

RESEARCH ARTICLE

'Factory farming'? Public perceptions of farm sizes and sustainability in animal farming

Gesä Busch¹*, Elisa Bayer², Achim Spiller, Sarah Kühn

Marketing for Food and Agricultural Products, Department of Agricultural Economics and Rural Development, University of Göttingen, Göttingen, Germany

* Current address: Food Consumption and Wellbeing, Department of Sustainable Agriculture and Energy Systems, University of Applied Sciences Weihenstephan-Triesdorf, Freising, Germany

* gesa.busch@hswt.de



Abstract

Farm sizes play an important role in increasing public debates surrounding the sustainability of agriculture, specifically of animal farming. While research cannot find consistent relationships between sustainability and farm sizes, the 'small-is-beautiful'-hypothesis remains still prominent in public perceptions. The aim of this study is to deeply analyze public associations coming with small and large farms with a focus on sustainability issues, including animal welfare. We additionally consider the memory of media reporting on farms with different sizes, wishes for legal regulations on farm and herd sizes, and the persuasiveness of scientific results that disentangle farm size from sustainability aspects. To answer these questions, an online survey with 985 German residents was conducted in May 2021 and descriptively analyzed. Although the attribute 'small numbers of animals' range among the less important ones that constitute an 'ideal animal farm' (rank 10 of 12 attributes), the large majority of participants (75.8%) reveal a preference for small over large animal farms. This is backed up by the perception that small farms are advantageous in terms of good animal welfare, environmental protection and product quality, but disadvantaged when it comes to profitability. Additionally, negative media reporting on animal farms (remembered by 92%) is more frequently related to large farms (82.5%) whereas positive media reporting (remembered by 81.4%) are mainly linked to small farms by 56.8%. More than half of respondents wish for regulations that limit farm and barn sizes. Scientific results finding no relationship between farm size and animal protection or climate protection are convincing for only 33.0% and 39.8% of the sample, respectively. A large farm size acts as a proxy for farming systems with low animal welfare and conservation levels. This challenges communications about the future of farming with the public as it can be assumed that farm sizes will further increase.

OPEN ACCESS

Citation: Busch G, Bayer E, Spiller A, Kühn S (2022) 'Factory farming'? Public perceptions of farm sizes and sustainability in animal farming. *PLOS Sustain Transform* 1(10): e0000032. <https://doi.org/10.1371/journal.pstr.0000032>

Editor: Amanda E. Sorensen, Michigan State University, UNITED STATES

Received: April 4, 2022

Accepted: September 21, 2022

Published: October 28, 2022

Copyright: © 2022 Busch et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability Statement: All data are available in Figshare public data repository under DOI: [dx.doi.org/10.6084/m9.figshare.19493783](https://doi.org/10.6084/m9.figshare.19493783).

Funding: We are grateful to the Federal Office for Agriculture and Food (BLE) and Federal Programme for Organic Farming and Other Forms of Sustainable Agriculture (BÖLN) for financing this study in the project: "Improving social acceptance of organic livestock systems – Analysis of public expectations and development of trust marketing concepts" (grant number 28180E097 to AS). The funders had no role in study design, data collection

Author summary

In public discussions, farm size is often mentioned as an important factor for good animal welfare and high environmental protection in animal farming. Scientific findings contrast this 'small-is-beautiful' perceptions by not finding such simple relationships. In this study,

and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

we analyze peoples' associations with farm sizes in order to better understand the underlying mechanisms of preferences for small farms. We could find that farm size is used by people from the broader public as proxy for good animal welfare and environmental protection on farms. It is not farm size per se that is perceived as important and sustainability aspects are more important but large farms are associated to consider sustainability less and focus more on profit on the expense of sustainable practices. Our findings point to a challenge in the communication of future sustainable farming systems that might rely on larger operations due to their advantages in terms of technology adaption, professionalism and economies of scale.

1 Introduction

In recent years, the sustainability of agriculture including livestock farming is highly debated in many countries public and politics such as in Germany or the Netherlands. This leads to pressure on farmers to transform the sector towards more sustainability under insecurity, resulting in discontent and even protest [1,2]. Farm size plays an important role in public discussions surrounding agriculture and critiques on livestock farming [3,4,5]. The public often perceives large-scale farming as being detrimental for animal welfare and achieving lower sustainability levels [5–8]. Contrastingly, scientific studies show that farm size is not a good indicator for sustainability [4,9–12]. Both large as well as small farms have their advantages and disadvantages concerning sustainability aspects. For example, biodiversity decreases as the size of the cropland plots increases [13,14] and large-scale dairy farms manage less grasslands, resulting in higher pesticide use [15]. At the same time, large farms usually show clear advantages in productivity and efficiency per production unit [3,16–18], financial outcome [3,16,18] and contribute to low food prizes due to economies of scale [19]. They are further more advantageous because of specialization, which favors high levels of knowledge [20,21], and the development of modern technologies i.a. those that have the potential to reduce the use of pesticides [16]. Small family farms in Germany are not generally more sustainable compared to larger farms [22]. Although slightly more production diversification is observed, small farms are likely to cultivate somewhat more monoculture, a little more bare soils during winter and slightly less conservation of structural elements in crop lands such as hedges, walls and trees, probably due to higher scarcity of land and increased economic pressure [22]. However, small farms may favor a more diverse agriculture [23], support local food availability [24], are more flexible in implementing new forms of agriculture such as the concept of Community Supported Agriculture [25] and provide space for endangered livestock breeds and varieties. Some argue that 'small pioneers' may be more likely to make an important contribution to the sustainable transitioning of a sector [26] which would also make small farms more advantageously.

Looking at animal welfare levels, a literature review [21] shows that farm size is not the decisive factor for animal welfare. It is rather the type of husbandry system and farm management that plays an important role [5,11,21,27,28]. In addition, farmers' behavior and attitudes towards the animals affect the human-animal relationship more than herd size [29]. However, large farms may be more specialized which can be beneficial for good management [20]. Contrastingly, practices like access to pasture that benefit animal welfare tend to decrease with increasing farm size [15,21]. Additionally, large-scale livestock farms bear a higher risk to impair welfare of a higher number of animals at once in the event of disasters such as stable fires, disease outbreaks or bad management.

Thus, there is no clear evidence on the overall effect of farm size towards sustainability and animal welfare. However, since many years the ‘small is beautiful’-hypotheses shapes public discussions on agriculture and food production [30] and may bias perceptions regarding the relationship between size of operation on the one and sustainability and animal welfare on the other hand. The term ‘factory farming’ is often used to describe large operations with little welfare and low sustainability levels. In a survey with German residents in 2011, it was found that people have negative associations with the term ‘factory farming’, such as animal-abuse and cruelty, high stocking densities and diseases [7]. Regarding farm sizes, ‘factory farming’ started for many respondents with a number of animals clearly below average herd sizes in Germany [7]. Another study points into similar directions and shows that intensive livestock production is evaluated as unethical by a majority of respondents in five European countries and the most seen risks are animal stress, unnaturalness and an increased incidence of animal diseases [31]. The mentioned might contribute to why consumers prefer products from small farms, with purchase motivations similar to those for organic or locally sourced foods—especially with regard to the treatment of animals but also in terms of support for farmers [32]. Indeed, organic farms are assumed to be smaller than conventional ones and the idea of fair payment for ‘small family farms’ is an important motive for buying organic produces [33].

Nevertheless, so far, little is known about the ‘small is beautiful’-frame and what farm characteristics and associations contribute to this perception. Therefore, the aim of this study is to determine how the public perceives farm sizes in animal farming and how people relate sustainability aspects and animal welfare to farm size. This is particularly important as large-scale farming is increasingly dominating agriculture in Western countries [24] and public acceptance is needed as one dimension of long-term sustainability [34]. We further investigate how convincing scientific results about disentangled farm size and sustainability aspects are for citizens. The latter is important for science communication about sustainability aspects in farming (other than size).

In this context our research questions are the following: 1) Do citizens prefer small or large animal farms and how is media reporting on animal farming and farm sizes perceived? 2) What role plays farm size in citizens’ perceptions of an ideal animal farm? 3) How are different sustainability dimensions related to farm size in public opinions? 4) Do citizens favor regulations concerning farm and herd sizes? 5) How convincing are scientific results that disentangle sustainability from farm size for citizens?

2 Material and methods

2.1 Ethics approval

The study was approved by the Ethics Commission at University of Göttingen before data collection. Participants were informed about the use of data and they provided written informed consent online. They were informed that they can withdraw consent at any time by leaving the survey through closing their internet browser.

