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A survey of Australian dairy farmers' attitudes to their business, its challenges and transitioning to alternative enterprises

Esra Celik[1,2], Diana Bogueva[1], Clive J.C. Phillips[1,3]✉ & Dora Marinova[1]

Dairy farmers are grappling with serious business challenges, including rising operational costs, labour shortages, unstable milk prices, changing consumer preferences, long hours with minimal downtime and unstable weather patterns due to climate change impacts. Using a telephone-based representative survey and interviews with 147 Australian dairy farmers conducted in 2023, we employed a mixed-method approach combining quantitative and qualitative analysis to determine the challenges and primary concerns of the participants, as well as to explore potential solutions. Four key variables that contributed significantly to a binary logistic regression model of transition intentions were identified, namely: level of satisfaction with dairy farming, openness to exploring other agricultural alternatives to dairy farming, preference to receive financial and/or other support to remain in the industry and preference to receive financial and/or other support to transition into a different form of farming or business. This model accurately predicted the probability that farmers were considering transitioning away from dairy farming and the probability that they were considering staying in dairy farming. This deepens our understanding of the challenges faced by farmers in the Australian dairy industry, and provides policymakers, industry stakeholders and researchers with critical insights to facilitate transition pathways that will enhance farmers' future sustainability.

Keywords Australian dairy farmers, Alternative enterprises, Challenges, Dairy farming, Sustainability, Transitioning

The world population is estimated to reach 9.8 billion people by 2050[1] and with this, and the rise of incomes in developing countries, the demand for dairy products is expected to approximately double by this date, compared to 2000[2]. Although there has been limited growth in global milk production in recent years, it is predicted to increase by 22% in 2027, compared to 2015–2017[3]. The developed countries' share in global dairy production, however, is decreasing (along with the number of dairy cows and farms). Eating habits are changing in many developing countries, especially in East and Southeast Asia, where milk production and consumption are increasing strongly[4–6].

Financial viability is key to the profitability of dairy farms in developed countries[7]. Technological advances have allowed many countries to keep their dairy farming and processing sectors dynamic and in a position to meet current demand[8–10]. Still, profitability is necessary for farms to be viable, and this is determined by the costs of milk production and the revenue from the sale of products, especially milk[11]. However, this financial model and the performance of the entire sector are being challenged by recent developments. In particular, dairy farming in high-income countries faces internal and external challenges. Among these is declining profitability, a result of increased competition from alternative products, labour shortages, instability in milk prices and climate change, all of which affect dairy farmers' financial viability and their well-being[12–14]. In particular, the COVID-19 pandemic created an imbalance between supply and demand of dairy products, causing price instability[15]. The high cost of milk production compared to the income obtained from milk sales leads to low morale and a decreased interest in dairy farming[12]. These changing dynamics of the sector have the potential to affect competition, productivity and efficiency, as well as the well-being of rural communities[16].

[1]Curtin University Sustainability Policy Institute, Perth 6845, Australia. [2]Faculty of Veterinary Medicine, Department of History of Veterinary Medicine and Deontology, Selçuk University, 42003 Konya, Türkiye. [3]Institute of Veterinary Medicine and Animal Science, Estonian University of Life Sciences, 51014 Tartu, Estonia. ✉email: clive.phillips@curtin.edu.au

Increasingly, there are stricter control measures associated with practices affecting animal welfare, such as the treatment of unwanted male calves from dairy cows[17–19]. Poor dairy cattle welfare is one reason that milk alternatives are replacing dairy products, as well as environmental concerns and human nutrition impact[20]. A rising awareness of animal cruelty has resulted in an increasing number of consumers tending to avoid animal products[21–23]. Recognising the multifaceted impact of changing dynamics, farmer welfare and animal welfare indicators have a direct positive relationship[24]. The positive relationship between animal welfare on dairy farms and farmers' satisfaction with overall farm performance, including profitability, illustrates the importance of the One Welfare concept[25,26]. Therefore, increasing the well-being of farmers and reducing the stressors to which they are exposed is just as important for the farmed animals[24].

