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Searching for Dairy Farm Resilience with the R4D Project: Innovation Needs to Be Sustainable

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Abstract: Farms face new challenges due to both climate change and the influence of economic, social, and institutional factors. The study examines the key aspects of the resilience of dairy farms that, if in place, can ensure their sustainable functioning. The purpose of the article is to diagnose and classify the main needs for strengthening the resilience of dairy farms. In implementing the research, an interdisciplinary approach developed within the framework of the Resilience for Dairy (R4D) project was used. The results of the research reveal differences in the classification of key needs to strengthen resilience by stakeholder groups. Farmers reported a need for solutions that increase their income and production flexibility. The other groups of respondents focused on reducing antibiotic use and improving resource efficiency and environmental protection. The analysis of key needs classifications among respondent groups, segmented by age, and the comparison of needs between respondents from Western European and Central and Eastern European countries showed minor differences, indicating a similarity in the perceived importance of needs. The study also identified needs perceived by respondents as essential to increasing dairy farm resilience. These primarily include the following: the work–life balance of farmers, effective communication with the community, and implementation of technical innovations related to dairy farming.

Keywords: resilience; needs; innovations; knowledge exchange; AKIS; dairy sector stakeholders; sustainable development

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1. Introduction

Farms face the volatility, uncertainty, complexity, and ambiguity of phenomena occurring in the world today, a world called VUCA (an acronym standing for volatility, uncertainty, complexity, and ambiguity) [1,2]. Meeting its challenges requires building an appropriate strategy based on the vision of the position and the future role the farm will play. One possibility of operationalizing strategic activities is by building resilience, which is typically associated with three related concepts: robustness, adaptation, and transformation, harmonized with specific decisions and actions taken by farmers [3–5]. Many definitions of resilience, including its various categories [6–8], can be found in the literature, but, in this part of the article, the terminological issues concerned with resilience are omitted and will be presented in Section 2.

The impact of the VUCA world results means farms are encountering ever more challenges. The latter concern economic, environmental, and social aspects, adding pressure to the way business is conducted and creating the conditions for limiting production or even discontinuing it [5,9]. These are further reasons for boosting the resilience of farms. While there are many possibilities of creating it, concepts based on the transfer of knowledge and

learning of farmers in specially created networks are increasingly emerging. An example of such an initiative in the European Union is the Agricultural Knowledge and Innovation Systems (AKIS) composed of stakeholders from the farm environment [10,11]. One of the many goals of AKIS is to create innovative solutions that limit the negative impact of factors in the farm environment. A change in the mentality of entities in this network, where competitors must become partners operating in the same ecosystem, is important for the future success of AKIS. The flow of knowledge occurring within AKIS should be supported by the development of good practices containing innovations that allow for farms' operational flexibility and continuous development [3,12,13]. Building the resilience of farms should be based on identifying the needs and gaps in knowledge, taking into account the operating conditions and possibilities of implementing the proposed innovative solutions. There is a clash of groups of needs here. The first group of needs is created by advisors, scientists, suppliers of inputs needed on the farms, institutions creating the political and legal environment, consumers, etc. The second group of needs is created by farmers themselves, who know how to run a farm in a given environment and assess their own efficiency and capabilities. It may, thus, be assumed that only the balance of these two "worlds" (types of needs) creates the circumstances for the correct definition and implementation of innovations that build resilience.

The above considerations on resilience and how to build it through knowledge transfer using the AKIS network are reflected in the Resilience for Dairy (R4D) project. Financed by the EU Horizon 2020 program, the project is implemented by 18 organizations from 15 European countries. Work on the project is co-ordinated by the French Institut de l'Élevage IDELE. Project participants aim to improve business and operational strategies related to dairy farming, as well as to stimulate positive interactions between farmers and society. In line with the approach adopted in R4D, National Dairy Agricultural Knowledge and Innovation Systems (NDAKIS) have been built and, via them, a crowd-innovation which will stimulate wider opportunities for the collection and exchange of the existing knowledge, while the co-operation and dissemination of information and Best Practices are also promoted. The exchange of knowledge between the 15 NDAKIS networks is intended to address the challenges of improving animal welfare, biodiversity, economic and social resilience, technical efficiency and environment, and welfare and society issues; reducing greenhouse gas emissions; and lowering the environmental impact of dairy farming.

The aim of the article is to diagnose and classify key needs for strengthening the resilience of dairy farms in the opinion of dairy sector stakeholders forming NDAKIS. The achievement of the goal is guided by the following research hypotheses:

H1: *There are considerable differences among individual stakeholder groups in the dairy sector regarding the classification of key needs to strengthen the resilience of dairy farms.*

H2: *The age of the surveyed dairy sector stakeholders determines the classification of key needs strengthening the resilience of dairy farms.*

H3: *Differences can be observed among NDAKIS members in Western Europe and NDAKIS members in Central and Eastern Europe concerning the classification of key needs to strengthen the resilience of dairy farms.*

The article is divided into five parts. The first presents the concept of resilience in agriculture, with emphasis given to the methods of transferring knowledge and tools used to build the resilience of farms. The next part is devoted to describing the research method and research material. The research results included in the third part of the article are presented in the form of a comparative analysis, focusing on the needs related to boosting the resilience of dairy farms. The comparison was made within three categories, such as the respondents' connection with agricultural production (direct or indirect), the respondents' age, and the location of the business (Western Europe or Central and Eastern Europe). The last parts of the article bring a discussion of the results and conclusions from the study.