2.2 Survey design

To answer our research questions, an online survey with 985 German residents was conducted in May 2021. The survey started with questions about gender identity, age, education, and place of residence. These questions were set as quotas according to the population in Germany. People were further asked about household income and size and what type of diet they follow. The next question asked whether participants prefer small or large farms and this question was repeated at the very end of the survey. By repeating the question at the end, we intended to measure if attitudes have changed after engaging more deeply with the topic. In a next step,

participants were shown a set of attributes, including aspects related to farm size such as ‘small numbers of farmed animals’ and ‘few employees’, and were asked to indicate on five-point scales what they consider important for an ‘ideal’ animal farm they want to purchase produce from. They were also asked whether they have seen or read about positive and negative media reporting on animal farming and if yes, whether this was about small or large farms. Subsequently, participants were asked to indicate for different sustainability aspects (animal welfare, ecology, economy, social aspects) if they think these are met on small farms, large farms or independent of farm size. They were additionally asked whether there should be regulations on how many animals should be allowed per farm or per stable and if yes, how many they consider appropriate in the case of poultry, pigs and cattle. For this question, the sample was randomly split into two sub-samples in order to limit survey length. Half of the sample answered the questions for farm and the other for stable size. Questions were repeated for organic farms/stables, respectively. Finally, participants were confronted with a short text describing that scientific results do not see a clear relationship between farm sizes and animal welfare or farm sizes and conservation and climate protection. Again here, participants were randomly assigned into one of two splits, either the animal welfare or conservation/climate protection sub-sample in order to limit response times adequately.

2.3 Data collection, cleaning and analyses

Recruitment of participants was facilitated by an online panel provider. Data was collected online between May 4th and May 8th 2021. A total of 1,686 participants opened the link to enter the survey. 365 participants were screened out due to quota requirements, 174 participants did not pass the quality check questions, and 17 declined their consent. From the remaining 1,130 participants, 1,050 finished the survey. The median response time was 1150 seconds. Participants with a shorter response time than half of the median (575 seconds) were excluded due to speeding behavior which is related to straightlining [35]. This was true for 65 participants. The final sample for analyses consists of 985 respondents. Data was analyzed using IBM SPSS Statistics 26.

2.4 Sample description

[Table 1](#) shows the distribution of demographics in the sample and the German population. It shows that the sample is similar to the population in terms of age, gender education and place of residency.

3 Results

3.1 Preference for small vs. large farms

[Fig 1](#) shows a majority of respondents (rather) preferring small over large farms both at the beginning as well as at the end of the survey. Participants preferring large farms constitute less than 10% of the sample. 6.1% do not know or do not care at the beginning and 3.9% after completing the survey.

Looking at gender differences, we observe that female participants prefer small farms more compared to male participants at the beginning of the survey ($\text{mean}_{\text{female}} = 1.66$; standard deviation (SD) = 0.75 and $\text{mean}_{\text{male}} = 1.88$; SD = 0.87; $p < 0.001$; scale from 1 = “I prefer small farms” to 5 = “I prefer large farms”). At the end of the survey, these differences disappear ($\text{mean}_{\text{female}} = 1.85$; SD = 1.06 and $\text{mean}_{\text{male}} = 1.89$; SD = 0.77; $p \geq 0.05$) reasoned by a change in the women’s answers.

Table 1. Description of demographics in the sample and population in Germany.

	Sample (n = 985)	German population
Age		
18–24	8.4%	9.1%
25–39	21.4%	22.8%
40–54	19.8%	24.9%
55–69	25.8%	24.3%
over 70	24.6%	18.8%
Gender		
Female	49.8%	49.4%
Male	50.2%	50.7%
Education		
Low	36.0%	36.5%
Middle	31.4%	30.0%
High	32.6%	33.5%
Place of residency		
North	16.6%	16.1%
East	18.6%	19.5%
South	29.6%	29.1%
West	35.1%	35.2%

Age, Gender, Place of residency: [36]; Education: [37].

<https://doi.org/10.1371/journal.pstr.0000032.t001>

There is a weak positive correlation between age and the preference for large farms at the beginning of the survey ($r = 0.10$; $p \leq 0.01$), while this correlation also disappears at the end of the survey ($r = -0.05$; $p \geq 0.05$).

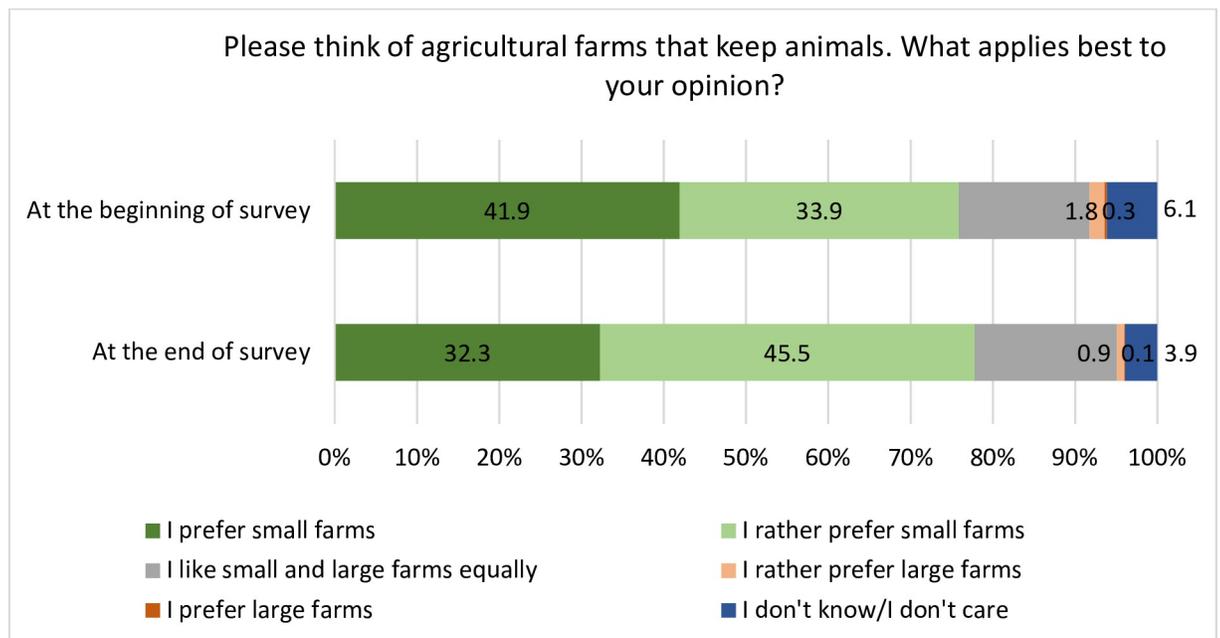


Fig 1. Participants general preferences for small or large animal farms at the beginning and end of the survey (n = 985).

<https://doi.org/10.1371/journal.pstr.0000032.g001>

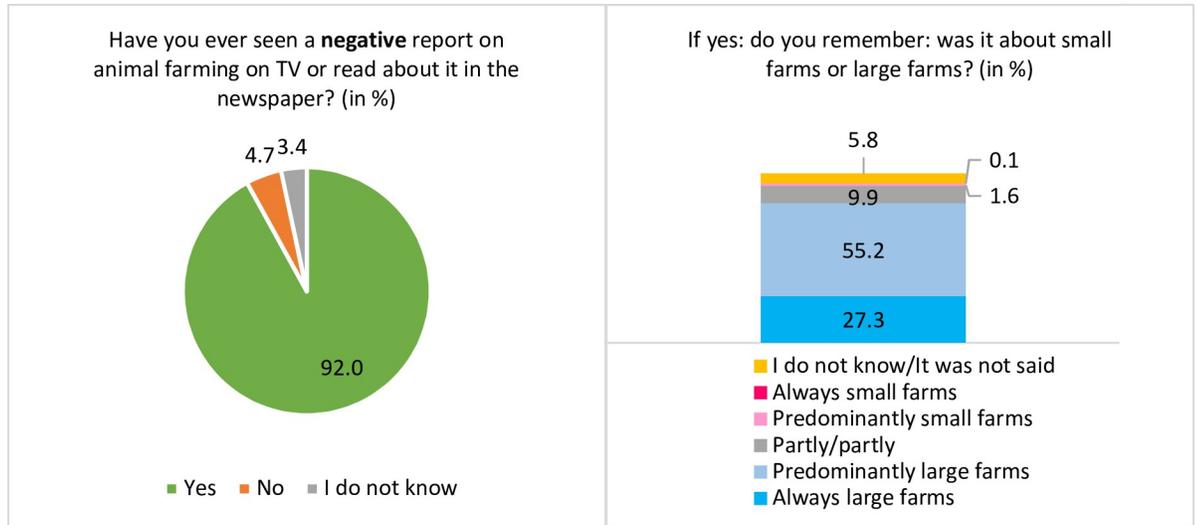


Fig 2. Negative media reports on animal farming that respondents remember and farm size in the reporting (n = 906).

<https://doi.org/10.1371/journal.pstr.0000032.g002>

3.2 Media reports on small and large farms

Figs 2 and 3 show how many participants remember to have seen or read about animal farming in a positive or negative way on TV or in the newspaper. 92.0% of respondents indicate to already have seen a negative report about animal farming on TV or to have read a negative article in newspapers. Only 4.7% of respondents state to never have seen or read a negative reporting (3.4% do not know). From those 92.0% who already encountered negative reports, 82.5% state that it was about large farms. In total, 81.4% indicate that they have seen or read a positive report/article about agricultural husbandry on TV or in newspapers and 11.7% deny this (6.9% do not know). From those remembering a positive report, 67.2% state it was always/predominantly about small farms.