Temperature increases and variability resulting from climate change also create many challenges in terms of livestock husbandry and animal welfare[27]. It is likely that the effects of climate change, which are expected to increase in the future, will cause serious uncertainty in the dairy industry. Adapting to these changing climatic conditions is a challenge further reinforced by the constant increase in food demand as a result of global population growth[28]. Although the consumption of animal products continues to increase globally, in Western countries consumption behaviour is evolving towards more plant-based dairy alternatives[14]. The global dairy alternatives market was estimated to be worth US$27 billion in 2023 and is predicted to grow further, reaching US$43.6 billion by 2028[29]. Compared to plants used to produce alternatives, dairy farms are not as efficient in their use of basic resources – land, energy and water –leading to a significant increase in energy needs[28,30].

Due to all of these challenges that dairy farms face, many farmers in Western countries are reconsidering the viability of their businesses[16,31]. The age of farmers is another issue that should be taken into consideration, as increase in the farmer's age increases the likelihood of exiting the farm[32]. For example, according to 5-year forecasts in the USA, less than 10% of farms with 200 or more cows are expected to terminate milk production, but this probability increases to between 14% and 20% if the producer is 60 years or older[3]. Considering the dynamics of the sector, consumer expectations and factors, such as workload and time pressure[20,24,28,33], the closure of dairy farms may increasingly be important in the near future[3].

Australian dairy farms are exposed to most of these pressures, many of which are global in nature, such as climate change and financial difficulties[34,35]. A study of the expected profitability of Australian dairy farm businesses has identified serious negative impacts of climate change. If farmers do not adjust to the hotter and drier conditions, they could face a significant drop in operating profits, ranging from 10 to 30%, by 2040 due to the impact of climate change[34]. A shift in consumer preferences is also apparent in Australia, with 40% of Australian households reporting buying plant-based milk in 2023[36]. Although dairy farming has been providing a livelihood and business opportunities to many people across the vast Australian continent, the changing realities of climate change, increased labour, feed and fertiliser costs, limited access to feed during times of droughts and floods, combined with shifting consumer preferences and attitudes may be impacting farmers' views about their future. This study aimed to investigate Australian dairy farmers' level of satisfaction with dairy farming, the challenges they were confronted with, whether they were interested in transitioning away from dairy farming and what support should be provided to assist in such a process.

Methods

Study design and materials

Information from dairy farmers from the major dairying regions of Australia was obtained in this research. According to Dairy Australia (2023) data, the majority of milk production in Australia occurs in Victoria (47.3%), Tasmania (8.5%) and New South Wales (7.5%)[37]. Recognising this, the regions where the most data were collected in our study were Victoria (64.6%), New South Wales (17.7%) and Tasmania (6.8%) (Table 1). Following a detailed literature review, factors that have the potential to affect the continuity of the dairy sector were identified. One of the important criteria underlying dairy farmers' desire to move away from this sector was satisfaction with their work and quality of life[38]. In addition, financial support could also be decisive, considering the difficult economic conditions[7]. Furthermore and as expressed in various studies, farmer welfare and demographic variables such as age and gender, as well as criteria for the capacity of dairy farms such as herd size and farm size, were also evaluated[24,32,39]. The open and closed-ended questions developed as a result of this literature review aimed to reveal the current situation regarding Australian dairy farmers' satisfaction, and the difficulties and expectations that they were experiencing in this profession. The Australian dairy sector remains in a unique position, with Australian farmers receiving lower levels of government support than their international counterparts[40]. This situation and other factors to be investigated are important in determining the willingness of farmers in the Australian dairy sector to remain in this industry or not and to gain a perspective on the future of dairy farming. After identifying the factors that had the potential to affect the continuity of the dairy sector, a survey form was developed (see Supplementary Material), which aimed to collect quantitative information as well as record farmers' opinions expressed in free text. The survey was conducted by telephone interviews in 2023 using the professional Australian agricultural interviewing service KG2[41].