2. Resilience of Agriculture: A Literature Review

2.1. The Concept of Resilience in Agriculture

The concept of resilience has been widely studied in many disciplines, from science to humanities to political and legal sciences [14]. As a result, its definitions are ambiguous and deeply embedded in the fields in which it was analyzed [15,16]. Moreover, in agriculture, resilience is a multi-faceted concept. Resilient agricultural systems can be most simply defined as those that are able to cope with challenges [17,18]. These challenges arise from a variety of causes, thereby defining a specific resilience context. Taking into account the sequence of the concept of resilience, from a narrower interpretation to its broader context, according to Folke [19], one can distinguish resilience in engineering, ecological, and socio-ecological terms. In the narrowest, engineering approach, resilience is understood as the ability of the system to return to a state of equilibrium after a disturbance [19]. From an ecological perspective, resilience refers to the ability to absorb disturbances and reorganize while undergoing change to maintain an essentially identical function, structure, and identity [20]. These reorganizations lead to the transformation of the system into a new, alternative stable state [19,21]. This definition highlights the ability of agricultural systems to withstand environmental shocks such as climate change, extreme weather events, and epidemic events. The context of social–ecological resilience is the broadest approach. It includes physical elements, i.e., natural resources and ecological factors, as well as social elements that are involved in production, processing, supply, and consumption. The concept is understood as the ability to adapt or transform following changes in social–ecological systems, especially unexpected ones, in a way that continues to support human well-being [22] (p. 9). Focusing on the resilience of agricultural systems, Meuwissen et al. [5] understand it as the ability to permanently implement farm functions in the face of increasingly complex and accumulating economic, social, environmental, and institutional shocks and stresses, through resilience, adaptation, and transformation capabilities [5]. Robustness is the ability to maintain desired levels of agricultural production despite disruptions. Adaptability concerns the ability to learn, combine experiences and knowledge, introduce innovations, and adapt responses to changing external factors and internal processes. In turn, transformability is the ability to significantly modify the internal structure and feedback mechanisms of the system in response to serious shocks or permanent stresses that make conducting business in the current way impossible or undesirable [5,6,23,24]. It is worth emphasizing that the above-mentioned capabilities of agricultural systems are interdependent and mutually reinforcing. It is assumed that robustness represents short-term responses to uncertainty, adaptability covers medium-term responses, and transformability is visible in long-term responses [25]. Improving one of them may require improving the other two; e.g., the ability to adapt or transform in the long term may require robustness in the short term [26].

2.2. The Role of Innovation and Knowledge Transfer in Building Resilience

Building resilient agricultural systems relies on innovation, networks, and collaboration [27]. Innovation can be defined and measured narrowly in terms of research and development or technological improvements linked to the development of new products and processes [28]. In a broader perspective, they are the result of various methods of thinking and implementation approaches, as well as the recombination of various pieces of knowledge in an innovative way. Each innovation is characterized by a unique combination of technical, economical, organizational, and social aspects. It involves both solving problems and taking advantage of opportunities, which is a reaction to internal and external factors [11]. Innovation plays a key role in achieving resilience and sustainability. Resilience is related to processes that aim to achieve and maintain balance. In contrast, sustainability focuses more on the effects and results of these activities [29]. Innovation can significantly shape how quickly and effectively entities adapt to a changing environment [28].

Nowadays, innovations in agriculture are understood more broadly; namely, they must take complex socio-scientific problems into account and thus require an increasing

number of stakeholders from multiple perspectives [30–32]. Co-innovations, which are based on the participation of various stakeholders aimed at supporting broad changes in systems, sectors, institutions, territories, and value chains, can play an important role in finding the best answers to problems and in increasing the effectiveness of innovations [33]. Presently, achieving this collective intelligence and crowdsourcing is possible through formal channels and/or social networks [34]. In this case, it is important to assume that each entity plays a role in designing its future. The interactive and practical co-operation of all actors (researchers, advisors, farmers, etc.) based on direct involvement allows partners to verify their activities and contributes to the change process [35]. The identification of problems and the co-creation of solutions in co-innovation occur through a process of collective learning, including knowledge sharing [36]. It is worth emphasizing that the belief that knowledge is transferred in one direction, from scientists, through advisors, to farmers, is wrong. In fact, advisors gain significant benefits from the knowledge and experience of the farmers they advise. These interactions add significantly to the knowledge exchange process between different actors in the agricultural innovation system [37].

The exchange of knowledge, both formal and informal, has a huge role in strengthening resilience [12]. Curiosity and willingness to learn, together with social networks, farmer organizations, and supporting formal knowledge and governance structures, are key elements of effective learning, knowledge integration, and innovation for sustainable development [3]. It is recommended that farmers and scientists jointly build new knowledge using holistic, transdisciplinary approaches [38]. It is because of the social interactions maintained between farmers, but also with a wide range of entities promoting changes, such as buyers, suppliers of production inputs, local authorities, etc., that farmers decide to implement innovations on farms [39].

Knowledge and innovation play a vital role in helping farmers and rural communities meet current and future challenges [40]. In this context, Agricultural Knowledge and Innovation Systems (AKIS) have an important role. AKIS connects farmers, advisors, scientists, and politicians online, promotes knowledge exchange, and supports innovation in agriculture. AKIS is a "space" where many knowledge exchange and co-innovation activities take place through a matrix of networks and partnerships [38]. Scientists stress that farmers, as researchers and participants in experiments on their own farms, can better understand and adopt innovations when they are applied to their real needs and operating conditions [41,42]. Participatory research methods and farmer-centered approaches are thus becoming crucial for the effective adoption of new technologies and practices. Research indicates the importance of AKIS systems in the innovation process, underscoring that effective knowledge transfer and innovation adoption depend on various factors, including access to information, communication skills, and technical support [43]. Due to this, it has contributed to strengthening the resilience of farms by providing the necessary information and tools for risk management and adaptation to changing conditions [10]. AKIS is hence becoming a key element in the process of transforming theoretical knowledge into practical solutions that can be used in agricultural reality [5].