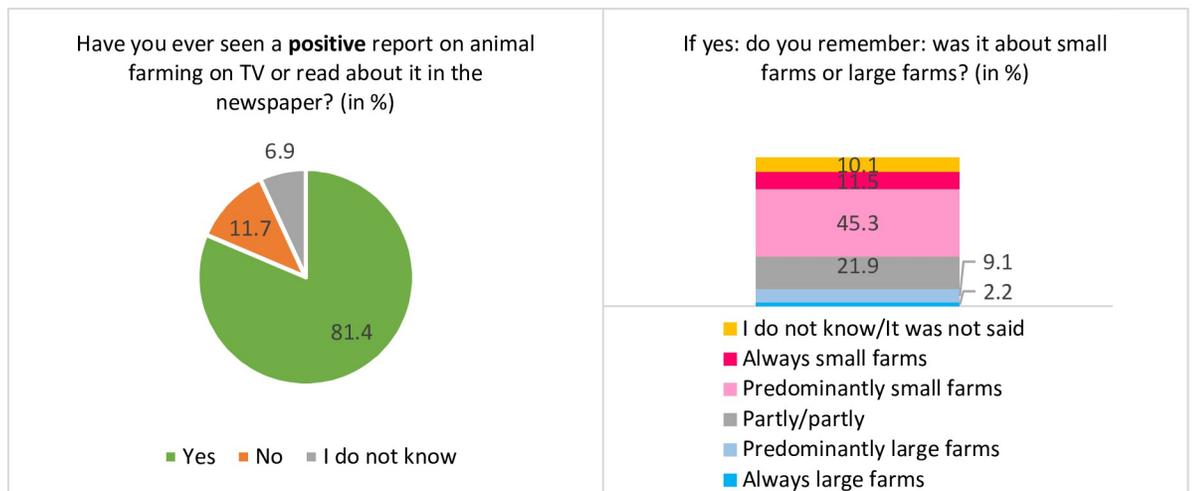


Fig 3. Positive media reports on animal farming that respondents remember and farm size in the reporting (n = 906).

<https://doi.org/10.1371/journal.pstr.0000032.g003>

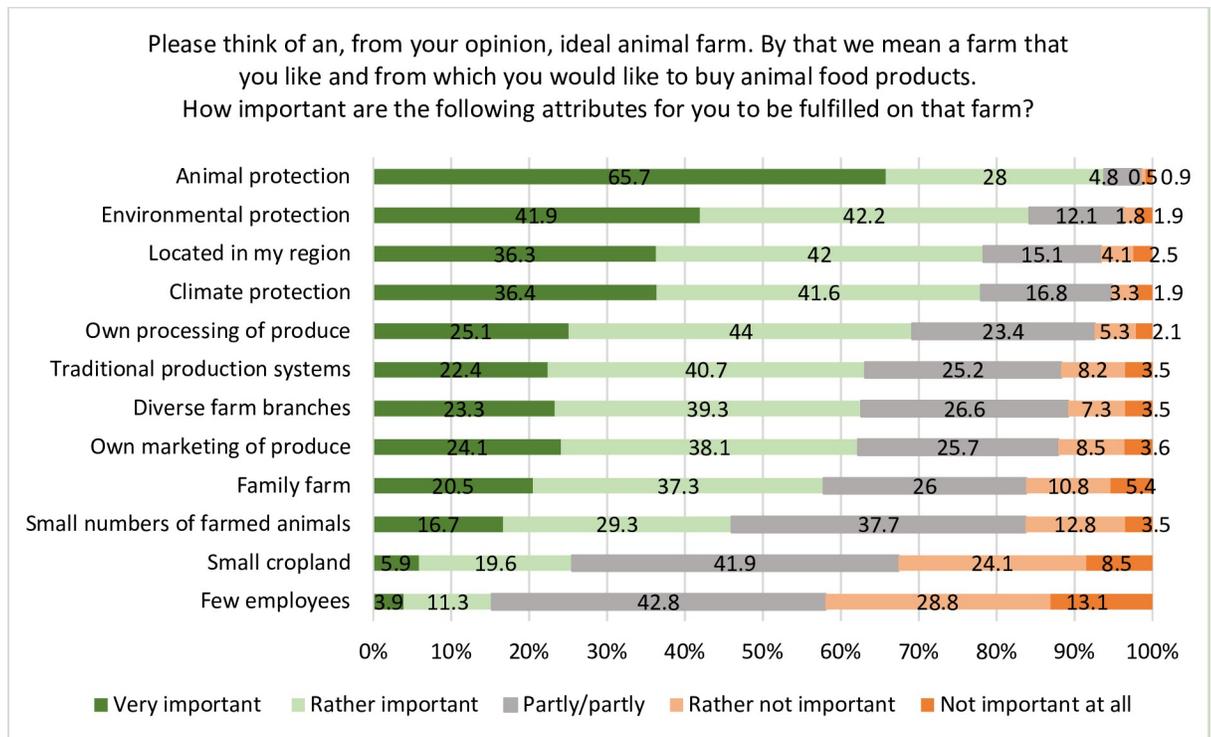


Fig 4. Importance of different attributes for what participants consider an ideal animal farm (n = 985).

<https://doi.org/10.1371/journal.pstr.0000032.g004>

3.3 Important attributes of an ideal farm

On an ideal farm, from which participants like to buy animal produce, farm size (‘small numbers of farmed animals’), range among the less important attributes, although 46.0% of respondents consider it as very or rather important (Fig 4). Animal protection is considered as important by the highest share of participants (93.7%), followed by environmental protection (84.1%), location of the farm in the region (78.3%) and climate protection (78.0%).

3.4 Perceptions of sustainability dimensions on small and large farms

Sustainability dimensions (ecologic, animal welfare, social and economic) are perceived to be fulfilled differently depending on farm size.

Fig 5 shows how participants believe that different attributes related to ecology are fulfilled on small and large farms or independent of farm size. All aspects related to good ecology are perceived to be (rather) fulfilled on small farms. More than 80% of the sample believes that only/rather small farms are connected with nature, nearly 70% believe that only/rather small farms protect biodiversity and conserve nature. Also, more than half of the sample thinks that organic farms are (rather) small farms but around 30% consider organic farming not related to farm size. Around 40% also believe that environmental and climate protection is not depending on farm size, whereas nearly 60% trust that small farms have advantages. Whether farms comply with law is perceived as being independent from farm size by more than half of the respondents. Monoculture tend to be associated with large farms (45.4%).

The overwhelming majority of respondents perceives that animal welfare, care and esteem for animals are better on small farms (Fig 6). Only for a few aspects, more than 20% of respondents assume that this is equally met on large farms. Animal health is the aspect where the highest share states that it is same on small and large farms (26.1%), followed by long life of

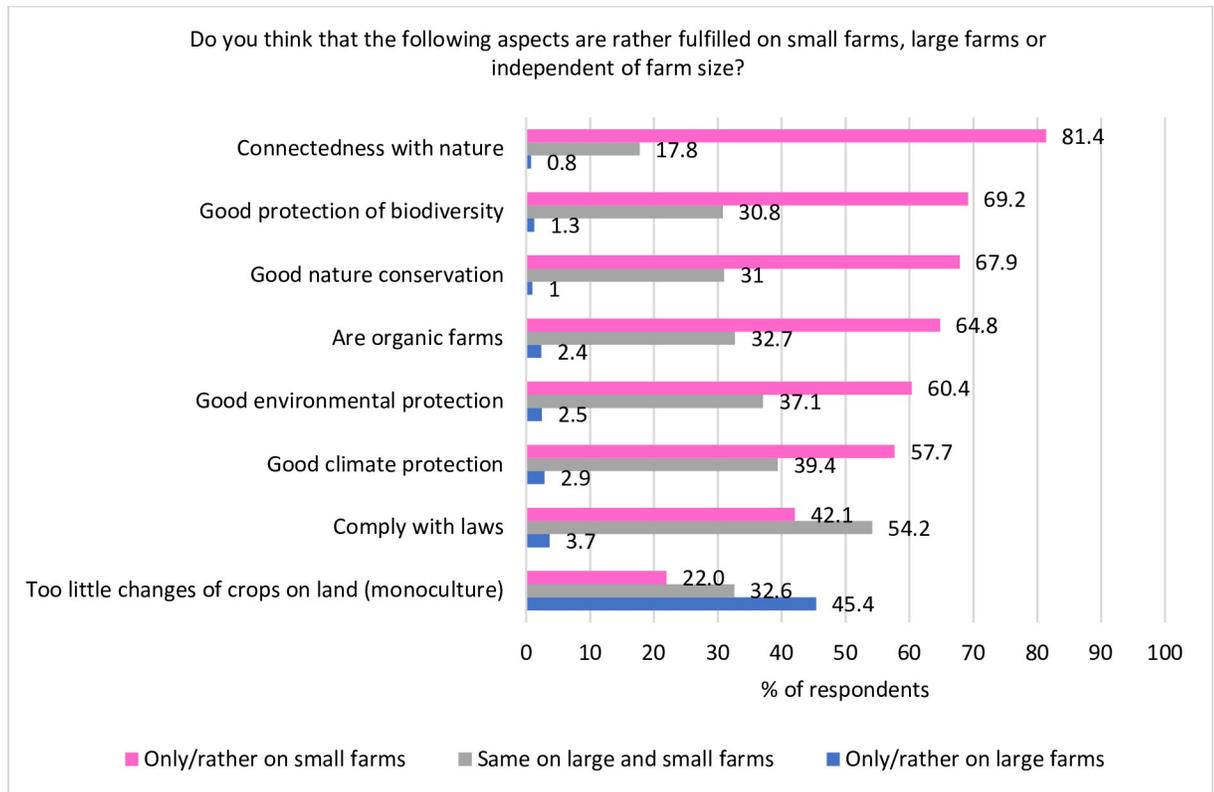


Fig 5. Perceived fulfillment of different ecological aspects on small and large farms in respondents' opinions (n = 985).