Participants

In Australia, where there is a total of 11,200 dairy farmers, there are 5,700 dairy farms spread across six states: Victoria, South Australia, New South Wales, Queensland, Tasmania and Western Australia[37,42]. As mentioned above, the majority of milk production takes place in Victoria (47.3%), Tasmania (8.5%) and New South Wales (7.5%)[37]. More data was collected from regions where dairy farms predominate, ensuring that Australia's dairy sector was represented, and that farm demographics were balanced. Since the population eligible to be included in the research was 11,200, the accepted margin of error was 8% and the confidence level was 95%, the theoretical sample size was determined as 149. A survey sample of 150 participants was recruited to obtain statistically significant results.

Variable		Frequency	Percent (%)
Gender	Male	136	92.5
	Female	11	7.5
	Total	**147**	**100.0**
Age	Under 25 years	1	0.7
	25 to 34 years	7	4.8
	35 to 44 years	17	11.6
	45 to 54 years	37	25.2
	55 to 64 years	50	34.0
	65 years or more	35	23.8
	Total	**147**	**100.0**
State	New South Wales (NSW)	26	17.7
	Victoria (VIC)	95	64.6
	Queensland (QLD)	6	4.1
	South Australia (SA)	9	6.1
	Western Australia (WA)	1	0.7
	Tasmania (TAS)	10	6.8
	Total	**147**	**100.0**
Herd size*	< 150 cows	18	12.2
	151–300 cows	62	42.2
	301–500 cows	39	26.5
	501–700 cows	17	11.6
	> 700 cows	11	7.5
	Total	**147**	**100.0**
Openness to exploring any other agricultural alternatives to dairy farming	No	67	45.6
	Yes	80	54.4
	Total	**147**	**100.0**
Any specific types of support or incentives from the Government to transition away from Dairy Farming	No	103	70.1
	Yes	32	21.8
	Don't know	12	8.2
	Total	**147**	**100.0**
Financial and/or other support to remain in the industry	No	61	41.5
	Yes	86	58.5
	Total	**147**	**100.0**
Financial and/or other support to transition into a different form of farming or business	No	118	80.3
	Yes	29	19.7
	Total	**147**	**100.0**

Table 1. Demographic characteristics of the participants and some factors for transitioning away from dairy farming. * For herd size grouping, references on average herd size on Australian dairy farms were used[43,49].

Our most common age range was 55 to 64 at 34.0%. The second most common age range, 45 to 54, constitutes the most common age of employees on dairy farms across Australia, with 25% of the population[42,43]. In terms of dairy herd size, the highest average number of cows per farm is found in Victoria (530 cows), followed by Tasmania (500 cows)[37]. We ensured equal representation in terms of dairy herd size, with Victoria having the highest average per farm (406), followed by Tasmania (350). With the interviews conducted over the phone, the response rate was 54%, with uncontactable numbers excluded from the sample.

Data analysis

A simultaneous mixed method model was preferred for this research[44]. The use of mixed methods (quantitative and qualitative analyses) in research is appropriate when dealing with complex issues, and the researchers are interested not only in finding answers to questions, such as "how many" but also in "why" the respondents are providing particular answers[45]. The main reason for choosing the mixed method was the complementary nature of the research techniques[46]. We aimed to enrich the research and provide more detail by using the complementarity of qualitative and quantitative data together. For this reason, the research questions were designed to allow qualitative and quantitative data to be collected that complement each other. Both methods examined slightly different aspects of the same phenomenon, namely dairy farmers' attitudes to their business, its challenges, and the transitioning to alternative enterprises. Using both methods together strengthened the overall quality of the analysis[45].

By using a professional interviewing service (KG2) to conduct telephone interviews with Australian farmers, the research team was able to ensure that there was no internal influence on data collection. The independent professional interviewers who specialised in agricultural topics were able to accurately capture the dairy farmers' responses in relation to the challenges confronting them. By this method, the survey captured the multifaceted issues faced by the diverse range of participants.