In the context of building resilience through knowledge transfer and innovation, it is important to understand which specific needs farmers report in this regard. Diagnosing these needs becomes even more important because it allows for the identification of specific challenges and opportunities that farmers encounter in the face of changing environmental and market conditions. Placing the farmer at the center of the knowledge transfer and innovation process allows for the better adaptation of solutions to the particular business conditions and needs of farmers, thereby increasing their resistance to various challenges [5]. It is highlighted that farmers are often looking for simple and effective practices and technologies that boost the resilience of their farms [44]. This makes it important to understand the needs for building farm resilience, given that it allows for more targeted support for farmers in the face of climate, economic, and social changes. Further research is needed to identify these knowledge gaps and needs among different groups related to AKIS, such as agricultural advisors, scientists, and policymakers.

3. Methodology for Examining the Innovation Needs of National AKIS Groups

3.1. Data Collection Methods

The methodology used in this paper entailed a comprehensive approach to examining and understanding farmers' resilience-building needs grounded in an interdisciplinary strategy. The mentioned approach involved integrating data from a diverse range of scientific disciplines, such as social sciences, natural sciences, and engineering, and complemented these with expert methods in data collection and processing. The questionnaire, a vital research tool, was designed to cover observation areas across multiple fields of science, allowing for a broad and in-depth examination of the phenomenon under study. Moreover, the methodology was based on a combination of literature analysis, interinstitutional co-operation, and direct consultation with interested parties, which allowed for an effective diagnosis of the challenges the agricultural sector is encountering. The methodology consisted of integrated steps to comprehensively identify and understand these needs. A diagram of the research procedure is presented in Figure 1.

Figure 1. Graphical presentation of the stages of examining the needs for building the resilience of dairy farms. (Source: own elaboration.)

Preparing a tool for examining farmers' needs was first based on two main activities: a literature review and consultations held among the R4D consortium partners. The literature review concentrated on recent research on similar topics. An important source of information was the EuroDairy project report [45], describing innovative tools and techniques in various areas of dairy production, such as the assessment of nutrient use and environmental impact on dairy farms, feed and feeding strategies, feed production and storage, slurry management, etc. Another important source used to create the baseline list of needs was the results of the EU Data Driven Dairy Decisions for Farmers project (4D4F) [46], focusing on the role of sensors in animals and the environment in collecting real-time information to support decision-making on dairy farms. The third specific source of information was publications of the International Committee for Animal Recording (ICAR) [47]. The ICAR also provides a range of best practices related to sensor devices, such as guides on calf and youth activity and behavior, data management, housing, lameness, metabolic disease, milking data, feeding data, reproduction, udder health, and the use of (sensor) technology for improving pasture management. A further source of information was the EuroSheep project [48]. The project was particularly important from a methodological perspective, providing knowledge on improving breeding practices, especially in the areas of disease prevention, herd health management, nutritional needs of different groups of animals and their feeding rules, breeding strategies, and reproductive management. Parallel to the literature review, information was collected on resilience-building needs revealed via interinstitutional co-operation between project partners. These collaborations were based on joint activities, projects, and initiatives previously implemented by the project partners with various institutions in different sectors (public, private, academic, and non-profit) and fields.

The literature review led to the development of an initial list of needs, which was then disseminated among the partners in order to expand it with elements appropriate to the national situation. The partners contributed to its creation from the end of January to the end of May 2021, creating a list of 186 items. Seven leading themes were redefined in line with the three key areas of resilience in the R4D grant agreement and comments from partners, resulting in 10 thematic areas. Due to the potential length of the survey containing 186 items, after a trial round of the questionnaire among the partners, it was decided to simplify the survey by grouping the items. The final version of the questionnaire (November 2021) consisted of 43 questions, grouped into 3 key areas. The structure of the questionnaire enabled us to obtain detailed information on respondents' perceptions and experiences related to various aspects of farm resilience. The questionnaire included closed questions, enabling quantification of responses, as well as an open question, giving respondents the opportunity to express their own opinions and experiences. It contained questions on various aspects of dairy farms, including technical efficiency, innovative equipment, animal feeding strategies, animal health, environmentally friendly production systems, animal welfare, economic efficiency, and social resilience.

The next step was to conduct a survey using the questionnaire in each country participating in the R4D project. Due to the ongoing COVID-19 pandemic, direct consultations with NDAKIS and other stakeholders were impossible in most countries. A more pragmatic approach to creating the inventory was therefore chosen. A bottom-up consultation with NDAKIS and stakeholders was organized. During and after the National Dairy AKIS and stakeholder meetings (live or online), heuristic methods, including brainstorming, were used to identify key challenges dairy farms were facing and develop a definition of farm resilience. Discussion participants individually assessed the importance of identified needs using a scale from 1 (no interest) to 5 (very interest). Participants also had the opportunity to select the option "0", which was interpreted as "I don't know"—indicating a lack of sufficient knowledge or confidence in a given aspect. The survey also included questions about general information concerning the respondents, such as profession, age, gender, education, marital status, and having children, as well as detailed information about the farm.

This approach permitted the collection of detailed and diverse opinions, which is crucial in the process of identifying and assessing needs on a dairy farm. The rating scale allowed for an effective analysis of participants' priorities and preferences, which is important in the context of designing effective resilience strategies.

3.2. Calculation Method and Characteristics of the Research Area

Conducting a questionnaire among members of 15 national AKIS and stakeholders from these countries led to an extensive database on the needs for building resilience on dairy farms being obtained. The presentation of the results here is limited to needs that were identified as key. The term key reflects the ten highest-rated needs by respondents, shown in the form of a hierarchy using the *INC* indicator.

$$INC = \frac{\sum_{i=0}^{n} RN_i}{NoR * max.RN_i} \times 100 \quad (1)$$

INC—Index of Needs Classification;
RNi—Rank of Needs;
NoR—number of respondents;
max.RNi—maximum value of Rank of Needs.