<https://doi.org/10.1371/journal.pstr.0000032.g005>

animals (24.1%) and outdoor access (22.0%). But again, with high agreement, these aspects are also seen as more likely to be met on small farms.

Product characteristics also differ between small and large farms, according to participants (Fig 7). Naturalness of products is attributed to small farms by 83.6% and only 15.6% perceive naturalness independent of farm size. 75.5% also think that small farm products are more expensive. 66.7% assume that only/rather products from small farms are healthy, whereas 33.3% state this to be the same on small and large farms. This evaluation is similar for the taste of produce.

Looking at economic sustainability, large farms are perceived as advantageous (Fig 8). The majority of participants (more than 70%) believes that only/rather large farms put profit first and that these farms make a lot of money. Correspondingly, large farms are perceived by more participants as well-equipped to deal with crises and to offer farmers good financial protection compared to small farms. While half of participants believe that large farms receive many financial subsidies, nearly 40% perceive this to be the same on small and large farms. 45.0% of participants assume that good payment of employees is the same on small and large farms and 37.8% suspect this to be more the case on larger farms. 57.1% of respondents think that small and large farms are both depending on world market prices, 29.3% think this holds true more for large farms. In addition, the clear majority supposes that small farms are more likely to go out of business soon.

3.5 Needs for regulations of farm sizes from a public point of view

Most of respondents felt that there is a need for regulations by law on animal numbers that should be allowed to be kept in organic as well as in a conventional stables (split a, n = 486)

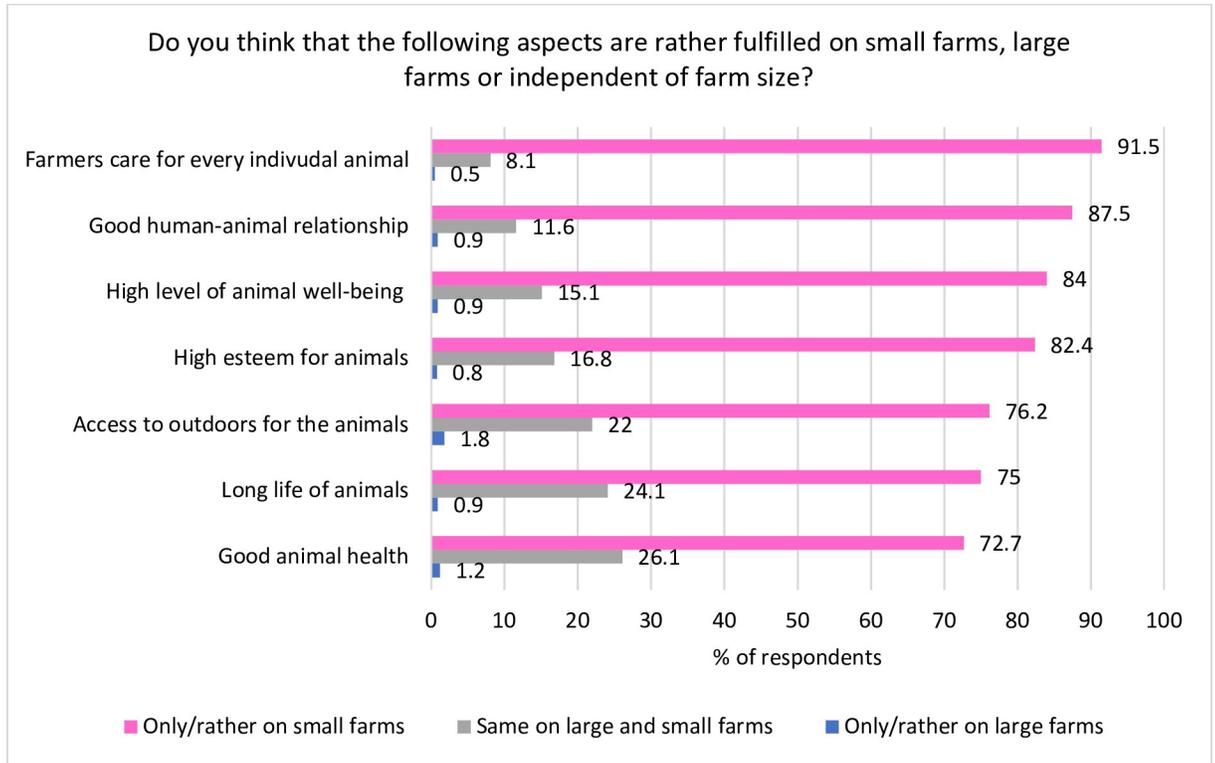


Fig 6. Perceived fulfillment of animal welfare attributes on small and large farms in respondents' opinions (n = 985).

<https://doi.org/10.1371/journal.pstr.0000032.g006>

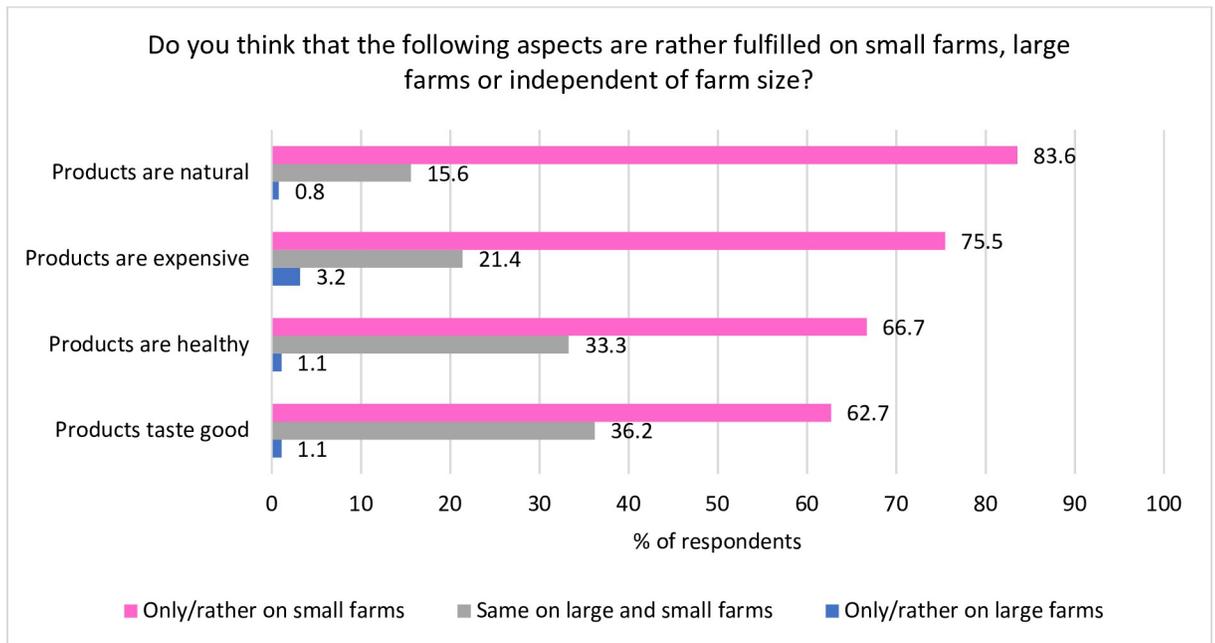


Fig 7. Perception of product characteristics produced on small and large farms in respondents' opinions (n = 985).

