



## OPEN Social conditions of smallholder dairy farmers influence their environmental decisions

Joanna Frątczak-Müller<sup>1✉</sup>, Anna Rychła<sup>2</sup>, Wilfried Winiwarter<sup>2,3</sup> & Barbara Amon<sup>2,4</sup>

The objective of this study is to characterize the social conditions for making agricultural decisions. Particular attention is paid to sustainable agricultural practices in dairy farming. The theoretical framework has been developed around two major explicatory perspectives: sustainable development and quality of life. In the study, we assume that the regional dimension of problems related to the sustainable development of the dairy sector requires solutions adequate to the needs of the regions to create sustainable milk production systems. We put forward a thesis on the impact of objective living conditions of farmers on the readiness to introduce changes in the farm and to apply sustainable agricultural practices. The study has been carried out using the survey method, conducted in a face-to-face interview with fifty farmers engaged in milk production. This study contributes to revealing the role of social sustainability criteria for adopting environmentally friendly farming practices. The novelty of the approach is the use of in-depth sociological analysis in research on the sustainable development of agriculture in small farms (1–5 cows). The results have revealed a significant positive relationship between the assessment of farmers' well-being and the willingness to adopt sustainable agricultural practices. The results also suggest that the analysis of social determinants of agricultural decisions is essential for the implementation of the assumptions of sustainable agriculture. Here we demonstrate that the criteria of subjective well-being can be considered important factors in a positive attitude towards sustainable development and openness to changes in agricultural production.

**Keywords** Sustainable development, Quality of life, Agricultural practices, Dairy farming

### Background

Smallholder farms are usually family enterprises substantially contributing to the agri-food sector globally<sup>1</sup>. They specifically are characterized by a limited area of arable land, low production volume, small number of employees and low income compared to other farms<sup>2,3</sup>. Yet, their multiple functions in the environment, economy, and society have been widely highlighted at local and regional scale through e.g. maintaining natural resources, ensuring diverse products to cover local needs, providing work places for economic stabilization in the region, establishing ties with the local community, maintaining tradition of cultural and historical significance<sup>4,5</sup>. For these reasons, the interest in supporting smallholding farms has become as one of main objectives of the European Common Agricultural Policy<sup>6,7</sup>.

Current farming systems face significant pressure to produce food sustainably while minimizing environmental impacts<sup>8</sup>, necessitating a multidisciplinary approach that considers environmental, economic, and social dimensions<sup>9–13</sup>. However, most studies concentrated so far on environmental or economic aspects, with limited research on the social dimension<sup>14,15</sup>, despite its strong potential to interact with other sustainability pillars<sup>9,13</sup>. There is also empirical evidence that farmers' decisions regarding the implementation of sustainable environmental solutions can be significantly influenced by psychological and social factors<sup>16–18</sup>. Thus, to effectively address the social dimension of sustainable agriculture, a deeper understanding of farmers' values, perceptions, and decision-making processes is crucial. This is particularly important for smallholder farms, which exhibit a high degree of diversity in terms of geographical location, production types, land use, demographics, labor, and income levels<sup>3,18,19</sup>. This diversity requires a context-specific approach when examining social aspects of agricultural production at farm level, as these factors can vary significantly across different farming systems

<sup>1</sup>Institute of Sociology, Faculty of Social Sciences, University of Zielona Góra, Zielona Góra, Poland. <sup>2</sup>Institute of Environmental Engineering, Faculty of Civil, Architecture and Environmental Engineering, University of Zielona Góra, Zielona Góra, Poland. <sup>3</sup>International Institute for Applied Systems Analysis, Laxenburg, Austria. <sup>4</sup>Leibniz Institute for Agricultural Engineering and Bioeconomy, Potsdam, Germany. ✉email: j.fratzczak-muller@wns.uz.zgora.pl

and location<sup>5,20</sup>. Thus, in our study we specifically focus on the dairy smallest farms, which are often prevalent across the European countries and regions<sup>9</sup>.

By examining these aspects, we aim to provide a valuable contribution to the literature, which could also inform policy recommendations to support sustainable practices among smallholder dairy farmers. Our work aims also to characterize operating and social conditions as well as identify social determinants of decision making on the adoption of selected practices particularly associated with animal welfare and manure management in Polish smallholder dairy farming. Animal welfare deserves special attention because it is one of the most specific indicators for measuring sustainable development by covering ethical and moral aspects, as well as drawing the most attention among dairy consumers<sup>21,22</sup>. In addition, manure management becomes greater attention among the farmers since measures preventing water pollution and emission reductions from agriculture mainly focus on improving manure management and were introduced by Polish policy acts<sup>23,24</sup>.

### The concept of social sustainability—challenges and limitations

Sustainable development refers to approaches how societies can satisfy needs and development to ensure the same conditions for future generations<sup>25</sup>. From this point of view, sustainable development includes considerations regarding the dynamics of socially shaped relations between society and the environment. As a field of research, this extends from investigating merely ecological conditions. Therefore, environmental sustainability is also closely related to social structure problems and the processes occurring within it<sup>26,27</sup>. Sustainable development is considered within the framework of diverse research of a fundamentally social nature, focusing on the process by which societies manage the material conditions of their reproduction, including the social, economic, political and cultural principles that influence the management of environmental resources<sup>25</sup>. One of the implications of this state of affairs is the widely shared position in the social sciences that nature places measurable limits on human achievements<sup>28–30</sup>. This approach can be observed in official decisions for sustainable development regarding key international documents, in which the main goal is to set the rules for human activity so that socio-economic development is adequate to the finite ecological possibilities of the environment<sup>25</sup>.

The scientific discourse on sustainable development focuses on ecological and economic aspects, often ignoring the social dimension. As a result, as current literature shows, the concept of sustainable social development lacks a coherent definition that could be operationalized in research<sup>31,32</sup>. In recent years, however, efforts have been made to conceptualize social sustainability, placing greater importance on the “human dimension” of global environmental change. This term still raises doubts because it refers to a new area of social science research, added to the research program defined by environmental sciences relatively late<sup>32,33</sup>.

Some studies indicate that social definitions of sustainability are linked to strategies and socially negotiated goals that relate to the interactions of societies with their natural environments, including the interpenetration of various social processes with each other and with ecological processes<sup>33</sup>. First, we find among them the characteristics of economic processes caused by the production and consumption of goods<sup>25</sup>. Secondly, there are also descriptions of social processes related to the features of social structures, access to resources and exclusion from their distribution, lifestyle, work environment and division of labor, also in the context of the analysis of cultural aspects, such as systems of values, norms and social practices<sup>26,34</sup>. For example, in the work of Sachs<sup>26</sup>, several components of sustainable social development appear, such as social homogeneity, fair income and access to goods, services and employment. The importance of “cultural sustainability” is also emphasized. According to the author, this requires “political sustainability” based on democracy, human rights, effective institutional control, risk avoidance, and management. Thirdly, references can also be found on decision-making and response processes, as well as the ability to implement political strategies and public participation in their development and implementation. This strand of literature on social sustainability also actively explores ways to promote pro-environmental behaviors<sup>35–37</sup>.

Finally, social sciences introduce a hermeneutical or interpretive dimension to sustainability research by examining the cultural and social meanings attached to social practices. Exploring the symbolic dimension of social practices allows to identify the perspective of their actors as the underlying factors simultaneously influence the perception and evaluation of the environment and govern everyday behaviors<sup>25,38</sup>.

### Social sustainability of agricultural farms

The scientific literature covers many factors corresponding to relevant social processes and structures. Here we specifically focus on the social sustainability of farms. The review of sustainable agricultural development tools by Janker and Mann<sup>39</sup>, demonstrates that there is still need for more shared understanding, despite recurring research topics. Such topics include those concerning human and labor rights, working conditions and Quality of Life (QOL), in most cases understood as objective well-being criteria. Social sustainability in agriculture often centers on work aspects, like hours, time-off, remuneration, training, environment, and satisfaction or stress<sup>33,40</sup>. These studies indicate positive correlation between living conditions, economic situation and psychological comfort. They also emphasize the importance of ensuring the operation of farms after the respondents cease their professional activity. Research dealing with social sustainability in dairy farming also concern burnout factors<sup>41</sup>, suggestions for future improvements<sup>42</sup>, and work mechanization or optimization. The results indicate that farms that achieved good work and life satisfaction had a moderate to high degree of mechanization<sup>43</sup>. The last important thread is the social expectations of farmers in developing policies. In this regard, Austrian research showed that the dominant stress factors for dairy farmers were EU policy, public perception, and animal diseases<sup>33</sup>.

### Quality of life from a sustainability perspective

Sustainable development governs both the quality and quantity of economic growth and covers three dimensions of well-being, on the economic, environmental and social scale<sup>44,45</sup>. This means it is impossible

to achieve the desired level of sustainability in the economic, social and environmental dimensions without considering their mutual impact. Thus, it seems justified to emphasize that well-being or standard of living as elements of social sustainability development play a significant role in this concept<sup>40</sup>. Research also uses a new approach, emphasizing the importance of non-economic growth indicators, replacing the concept of well-being with the concept of QOL<sup>46</sup>. QOL is a well-established concept in the social sciences, with the first research on this topic published in the 1960s<sup>47,48</sup>. Today, the term QOL is used in many different disciplines to reflect the idea of an individual's well-being in a framework that extends beyond a simple economic assumption equating well-being with the level of income. The basis of QOL is an individual's well-being and mental state in a broad, multidimensional sense<sup>49</sup>. QOL is the degree to which an individual is healthy, comfortable, and able to participate in or benefit from life events. It is also an integrated system of motivational and aspirational factors based on the needs and values of the individual<sup>50,51</sup>. Satisfaction with QOL depends on the individual's and society's expectations, the type of activity of the individual and his or her life choices<sup>52</sup>. QOL may be quantified in two ways: (1) an objective criterion, determining the relationship of an individual's needs to environment, (2) a subjective criterion, i.e. the individual's mental state regarding needs fulfillment, assessed through perceived success and opportunities for achieving life goals<sup>53</sup>. Subjective and objective QOL measures often show weak relationships, posing a great challenge for researchers<sup>40</sup>. In the case of a deficient standard of living, the objective and subjective indicators mentioned above seem to co-occur more strongly. Researchers thus emphasize the complementary nature of these two approaches and suggest using both simultaneously<sup>54</sup>. When it comes to indicators for sustainable agriculture, some of them raise issues of farmers' QOL. However, they usually focus on the status of the family, ways of supporting decision-making, living conditions, involvement in community affairs or safety - without treating the QOL as a construct based on objective and subjective assessments of living conditions. Moreover, available tools are of limited use in assessing the social situation of farmers<sup>40</sup>.

### Purpose of the study

This study analyzes decision-making for sustainable dairy practices on small farms by exploring three areas: farmers' QOL, their involvement in the development of the dairy sector, and environmental challenges in dairy production including actions taken for sustainable development. In this article, we answer three basic questions: What is the current status of implementing selected pro-ecological practices on small dairy farms? Does QOL influence farmers' environmental awareness of their farms and readiness to change current practices? What changes (legal, financial, social) do farmers require to achieve sustainable production and development? We hypothesize that farmers' objective living conditions and subjective well-being influence their readiness to introduce changes on the farm and apply sustainable practices. We use here in-depth sociological analyses of the QOL rarely encountered in research on sustainable development of agriculture on small farms. We also assume that the regional dimension of problems related to the sustainable development of the dairy sector is important to ensure effective functioning of the system: society - economy - environment. The answers to these questions are particularly relevant as small farms contribute to a large share of people involved in agriculture, and hence to their public perception, while their overall production volume is small and thus they are largely neglected by scientific studies. The present work strives to close this research gap, as much as social conditions these farmers work in are concerned.