In order to verify the possibility of using the *INC* index in research, the correlation between its value and the median and average of the ranks was calculated. These two statistical measures are among the most frequently used to create hierarchies in qualitative research using the ranking method. The correlation coefficient of the *INC* index with the median of the ranks was higher than 0.8 in 90% of cases, which means a very strong correlation. In the remaining 10% of cases, the correlation coefficient was in the range of

0.6–0.7. However, the *INC* indicator is perfectly correlated with the average of the ranks (correlation coefficient equal to 1.0), which results from the way it is calculated.

A special approach to determining the ranking of resilience-building needs concerned European regions. The reason for its use was the varied number of study participants from individual countries. For example, 178 Belgians completed the survey questionnaire, which is almost 15 times as many as Danes (Table 1). Building one common hierarchy for all respondents, e.g., from Western Europe, could mean that such a ranking would only reflect the needs of the 2–3 countries with the largest number of respondents. This approach was considered incorrect. In order to avoid this problem, rankings of needs were built separately for each of the 15 countries. Then, depending on a need's place in the classification, it was awarded 1–43 points, where 43 points were awarded to the need that ranks first in the hierarchy of needs in each country. The sum of points from the national hierarchies was the basis for creating general rankings of needs for two regions: Western Europe and Central and Eastern Europe.

Table 1. Characteristics of the research group (n = 535).

Stakeholder Groups	Number of Respondents	Percentage	Group of Countries/Country	Number of Respondents	Percentage
Farm owners & Farm workers	374	69.9%	Western Europe	438	81.9%
Vets & Advisors	81	15.1%	Belgium	178	33.3%
Researchers & Teachers	48	9.0%	Denmark	12	2.2%
Others (students, competent authority, and others)	32	6.0%	Finland	34	6.4%
Age of respondents	**Number of respondents**	**Percentage**	France	38	7.1%
≤39 years	190	35.5%	Germany	23	4.3%
<25	18	3.4%	Ireland	9	1.7%
25–34	93	17.3%	Italy	55	10.3%
35–39	79	14.8%	Luxembourg	16	3.0%
40–55 years	209	39.1%	Netherlands	25	4.7%
40–44	58	10.9%	Northern Ireland	14	2.6%
45–55	151	28.2%	Spain	34	6.3%
>55 years	136	25.4%	Central and Eastern Europe	97	18.1%
55–65	115	21.5%	Lithuania	14	2.6%
>65	21	3.9%	Poland	14	2.6%
			Slovenia	46	8.6%
			Hungary	23	4.3%

Research on the needs that, if met, can build the resilience of dairy farms was conducted among 535 respondents. The data in Table 1 show that the number of respondents from individual countries varied considerably. It ranged from 9 to even 178 people, where Belgians constituted one-third of all respondents, while, in most countries, the number of respondents did not exceed 30 people. Information on the age of people shows that almost two-thirds of the respondents were over 39 years old, and the largest among all age groups were 45–55 and 55–65 years old. In total, they constituted approximately 50% of the respondents. The data in Table 1 also show that dairy farm owners and farm workers formed the dominant group of respondents with a nearly 70% share among all stakeholder groups.

Table 1 contains the names of the variables and the numerical data characterizing them written in italics. They show the method of data classification adopted by the authors of the article and used to present the research results. Depending on a respondent's profession, four stakeholder groups were distinguished. In addition to the previously mentioned dairy farm owners and farm workers, the classification includes the groups: Vets & Advisors, Researchers & Teachers, and Others (students, competent authority, and others). According to age, the respondents were divided into three categories: up to 39 years old, from

40 to 55 years old, and over 55 years old. This separation was the most logical because the limitation of the questionnaire was the inability of the respondent to provide their age. Respondents could only select the age range offered by the creators of the survey. The classification by age was made to identify a group of young farmers, which was defined as respondents aged under 40 years. The aim of this was to determine how this group was characterized by a pro-innovative approach to building dairy farm resilience. Further, this division was intended to indicate the extent to which, with the next separated group, there is a change in the set of key needs for building resilience from those related to new technologies to the "classic" ones of animal welfare and well-managed factors of production.

The research results, containing information on the country of origin of the surveyed people, were divided into two groups of countries. This division is very often used in the global taxonomy and in the European Union, where the countries of Western Europe and the countries of Central and Eastern Europe are distinguished.

4. Results

The first classification made is based on the division according to stakeholder groups. Figures 2–5 present the ten most important needs for building the resilience of dairy farms. In the opinion of three groups: Farm owners & Farm workers, Vets & Advisors, and Researchers & Teachers, constituting 94% of the respondents, they show that at least 50% of the key needs ensuring resilience concern the area of "Environment, animal welfare and society friendly production systems" (Figures 2–4). A different situation occurs in the Others group, where the needs focused on implementing innovations in the area of "Technical efficiency" dominate.

Figure 2. Key needs in building resilience according to Farm owners & Farm workers.

Figure 3. Key needs in building resilience according to Vets & Advisors.