<https://doi.org/10.1371/journal.pstr.0000032.g007>

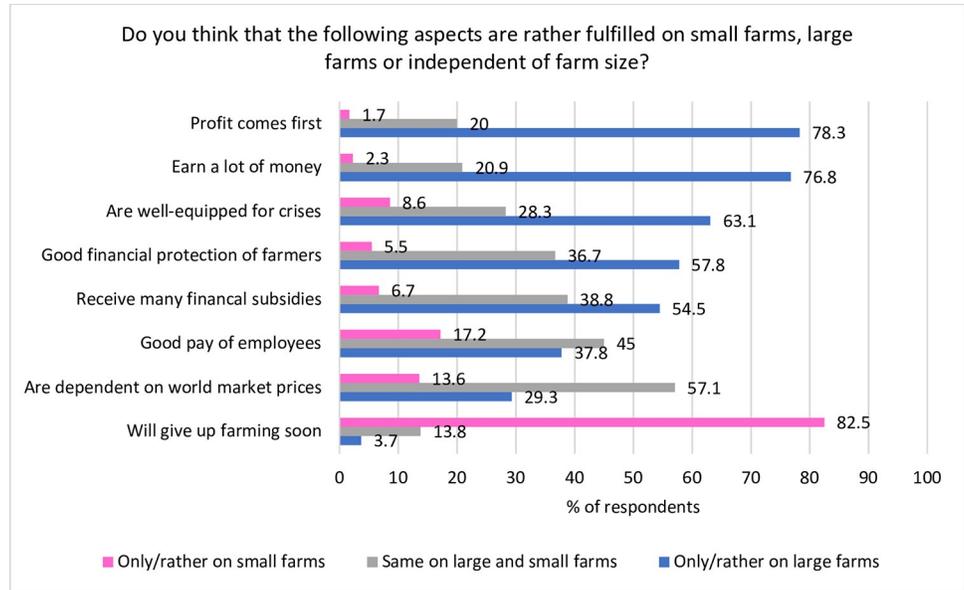


Fig 8. Perceived fulfillment of economic aspects on small and large farms in respondents' opinions (n = 985).

<https://doi.org/10.1371/journal.pstr.0000032.g008>

and on farms (split b, n = 499) (see Fig 9). There is no difference in respondents agreeing to a need for regulations on organic compared to conventional stables (t-value = 1.91, p = 0.06) but for farms there is a slightly higher wish for regulations on organic compared to conventional farms (t-value = 2.46, p = 0.01).

Those participants that stated to be in favor of regulations were asked about the number of animals per stable or farm they think should be allowed. Fig 10 shows the results per stable and

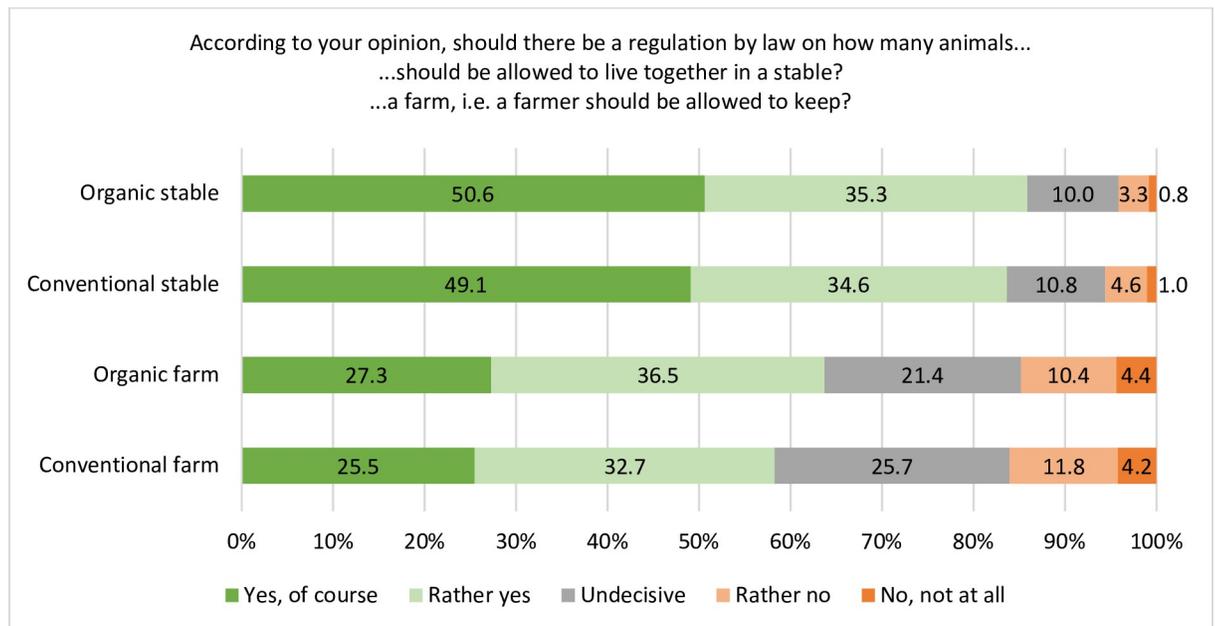


Fig 9. Participants' assessment of whether there should be legal regulations on animal numbers in stables (n = 486) and on farms (n = 499) for organic and conventional animal farming.

<https://doi.org/10.1371/journal.pstr.0000032.g009>

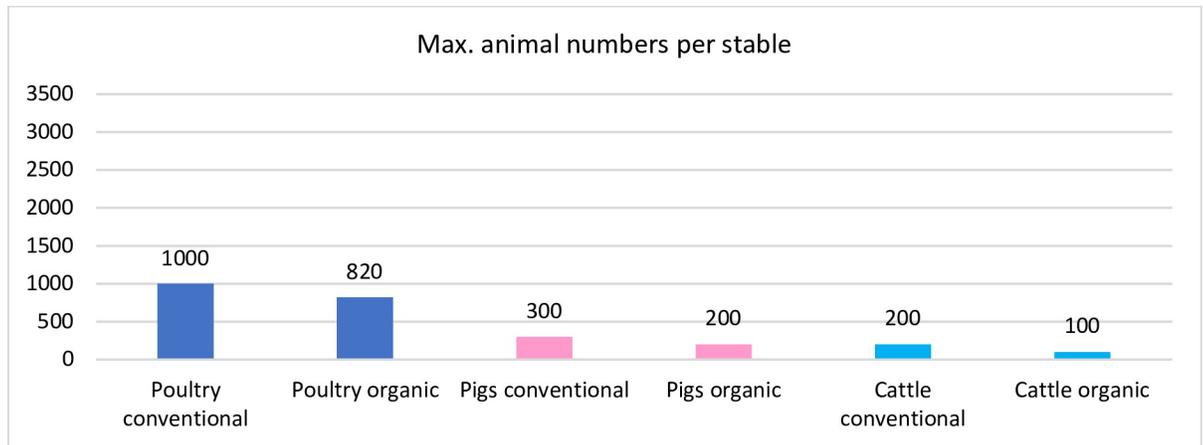


Fig 10. Participants assessment of maximum numbers of animals (percentile 0.9) that should be allowed to be kept in conventional and organic stables by species (n = 378).

<https://doi.org/10.1371/journal.pstr.0000032.g010>

Fig 11 per farm. Displayed are the 90-percentiles. The numbers in a poultry stable should be limited to 1,000 animals in conventional, and 820 in organic stables. For pigs, a maximum of 300 conventional and 200 organic pigs should be allowed to live together. For cattle, the maximum number should be 200 for conventional, and 100 for organic cattle stables.

On poultry farms, a maximum of 3,000 animals for conventional, and 1,000 for organic is perceived as adequate by 90% of respondents (Fig 11). In the case of pigs these numbers are a maximum of 600 for conventional and 382 for organic farms, and for cattle 500 and 250 heads per farm respectively.

3.6 Persuasion of scientific results on relationships between farm size and animal/climate protection

Participants were finally asked to read a short text about scientific findings on farm size and either animal protection or climate/environmental protection they were randomly assigned to. Fig 12 shows the results for animal protection. Around one third of participants do not

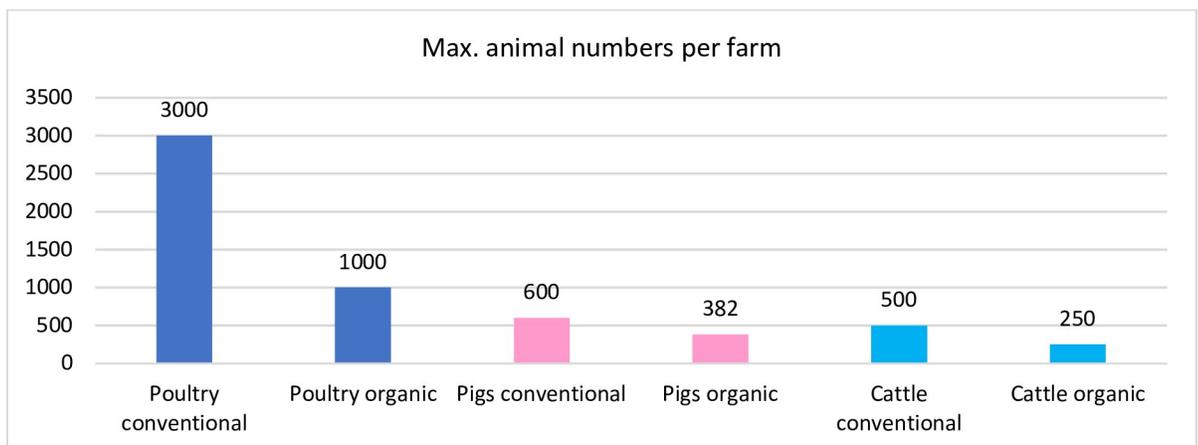


Fig 11. Participants assessment of maximum numbers of animals (percentile 0.9) that should be allowed to be kept on conventional and organic farms by species (n = 279).