## Materials and methods

### Survey

This study used the survey method to analyze small dairy farms in Poland, conducted in a face-to-face contact. The study sample consisted of 50 purposefully selected farmers. The controlled variables were the number of dairy cattle per farm and the percentage share of small farms in the total number of dairy farms per voivodeship. A farm with 1 to 5 cows was considered a small farm. Each farm was represented by the person who did most of the work there. The study was conducted in accordance with the principles of sociological research outlined in the American Sociological Association (ASA) Code of Ethics. All participants were informed about the purpose, procedure, and duration of the study and expressed their informed consent to participate. The research procedures and tools were approved by the Committee for Ethics of Sociological Research at the University of Zielona Góra and complied with the General Data Protection Regulation (GDPR).

The surveyed farms were in Poland's most concentrated area of small dairy farms (Małopolskie and Podkarpackie voivodships constituting 87% and 89% of all dairy farms, respectively, based on unpublished data at the end of 2019, source: The Agency for Restructuring and Modernization of Agriculture) (Fig. S1 in the supplementary information). The empirical material was collected at the turn of 2021 and 2022. All 50 surveys (25 each from Podkarpackie and Małopolskie voivodships) were included in the analysis. There were two reasons for choosing this source. First and foremost, the research aimed to recognize the specificity of the functioning of small dairy farms with less than five livestock units (LU) in the European dairy sector, which constitute 40% of dairy farms in the European Union with considerably higher proportion in Romania (76%), Bulgaria (63%), Lithuania (59%), Latvia (51%), Slovakia (50%)<sup>55</sup>, as well as in Poland (60%; unpubl. data from 2019, The Agency for Restructuring and Modernization of Agriculture). Secondly, the availability of this information as well as concerns, attitudes or planned changes, could only be obtained as part of reactive research.

The survey tool was a structured questionnaire consisting of three main sections: farmers' quality of life, farm management, and technical information about the farm. Additionally, the questionnaire included a section on the socio-demographic characteristics of the respondents. The survey assessed the QOL for both, objective and subjective, criteria. The objective criteria were analyzed in terms of meeting existential needs and job security, while the subjective criteria referred to the assessment of an individual's well-being and satisfaction with agricultural activities, among which satisfaction with relationships with farmers and social involvement were also measured. Further, farm practices related to two environmental aspects of sustainability - animal welfare

and manure management - were assessed. With respect to the animal welfare, three leading practices were investigated: (a) the housing system, (b) the animal space in the barn, and (c) grazing. Considering the manure treatment, special attention was put on (a) manure storage and (b) application on fields as potential sources of nutrient losses and gas emissions. Lastly, farmers' opinions about environmental impact of dairy production and their attitude towards implementing sustainable practices on farms were surveyed.

Open-ended questions were also used in the survey, and on their basis, qualitative data analysis was performed. The analytical process included data reduction, data display, and the derivation/confirmation of conclusions. We searched for significant concepts and critical events in the answers. We also reconstructed the text until the connections between the topics selected for analysis were revealed<sup>56,57</sup>.

### Data analysis

The relationships between selected socio-economic criteria of farmers' QOL and of farmers' attitude towards aspects subjected to the environmental sustainability were tested with Spearman's rank correlations ( $Rho$ ) as the dataset comprised of the ordinal scaled data. The QOL criteria included four categories: 1) economic status/standard of living (ES) measured through two criteria: i) Correspondence of farmer's material level with other people of the same age (ES\_AGE), and ii) Correspondence of farmer's material level with his/her aspirations (ES\_ASP); 2) working conditions (WC) measured through two criteria: i) Assessment of overall working conditions and incomes (WC\_INC), and Assessment of overall satisfaction with life as being a farmer (WC\_PROF); 3) social needs (SN) measured through six criteria: i) Contacts with children (SN\_CHIL), ii) Contacts with family (SN\_FAM), Contacts with friends (SN\_FRIE), iv) Correspondence of farmer's attendance on social events/meetings towards other people of the same age, v) Having time for yourself (SN\_YOU), and vi) Having vacations (SN\_VAC); 4) Political stability measured through one criterion of Evaluation of environmental policy (PS). Further, farmers' attitudes towards aspects subjected to the environmental sustainability were tested through responses on the following statements: (a) „Milk production is a considerable contributor to greenhouse gas emissions and has negative impact on the environment”, (b) „From the point of view of the public perception of the dairy sector as a whole, it is good to minimize its negative impact on the environment” (c) „Animal welfare is important factor in milk production and should be taken into account sustainable development strategy”, (d) „I am interested in reducing greenhouse gas emissions caused by my farm”, (e) „I have (my agricultural advisor has) specific ideas on how to reduce the negative impact of my farm on the environment”, (f) „I will need financial support to reduce the negative environmental impact of my farm”. All statistical analyses were performed with software STATISTICA v.13.3. Detailed description of social variables used for the analyses is given in the Table S1 in the supplementary information.

## Results

### General characteristics of the surveyed farms

The surveyed farms were run mainly by men (31 respondents; 62%; Fig. 1a). They included small households, in which the maximum number of members was up to five people (40 households; 80%; Fig. 1b). A maximum of up to three people inhabited 17 households. Only one household had more than seven inhabitants. Additionally, 37 surveyed households (74%) had underage children living in them (Fig. 1c).

The analysis of farm income sources showed their strong diversification (Fig. 1d). Income from work on a farm was most often combined with hired work (23 respondents; 46%), pensions (23 respondents; 46%) and social assistance benefits and allowances (23 respondents; 46%) (Fig. S2 in the supplementary information). Moreover, eight households declared income from additional private entrepreneurship (excluding work on the farm), and seven reported income from other sources. None of the surveyed farms made their living solely from agricultural production.

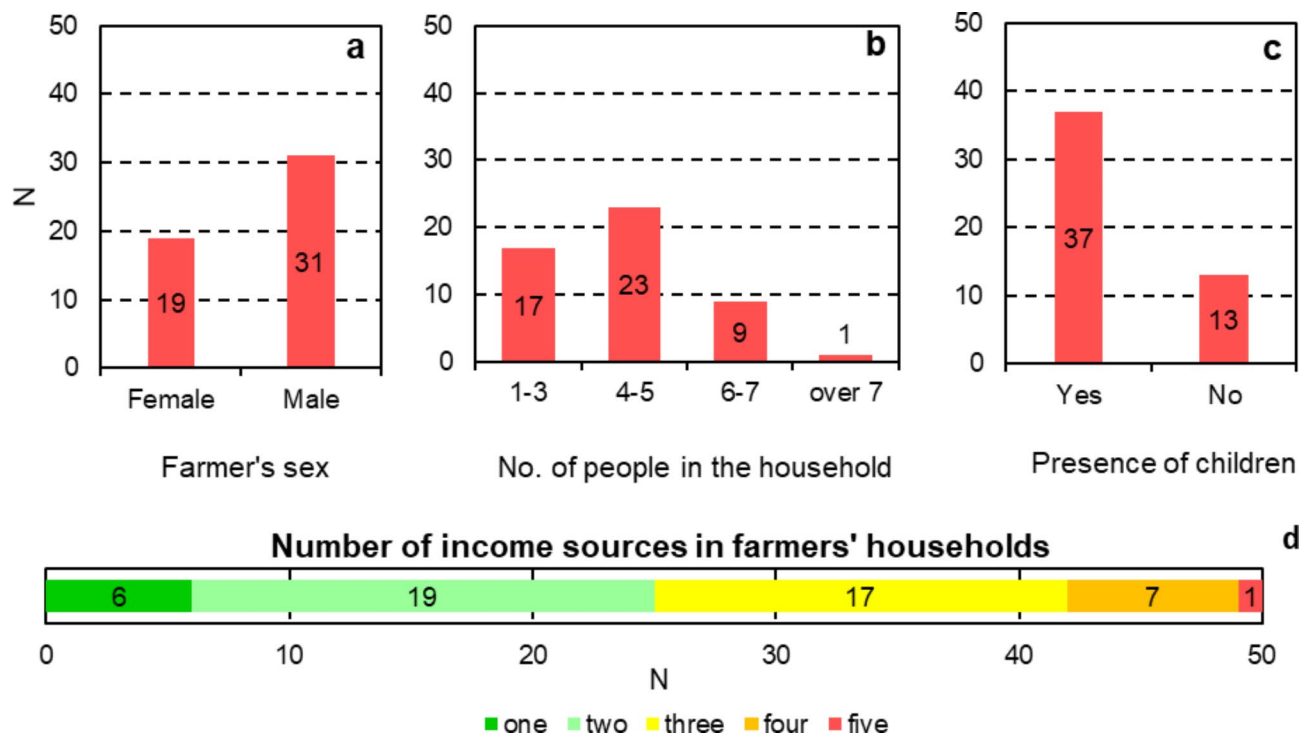
The number of dairy cows was almost equally distributed among the sample (Fig. 2a) and most farms (40 responses; 80%) only raised dairy cattle (Fig. 2b). Animals were usually fed with forage fully produced on the farm (38 responses; 76%), whereas 12 farmers (24%) purchased either roughage or concentrates (Fig. 2c). Tie-stalls dominated housing (48 responses; 96%; Fig. 2d), with all farms using straw bedding (Fig. 2e). Most removed it twice daily (38 responses; 76%; Fig. 2f). This type of practice resulted further in formation of both, solid and liquid manure on all farms (Fig. 2g). Also on all farms, the barns were ventilated naturally (Fig. 2h). In 94% of cases (47 responses), dairy animals were grazed (Fig. 2i). With respect to the land utilized, the average farm area was 5 ha of own land and 6.8 ha when summarizing the own and leased land (Table S2 in the supplementary information). The daily milk production was mostly declared at 20 L/animal, but fluctuated between 3 and 35 L/animal (Table S2 in the supplementary information).

### Meeting existential needs and job security

Most respondents were satisfied with life as a farmer (34 participants; 68%; Fig. 3a), although one-third were convinced that their standard of living was lower than that of other people of a similar age (Fig. 3b). Additionally, one-third of the respondents believed that their material standard of living corresponded to their aspirations, i.e., what they would like or desire (Fig. 3c).

Satisfaction in meeting needs was also measured in relation to other existential needs regarding the use of institutions' services in their area and the conflict between farmers' work and the institution's times of operations. Access to public facilities (city hall, commune office, municipal office, social welfare center) was rated highly, but only about two-thirds of the respondents had such access (32 respondents; 64%; Fig. S3a in the supplementary information). Exactly half of the respondents assessed access to the agricultural advisory center as good. Other high-access institutions included health centers, stores and services that respondents needed. Difficulties in access concerned recreational areas (sports halls, sports activities) and public transport, which is a more general feature of Polish villages. The study additionally showed that only 2/3 of the respondents were interested in





**Fig. 1.** Socio-economic characteristics of the surveyed farms with respect to respondents' sex (a), number of people (b), presence of children (c), and number of income sources (d) in the household.

using the places and services mentioned above. The situation was similar with using the services of agricultural advisory centers and other organizations related to agricultural production. Respondents who did not need such institutions or services selected the “not applicable” option, and 20 farmers did this. The respondents were also asked how often they participate in meetings, parties or social gatherings with friends compared to other people of a similar age. Almost two-thirds did it less often (sum of answers “less often” and “definitely less often” – 30 respondents; 60%; Fig. S3b in the supplementary information). However, 18 respondents responded that they socialized as often as others of their age.

