agriculture is accelerating climate change, Mitigation of climate

change, Organic farming, Conservation agriculture, Regenerative agriculture, Sustainable farm management).

These show that farmers combining both types of farming are the most informed for "Impact of climate change on food production" and "Regenerative agriculture". For "Agriculture is accelerating climate change", alternative farmers feel the most informed, while for "Sustainable farm management", conventional farmers feel the most informed.

It can be established that "In terms of education, there is enough support for farmers, if they would like to introduce alternative farming practices" and "There is enough financial support for farmers , if they would like to introduce alternative farming practices (e.g. The most important ones are "There is a general knowledge gap among farmers about the alternative ways of farming" and "There is a high need to re-direct agriculture towards new approaches to help to mitigate climate change" were able to agree with the findings. Farmers consider the uptake of alternative farming practices to be medium both at EU level and on their own farm. However, they consider its uptake in Hungary to be less favorable.

The most frequently selected response option for techniques already in use was "Increasing plant biodiversity", followed by "Reducing or eliminating mechanical interventions in the soil" and "Implementing habitat conservation techniques". Most farmers feel well informed about "Include livestock in farmland to fertilise the soil". The highest number of farmers reporting a lack of knowledge was for the second most used practice "Reducing or eliminating mechanical interventions in the soil". Among the techniques planned to be introduced, "Keeping the upper part of the soil overgrown with vegetation" was the one mentioned by the most respondents.

The next question in the questionnaire asked farmers whether they were aware of the benefits of regenerative agriculture. The most frequently identified benefits were "More beneficial for insects, "Higher CO2 retention in the soil" and "Enriched soil", "The varied appearance of the cultural landscape" and "Need for substantially less water". The least identified potential positive benefits of regenerative agriculture were "Increased farm revenue" and "Less problems with plant diseases". 97% of farmers are sceptical about regenerative agriculture due to "Suspicion regarding its results", 251 farmers are concerned about "Financial uncertainty regarding the short-term future" and 247 farmers feel that this form of production is problematic due to "Lack of know-how". Lack of financial support from the state" is also a concern for a significant proportion of respondents (80%). Expensive investments" is the least worrying (59%). A quarter of the total surveyed population were not interested in adopting RA.

The percentage of those who refuse to receive further information and to participate in the training is generally below 10%.

However, if it is necessary to prioritise, the factors "More financial support from government or EU" and "Good practice sharing among farmers, network" are considered by the farmers surveyed as the most important for the spread of regenerative agricultural practices.

3. Case studies (interviews with farmers)

3.1. Introduction

We have interviewed farmers about their use of regenerative agriculture practices to assess their knowledge of the topic, to learn about their attitudes and to collect good practices that could be used in the future in the training of students.

In total, 14 interviews were carried out by the Hungarian partners.

3.2. Case studies

The interviews covered the following questions:

General information: Name of the farmer/Holding, name of the respondent, location of the farm, size of the land (given in hectares), number of employees (permanent, seasonal), main activities of the farm (arable crop species, animal species, other activities if any).

Regenerative agriculture (RA) practices currently used: Whether they use the elements of regenerative agriculture, if not yet, do they plan it, if they do then on the whole area; what RA elements they use, which crops are grown in this way and for how they have been applying this practice.

Starting regenerative farming and motivation for doing so: What was the history of RA in the holding, what made them decide to start it; did they receive any education on the subject, if so where, if not where did they get the information; did they receive any financial support to start RA, if so from whom.

Results of regenerative agriculture: benefits, obstacles, difficulties, struggling, satisfaction, intention to continue, intention to change the existing practices.

Summarizing the interview responses, the following can be concluded:

General information:

The interviewed farmers all work in Győr-Moson-Sopron County, in its different districts (Moson plain, Rábaköz, Sopron-Vasi plain).

Apart from the vegetable community operating on a very small area (3 hectares in total, of which 6000m^2 is horticulture, 600m^2 is greenhouse, the remaining area is meadow and pasture), the sizes of land areas fall between 26 to 1100 hectares. There are 5 farmers with less than 100 hectares, 1 farm with more than 1000 hectares and 5 farmers/holdings with more than 150 hectares but less than 1000 hectares.

The number of permanent (full-time) employees on holdings with a crop production profile is typically less than 5 people. In contrast, livestock profile farms, quite understandably, employ a staff of 82 employees. These numbers are typically supplemented by a few (up to 10) seasonal employees. Higher numbers of seasonal employees are found where horticultural crops are more predominant.

The following arable crop species are most common among the respondents:

winter wheat, winter barley, winter swede rape, maize, poppyseed, soybean, sunflower, purple clover, phacelia, buckwheat, seed maize, seed green peas, alfalfa, Egyptian clover, potatoes, winter fodder peas, silage maize, rye.

Typical livestock sectors: Dairy cattle breeding, pig breeding, pig fattening

Horticultural production: carrot, parsley, strawberry, sour cherry, squash, sweetcorn, sweet potatoes, in the vegetable community: 50 species of vegetables and 25-30 species of fruit.

Regenerative Agriculture (RA) practices currently in use:

The farmers interviewed all use the elements of regenerative agriculture. About half of farmers use it on a part of their farmland, the other half on the whole area of their farmland. Where it is used only on a part of the area, the principles and recommendations of RA are mainly applied in arable crops production.

Overall, all farmers have a long history of integrating the different elements of RA.