Quantitative data was collected through structured survey questions, requesting answers on a Likert scale regarding dairy farmers' satisfaction levels, rising production costs, fluctuating market dynamics and technological adoption. Answers to open-ended questions were provided during in-depth interviews focusing on farmers' experiences, perceptions and aspirations. This allowed for a nuanced and in-depth exploration of the complex landscape of challenges and opportunities for the farmers engaged in the Australian dairy industry. Questions were also asked to the farmers as a follow-up to the open-ended questions that were directed to them after a closed-ended question. For example, after dairy farmers answered a closed-ended question (Would there be any specific types of support or incentives from the Government that could encourage you to transition away from Dairy Farming?), in-depth information was collected by asking "What type of support or incentives would this be?" as an open-ended question. Then, more in-depth questions were directed to all dairy farmers to obtain more detailed data: "If you were to transition your farm to a different agricultural model or business, what challenges do you foresee occurring?" and "How could such challenges be addressed or mitigated?". The quantitative and qualitative data were analysed separately. As these two components of the mixed-method research complemented each other, the results obtained from the quantitative and qualitative analyses were considered together when drawing conclusions and making the final interpretation[47].

Quantitative data were analysed using SPSS 20.0. The data obtained from the 150 participants were subjected to Binary Logistic Regression Analysis to investigate the significance of the variables relevant to participants "considering transitioning away from the dairy farming". Multiple Linear Regression was performed to determine the multicollinearity between the independent variables. With Binary Logistic Regression Analysis, data from three participants containing extreme values (>*2.5* ZResid) were identified and excluded from the analysis, and the analysis was repeated with the data obtained from 147 participants[48]. In addition to the eight variables initially listed in Table 1, the following questions regarding dairy farmers' attitudes towards transitioning away from dairy farming were also included in the model: "farm size", "satisfaction with dairy farming", "sustainability of dairy farming", "openness to transitioning away from dairy farming and exploring the possibilities of horticulture or other business ventures if support and assistance were provided by the government". Stepwise regression analysis yielded the best-fitting model that included four variables that were most important for transitioning away from dairy farming (Table 2). The critical significance level for the factors was accepted as $p < 0.05$. The insignificant value of Hosmer and Lemeshow's goodness of fit guided us to accept the null hypothesis, that is, there was no difference between the observed and model-predicted values ($p > 0.05$). Additionally, the omnibus test showed that dropping variables other than these four variables did not make a difference in the significance of the prediction ($p < 0.01$). All these tests justify that the model provides the best fit. Additionally, Mann-Whitney U tests were used to determine the variables affecting the farmers' satisfaction levels with their current dairy farming operations and to determine the relationship between dairy farmers' outlook on the sustainability of dairy farming in Australia and other relevant factors (Table 3 and Supplementary Table S4). The Kruskal-Wallis test was performed to determine whether herd size affected the need for additional financial resources to make an informed decision about the future of the farm, and the Mann-Whitney U test was performed for multiple comparisons (Table 4).

The qualitative data analysis was conducted using NVivo software (a computer-assisted qualitative data analysis) to code for specific themes. The collected responses were thoroughly reviewed, and interesting excerpts were coded into nodes, designed to capture relevant themes. Four primary nodes (Table 5) were created to categorise the data effectively:

- Satisfaction with the current dairy farming industry: including both positive and negative attitudes.
- Major challenges faced by farmers.
- Outlook on the sustainability of dairy farming.
- Transitioning away from dairy farming.