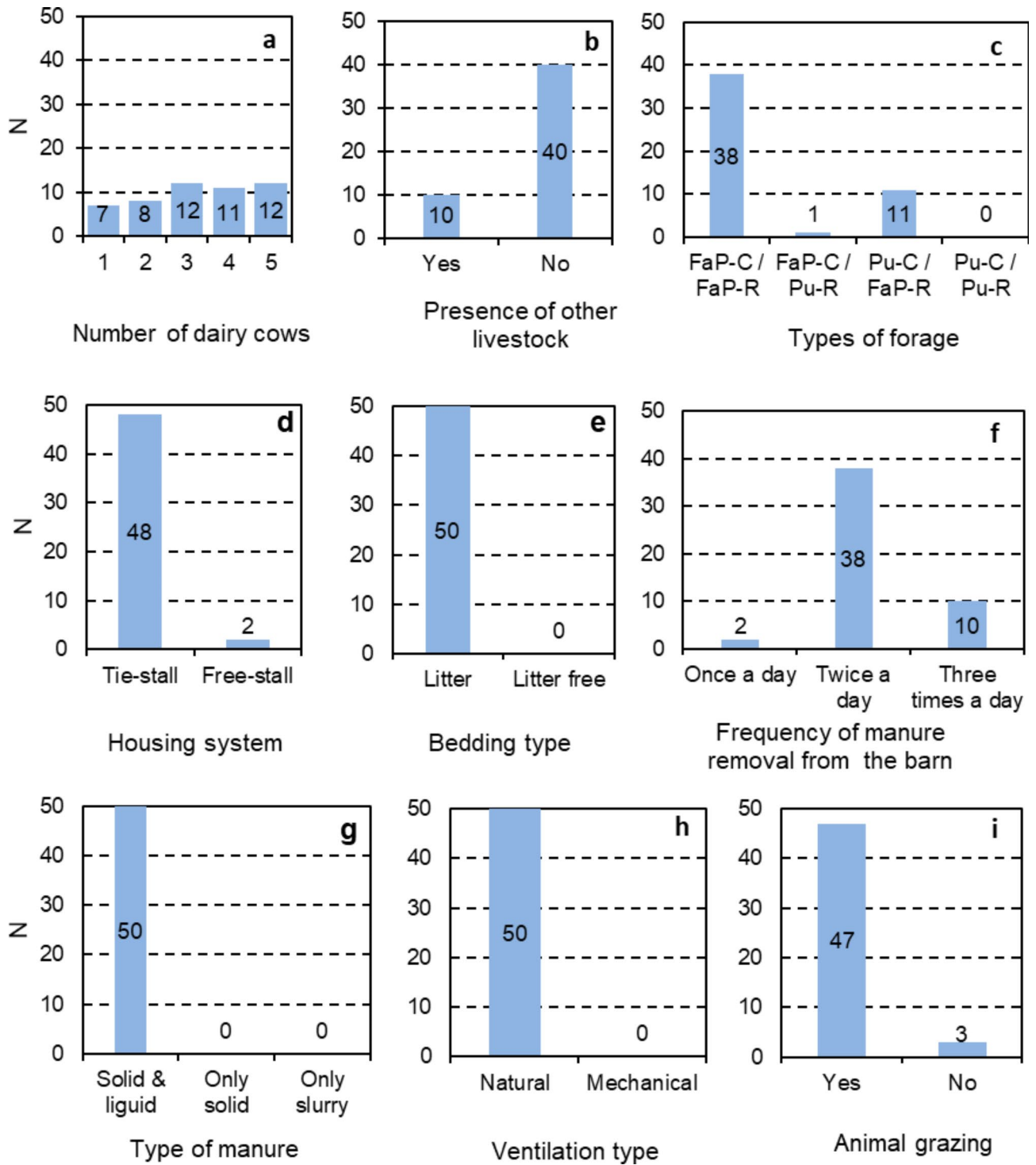
The assessment of working conditions (monthly salary, working time, risk of accidents, variety of tasks) received lower marks. One-fourth of the respondents believed they are able to cope with their daily work and current income (Fig. 4a).

The remaining farmers reported that their work was demanding and needed better remuneration. In addition, eight people indicated at least one accident at work in the last three years preceding the study (Fig. 4b). As none of the farms employed non-family workers, the vast majority (46 respondents; 92%) declared temporary overload with work on farm (Fig. 4c). Particularly, most respondents spent 21–30 h a week of work on the farm (18 respondents; 36%), and another ten respondents declared 41–50 h a week (Fig. S4a in the supplementary information). Moreover, 29 farmers (58%) defined up to 6 h as the daily workload, but there was a group of farmers (10%), who declared even more than 12 h of work per day (Fig. S4b in the supplementary information). Women were mostly assigned from 40 to 50% of the annual labor input on the farm (Fig. S4c in the supplementary information). It is worth emphasizing that over two-fifths of respondents did not rate milk production as profitable.

### Well-being and satisfaction from agricultural activities

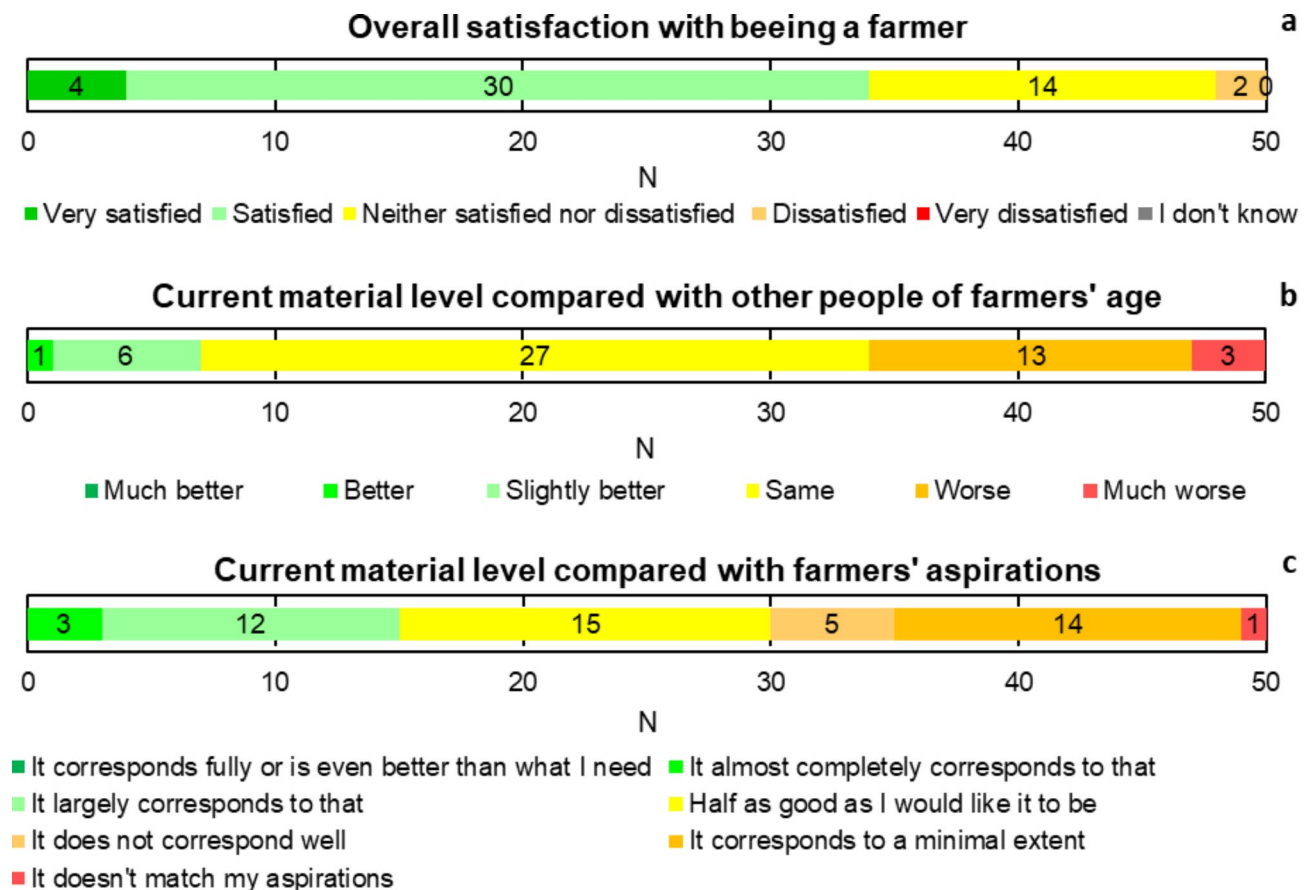
The majority of farmers were satisfied with their life and would not want to change their profession, even if they could do so (31 respondents; 62%; Fig. 5a). Worth noting is that most of these respondents had over 20 years of work experience (30 respondents; 60%; Fig. S5a in the supplementary information) and had no formal education related to agriculture (38 respondents; 76%; Fig. S5b in the supplementary information). Additionally, a similar number of farmers did not participate in courses, lectures, or conferences to expand their knowledge or professional skills in the three years before the survey date (30 respondents; 60%; Fig. S5c in the supplementary information). Their relations with farmers and other village residents are also assessed as positive. There were 44 participants in the sample rated these contacts as good or very good (Fig. 5b). It was generally agreed that most farmers try to be helpful and support each other (34 respondents; 68%, Fig. 5c). In this context, the characteristics of farms are attractive due to the supply network they use. Of 25 farms that used such supplies, 23 did not use resources locally (Fig. 5d). According to their declarations, the area where they purchased products was up to 50 km from their farm.