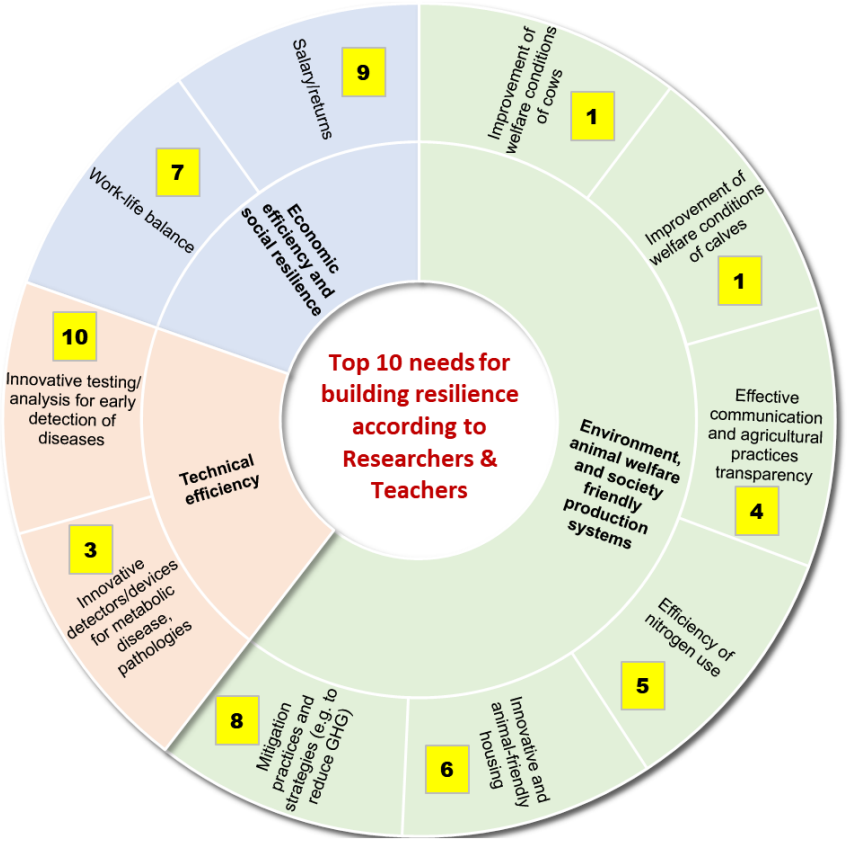

Figure 4. Key needs in building resilience according to Researchers & Teachers.

Figure 5. Key needs in building resilience according to Others.

The analysis of the repeatability of needs in individual hierarchies showed that, in all four separate stakeholder groups, three types of key needs were repeated: (1) work–life balance; (2) effective communication and agricultural practices transparency; and (3) innovative testing/analysis for the early detection of diseases. The survey results also show that the need for a balance between farm work and private life is the most valued among Farm owners & Farm workers and Vets & Advisors (85% of all respondents). Technological innovation, animal welfare and environmental issues are the next groups of needs to create resilience on dairy farms placed in the two hierarchies of the key needs of the Farm owners & Farm workers and Vets & Advisors. Other priorities were identified by the next two groups: Researchers & Teachers, and Others. They placed work–life balance much lower among the key needs creating the resilience of dairy farms. An important observation is that significant needs included needs closely related to the roles performed by the respondents. In summary:

- the Farm owners & Farm workers group highly assessed the needs of salary/returns and flexibility, which are closely related to the business approach to running a dairy farm;
- the Vets & Advisors group identified reducing antibiotic use as one of the key needs because this need does not appear in any other hierarchy developed according to the stakeholder group; and
- in the hierarchy of key needs of the Researchers & Teachers group, we find mitigation practices and strategies (e.g., to reduce GHG and/or ammonia emissions), which do not appear in any other hierarchy.

The research results showed that, among the four separate stakeholder groups, no two groups have an identical set of key needs. The conducted research shows one more conclusion; namely, regardless of the analyzed stakeholder group, two needs are extremely important for building resilience: proper communication with society, and the transparency of agricultural practices used on dairy farms.

The second list of key needs for creating resilience in dairy farms was based on the age of respondents. The results of this action are presented in Figures 6–8. It was found that, regardless of the distinguished age group, the need for work–life balance was in the first place in all three hierarchies of needs. Moreover, all three groups recognized that resilience can be ensured by the following: (1) effective communication and agricultural practices transparency; (2) the improvement of the welfare conditions of cows; (3) innovative detectors/devices for metabolic disease, and pathologies; and (4) innovative testing/analysis for the early detection of diseases. It was also observed that, when we compare the results for the groups under 39 and those aged 40–55, we obtain an almost identical set of needs building the resilience of dairy farms. Nine of the ten needs presented are the same. However, for the group aged over 55, among the needs that were not indicated as key in the other two groups, we see the inclusion of the following, among others: reliable information sources, knowledge and training, soil management (e.g., land rotation), and prevention (e.g., vaccination, and good practice).