These primary nodes were consistently applied to the remainder of the interviews. During the review process, three additional nodes were added to accommodate emerging themes:

Variables	B	S.E.	Wald	df	*p*	Exp(B)
Satisfaction with dairy farming	-0.837	0.165	25. 672	1	*0.000***	0.433
Openness to exploring any other agricultural alternatives to dairy farming	1.310	0.550	5.676004	1	*0.017**	3.705
Financial and/or other support to remain in the industry	-2.255	0.558	16.313	1	*0.000***	0.105
Financial and/or other support to transition into a different form of farming or business	1.295	0.604	4.593	1	*0.032**	3.650
Constant	**5.178**	**1.317**	**15.464**	**1**	***0.000*****	**177.244**

Table 2. Variables and coefficients in the regression model describing transitioning away from dairy farming. B: The coefficients of the independent variables in the regression equation, SE: Standard error, Wald: A statistic that tests the significance of coefficients, df: Degrees of freedom, Sig: Significance of coefficients, Exp(B): Exponential value of B coefficients. * $p < 0.05$, ** $p < 0.01$.

Variables	Group	*N*	Median#	Mean Rank	Sum of Ranks	U	*P*
Mental health and wellbeing challenges faced by Australian dairy farmers in their dairy farming operations.	No	72	8	86.15	6202.50	1825.50	*0.000***
	Yes	75	7	62.34	4675.50		
	Total	**147**					
The impact of the challenges they face as dairy farmers on their mental wellbeing and that of their families	No	46	8	89.48	4116.00	1611.00	*0.002***
	Yes	101	8	66.95	6762.00		
	Total	**147**					
Concerns experienced by dairy farmers regarding rising costs	No	89	8	81.07	7215.50	1951.50	*0.010**
	Yes	58	7	63.15	3662.50		
	Total	**147**					

Table 3. Factors affecting farmers' satisfaction levels associated with their current dairy farming activities. * $p < 0.05$, ** $p < 0.01$. # on a scale of 1, very unconcerned to 10, very concerned

Herd size	*N*	Mean Rank	df	χ2	*p*	Significant Differences
< 150 cows	18	66.56	4	14.649	*0.05**	> 700 cows and 151–300 cows > 700 cows and 501–700 cows
151–300 cows	62	79.44				
301–500 cows	39	71.60				
501–700 cows	17	92.32				
> 700 cows	11	35.73				
** p < 0.05*						

Table 4. The effect of herd size on the perceived need for additional financial resources to make an informed decision about the future of the farm.

Node	Description
Primary Nodes	
Satisfaction with the current dairy farming industry	Captures positive and negative attitudes of participants towards dairy farming
Major challenges faced by farmers	Addresses primary difficulties experienced by farmers
Outlook on the sustainability of dairy farming	Examines perspectives on the long-term viability of dairy farming
Transitioning away from dairy farming	Covers ideas and considerations related to moving away from dairy farming
Additional Nodes	
Hardship from external factors	Includes operational costs, drought, and flood impacts on farming
Consideration of agricultural alternatives	Looks at potential shifts to other agricultural practices outside of dairy farming
Need for additional resources	Highlights the need for more resources to help farmers make informed decisions

Table 5. Primary and additional nodes derived from the dataset of responses of dairy farmers ($n = 147$).

- Hardship from external factors: covering operational cost, drought, and flood.
- Consideration of agricultural alternatives to dairy farming.
- Need for additional resources to make an informed decision.

The content of each node was constantly reviewed to ensure accuracy. Memos were also created throughout the analysis to document researchers' thoughts, doubts, questions, and insights.

Ethical approval

The questionnaire and survey method were approved by the Human Research Ethics Committee of Curtin University, Australia (HRE2022-0047). This research met the requirements described in Australia's National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research. All interviews and data analysis were performed in accordance with the ethics-approved protocol and the relevant university's guidelines and regulations.

Informed consent

Informed consent was obtained from all subjects involved in the research.