We also analyzed whether the needs in social contacts were satisfied. The latter concern availability of time for family, time to play with children, communication with friends, time for themselves and the possibility



**Fig. 2.** Main characteristics of the smallholder farms with respect to the number of dairy animals (a); presence of other livestock (b); type of forage used for dairy animals (c): FaP—farm-produced; Pu—purchased; C—concentrates; F—roughage; housing system (d); bedding type (e); frequency of manure removal from the barn (f); type of manure produced by dairy animals (g), type of ventilation in barn (h), and presence of dairy animals grazing (i).

of taking holidays. Farmer’s perceptions of their time resources show a high variability between agreement and disagreement. They were most often satisfied with the time they had for social contacts with friends (34 respondents; 68%) and least satisfied with the time they had for taking holidays (38 respondents; 76%) (Fig. 6a). Because connections with friends, as indicated above, were assessed as rare, deprivation of this type of needs most likely occurs here. Other difficulties in meeting social needs included having time for the family (14



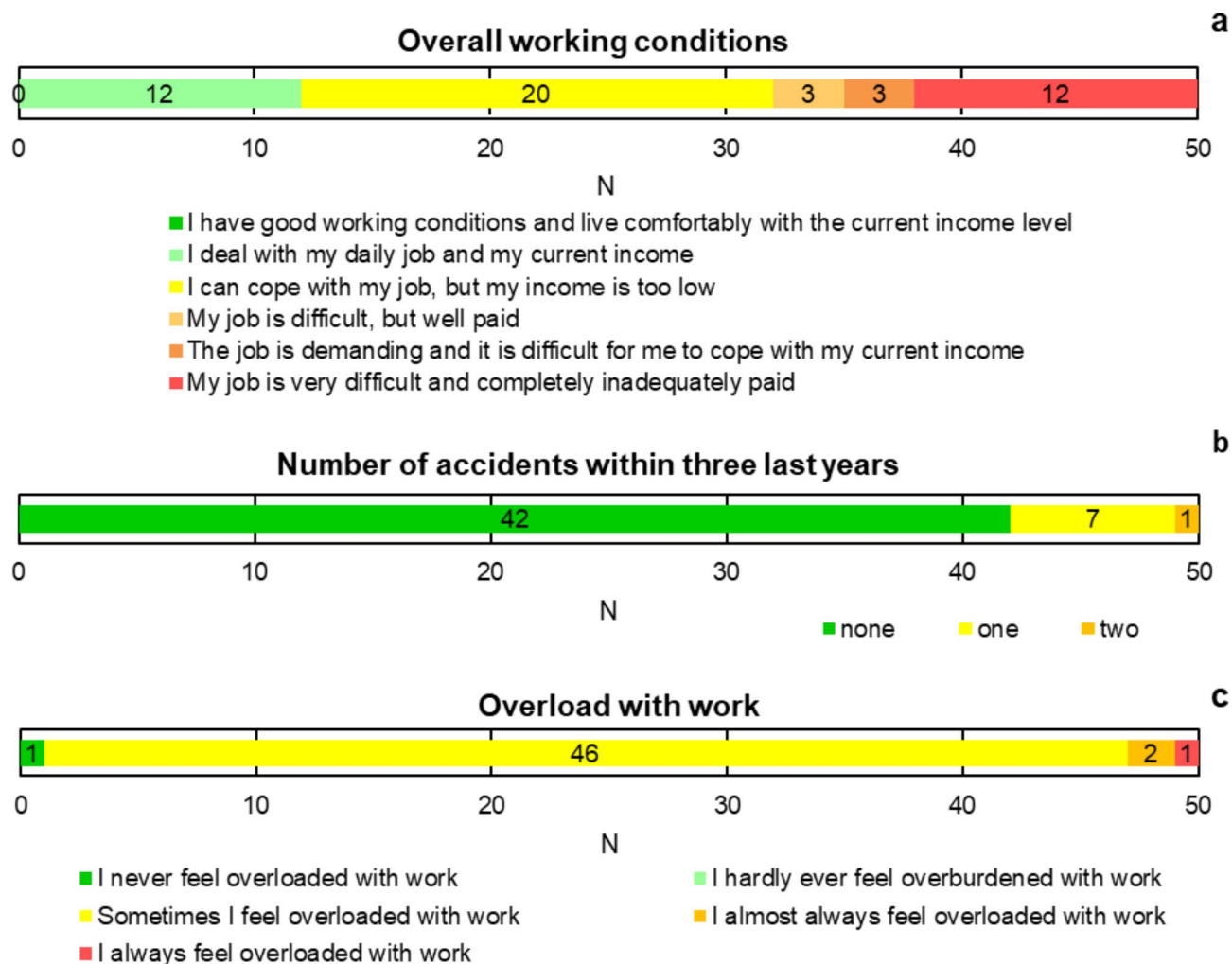
**Fig. 3.** Estimation of quality of life by the farmers with respect to overall satisfaction with being a farmer (a), material level in relation to other age-mates (b), and material level in relation to farmers' aspirations (c).

respondents; 28%), although in general, the farmers believed that the nature of their work allowed them to combine professional and family roles (36 respondents; 72%; Fig. 6b). The last category of difficulties concerns the function of mental hygiene, understood as the set of practices that allow a person to enjoy mental health and be in harmony with his or her socio-cultural surroundings<sup>58</sup>. In this area, one-third of farmers considered they needed more time to develop their hobbies or just for themselves.

### Reasons for milk production, farmers' operational plans and expectations towards the authorities

In light of the farm characteristics discussed, we explored the reasons and goals behind milk production through an open-ended question: "Why do you produce milk?" This qualitative analysis revealed four main categories of motivations, highlighting that farmers often expressed bundles of reasons rather than single motives. Firstly, many responses reflected a sense of inheritance and tradition, with 22 farmers noting phrases like "it's in my blood" and "common family traditions." Additionally, 20 respondents viewed milk production as a rewarding and fulfilling way of life. A significant number (19 responses) emphasized the importance of utilizing available resources, citing reasons such as "it's a pity to let the land go to waste" and "the cattle were already here." The least common motivations were fatalistic, expressing inevitability or chance, with 10 farmers stating things like "it just happened this way" or "I don't know any other way to live." Regarding the usage of produced milk, 26 respondents (52%) indicated that it was primarily for both household needs and sale, while two-fifths produced exclusively for personal consumption, and only three farmers primarily sold their milk.

In examining farm management and operational strategies, we inquired about sector activities and expectations regarding agricultural policy. The results indicated relatively positive assessments of Poland's agricultural policy, with nearly half of the respondents expressing favorable views (Fig. 7a). It is important to note that this study was conducted during the COVID-19 pandemic before the Polish government decided to lift quantitative import quotas on cheaper agricultural products from Ukraine, a significant issue for Polish farmers. Respondents identified various expected changes, particularly legal (15 responses) and financial reforms (37 responses; 74%). The primary concerns included (a) receiving production subsidies and (b) ensuring fair prices for agricultural products. Additionally, better access to equipment and industry information was frequently mentioned. Despite these concerns, respondents seldom took action to improve the agricultural sector or to address unfavorable political decisions (Fig. 7b). Proposed actions included contacting politicians, engaging with dairy-related social organizations, signing petitions, and sharing posts on social media. Succession planning



**Fig. 4.** Assessment of working conditions and incomes (a); number of accidents on the farm within three last years (b); and assessment of overload with work (c).

was also addressed, with exactly half of the surveyed farmers indicating they had plans for successors (Fig. 7c), primarily focused on transferring production responsibilities to their children.

#### Current practices related to sustainability of dairy production

In our study, special attention was paid to the current status of animal welfare and manure treatment practices as indicators used for measuring sustainability of dairy production. With respect to the animal welfare, the dairy cows were mostly housed in tie-stall barns (96% of farms), only in two cases there was free stall housing adapted (Fig. 2d). The area per cow mainly ranged between 2 and 4 m<sup>2</sup> (32 farms; 64%) or more (17 farms; 34%), whereas in one case it was lower than 2 m<sup>2</sup> (Fig. 8). In almost all farms (94%), the animals grazed on pastures during the vegetation period (Fig. 2i).

Considering the practices of manure treatment, the solid manure was stored outdoor on uncovered piles. On 45 farms (90%), the piles were located on concrete (Fig. 9a), from where the leachate was directed to covered, tight tanks. On the other hand, on five farms (10%), the solid manure was stored directly on the ground and leachates could seep into the soil. Furthermore, the solid manure was mostly loosely distributed on the concrete (96% of cases, Fig. 9b), whereas only two farmers (4%) compacted it manually. All farmers used both, solid and liquid manure, as organic fertilizers on their fields. In all cases the manure was broadcasted, whereby 34 farmers (68%) declared plowing the area after application of solid manure within 12 h and only 10 farmers (20%) did this in case of liquid manure within 4 h (Fig. 9c).

#### Farmers' opinion about environmentally relevant farm management practices

Farmers were also asked about their attitudes towards sustainable farming practices. Questions referred specifically to the possibilities of reducing greenhouse gas (GHG) and ammonia (NH<sub>3</sub>) emissions. Eleven respondents (22%) were convinced they could introduce such solutions, 13 farmers (26%) declined that they were able to adopt such options, and 26 (52%) doubted them (Fig. 10a). The most frequently declared ideas concerned manure management, particularly during storage stage. Farmers discussed plans for constructing



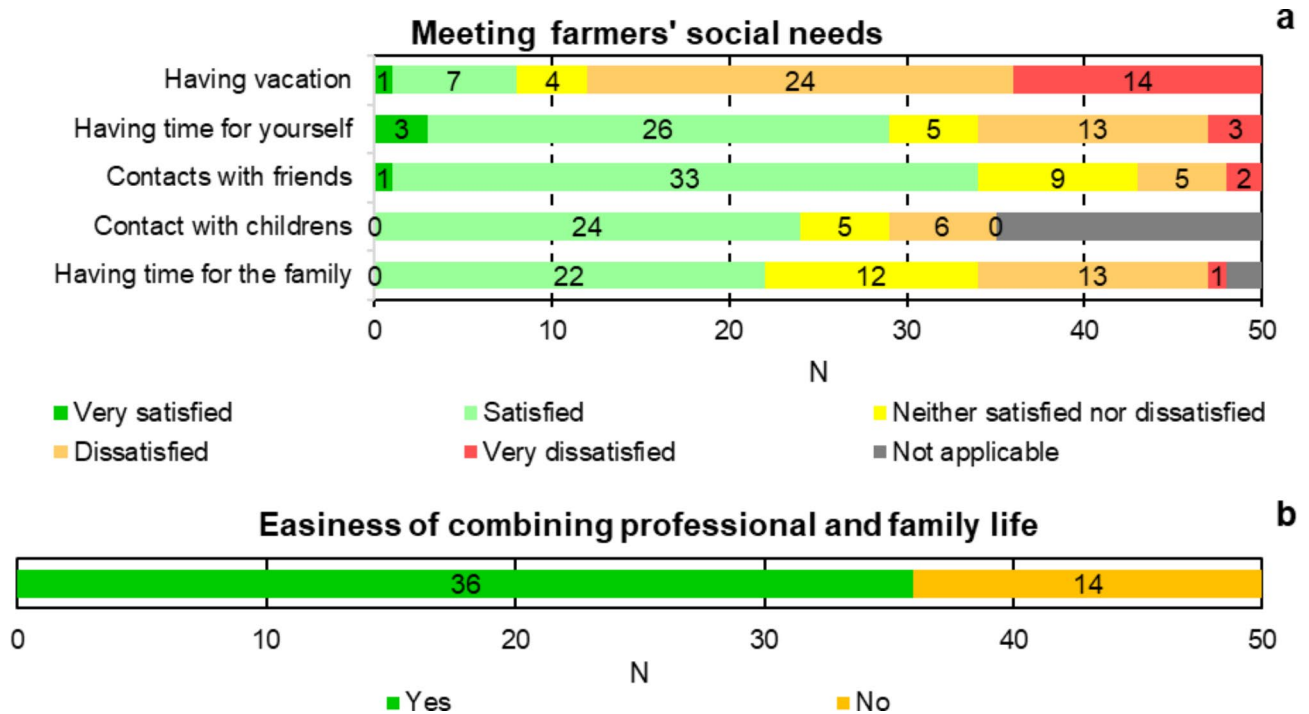


**Fig. 5.** Assessment of farmers' satisfaction with being a farmer (a), relations with other farmers (b, c), and use of local delivery network (d).

or refurbishing manure plates by enlarging them or adding retaining walls (8 responses). Additionally, four farmers considered compaction of solid manure during the storage phase. In one case, even a micro biogas plant was mentioned as a potential solution for manure treatment. Some farmers (3 responses) favored modernizing livestock buildings, while others (4 responses) focused on improving liquid manure application efficiency. It is worth emphasizing that most surveyed farmers declared that they had never received funding to improve the efficiency of their farm operation (42 respondents; 84%; Fig. 10b).