<https://doi.org/10.1371/journal.pstr.0000032.g011>

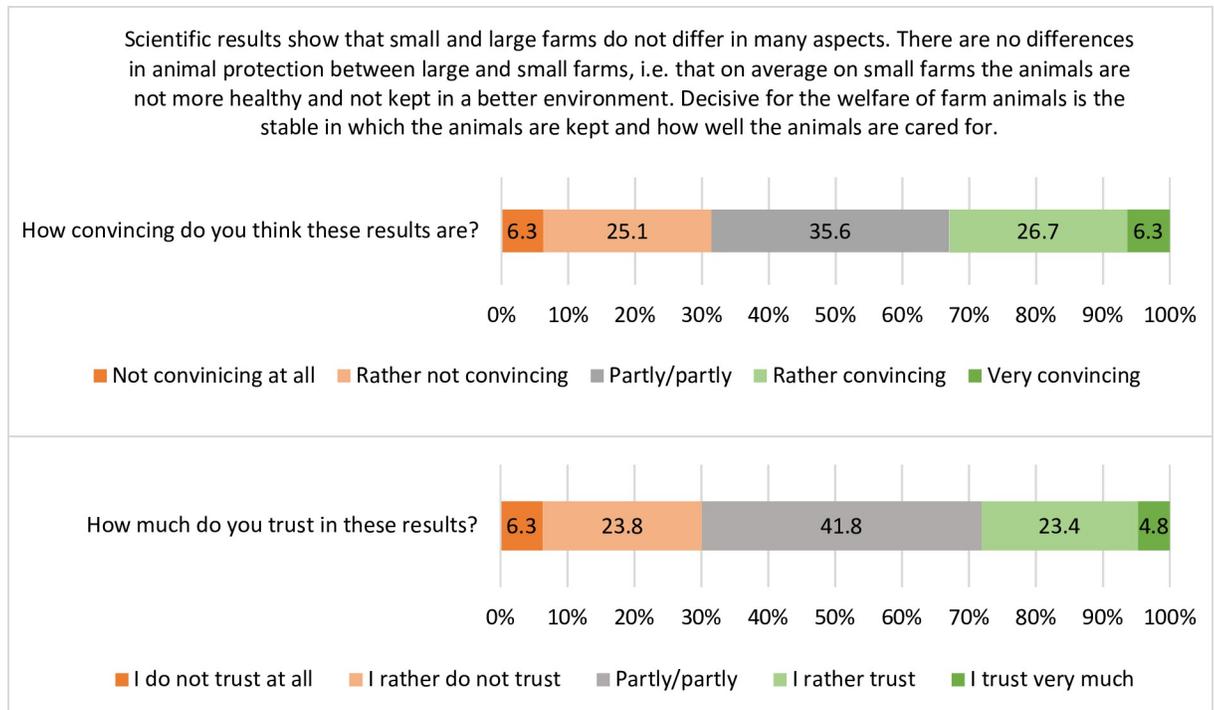


Fig 12. Participants' conviction and trust in scientific results on animal protection in relation to farm size (n = 506).

<https://doi.org/10.1371/journal.pstr.0000032.g012>

perceive the scientific results that animal protection is not related to farm size as convincing, another third is undecided and another third is convinced. The findings for trust in scientific results are similarly, with a higher share of partly/partly-answers.

In the case of climate and environmental protection, less people perceive the results as (rather) not convincing (21.3%) and more people are convinced (39.8%) (Fig 13). The same holds true for trust in the results. In the latter case nearly half of respondents (46.0%) answer with partly/partly.

No differences between female and male participants regarding these questions could be observed. There are further no correlations between age or education and conviction as well as trust in scientific results neither for animal nor for climate/environmental protection.

4 Discussion

The public has, on average, a general preference for small farms [5,12,30]. This is supported by our findings showing that a large majority prefers small over large farms with a stronger manifestation in women, which however, converges to the mean value of men at the end of the questionnaire. Other studies also show that women are generally more critical of animal husbandry in agriculture [36]. However, the stronger alignment in a discussion of the topic, as it was the case during the survey, is a new result. It could indicate uncertainty in the initial assessment, but requires further investigation. The clear position of preferring small over large farms in general might be influenced by media reports surrounding agriculture. It is well known that media coverage influences opinion formation, e.g. in cases of scientific findings such as global warming [38] or vaccinations [39]. In case of scandals, media reporting might even influence behavior through popularizing meat scandals which lead to lower meat consumption [40]. An evaluation of reports about animal farming in German newspapers showed that the coverage

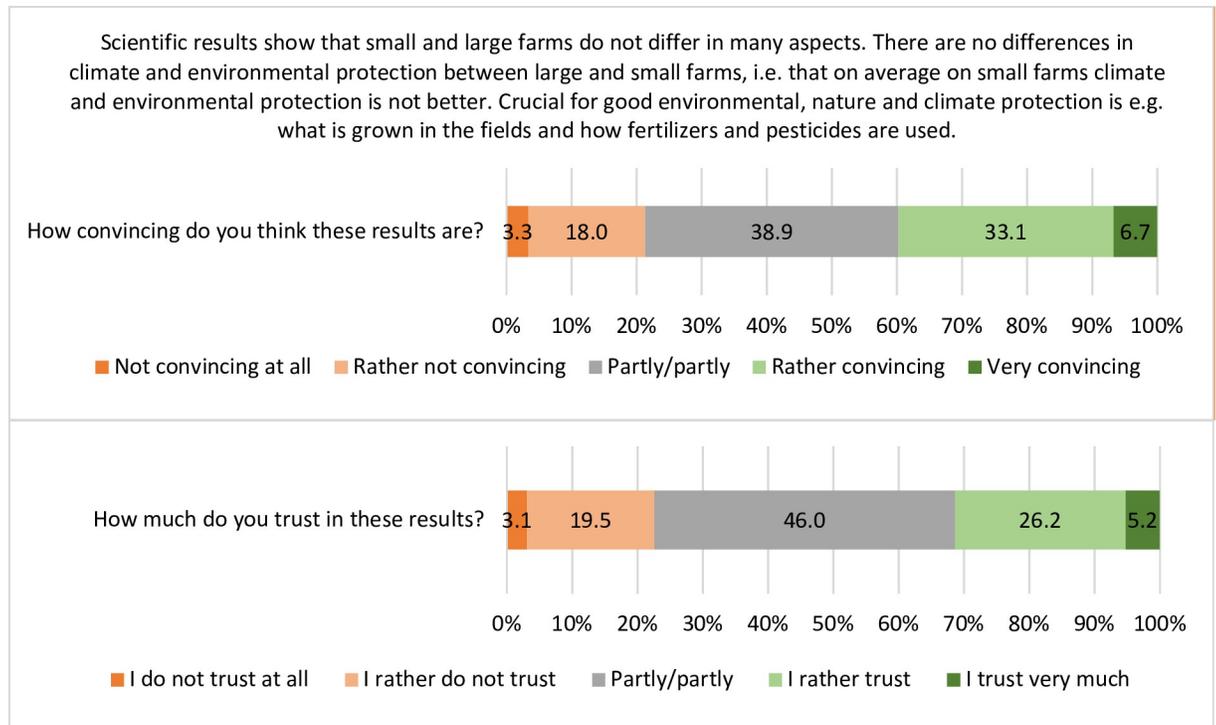


Fig 13. Participants' conviction and trust in scientific results on climate and environmental protection in relation to farm size (n = 479).

<https://doi.org/10.1371/journal.pstr.0000032.g013>

is balanced between negative and positive topics [41]. This fits with the results of a survey in Germany [42] showing that reporting on agriculture is perceived as balanced by the public. However, to the best of our knowledge, there is no evaluation that considers farm size in reporting. Thus, our study is the first taking farm size systematically into account when analyzing people's perceptions of media reports. The results clearly show that when reporting is remembered, large farms are more likely to be evoked with negative reports and small farms with positive ones.

However, when respondents select what constitutes an 'ideal farm', the number of animals per farm is of less importance compared to aspects related to animal and environmental protection or local and traditional production. These results indicate that it is mainly not farm size per se but rather the associated husbandry systems and production methods that shape the negative image of large farms. Indeed, all sustainability dimensions, except economic assessment, are perceived to be better fulfilled on small compared to large farms, especially with regard to animal welfare. This is in line with existing studies showing that large-scale farming or intensive livestock production is associated with animal cruelty, stress for the animals and a higher risk for animal diseases [7,27,31]. Large farms are perceived as primarily being profit-oriented. This image may contribute to the perception of these farms neglecting sustainability and the observed sympathy with small farms. It is known that, in the public's view, profit-orientation is contrasting a company's sustainable and responsible behavior [43,44]. Consumers often perceive profit-oriented companies as less sympathetic but more competent leading to a higher desire to buy products from large companies. However, this preference vanishes when small companies achieve high credibility values [45]. This seems to be the case for small farms as respondents assume small farms to comply more with existing laws. It is further known that people prefer buying products from small farms because they wish to support (allegedly)

disadvantaged farmers [32,33]. Furthermore, due to the perceived better level of animal health and naturalness, products from small farms are expected to be more natural, healthier and of better taste. A relation between the assessment of husbandry systems and a perceived better quality of products was also found by others [46].