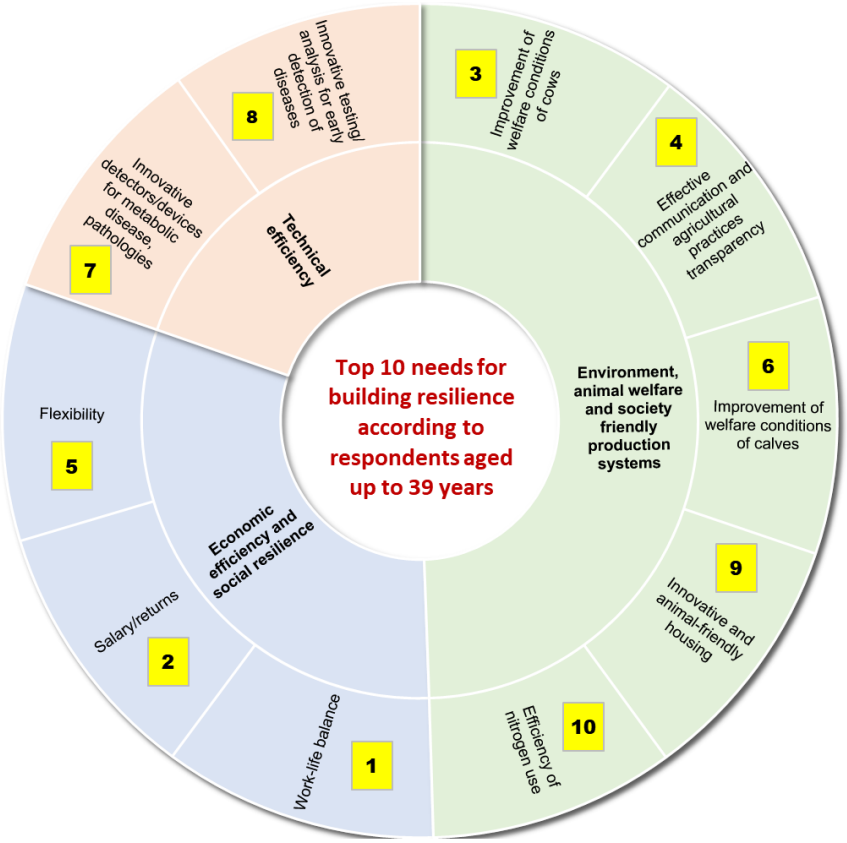

Figure 6. Key needs in building resilience according to respondents aged up to 39 years.

The results of the survey were also categorized according to the region of Europe. Two regions were distinguished: Western European countries and countries located in Central and Eastern Europe (the names of the countries included in the regions are given in Table 1). Comparing the results for these two regions, among the ten key needs building resilience, six of them are identical; only their places in the hierarchies differ (Figures 9 and 10). This set consists of the following: work–life balance; flexibility; the improvement of the welfare conditions of cows; effective communication and agricultural practices transparency; innovative testing/analysis for the early detection of diseases; and innovative detectors/devices for metabolic disease and pathologies.

Figure 7. Key needs in building resilience according to respondents aged 40–55 years.

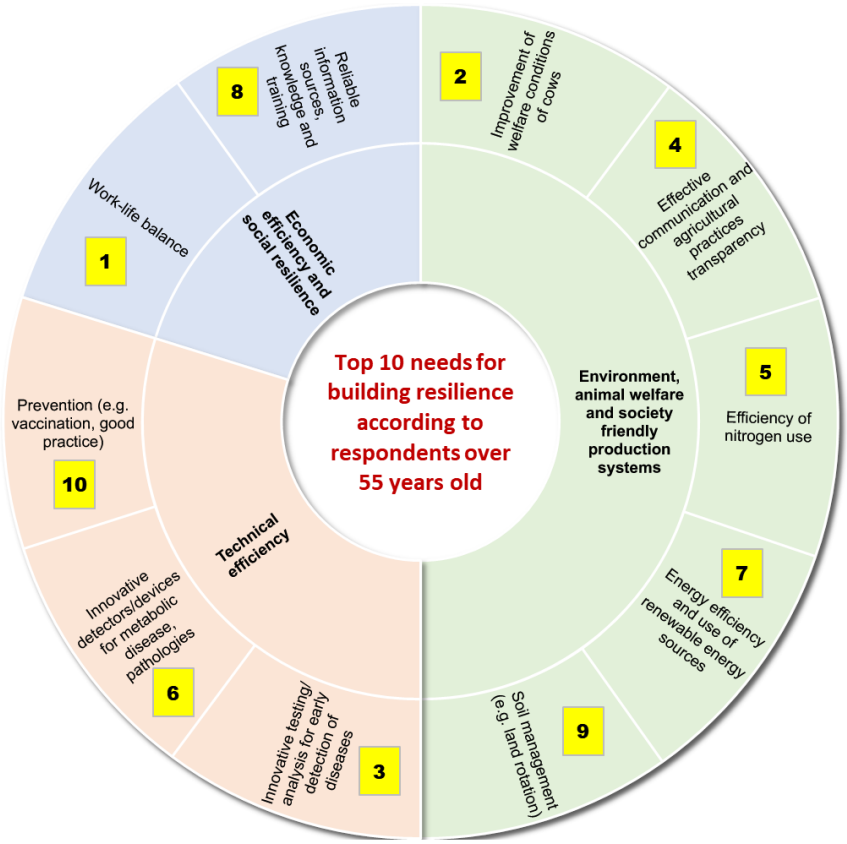

Figure 8. Key needs in building resilience according to respondents aged over 55 years.

Figure 9. Key needs in building resilience according to respondents from Western Europe.

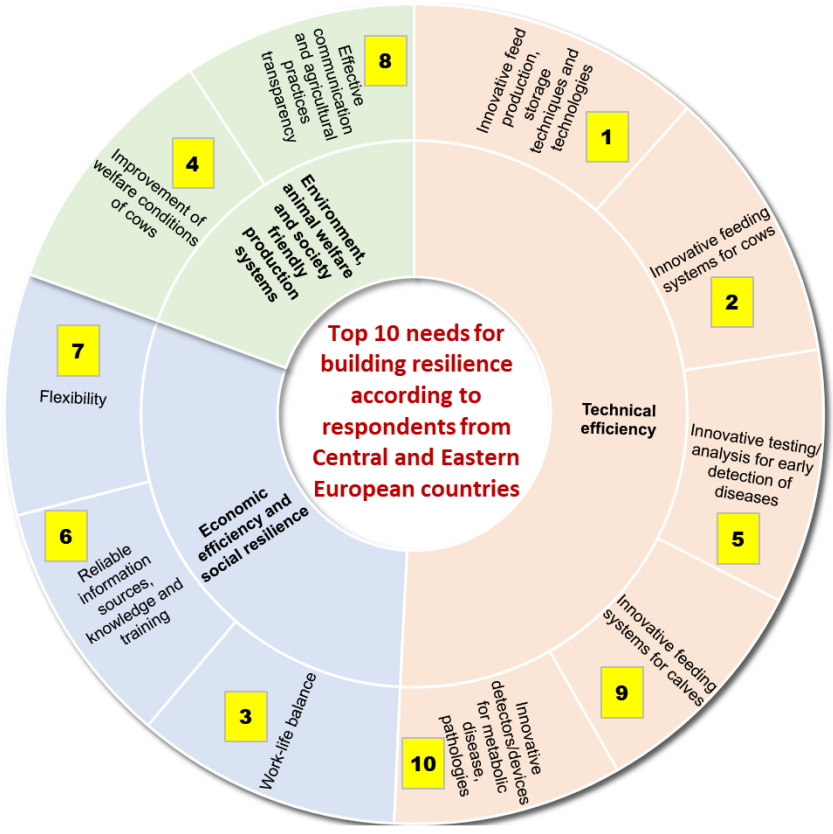

Figure 10. Key needs in building resilience according to respondents from Central and Eastern Europe.