To assess farm sustainability, farmer awareness of dairy's environmental impact and their interest in on-farm improvements was also examined. The social element in this approach reflects attempts to harness the human potential to achieve improved environmental outcomes or, as Chiu<sup>59</sup> put it, to identify "the social conditions necessary to support ecological sustainability". We thus enquired farmers' perception of: (a) milk production as a considerable source of environmental pollution, (b) minimizing negative impact of the dairy sector considering public expectations, (c) importance of the welfare of animals in milk production and sustainability of the farm. Additionally, the farmers' interest for mitigation of GHG emissions on their farms (d) as well as ideas (e) and the needs for financial support (f) were investigated. Two-thirds of respondents (33 respondents; 67%) did not consider milk production as considerable factor of GHG emissions and environmental changes, all other 17 respondents (33%) stayed neutral and none of the farmers thought milk production would be relevant (Fig. 11).

However, 18 respondents (36%) agreed and only eight (16%) disagreed that minimizing negative impacts of the dairy sector was a good option taking, into account social expectations. Additionally, the importance of animal welfare in milk production and its significance in developing strategies were assessed as definitely positive. High interest to reduce GHG emissions on their own farm was expressed by about one-third of the farmers (16 respondents; 32%), but exactly the same number remained undecided, and the rest (18 respondents; 36%) was not interested in this respect. The most ambivalent opinions were expressed in the responses regarding



**Fig. 6.** Assessment of farmers' satisfaction with social needs (a) and implementation of social roles (b).

the need for financial support to reduce the negative impact of farms on the environment. For 31 respondents (62%), it was not apparent whether they needed such support (the answer "neither agree nor disagree"). The reason for this may be the need for more experience in obtaining subsidies for agricultural development. As we indicated above, 84% of farmers declared that they had never received funding to improve the efficiency of their farm operation. However, 14 people (28%) emphasized the need for financial support for these activities. It is also worth to mention, that only one farmer interested in GHG reduction and with an idea how to implement it on his farm declared no need for financial support. The other nine (out of ten) respondents expressing no need for financial support were from the group with no interest in GHG reduction.

### Relationships between farmers' attitude towards environmental aspects and their QOL

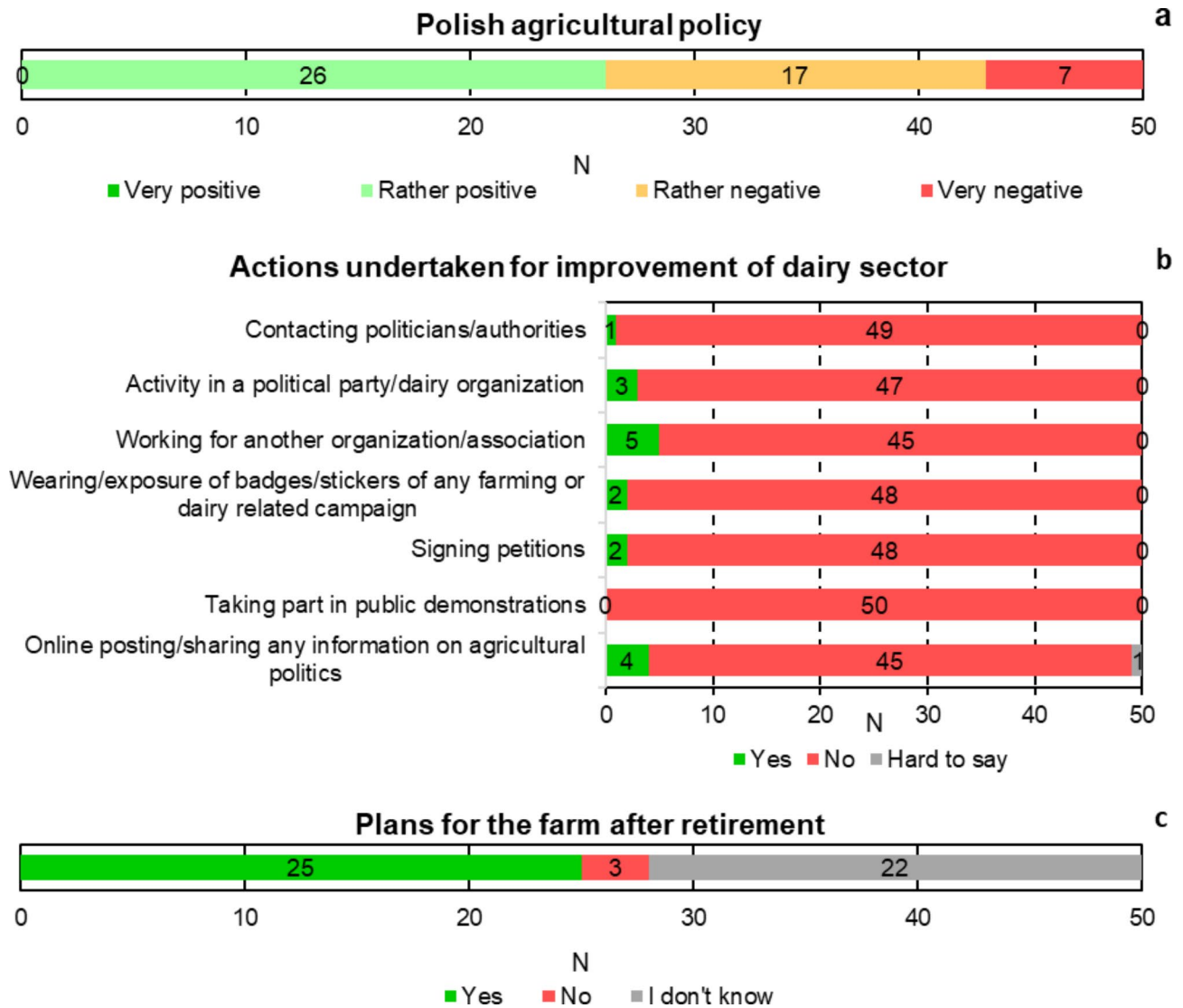
Taking action on environmental problems that directly impacted the farms enabled to investigate the link between farmers' attitudes towards environmental concerns and their QOL. Several significant connections were found (Table 1).

Generally, the interest in reducing GHG emissions grew with greater satisfaction with the current level of material wealth ( $Rho = -0.42, p = 0.002, n = 50$ ), better working conditions ( $Rho = 0.32, p = 0.022, n = 50$ ), and time available for the whole family ( $Rho = -0.34, p = 0.025, n = 48$ ). Farmers with mitigation ideas showed even stronger interest ( $Rho = 0.59, p < 0.001, n = 50$ ). Additionally, the higher interest of the farmers was the more needs for financial support were stated ( $Rho = 0.54, p < 0.001, n = 50$ ). In contrast, neither social needs related to having contacts with children ( $Rho = -0.13, p = 0.769, n = 35$ ) or friends ( $Rho = -0.16, p = 0.252, n = 50$ ), nor using the leave from farm ( $Rho = -0.25, p = 0.074, n = 50$ ), nor declared level of satisfaction with being a farmer ( $Rho = -0.13, p = 0.379, n = 50$ ) provided a statistically significant explanation to respondent's attitude to reduce negative environmental impact of the farm. Additionally, animal welfare mattered to farmers and significantly correlated with working conditions and financial situation ( $Rho = 0.34, p = 0.014, n = 50$ ), satisfaction with being a farmer ( $Rho = -0.29, p = 0.039, n = 50$ ), as well as farmers social interaction with peers ( $Rho = -0.32, p = 0.021, n = 50$ ). In contrast, farmers' opinions concerning general aspects of environmental impact from dairy production and dairy sector correlated with hardly any of the criteria characterizing the QOL (Table 1). The only exception indicated that farmers happy with work and finances were less likely to prioritize environmental reduction in milk production considering social expectations ( $Rho = 0.37, p = 0.007, n = 50$ ).

### Discussion

This research was carried out to better understand aspects for sustainable management and decision-making in smallholder dairy farms highlighted by an analysis of the current state and correspondence between socially and environmentally relevant criteria. The analysis of farmers' QOL and its impact on environmental decision-making revealed three significant findings.

Firstly, objective and subjective measures of farmer QOL showed weak relationships. Most participants were satisfied with their current lives, professional roles, social contacts, and relationships with other farmers, even though they considered their work demanding and not well-rewarded. Moreover, most respondents were



**Fig. 7.** Evaluation of Polish agricultural policy (a), actions undertaken to improve dairy sector (b), and plans for the farm after retirement (c).

satisfied with their material standard of living despite feeling overloaded with work. This confirms the importance of combining objective and subjective criteria in measuring the QOL and treating them complementary<sup>40,54</sup>.

Secondly, the high level of well-being observed may stem from the cohesion within local communities represented by the respondents. This cohesion fosters a sense of community and motivates collective actions for the common good. Respondents showed this in their commitment to the agricultural sector and their expectations for policy changes, improved access to technology, and consulting support. This sense of community is rooted in shared values, social principles, heritage, and common goals<sup>60</sup>. The reasons and goals for milk production among farmers reflect these threads. For many, it results from inheriting farms, utilizing available resources, and finding agricultural satisfaction. Most respondents felt that farmers support each other and rated contact with other villagers highly. Literature suggests that quality of life improves in such cases based on subjective criteria<sup>61,62</sup>. Additionally, researchers argue that spending more time in social interactions leads to more positive emotions, contributing to better well-being outcomes<sup>63</sup>. Here, however, the results are ambiguous. Most surveyed farmers were satisfied with contacts with other farmers and their time for social contacts, but the contacts themselves were rare. The indicated deprivation of needs may be unconscious needs resulting from life patterns characteristic of local communities and lifestyle associated with the farming profession in Poland<sup>64</sup>.

Thirdly, social cohesion relies on a degree of equality, specifically functional equality, where a similar standard of living promotes communication and cooperation<sup>65</sup>. In this approach, the study's results using objective and subjective criteria regarding satisfaction with current life despite the belief that the material standard of living does not correspond to the aspirations of the surveyed farmers are essential. For equality in the functional sense, some material equalization is necessary. Within this context, reference groups help individuals understand their place within their social group and in relation to others<sup>66,67</sup>.