Summing up, small farms are perceived to be better for animal welfare, the environment and product quality. This leads to many respondents pleading for limited herd sizes at farm and barn level for conventional and organic production systems. The maximum number of animals per farm rated as appropriate by the majority is thereby far below the average number of animals per farm in Germany for pigs and especially for poultry. In 2020, the average number of animals per farm was 1,243 for fattening pigs and 71 for dairy cattle [47]. For poultry it is known that in the year 2016 almost 80% of broilers and more than 50% of laying hens in Germany were kept on farms with more than 50,000 animals [48]. This large gap between actual farm sizes and farm sizes accepted by the broader public points on either people having little knowledge about actual farm sizes and underestimating current sizes of production or that they really feel the current sizes to be larger than what is tolerable. Based on our results, we cannot answer this question comprehensively. However, the literature shows that even when knowledge is low, communicating information does not automatically increase acceptance [49,50]. Additionally, the fact that the majority of respondents state that there should be an upper limit of animals per farm or barn indicates that this topic is potentially conflicting.

Due to large economies of scale, farm sizes are expected to further increase [4]. This indicates that agricultural policy that aims to preserve small farming structures and keeping farm numbers stable will be expensive. The latter has just recently been recommended by the Future Commission Agriculture of the German government [51]. In order to maintain competitiveness of these farms, economic disadvantages on small farms would need to be compensated. Although participants in our study acknowledge differences in economic efficiency between different farm sizes, it remains open from this study whether real costs of subsidizing small farms and keeping farm numbers stable, are known and supported by the public.

However, next to economic advantages, larger farms might also increase sustainability through ecologies of scale, e.g., by a more efficient use of resources, i.e. the application of new technologies that are often not economical on small farms [15]. Moreover, there is no clear correlation between farm size and animal welfare or environmental protection. Production systems and management as well as farmers personality and attitudes are better indicators [29]. Thus, a return to small-scale agriculture or strict limitation of farm sizes are neither feasible nor desirable.

This issue might challenge public communications both for scientists as well as for the sector. Especially as our findings have shown that people have very heterogeneous attitudes towards scientific findings that disentangle farm size from sustainability. The conclusion that can be drawn from this: there is a group of about 21–32% that cannot be convinced by scientific argumentation, at least as it was conducted in this study. One explanation can be motivated reasoning in which peoples' preferences affect their beliefs. This is grounded in that evidence is frequently evaluated dependently on existing preferences and beliefs [50]. In our case such motivated reasoning might have happened when judging the scientific evidence we presented. This makes especially sense when considering that the preferences for small farms seem to be quite stable as they did not change in the course of the survey for most participants. With regard to animal welfare, it seems to be even more difficult to detach society from the 'small is beautiful'-perception. For small farms or farms with small herd sizes these results offer the opportunity to highlight farm size when selling their product.

Further, it should be remembered that in the past the strong focus on economic outcome and high specialization in animal farming led to a series of animal welfare problems [52],

which now have to be improved. In society this may be strongly associated with large scale farming. Future sustainable farming systems will very likely involve large farms due to their advantages in being more specialized with high levels of knowledge as well as economies of scale. This makes it likely that such farms are more prone to adapting new technologies that enhance sustainability of animal farming, including animal welfare. This development is contrasting widely held public perceptions of small farms being per se advantageous and might challenge social acceptance of future animal farming systems on large scales, although with improved animal welfare levels. This should encourage particularly larger farms to demonstrate their corporate social responsibility through a stronger commitment to animal welfare, and to further communicate these efforts publicly.

Supporting information

S1 Questionnaire. Full questionnaire in English language (translated from the German original).

(PDF)

S1 Letter. Approval of the study by the Ethics Commission at Göttingen University.

(PDF)

Author Contributions

Conceptualization: Gesa Busch, Elisa Bayer, Achim Spiller, Sarah Köhl.

Data curation: Gesa Busch.

Formal analysis: Gesa Busch.

Methodology: Gesa Busch, Elisa Bayer, Achim Spiller, Sarah Köhl.

Project administration: Gesa Busch.

Supervision: Gesa Busch, Sarah Köhl.

Visualization: Gesa Busch.

Writing – original draft: Gesa Busch, Elisa Bayer, Sarah Köhl.

Writing – review & editing: Gesa Busch, Elisa Bayer, Achim Spiller, Sarah Köhl.

References

1. van der Ploeg JD. Farmers'upheaval, climate crisis and populism. *J Peasant Stud.* 2020; 47(3): 589–605. <https://doi.org/10.1080/03066150.2020.1725490>
2. Nowack W, Hoffmann H. 'We are fed up'—encountering the complex German call for sustainable, small-scale agriculture. *J Peasant Stud.* 2019; 47(2): 420–429. <https://doi.org/10.1080/03066150.2019.1628019>
3. Quendler E. Characterisation of Agricultural Farms—especially according to Sustainability. How does the farm size influence the sustainability and why do small farms show a „special“ sustainability? *Die Bodenkultur.* 2005; 56 (4).
4. Nowack W, Schmid J, Grethe H. Wachsen oder weichen!? Eine Analyse der agrarstrukturellen Debatte im Kontext der EU-Agrarpolitik nach 2020. *GAIA—Ecological Perspectives for Science and Society.* 2019. Dec 28. <https://doi.org/10.14512/gaia.28.4.7>
5. Wissenschaftlicher Beirat Agrarpolitik beim BMEL. Wege zu einer gesellschaftlich akzeptierten Nutztierhaltung. 2015. Available from: https://www.bmel.de/SharedDocs/Downloads/DE/_Ministerium/Beiraete/agrarpolitik/GutachtenNutztierhaltung.pdf;jsessionid=80161EDAE62825CF166EEB52AD64117A.live842?__blob=publicationFile&v=2.

6. Busch G, Kayser M, Spiller A. Factory Farming from a Consumer's Perspective: Associations and Attitudes. *Jahrbuch der Österreichischen Gesellschaft für Agrarökonomie*. 2013; 22 (1): 61–70.
7. Kayser M, Schlieker K, Spiller A. Die Wahrnehmung des Begriffs „Massentierhaltung“ aus Sicht der Gesellschaft. *Berichte über Landwirtschaft* 2012; Dec 90(3): 417–428.
8. Pirsich W, von Hardenberg L, Theuvsen L. Eine empirische Analyse zum Angebot von Tierwohl-Fleisch in Fleischerfachgeschäften. *Berichte über Landwirtschaft*. 2017; Aug 95 (2). <https://doi.org/10.12767/buel.v95i2.165>
9. Andersson E, Lindborg R. Species Richness and Assemblages in Landscapes of Different Farming Intensity—Time to Revise Conservation Strategies? *PLoS ONE*. 2014; 9(10): e109816. <https://doi.org/10.1371/journal.pone.0109816> PMID: 25275484
10. Gödeke K. Zustandserhebung der Umweltwirkung ökologisch wirtschaftender Betriebe—Ergebnisse des Umweltsicherungssystems Landwirtschaft (USL). *Ökolandbau in Thüringen 2013, Entwicklung und Ergebnisse* Schriftenreihe. 2013; 5: 21–32.
11. Gieseke D, Lambertz C, Gault M. Relationship between herd size and measures of animal welfare on dairy cattle farms with freestall housing in Germany. *J Dairy Sci*. 2018; Aug 101 (8): 7397–7411. <https://doi.org/10.3168/jds.2017-14232> PMID: 29778480
12. Ebel R. Are Small Farms Sustainable by Nature?—Review of an Ongoing Misunderstanding in Agroecology. *Challenges in Sustainability*. 2020 April. 8(1): 17–29. <https://doi.org/10.12924/cis2020.08010017>
13. Tschamtko T, Grass I, Wanger CW, Westphal C, Batáry, P. Beyond organic farming—harnessing biodiversity-friendly landscapes. *Trends Ecol Evol*. 2021; 36(10) 919–930. <https://doi.org/10.1016/j.tree.2021.06.010> PMID: 34362590
14. Richner N, Holderegger R, Linder HP, Walter T. Reviewing change in the arable flora of Europe: a meta-analysis. *Weed Res*. 2015 55, 1–13. <https://doi.org/10.1111/wre.12123>
15. von der Meulen HAB, Dolman MA, Jager VH, Venema GS. The impact of farm size on sustainability of dutch dairy farms. *International Journal of Agricultural Management*. 2014; 3(2) 119–123. <https://doi.org/10.5836/ijam/2014-02-07>
16. Ren C, Lui S, van Grinsven H, Reis S, Jin S, Lui H, et al. The impact of farm size on agricultural sustainability. *J Clean Prod*. 2019 May 220 (20): 357–367. <https://doi.org/10.1016/j.jclepro.2019.02.151>
17. Bánkuti FI, Prizon RC, Damasceno JC, De Brito MM, Pozza MSS, Lima PGL. Farmers' actions toward sustainability: a typology of dairy farms according to sustainability indicators. *Animal*. 2020; 14 (2): 417–423. <https://doi.org/10.1017/S1751731120000750> PMID: 32290889
18. Schulte HD, Armbrrecht L, Bürger R, Gault M, Musshoff O, Hüttl S. Let the cows graze: An empirical investigation on the trade-off between efficiency and farm animal welfare in milk production. *Land Use Policy*. 2018; Dec 79: 375–385. <https://doi.org/10.1016/j.landusepol.2018.07.005>
19. Kleinhanß W, Murillo C, Sa Juan C, Sperlich, S. Efficiency, subsidies, and environmental adaptation of animal farming under CAP. *Agricultural Economics*. 2007; 36: 49–65. <https://doi.org/10.1111/j.1574-0862.2007.00176.x>
20. Plagge J, Zander K, Nieberg H, Strohm-Lömpcke R. Strategy consultancy regarding diversification, specialization and cooperation in organic farming. *Schriftenreihe der Bayerischen Landesanstalt für Landwirtschaft (LfL)*. 2009; 7: 133–139.
21. Robbins JA, von Kevserlingk MAG, Fraser D, Weary DM. Invited Review: Farm size and animal welfare. *Journal of Animal Science*. 2016; Dec 94 (12): 5439–5455. <https://doi.org/10.2527/jas.2016-0805> PMID: 28046157
22. Wuepper D, Wimmer S, Sauer J. Is small family farming more environmentally sustainable? Evidence from a spatial regression discontinuity design in Germany. *Land Use Policy*. 2020; 90: 104360.
23. Quendler E. Future Scenarios for the Agriculture—Results of an Expert Survey. Which future scenarios are defined for the Austrian Agriculture and how important is the small farm? *Die Bodenkunde*. 2005; 56 (4): 241–247.
24. Rivera M, Guarín A, Pinto-Correira T, Almaas H, Arnalte Mur L, Burns V, et al. Assessing the role of small farms in regional food systems in Europe: Evidence from a comparative study. *Glob Food Sec*. 2020; Sept; 26: 100417. <https://doi.org/10.1016/j.gfs.2020.100417>
25. Wellner M, Theuvsen L. Landwirtschaft von unten: Community Supported Agriculture als zivilgesellschaftliche Nachhaltigkeitsinitiative. *Nonprofit-Organisationen und Nachhaltigkeit, NPO-Management*. https://doi.org/10.1007/978-3-658-18706-4_21
26. Glied T, Hoicka CE, Jackson N. Innovation intermediaries accelerating environmental sustainability transitions. *J Clean Prod*. 2018; Feb 174 (10):1247–1261. <https://doi.org/10.1016/j.jclepro.2017.11.054>