Results

The distribution of dairy farms around the states in Australia is reflected in the geographical location of the respondents to the questionnaire. Most of the respondents were from Victoria, and there were no participants

from the Northern Territory and the Australian Capital Territory (where there are no dairy farms). As briefly described above, the sample aligns with the latest statistics from Dairy Australia which shows that 2.9% ($n=159$) of all 5,700 farms are located in Western Australia, 4% ($n=228$) in South Australia, 24.1% ($n=1,372$) in the Murray Region (Northern Victoria and Southern NSW), 22.4% ($n=1274$) in Western Victoria, 23.2% ($n=1324$) in the Gippsland Region, Victoria, 9.1% ($n=519$) in the Subtropical Region (Queensland, NSW), 7.2% ($n=411$) in New South Wales and 7.2% ($n=412$) in Tasmania[37]. In our sample, the respective percentages were 64.6% for Victoria, 17.7% for New South Wales, 6.8% for Tasmania, 6.1% for South Australia, 4.1% for Queensland and 0.7% for Western Australia (see Table 1).

According to Dairy Australia's 2020 survey data ($n=400$), which reflected the Australian dairy farmer population, 53% are over 55 years old, 24% are 45 to 54 years old, 18% are 35 to 44 years old, and $<6\%$ are under 35 years old. Additionally, 75% of farmers are men and 84% are farm owners[43]. In comparison, the biggest number of our dairy farmers (see Table 1) was in the age range of >55 (57.8%, $n=85$), followed by the age range of 45 to 54 (25.2%, $n=37$), while the smallest age category was under the age of 35 (5.5%, $n=8$). Our sample is therefore relatively older than the 2020 population of Australian dairy farmers. The proportion of female respondents in our study sample, where all participants were both workers and farm owners, was only 7.5%, which means that women are underrepresented in the sample.

In the study, the average number of dairy cows was 381, with the herd size ranging between 55 and 3500 cows. The average property size for the study sample was 395 hectares, ranging from 20 to 4500 hectares.

All participants were asked whether they were considering transitioning from dairy farming in the light of the industry's current market conditions and challenges (Question 6 in Supplementary Material). Binary Logistic Regression Analysis was conducted to obtain the regression model showing the effect of factors thought to be effective on the probability of the participants considering transitioning away from the dairy farm. The observed and predicted (using the Binary Logistic Regression model) distributions of respondents to this question by the effect of the independent variables included in the model are shown in Table 6. The first two rows under the heading "observed" in Table 6 represent the two possible outcomes, and the two columns under the heading "predicted" are for high and low probabilities, based on a cut-off point (0.5). The model was statistically significant ($\chi^2_{(4)}=83.9, p<0.01$) and explained 61.0% of the variation in the likelihood of considering transitioning away from dairy farming by the Nagelkerke R^2 coefficient and, overall, correctly classifying 84.4% of participants into the two categories (see Table 6). Of those that actually said no (100), the model predicted that 91 would be no and 9 yes: a 91% correct prediction. Of those that actually said yes (47), the model predicted that 33 would be yes and 14 no: a 70% correct prediction. The sensitivity was 70.2% and, specificity 91.0%. "Level of satisfaction with dairy farming", "openness to exploring other agricultural alternatives to dairy farming", "preference to receive financial and/or other support to remain in the industry", and "preference to receive financial and/or other support to transition into a different form of farming or business" were the significant predictors ($p<0.05$) (see Table 2). An increase in the satisfaction level reduced the likelihood of considering transitioning away from dairy farming, while openness to exploring other agricultural alternatives to dairy farming had the opposite effect. In addition, choosing to receive financial and/or other support to remain in the industry reduced the likelihood of considering transitioning away from dairy farming, while choosing to receive financial and/or other support to transition into a different form of farming or business increased this likelihood. Effects of herd size, gender and aging on transitioning away from dairy farming were not found ($p>0.05$). The coefficients of the important independent variables contributing to the model in the logistic regression equation and their significance levels are given in Table 2. Further discussion of the survey results is presented below, including qualitative interview quotes.

Satisfaction with dairy farming

Farmers were asked how satisfied they were with their current dairy farming operations, with 36.0% ($n=53$) holding a neutral stance, 19.0% ($n=28$) expressing a negative opinion, and a positive attitude towards dairy farming reported by 45.0% ($n=64$) of participants, with the majority of these respondents based in Victoria. The results indicated that the majority of the farmers (55.0%, $n=81$) did not express positive levels of satisfaction with dairy farming.