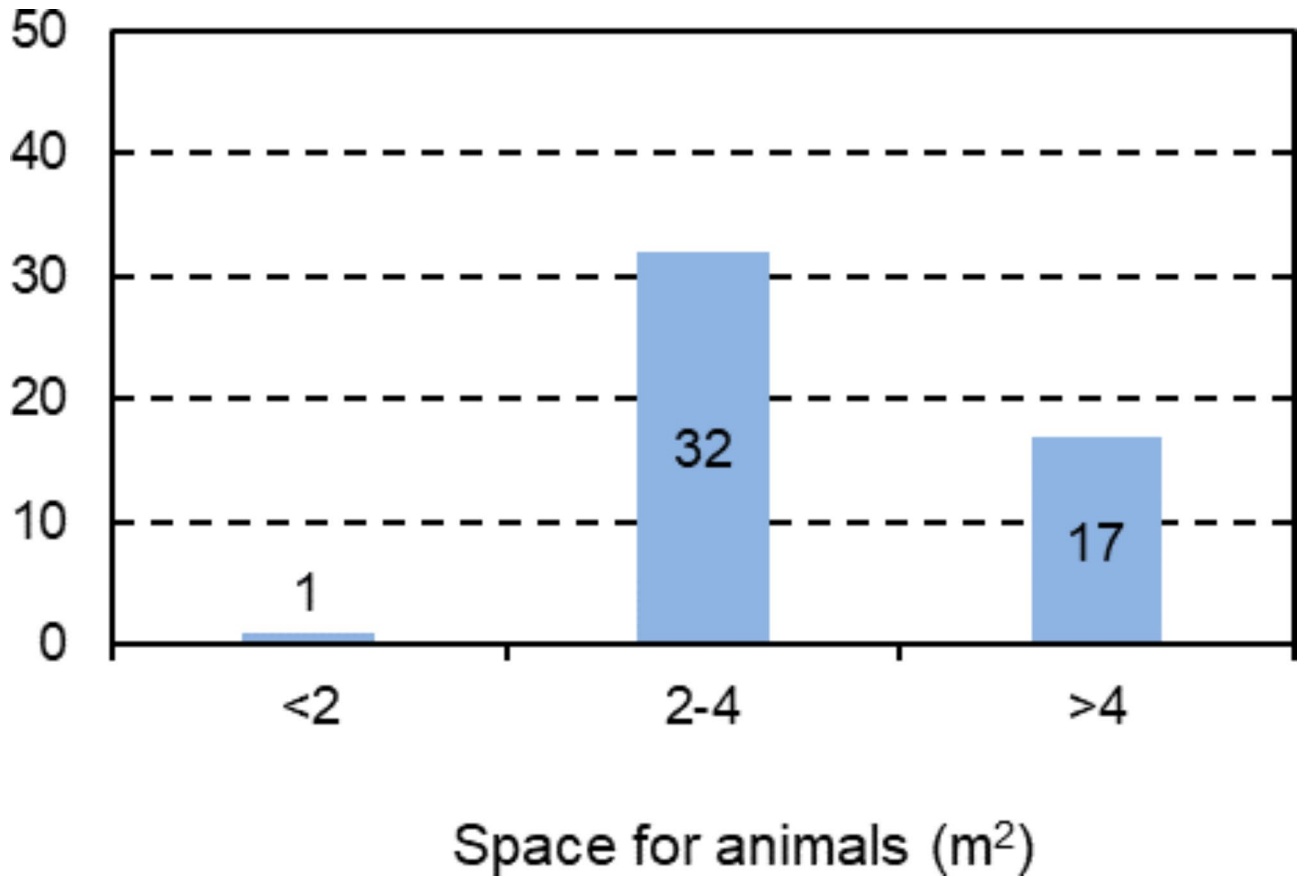


Fig. 8. Farm conditions related to animal welfare expressed as the average space for dairy animals in the barn.

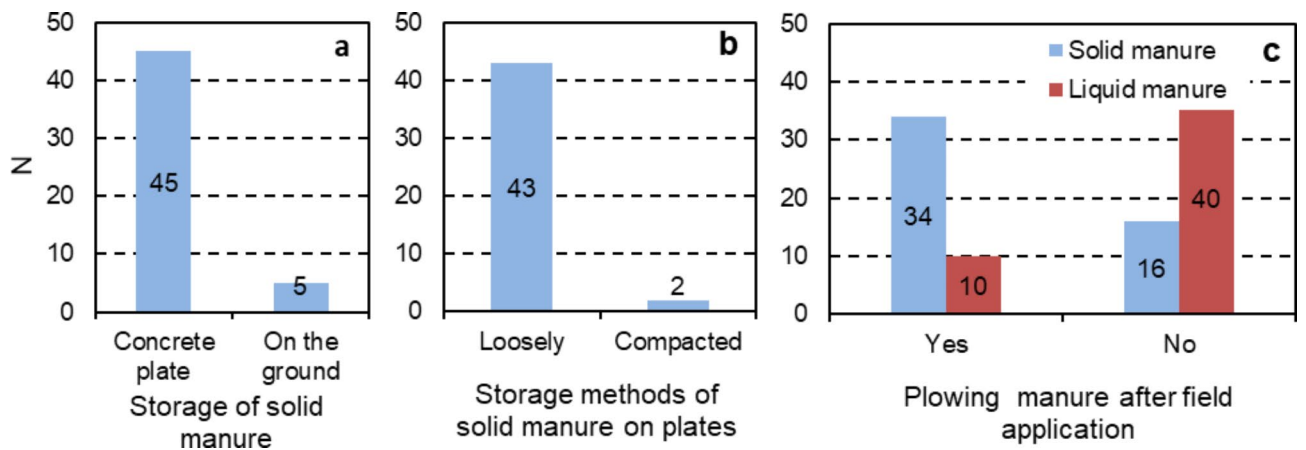
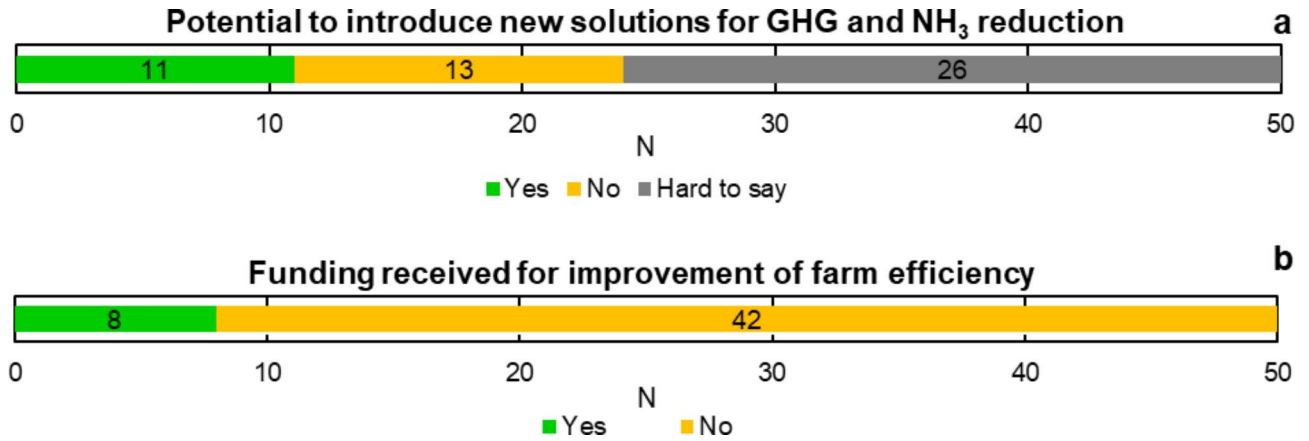


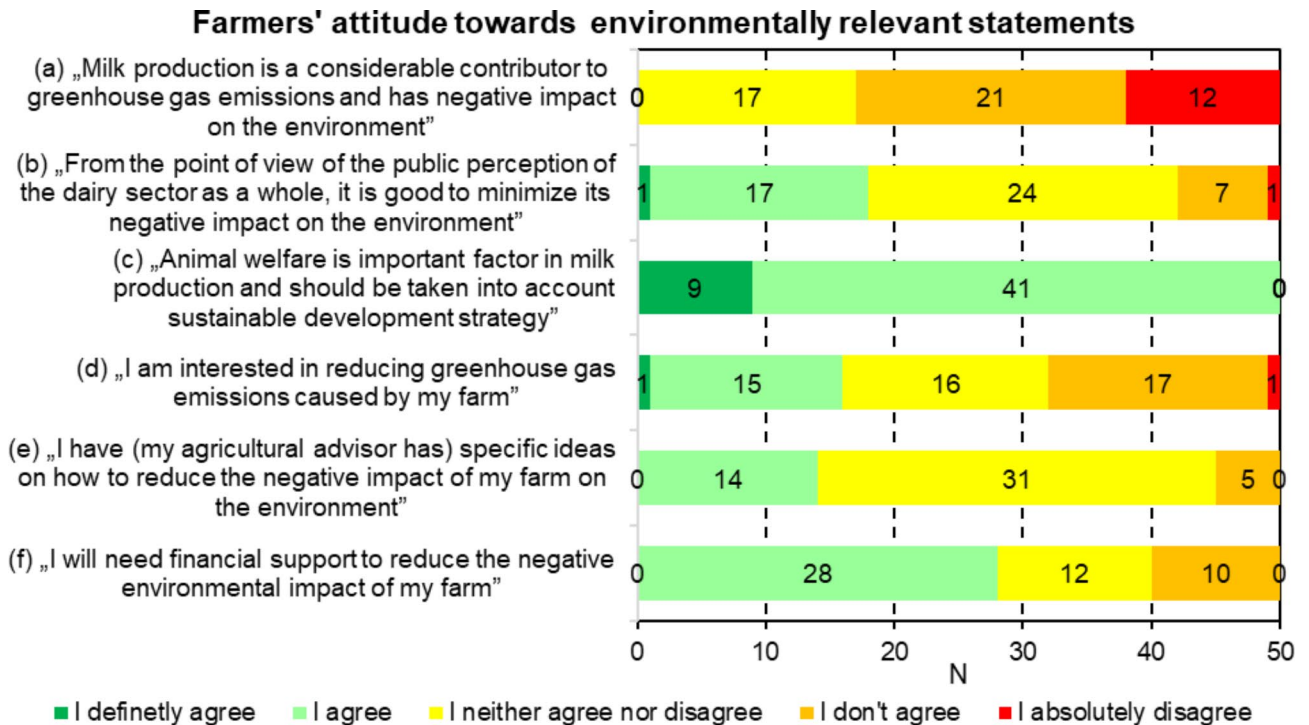
Fig. 9. Farm practices related to manure management characterized by type of storage place (a), storage method (b), and treatment method after manure application on fields (c).

Our animal welfare and manure management research aligns with findings for small farms in Central and Eastern Europe and some Alpine regions<sup>68</sup>. Most surveyed farms practiced winter tie-stall housing with summer pasture access, and 98% met the minimal standards dedicated to the tie-stall systems by Polish legislation<sup>69</sup>. Straw bedding was mainly changed twice daily, hygiene was maintained, and disease risk was reduced. Farmers expressed vital concern for animal welfare, although tie-stalls are criticized for limiting movement and social interactions, increasing morbidity, and lowering productivity<sup>70</sup>. Due to older infrastructure, many small farms cannot easily transition to free-stall systems, but pasture access helps mitigate barn restrictions<sup>68</sup>.

Surveyed farms predominantly also used traditional storage methods regarding manure treatment, with outdoor piles for solid manure and tanks for liquid near buildings or on manure plates. To reduce environmental



**Fig. 10.** Assessment of potential introduction of new solutions for emission reduction on farm (a) and funding received up to date of the survey for improvement of farm efficiency (b).



**Fig. 11.** Results of farmers' responses on fixed statements subjected to the environmental impact of dairy sector and to reduction of this impact at farm level.

pollution, decision-makers could promote additional solutions. The priority need for 10% of farms is an impermeable plate for solid manure connected to a liquid tank, which helps prevent nutrient loss and is required for livestock farms in Poland by the end of 2024<sup>71</sup>. Consequently, many farmers focused on building or expanding manure plates, adding retaining walls or reconstructing existing plates.

Only a few farmers considered other improvements, like compacting manure, and none planned to adopt covers that could reduce nitrogen loss by 60–80% and enhance fertilizer quality<sup>72</sup>. Improvements in manure used as fertilizer revealed that many farms still use broadcast applications, with delayed soil incorporation, leading to significant nitrogen loss as ammonia emissions. Although some (8%) expressed interest in more efficient application methods, they cited financial support as essential. This interest signals that many small farmers are open to improved practices but associate them with investment needs. Decision-makers should note that enhancing manure application could substantially reduce ammonia emissions in Poland<sup>73</sup>, representing a key opportunity for policy-driven environmental benefits.