27. Heise H, Kemper N, Theuvsen L. The attitude of German veterinarians towards farm animal welfare: results of a cluster analysis. *Berliner und Münchener Tierärztliche Wochenschrift*. 2016; May 129: 225–233. <https://doi.org/10.2376/0005-9366-129-15051>
28. Egger-Danner C, Köck A, Fuchs K, Grassauer B, Fuerst-Waltl B, Obritzhauser W. Use of benchmarking to monitor and analyze effects of herd size and herd milk yield on cattle health and welfare in Austrian dairy farms. *J J Dairy Sci*. 2020; Aug 103 (8): 7598–7610. <https://doi.org/10.3168/jds.2019-16745> PMID: 32505408
29. Waiblinger S, Menke C. Influence of Herd Size on Human—Cow Relationships. *Anthrozoös*. 1999; 12:4: 240–247.
30. Schumacher EF. *Small is beautiful. Economics as If People Mattered*. Blond & Briggs, 1973 London.
31. Clark B, Panzone LA, Stewart GB, Kyriazakis I, Niemi JK, Latvala T, et al. Consumer attitudes towards production diseases in intensive production systems. *PLoS ONE*. 2019 Jan; 14(1): e0210432. <https://doi.org/10.1371/journal.pone.0210432> PMID: 30629667
32. Berlin L, Lockeretz W, Bell R. Purchasing foods produced on organic, small and local farms: A mixed method analysis of New England consumers. *Renewable Agriculture and Food Systems*. 2009 Dec; 24 (4): 267–275.
33. Briggemann BC, Lusk JL. Preferences for fairness and equity in the food system. *European Review of Agricultural Economics*. 2011 March; 38(1):1–29.
34. Broom DM. Animal welfare: an aspect of care, sustainability, and food quality required by the public. *J Vet Med Educ*. 2010; 37(1):83–8. <https://doi.org/10.3138/jvme.37.1.83> PMID: 20378884
35. Zhang C, Conrad FG. Speeding in web surveys: the tendency to answer very fast and its association with straightlining. *Surv Res Methods* 2014; 8(2): 127–135. <https://doi.org/10.18148/srm/2014.v8i2.5453>
36. Statistisches Bundesamt 2021a. Fortschreibung des Bevölkerungsstandes. Available at: <https://www-genesis.destatis.de/genesis/online?operation=previous&levelindex=0&step=0&titel=Statistik+%28Tabellen%29&levelid=1625741252431&acceptscookies=false#abreadcrumb>
37. Statista 2021. Bildungsstand: Verteilung der Bevölkerung in Deutschland nach höchstem Schulabschluss (Stand 2019). Available at: <https://de.statista.com/statistik/daten/studie/1988/umfrage/bildungsabschluesse-in-deutschland/>
38. Carmichael JT, Brulle RJ. Elite cues, media coverage, and public concern: an integrated path analysis of public opinion on climate change, 2001–2013. *Env Polit*. 2017 26(2): 232–252. <https://doi.org/10.1080/09644016.2016.1263433>
39. Bongiorno A. The Battle Between Expertise and Misinformation to Influence Public Opinion: A Focus on the Anti-Vaccination Movement. 2021. Undergraduate Honors Theses. Paper 1613.
40. Verbeke W, Ward R.W. Consumer interest in information cues denoting quality, traceability and origin: an application of ordered probit models to beef labels. *Food Qual Prefer*. 2005 17: 453–467. <https://doi.org/10.1016/j.foodqual.2005.05.010>
41. Wolfram J, Kothe C, Brümmer N, Mergenthaler M. Medien-Frames in der Berichterstattung über landwirtschaftliche Tierhaltung. *Bericht über Landwirtschaft*. 2021 99(1): 1–46. <https://doi.org/10.12767/buel.v99i1.313>
42. Emnid Kantar. *Das Image der deutschen Landwirtschaft. Ergebnisbericht*. 2017 March.
43. Bhattacharjee A., Dana J, Baron J. Anti-Profit Beliefs: How People Neglect the Societal Benefits of Profit. *J Pers Soc Psychol*. 2017. 113(5): 671–696. <https://doi.org/10.1037/pspa0000093> PMID: 28726437
44. Chakravarti J, Basso F. An intentional profit-generating strategy can be detrimental to a sustainable organization. *J Clean Prod*. 2021 March. 287(10): 125057.
45. Aaker J, Vohs KD, Mogilner C. Nonprofits are seen as warm and for-profits as competent: firm stereotypes matter. *J Consum Res*. 2010 (37): 224–237. <https://doi.org/10.1086/651566>
46. Kühl S, Gaulty S, Spiller A. Analysing public acceptance of four common husbandry systems for dairy cattle using a picture-based approach. *Livest Sci*. 2018 (220): 196–204. <https://doi.org/10.1016/j.livsci.2018.12.022>
47. Statistisches Bundesamt. Gehaltene Tiere: Deutschland, Jahre, Tierarten. 2021. Available from: https://www-genesis.destatis.de/genesis/online?operation=find&suchanweisung_language=de&query=41311-0001#abreadcrumb, Codes 41311–0001, 41311–0003.
48. Bundesministerium für Ernährung und Landwirtschaft. Betriebe mit Masthühnerhaltung / Legehennenhaltung nach Bestandsgrößen. 2021. Available from: <https://www.bmel-statistik.de/landwirtschaft/tierhaltung/gefluegelhaltung/>.

49. Hötzel MJ, Cardoso CS, Roslindo A, von Keyserlingk, MAG. Citizens' views on the practices of zero-grazing and cow-calf separation in the dairy industry: Does providing information increase acceptability? *J Dairy Sci.* 2017 100(5): 4150–4160. <https://doi.org/10.3168/jds.2016-11933> PMID: 28259414
50. Busch G, Spiller A. Consumer acceptance of livestock farming around the globe. *Anim Front.* 2018 8(1): 1–3. <https://doi.org/10.1093/af/vfx005> PMID: 32002207
51. Zukunftskommission Landwirtschaft (ZKL) Zukunft Landwirtschaft. Eine gesamtgesellschaftliche Aufgabe. Empfehlungen der Zukunftskommission Landwirtschaft. 2021. Available from: https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/abschlussbericht-zukunftskommission-landwirtschaft.pdf?__blob=publicationFile&v=14
52. Cronin GM, Rault J.-L., Glatz P.C. Lessons learned from past experience with intensive livestock management systems. *Revue scientifique et technique (International Office of Epizootics).* 2014 33(1): 139–151. <https://doi.org/10.20506/rst.33.1.2256> PMID: 25000786