Looking for differences in the two "regional" hierarchies of needs, it is observed that NDAKIS members from Central and Eastern European countries are more focused on the use of modern feed production systems. These are the needs that were in the top two places among the key ones that build resilience. In turn, respondents from Western European countries are more interested in improving animal welfare and the proper management of farm resources. It is also important to note that respondents from Central and Eastern Europe countries identified the transfer of knowledge and training as one of their key needs. We do not find this need in the list created for Western European countries.

As part of the research, an additional analysis was performed, including the identification of the three highest-rated needs that build resilience among all members of the 15 NDAKIS participating in the R4D project. It showed that the most frequently occurring need was the work–life balance, followed by the needs related to improving the welfare of cows or calves, while third place was taken by the need for innovation, allowing for the early detection of animal diseases. This means that the research confirmed the concept adopted for the entire project. It assumes that resilience can be increased if activities in the economic, technological, and social areas are combined, considering the provision of care and decent living conditions for animals.

5. Discussion

The research results presented in this article shed light on the types of needs for building resilience on dairy farms, while considering different perspectives: AKIS and stakeholder groups, and age groups, as well as regional differences between Western and Central and Eastern Europe.

In the context of different groups of AKIS and stakeholders related to agriculture, significant differences emerged in their needs and their solutions that can improve farm resilience. Farmers, who are direct users of new technologies, are looking for solutions that directly contribute to improving the efficiency and profitability of their farms, as emphasized by Klerkx and Proctor [49]. This is understandable, given that each investment in new technologies must bring tangible benefits. Agricultural advisors, in turn, play a key role in the process of transferring knowledge and technology to farmers. As pointed out by Sutherland et al. [50], advisors often promote innovations that are practical and based on solid scientific evidence. In this context, it is important to understand the specific needs and conditions of different farms. In turn, representatives of the agricultural industry tend to focus on innovations that bring economic benefits. Knickel et al. [51] note that these companies focus on the development of technologies that are easy to implement and provide quick results, while stressing the need to take aspects of sustainable development and equality in agriculture into account. This perspective highlights the need to balance economic benefits with long-term socio-economic and environmental goals.

Scientific research draws attention to differences in interest in innovations among various age groups of respondents. Younger farmers, as indicated by Akgün et al. [52], show greater openness to new technologies and methods. Their stronger familiarity with digital technologies and modern tools makes them more willing to adapt innovative solutions. Middle-aged farmers who are stabilizing their activities often have adequate resources, both financial and experience, to invest in new technologies, although they are more cautious than younger generations [53]. In the context of interest in innovation among older farmers, there is some resistance to adapting new technologies and methods. As Sutherland and Darnhofer [44] note, older farmers are often less willing to introduce changes, which may be a result of their attachment to traditional working methods and fear of the risks associated with investing in new solutions. In this study, no significant differences were observed in the needs for building resilience among the groups of respondents separated by age.

At the regional level, there are significant differences in interest in innovations that build resilience in agriculture between Western and Central and Eastern Europe. In Western Europe, which has a longer history of implementing advanced technologies and environ-

mental policies, there is a strong focus on innovation related to precision agriculture, sustainable development, and the integration of digital technologies [31]. Meanwhile, the countries of Central and Eastern Europe underwent ownership and structural reforms after the fall of communist systems. They formed the basis for innovation in agriculture. In this context, modernization and efficiency gains were the main areas where innovation played a key role [54]. These processes contributed to the introduction of modern management and mechanization techniques, which was a response to the needs of the transforming agricultural sector in the region. This is confirmed by the research presented herein, which clearly shows that the needs of respondents from Central and Eastern Europe have much more to do with improving the technical efficiency of farms, compared to the needs of respondents from Western Europe.

In summary, interest in agricultural innovation is a complex issue that varies depending on the needs of stakeholder groups, their age, and geographical region. Understanding these differences is vital while developing effective innovation strategies that will be accepted by farmers, advisors, industry, and policymakers. Introducing innovations in agriculture should take into account not only the technical aspects, but also the social, economic, and cultural ones, to ensure their effectiveness and adoption by various stakeholder groups. Further, these strategies should be adapted to specific regional conditions, noting the differences in history, agricultural development, and resource availability in various European regions.

6. Conclusions and Recommendations

The analysis of scientific sources revealed the multi-aspect nature of the concept of resilience in agriculture. The term resilience is usually considered in the context of environment protection, climate change, and the involvement of natural resources in the supply chain. The issue of resilience in agriculture is often related to the adaptation or transformation of processes that are a consequence of socio-ecological changes in the short and long term. Scientific research shows that only resilient farms can achieve their goals, reduce the impact of disruptions, and effectively respond to changes in the environment.

Some scientists propose building resilience in agriculture using knowledge transfer, based on close co-operation between stakeholders of individual agricultural sectors, which will lead to increased innovation. An important aspect of this approach is the creation of original solutions and development of specific tools that can ensure the resilience of farms. Stakeholder interactions should rank high in importance in the actions taken because innovative ideas can sometimes be generated from many directly unrelated elements of knowledge. A practical reflection of this approach is the creation of Agricultural Knowledge and Innovation Systems (AKIS). The way this system functions is the foundation of the R4D project whose main goal is to search for sources of resilience in dairy farms.