The analysis of farmers' attitudes towards sustainable practices in agriculture showed relatively little interest in introducing new solutions to reduce GHG and NH<sub>3</sub> emissions. Even beyond monetary requirements and



Criterion QOL <sup>1</sup>	Statement					
	(a)	(b)	(c)	(d)	(e)	(f)
ES_AGE	0.03	- 0.23	- 0.07	<b>- 0.42</b>	<b>- 0.33</b>	- 0.27
ES_ASP	0.18	- 0.26	- 0.17	- 0.06	- 0.10	- 0.14
ES_FIN* (n = 49)	- 0.13	- 0.07	0.18	0.03	0.11	0.06
PS	- 0.21	- 0.06	- 0.19	- 0.17	- 0.09	- 0.03
SN_CHIL* (n = 35)	0.07	0.10	- 0.12	- 0.13	0.08	- 0.24
SN_FAM* (n = 48)	0.13	0.00	- 0.10	<b>- 0.32</b>	<b>- 0.34</b>	<b>- 0.47</b>
SN_FRIE	0.11	0.17	- 0.17	- 0.16	- 0.02	- 0.15
SN_MEET	- 0.07	- 0.14	<b>- 0.32</b>	- 0.16	<b>- 0.32</b>	0.01
SN_YOU	0.09	0.11	0.01	- 0.16	- 0.14	- 0.25
SN_VAC	0.14	- 0.04	- 0.05	- 0.25	- 0.13	- 0.17
WC_INC	0.04	<b>0.37</b>	<b>0.34</b>	<b>0.32</b>	<b>0.30</b>	0.22
WC_PROF	0.08	- 0.24	<b>- 0.29</b>	- 0.13	- 0.20	- 0.11

**Table 1.** Results of Spearman rank correlations ( $\rho$ ) between farmers' statements towards environmental aspects (see Fig. 11 for explanations of column letters) and selected criteria of quality of life (QOL). Bold values indicate significant correlations at the level of probability  $p < 0.05$ ; \* - indicates correlations performed with lower number of cases resulted from non-applicability of the responses. <sup>1</sup> Abbreviations in rows: ES\_AGE - Correspondence of farmer's material level with other people of the same age; ES\_ASP - Correspondence of farmer's material level with his/her aspirations; ES\_FIN - Assessment of overall financial status of the family and farm; PS - Evaluation of environmental policy; SN\_CHIL - Contacts with children; SN\_FAM - Having time for the family; SN\_FRIE - Contacts with friends; SN\_MEET - Correspondence of farmer's attendance on social events/meetings towards other people of the same age; SN\_YOU - Having time for yourself; SN\_VAC - Having vacations; WC\_INC - Assessment of overall working conditions and incomes; WC\_PROF - Assessment of overall satisfaction with life as being a farmer.

challenges in work organization, the change in production forms also creates the need to change habits, which is important from the perspective of the work of small farms. The literature shows that when the context changes significantly, people may be required to reinvent new ways of performing habitual activities<sup>74,75</sup>, such as milking, pasturing, and manure management. This is called "habit discontinuity", which requires a behavior change<sup>76</sup>. It is taken advantage of by people starting new branches of production, but it does not apply to people living in traditional communities and inheriting farming principles. This demonstrates the importance of identifying and analyzing social practices, often based on local knowledge, that mediate professional knowledge. This aspect should be deepened in subsequent studies. However, the main reason for the lack of openness to changes may be the lack of educational support and formal professional education shown in these studies.

Farmers exhibited ambivalence about minimizing the environmental impact of the dairy sector, often not perceiving it as a primary contributor to GHG emissions or environmental change. This supports research suggesting that perceptions of environmental threats and climate change are shaped by cultural and social contexts, which impose specific constraints on behaviors<sup>77-79</sup>. Thus, environmental change is also a social construct, with judgments about environmental quality influenced by individual attitudes and local concerns<sup>80</sup>. British studies affirm this, showing that environmental issues are given more weight when they are local rather than global<sup>79</sup>.

The strong emphasis on animal welfare observed among farmers can be similarly interpreted. Farmers in this study valued animal welfare as crucial in milk production and agricultural strategies, reflecting an informal bond with their animals and a commitment to their well-being. This aligns with findings that farmers' responsibility for animal welfare enhances the quality of production and farmers' own well-being<sup>81</sup>. Research suggests that greater awareness of human-animal relationships leads to increased responsibility for animal care<sup>82</sup>. Despite objective limitations (e.g., resource constraints, cultural and economic factors), our findings indicate that farmers with small herds strive to maximize their resources to support animal welfare.

Our findings highlight how objective living conditions impact farmers' readiness to implement changes and adopt sustainable practices. Subjective well-being—determined by material stability, good working conditions, and family time—emerged as a significant factor fostering positive attitudes toward sustainability and openness to change. These aspects address safety and work-life balance and are enhanced by access to knowledge and agricultural advisory services, particularly valuable for farmers inheriting traditional practices but needing updated training. Policymakers should recognize these factors when developing environmental sustainability policies for dairy production. Beyond technology and regulations, policy efforts should focus on improving farmers' quality of life and enhancing their surroundings.

Rural residents consistently emphasize that working and living conditions drive agricultural decisions, a point underscored by the strong link between concern for animal welfare and work satisfaction. For smallholder farmers, the farm is more than a workplace; it is a family home and a way of life. Therefore, supporting the quality of their surroundings—through local infrastructure, accessible services, and agricultural skill development—is

essential. Without addressing these lifestyle aspects, agricultural work will continue to be viewed as a lifestyle rather than a modern profession, which may slow the pace of sustainable change.

Nevertheless, some limitations of the present study should be considered. This study employed a purposive sampling method, selecting 50 small dairy farms controlled by farm size and regional location. While this sample size represents the upper feasible limit for direct-contact interviews in studies of this type, its modest scale limits generalizability. This sampling method is suitable for small, specific populations where compiling a complete list is challenging. Thus, while not fully representative, participants accurately reflect the target population's farming methods, management styles, and lifestyles, and the face-to-face interviews provided rich, in-depth data, maximizing insights in this format. However, further studies in other regions and on different samples would be valuable in supporting and expanding these findings.

## Conclusions

This study aimed to identify social conditions and determinants of decision-making about the use and readiness to adopt sustainable and circular practices in small dairy farms. Based on this research, some general conclusions can be drawn. Combining environmental and social analyses is essential for better understanding farmers' choices regarding implementing environmental recommendations in agricultural production. In social research, the axis of consideration is the human person. His or her objective and subjective assessments of living conditions, goals, expectations, interests, and family relationships influence the professional work and lifestyle. These are important determinants of the attitude towards work in agriculture and the use of environmentally friendly practices that should be taken into account in subsequent research. There are also implications for practice. When establishing public policies regarding environmental protection strategies and plans, tasks related to rural areas' social and infrastructural development should also be considered as part of an overall package together with adequate training and education. Easier access to public facilities and social services supports farmers in combining their professional and family roles and strengthens the local community, which may be an essential factor influencing environmental decisions.

## Data availability

The original contributions presented in the study are submitted to the Institute of Environmental Engineering of the University of Zielona Góra. Further inquiries can be directed to the author for correspondence.

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## References

- Knezevic, I., Blay-Palmer, A. & Clause, C. J. Recalibrating data on farm productivity: Why we need small farms for food security. *Sustainability* **15**, 14479 (2023).
- Guiomar, N. et al. Typology and distribution of small farms in Europe: Towards a better picture. *Land. Use Policy*. **75**, 784–798 (2018).
- Guarin, A. et al. A new typology of small farms in Europe. *Glob Food Secur.* **26**, 100389 (2020).
- Michalska, S. Społeczny wymiar funkcjonowania drobnych gospodarstw rolnych—social aspects of the functioning of small farms. *Probl. Small Agric. Hold.* **1**, 85–94 (2012).
- Smeđzik-Ambroży, K., Stepień, S., Matuszczak, A. & Tosovic-Stevanovic, A. Small-scale farms in the environmental sustainability of rural areas. Opinions of farmers from Poland, Romania and Lithuania. *Econ. Environ.* **81**, 168–185 (2022).
- Regulation, E. U. Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing regulations (EU) 1305/2013 and (EU) 1307/2013. (2021).
- European Commission. Common Agricultural Policy for 2023–2027. 28 CAP strategic plans at glance. (2022).
- Hoek, A. C., Malekpour, S., Raven, R., Court, E. & Byrne, E. Towards environmentally sustainable food systems: Decision-making factors in sustainable food production and consumption. *Sustain. Prod. Consum.* **26**, 610–626 (2021).
- Sulewski, P., Kłoczko-Gajewska, A. & Sroka, W. Relations between agri-environmental, economic and Social dimensions of farms' sustainability. *Sustainability* **10**, 4629 (2018).
- Melchior, I. C. & Newig, J. Governing transitions towards sustainable agriculture—taking stock of an emerging field of research. *Sustainability* **13**, 528 (2021).
- Lampredi, M. G., Sørensen, C. G. & Bochtis, D. Agricultural sustainability: A review of concepts and methods. *Sustainability* **11**, 5120 (2019).
- Piñeiro, V. et al. A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nat. Sustain.* **3**, 809–820 (2020).
- Wilfart, A. et al. DEXi-Dairy: an ex post multicriteria tool to assess the sustainability of dairy production systems in various European regions. *Agron. Sustain. Dev.* **43**, 82 (2023).
- Latruffe, L. et al. Measurement of sustainability in agriculture: A review of indicators. *Stud. Agric. Econ.* **118**, 123–130 (2016).
- Chopin, P., Mubaya, C. P., Descheemaeker, K., Öborn, I. & Bergkvist, G. Avenues for improving farming sustainability assessment with upgraded tools, sustainability framing and indicators. A review. *Agron. Sustain. Dev.* **41**, 19 (2021).
- Dessart, F. J., Barreiro-Hurlé, J. & Van Bavel, R. Behavioural factors affecting the adoption of sustainable farming practices: A policy-oriented review. *Eur. Rev. Agric. Econ.* **46**, 417–471 (2019).
- Gholamrezaei, S., Aliabadi, V. & Ataei, P. Understanding the pro-environmental behavior among green poultry farmers: Application of behavioral theories. *Environ. Dev. Sustain.* **23**, 16100–16118 (2021).
- Bartkowski, B., Schüßler, C. & Müller, B. Typologies of European farmers: approaches, methods and research gaps. *Reg. Environ. Change*. **22**, 43 (2022).
- Diaz, D. et al. Identification of representative dairy cattle and fodder crop production typologies at regional scale in Europe. *Agron. Sustain. Dev.* **42**, 94 (2022).
- Gaviglio, A., Bertocchi, M., Marescotti, M. E., Demartini, E. & Pirani, A. The social pillar of sustainability: A quantitative approach at the farm level. *Agric. Food Econ.* **4**, 15 (2016).
- Schiano, A. N. & Drake, M. A. *Invited review: Sustainable different perspectives, inherent conflict.* *J. Dairy. Sci.* **104**, 11386–11400 (2021).