The elements of regenerative agriculture mostly used by the respondents are the following:

- Growing green manure crops
- Growing nitrogen fixing crops

- Use of cover crops
- Working manure residues back into the soil to increase organic matter content and improve soil water holding capacity
- Application of no-tillage
- Reducing the number of cultivation passes
- Farmyard manure application
- Use of bacterium fertilisers
- Reducing the amount of fertilisers used
- Crop rotation
- Reduction or absence of chemical crop protection
- Exploiting the beneficial effects of crop combination
- Medium-depth loosening

Starting regenerative farming and the motivation leading to it

Among the farmers interviewed, some were motivated to adopt RA because they had wanted to do something to protect the environment and the soil, or at least to reduce the impact burdening the environment. Some respondents felt that this was the only way to preserve the land and the environment for future generations.

For most of them, the main motivation was that they were able to increase the soil's organic matter content and improve its water retention capacity. Stem residues and green manure crops (cover crops) can be worked into the soil to increase soil organic matter. Increasing the amount of organic colloids helps to bind and retain water in the soil, thus water management is improved. In addition, organic matter recycling and avoidance of unnecessary soil disturbance contributes to the formation of a more favourable C balance (organic carbon loss is reduced). Higher humus content contributes to stabilisation of the soil structure and thereby increases the soil's resistance to various degradation processes. The increase of soil biological activity and the stimulation of soil life were also important aspects to the respondents. Since water and microbial activity are the key to nutrient uptake processes, so that plants have access to the macro- and micro-nutrient content of the soil. The integration of certain crops (legume seeds) into the crop structure was also an important motivation because with them the amount of nitrogen fertilisers to be applied can be decreased. Thus, the protection of the environment, the soil and the groundwater, furthermore, cost-effectiveness are equally important in the use of RA elements.

The respondents have not received any specific training on RA. Many have learned what they know and use at different forums, abroad or with the help of literature found on the Internet.

Financial support is not available in Hungary today for regenerative agriculture.

Results of regenerative agriculture

Among the benefits, farmers mainly mention improved soil conditions. Especially those where it is also possible to apply farmyard manure. Improved soil conditions also bring several other benefits, such as improved yield safety, reduced fertiliser use and lower costs. Environmental awareness and that the application of high amounts of chemicals can be avoided are also defined as benefits. The ease of soil cultivation is mentioned by many farmers, as well.

Among the disadvantages, among others, they have mentioned: the slow return on investment and the emergence of plant protection problems most typically. These can be overcome with additional financial investment and a lot of patience.

3.3. Conclusion

Overall, the respondents are satisfied with the elements of regenerative agriculture they use, and they wish to continue this method of farming in the future. The need for continuous training, learning and development was also expressed by the farmers.

4. Overall conclusions

At the moment, there is no available representative national survey or analysis on regenerative agriculture, consequently, it is difficult to show where Hungarian farmers exactly stand regarding this topic. Preferably, it is worth reviewing the situation of agriculture on a whole and its development over the past ten years, which can be seen in detail from the Hungarian Statistical Office (HCSO). On the basis of the most up-to-date data, in 2021, 293 597 hectares were used for organic farming, which is interesting because it is maybe the closest approximation to the principles and recommendations found in regenerative agriculture. Notwithstanding, it should be noted that the vast majority of these 293 597 hectares, that is, 179 586 hectares are used as grassland, on 91 278 hectares they produce arable crops, the remainder is used as plantations, is fallow land and as green manure areas.

The obstacles to the application of RA are perceived as follows: The ecological production systems which belong to the concept of regenerative agriculture, unambiguously push Hungary's agriculture towards extensification. The scientific data published on the yield differences of organic production systems compared to conventional systems are quite frightening. If we take into account that in conventional farming, depending on the season, pests cause a 30% yield loss in an average year, this figure can exceed 70% in the absence of reasonable chemical crop protection, and we have not even mentioned other abiotic factors or yield losses due to the absence of fertilisers. There are benefits, such as improved soil structure in minimum tillage systems, improved soil air-water management and increased soil organic matter but weed control or the use of additional herbicides in no-tillage cover crops cannot be considered as a clear positive effect. The social acceptance of regenerative agriculture is a strongly propagated topic, which is intended to demonstrate the positive aspects of the raw materials produced this way.

In the primary survey, the largest proportion (36.8%) of farmers with land between 100 and 1,000 ha participated. The lowest number of farmers over 1,000 ha (5.9%) participated.

As almost two thirds of the total population surveyed said they considered themselves to be conventional.

Our hypothesis was that younger farmers might be more open and interested in alternative technologies. The results suggest that this is not entirely the case for the population studied, with the youngest farmers aged 25-35 (3.4%) and the oldest farmers aged 55+ (2.3%) having the lowest rates of adoption of alternative technologies. However, this hypothesis proved to be true for farms with characteristics of both types of farming.

These show that farmers combining both types of farming are the most informed for "Impact of climate change on food production" and "Regenerative agriculture".

The most frequently selected response option for techniques already in use was "Increasing plant biodiversity", followed by "Reducing or eliminating mechanical interventions in the soil" and "Implementing habitat conservation techniques". Most farmers feel well informed about "Include livestock in farmland to fertilise the soil". The highest number of farmers reporting a lack of knowledge was for the second most used practice "Reducing or eliminating mechanical interventions in the soil". Among the techniques planned to be introduced, "Keeping the upper part of the soil overgrown with vegetation" was the one mentioned by the most respondents.

A quarter of the total surveyed population were not interested in adopting RA.

The percentage of those who refuse to receive further information and to participate in the training is generally below 10%.

However, if it is necessary to prioritise, the factors "More financial support from government or EU" and "Good practice sharing among farmers, network" are considered by the farmers surveyed as the most important for the spread of regenerative agricultural practices.