The research conducted in the R4D project seeks to identify needs and develop universal solutions that can build or improve the resilience of farms. Our study presents some part of the information provided by members of the 15 National Dairy AKIS (NDAKIS). The article contains three research hypotheses. Their verification was based on a comparison of rankings of key needs among stakeholder groups, the respondents' age, and the aggregation of survey results according to the division into Western Europe and Central and Eastern Europe.

The analyses performed confirmed the first research hypothesis that differences exist in the classification of key needs strengthening resilience depending on the stakeholder group. Although the disparities between groups are not high, each one suggests unique pathways to strengthening resilience on dairy farms. Farmers, who constituted the largest group of respondents (70%), point to the business direction of dairy production, and ensuring resilience is to be related primarily to achieving high income and high production flexibility. In turn, in the Vets & Advisors group, the key needs included reducing the use of antibiotics, and, for the Researchers & Teachers, they included the efficient use of resources and environmental protection.

The hypothesis regarding the differentiation of the classification of key needs strengthening the resilience of dairy farms by the age of respondents was not confirmed. The differences between the identified needs lists for the three groups were not large. The sets of key needs indicated by respondents aged under 39 and 40–55 were almost identical—there was a 90% agreement between the groups. The key needs indicated by the group over 55 also do not differ significantly from the two distinguished age groups.

The last hypothesis concerned the discrepancies in the classifications of resilience-building needs in the opinion of NDAKIS members from Western Europe and Central and Eastern Europe. In this case, six of the ten needs identified as key are identical. The hypothesis was confirmed, albeit the diversity of the classifications performed is not high. It was noted that respondents from Central and Eastern European countries see the improvement of dairy farm resilience in the production of high-quality cattle feed. In turn, respondents from Western Europe link strengthening resilience with animal welfare.

The results of the research hold several implications concerning the building of dairy farm resilience. First, they identify the perspective of farmers in building resilience and the perspective of other dairy stakeholder groups. The research confirmed that these are not identical and that different viewpoints must be considered to build an optimal portfolio of needs to address to ensure dairy farm resilience. Second, the research results suggest that, independent of the age of the respondents, there is a strong interest in innovative solutions that can create resilience associated with the technological efficiency of dairy farms. This provides a basis for concluding that respondents are open to and interested in introducing new technologies that can improve processes on dairy farms. Third, it was shown that there is regional diversification (on the country level) regarding the set of key needs that build resilience on dairy farms. For this purpose, it is crucial to gain knowledge on how and from which opportunities to build dairy farm resilience on the national or regional level.

Despite some disproportionality, our research identified a set of common needs that strengthen resilience and appear in all analyzed classifications. They provide the basis for formulating recommendations concerning the areas in which solutions should be sought to enable the efficient functioning of dairy farms in a changing environment. The first area is work–life balance related to the development of innovative concepts, methods, and ways of saving working time on the farm. The concept that corresponds to this area is Lean Management. Its use is aimed at identifying and introducing small changes whose cumulative effect contributes to a significant improvement in value. Of particular importance here is streamlining processes and limiting time wastage without compromising current and future results achieved on the farm. As a consequence, the application of the Lean Management philosophy is intended to increase the efficiency and smoothness of processes on dairy farms.

The second area of solutions to boost the resilience of dairy farms concerns the effective communication with the community about the transparency of production processes, including the practices used in them. This area is closely related to the next one, which is ensuring the welfare of calves and cows. The response to this challenge is the activity implemented in the R4D project related to visits by NDAKIS members to dairy farms with a high degree of resilience. The trends observed during these visits are aimed at increasing the space of barns allowing the free movement of cows that can meet herd needs. This is combined with the concept of open days on the farm, where outsiders can see how production processes are carried out, which technologies are used, and which products are obtained following their use.

The last important area of solutions for building the resilience of dairy farms is the implementation of innovations relating to the technical aspects of dairy farming. The research showed the particular interest of milk producers in innovative detectors/devices for metabolic disease, pathologies (e.g., mastitis, and lameness), estrum, eating/grazing behavior, calving time detectors, and innovative testing/analysis for the early detection of diseases (e.g., mastitis, infertility, metabolic diseases, and lameness). This leads to the conclusion that farmers report a strong demand for new technologies

enabling quick access to information on animal health and animal welfare, which will assure an immediate response and reduce the risk of herd health disorders.

While the study provides a lot of valuable information on the search for solutions that can add to the resilience of dairy farms, it also has some limitations. In the first instance, they relate to the research area, which covered a specific group of respondents, and, therefore, cannot be considered complex and include the perspectives of all dairy stakeholders in the 15 European countries. The research itself is also not representative. First, a very small number of people responded to the survey, indicating that the results show only a slice of the reality. Second, the dominant share of respondents, namely, farmers and farm workers and respondents from Belgium, may represent the specific needs of these groups in building dairy farm resilience. Moreover, the data located in the database from which the results were compiled only refer to a closed list of 43 dairy farm resilience-building needs identified according to the authors of the questionnaire.

Further research on this topic should focus more on the distribution of respondents. The number of respondents coming from the countries surveyed should reflect their importance in the European dairy sector. There should not be the domination of, for example, one nation. Further, there should also be an increase in the participation of stakeholders who are not farmers, which will provide several perspectives on ensuring the resilience of dairy farms, not just the farmer's perspective that dominated in this study.

The topic of examining the needs to increase the resilience of dairy farms using information from many sources should be continued. The research presented may be considered pioneering, and its results should constitute a reference point for dairy sector stakeholders working to build resilience on dairy farms. The multi-source nature of the data analyzed in our article can reduce the risk of failure or the constant search for new, often theoretical solutions to protect dairy farms from the consequences of operating a VUCA environment.

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