22. Keeling, L. J. et al. A global study to identify a potential basis for policy options when integrating animal welfare into the UN Sustainable Development Goals. *Front. Anim. Sci.* **3**, (2022).
23. Council of Ministers. Resolution No. 34 Regarding the Adoption of the National Program for Reducing Air Pollution. *Monitor Polski* vol. poz. 572. (2019).
24. Council of Ministers. Ordinance on the adoption of the 'Action program aimed at reducing water pollution with nitrates from agricultural sources and preventing further contamination' (in Polish). *Dz Ustaw.* **244**, 130 (2023).
25. Becker, E. & Jahn, T. *Sustainability and the Social Sciences: A Cross-Disciplinary Approach to Integrating Environmental Considerations into Theoretical Reorientation* vol. Volume 7 (Zed Books, 1999).
26. Sachs, I. Social sustainability and whole development: exploring the dimensions of sustainable development. in *Sustainability and the Social Sciences: A cross-disciplinary Approach to Integrating Environmental Considerations into Theoretical Reorientation* 25–36 (Zed Books, London, (1999).
27. Vallance, S., Perkins, H. C. & Dixon, J. E. What is social sustainability? A clarification of concepts. *Geoforum* **42**, 342–348 (2011).
28. Redclift, M. In our own image: The environment and society as global discourse. *Environ. Hist.* **1**, 111–123 (1995).
29. Yearley, L. H. Zhuangzi's understanding of skillfulness and the ultimate spiritual state. in *Essays on Skepticism, Relativism, and Ethics in the Zhuangzi* (eds Kjellberg, P. & Ivanhoe, P. J.) 152–182 (State University of New York, Albany, (1996).
30. Grundmann, R. & Stehr, N. Climate change: What role for sociology? A response to constance lever-tracy. *Curr. Sociol.* **58**, 897–910 (2010).
31. Boström, M. A missing pillar? Challenges in theorizing and practicing social sustainability: Introduction to the special issue. *Sustain. Sci. Pract. Policy.* **8**, 3–14 (2012).
32. Eizenberg, E. & Jabareen, Y. Social sustainability: A new conceptual framework. *Sustainability* **9**, 68 (2017).
33. Scheurich, A. et al. Elements of social sustainability among Austrian hay milk farmers: Between satisfaction and stress. *Sustainability* **13**, 13010 (2021).
34. Macnaghten, P. & Urry, J. *Contested Natures* (Sage Publications, Inc., 1998).
35. Barr, S. & Gilg, A. Sustainable lifestyles: Framing environmental action in and around the home. *Geoforum* **37**, 906–920 (2006).
36. Lindenberg, S., Steg, L. & Normative Gain and hedonic goal frames guiding environmental behavior. *J. Soc. Issues.* **63**, 117–137 (2007).
37. Vlek, C. & Steg, L. Human behavior and environmental sustainability: Problems, driving forces, and research topics. *J. Soc. Issues.* **63**, 1–19 (2007).
38. Mitter, H., Larcher, M., Schönhart, M., Stöttinger, M. & Schmid, E. Exploring Farmers' climate change perceptions and adaptation intentions: Empirical evidence from Austria. *Environ. Manage.* **63**, 804–821 (2019).
39. Janker, J. & Mann, S. Understanding the social dimension of sustainability in agriculture: A critical review of sustainability assessment tools. *Environ. Dev. Sustain.* **22**, 1671–1691 (2020).
40. Wojewódzka-Wiewiórska, A. & Stawicki, M. Uneven demographic changes as a challenge to provide access to education in the rural areas in Poland. *Eur. J. Sustain. Dev.* **9**, 253–253 (2020).
41. Lunner Kolstrup, C. et al. International perspectives on psychosocial working conditions, mental health, and stress of dairy farm operators. *J. Agromedicine.* **18**, 244–255 (2013).
42. Hagevoort, G. R., Douphrate, D. I. & Reynolds, S. J. A review of health and safety leadership and managerial practices on modern dairy farms. *J. Agromedicine.* **18**, 265–273 (2013).
43. Hansen, B. G. & Stræte, E. P. Dairy farmers' job satisfaction and the influence of automatic milking systems. *NJAS - Wagening J. Life Sci.* **92**, 100328 (2020).
44. Giovannini, E. & Linster, M. Measuring sustainable development. Achievements and challenges. in *United Nations Div. Sustainable Dev. Expert Group. Meeting Indic. Sustainable Dev.* 13–15 (2005).
45. UNECE. *Measuring Sustainable Development* (United Nations, 2009).
46. Czapiński, J. Szczęśliwy człowiek w szczęśliwym społeczeństwie? Zrównoważony rozwój, jakość życia i złudzenie postępu. *Psychol. Jakości Życia.* **1**, 9–34 (2002).
47. Neugarten, B. L., Havighurst, R. J. & Tobin, S. S. The measurement of life satisfaction. *J. Gerontol.* **16**, 134–143 (1961).
48. Bradburn, N. M. *The Structure of Psychological Well-Being* (Chicago, 1969).
49. Böhnke, P. *First European Quality of Life Survey: Life Satisfaction, Happiness and Sense of Belonging.* (2005). <https://policycommons.net/artifacts/1843321/first-european-quality-of-life-survey/2586958/>
50. Nussbaum, M. & Sen, A. *The Quality of Life* (Clarendon, 1993).
51. Costanza, R. et al. Quality of life: an approach integrating opportunities, human needs, and subjective well-being. *Ecol. Econ.* **61**, 267–276 (2007).
52. Danna, K. & Griffin, R. W. Health and well-being in the workplace: A review and synthesis of the literature. *J. Manag.* **25**, 357–384 (1999).
53. Sirgy, M. J. *The Psychology of Quality of Life: Wellbeing and Positive Mental Health* (Kluwer Academic, 2002).
54. Diener, E. D. & Suh, M. E. Subjective well-being and age: An international analysis. *Annu. Rev. Gerontol. Geriatr.* **17**, 304–324 (1997).
55. Eurostat. Bovine types by utilised agricultural area and share of fodder area, size classes of livestock and NUTS 2 regions (online data code: ef\_lsk\_bovine). (2020). [https://doi.org/10.2908/EF\\_LSK\\_BOVINE](https://doi.org/10.2908/EF_LSK_BOVINE)
56. Patton, M. Q. *Qualitative Research & Evaluation Methods: Integrating Theory and Practice* (Sage Publications, Inc., 2014).
57. Qualitative Research. (Sage Publications, Inc., London, (2016).
58. Tremblay, G., Rodrigues, N. C. & Gulati, S. Mental Hygiene: What it is, implications, and future directions. *J. Prev. Health Promot.* **2**, 3–31 (2021).
59. Chiu, R. L. H. Social sustainability, sustainable development and housing development: the experience of Hong Kong. in *Housing and Social Change* (eds Forrest, R. & Lee, J.) 221–239 (Routledge, (2003).
60. Golinowska, S. & Kocot, E. *Spójność Społeczna: Stan i Perspektywy Rozwoju Społecznego Kraju w Przekrojach Regionalnych* (Wydawnictwo Naukowe Scholar, 2013).
61. Doumit, J. & Nasser, R. Quality of life and wellbeing of the elderly in Lebanese nursing homes. *Int. J. Health Care Qual. Assur.* **23**, 72–93 (2010).
62. Sirgy, M. J. *The Psychology of Quality of Life: Wellbeing and Positive Mental Health* vol. 83 (Springer International Publishing, 2021).
63. Williams, D. R., McIntyre, N. P. & Affinities Lifestyle mobilities, and quality-of-life. in *Handbook of Tourism and Quality-of-Life Research* (eds Uysal, M., Perdue, R. & Sirgy, M. J.) 209–231 (Springer Netherlands, Dordrecht, doi:[https://doi.org/10.1007/978-94-007-2288-0\\_12](https://doi.org/10.1007/978-94-007-2288-0_12). (2012).
64. Krzyminiewska, G. Humanizacja pracy a mentalność polskiego rolnika. *Zesz. Nauk. Ekon. W Poznaniu* 57–69 (2009).
65. Bernard, P. La cohésion sociale: critique dialectique d'un quasi-concept. *Lien Soc. Polit.* 47–59. <https://doi.org/10.7202/005057ar> (1999).
66. Lickel, B. et al. Varieties of groups and the perception of group entitativity. *J. Pers. Soc. Psychol.* **78**, 223 (2000).
67. Forsyth, D. R. *Group Dynamics (6th Ed)* (Wadsworth Cengage Learning, 2014).
68. Nielsen, S. S. et al. Welfare of dairy cows. *EFSA J.* **21**, e07993 (2023).
69. Minister of Agriculture and Rural Development. Regulation on minimum conditions for keeping farm animal species other than those for which protection standards are specified in European Union regulations (in Polish). *Dz Ustaw.* **116**, 7 (2010).

70. Nalon, E. & Stevenson, P. Protection of dairy cattle in the EU: State of play and directions for policymaking from a legal and animal advocacy perspective. *Anim. Open. Access. J. MDPI*. **9**, 1066 (2019).
71. Council of Ministers. Ordinance on the adoption of the 'action program aimed at reducing water pollution with nitrates from agricultural sources and preventing further contamination' (in Polish). *Dz Ustaw*. **1339**, 118 (2018).
72. *Kodeks Dobrej Praktyki Rolniczej Dotyczący Ograniczania Emisji Amoniaków*. (Ministerstwo Rolnictwa i Rozwoju Wsi, Warszawa, (2019).
73. Jarosz, Z. & Faber, A. Possibilities of reducing ammonia emissions from agriculture—scenario for 2030. *Rocz Ann*. **22**, 41–48 (2020).
74. Bamberg, S. Is a residential relocation a good opportunity to change people's travel behavior? Results from a theory-driven intervention study. *Environ. Behav*. **38**, 820–840 (2006).
75. Firnhaber, J. et al. People that are supporting [the] Whole Sector are on their knees: Uncertainty and socioeconomic change are occupational stressors for Irish farmers. *Rural Sociol*. **89**, 483–505 (2024).
76. *The Psychology of Habit: Theory, Mechanisms, Change, and Contexts*. (Springer International Publishing, Cham, doi: (2018). <https://doi.org/10.1007/978-3-319-97529-0>
77. Schwarz, M. & Thompson, M. *Divided We Stand. Redefining Politics, Technology, and Social Choice* (University of Pennsylvania, 1990).
78. Douglas, M. *Risk and Blame: Essays in Cultural Theory* (Routledge, 1992).
79. Macnaghten, P. & Urry, J. Towards a Sociology of Nature. in *Nature: Critical Concepts in the Social Sciences. vol. III. From 'Nature' to 'Natures': Contestation and Reconstruction* vol. 3 135–152 (Routledge Taylor & Francis Group, London, UK; New York, NY, USA, (2005).
80. Wynne, B. Risk and Social Learning: Reification to Engagement. in *Social Theories of Risk* (eds Krinsky, S. & Golding, D.) 275–297 (Praeger, (1992).
81. Fraser, D. et al. General principles for the welfare of animals in production systems: the underlying science and its application. *Vet. J*. **198**, 19–27 (2013).
82. Adamczyk, K. Dairy cattle welfare as a result of human-animal relationship—a review. *Ann. Anim. Sci*. **18**, 601–622 (2018).

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## Author contributions

BA: Funding acquisition, Project administration, Writing—review & editing. JFM: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Writing—original draft, review & editing. AR: Data curation, Formal analysis, Investigation, Figures and Tables, Writing—original draft, review & editing. WW: Funding acquisition, Project administration, Supervision, Writing—review & editing.

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## Declarations

### Competing interests

The authors declare no competing interests.

### Additional information

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**Correspondence** and requests for materials should be addressed to J.F.-M.

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