According to a Mann-Whitney U test, there was a statistically significant relationship between farmers' satisfaction levels and several key factors, including rising costs, mental health, and farmers' and their families' well-being (Table 3). Specifically, Australian dairy farmers who experienced mental health and wellbeing

	Observed		Predicted		
			In light of the industry's current market conditions and challenges, are you considering transitioning away from Dairy Farming?		Percentage Correct
			No	Yes	
Step 1	In light of the industry's current market conditions and challenges, are you considering transitioning away from Dairy Farming?	No	91	9	91.0
		Yes	14	33	70.2
	Overall Percentage				**84.4**

Table 6. The observed and predicted distribution of respondents to the question about transitioning away from dairy farming. Sensitivity = 70.2%, Specificity = 91.0%. Correct classification = 84.4%.

challenges related to their dairy farming activities (i.e. those who said yes) showed lower satisfaction levels ($U = 1825.50$, $p < 0.01$). Those who indicated that dairy farmers' challenges impacted their own and their family's wellbeing similarly reported lower satisfaction levels ($U = 1611.00$, $p < 0.01$). Additionally, rising operational costs were also significantly associated with reduced satisfaction among respondents ($U = 1951.50$, $p < 0.05$).

Qualitative feedback provided further insights, with 64 comments reflecting positive attitudes toward dairy farming, and 81 comments reflecting either neutral (53) or negative (28) perspectives (see Supplementary Table S1 and S2, Supplementary Graphic S1).

Common concerns among farmers with positive attitudes included a sense of satisfaction tempered by future uncertainties about the current situation of the dairy industry regarding rising costs, labour shortages, and mental well-being of farmers and their families. As one Victorian farmer noted: "Pretty good currently, but there is (the) uncertainty of milk price." Other farmers highlighted the significant work-life balance struggles in dairy farming, citing long hours, high operational costs, and labour shortages. Some farmers, even those who expressed optimism about the industry, revealed they were contemplating a shift away from dairy farming due to long-term concerns and changing industry dynamics.

"*Stage of life, extreme workload, and long hours. Shortage of labour and high stress.*" (VIC).

"*I [am] just having a bad time, can't find staff, I'm just over it. Too long hours not enough family time.*" (VIC).

"*Input costs, capital outlay, return on investment and red tape which pushes our costs higher.*" (TAS).

Among the farmers who expressed a positive attitude toward the current dairy farming industry, many were worried about future uncertainties and the future of their dairy products.

In a similar vein, despite trust in the industry and experiencing a good life within the dairy industry, a farmer revealed strong uncertainty about the industry and his decision to transition away from it:

"*The prices are going well, and the season is turning out alright now. My biggest problem is I am transitioning to beef.*" (VIC).

Another farmer expressed her opinion about some potential challenges related to future employment:

"*A good lifestyle, but sometimes employment is challenging, getting in other workers.*" (VIC).

One suggested that they were on the verge of making a decision for their future:

"*On the fence about whether it's worthwhile.*" (NSW).

Challenges in dairy farming

Australian dairy farmers also identified several primary challenges impacting their operations and livelihoods (see Table 7 and Supplementary Table S3). Farmers were asked whether a range of issues were primary challenges for them, and if they did consider an issue a primary challenge, how concerned they were about each one (on a scale of 1, very unconcerned, to 10, very concerned). Most farmers (89.8%, $n = 132$) viewed rising operational costs as a primary challenge to their business, and most also identified long working hours with minimal downtime (72.8%, $n = 107$), and labour shortages (70.1%, $n = 103$) as significant obstacles. In terms of severity, unpredictable weather patterns were considered a serious concern by 64.6% ($n = 95$) of farmers, with an average serious concern rating of 6.6 out of 10. Around half of the farmers (51.0%, $n = 75$) indicated that the mental health and well-being impacts were a primary challenge, with a similar number (46.3%, $n = 68$) also citing

		Level of concern										Yes
		1	2	3	4	5	6	7	8	9	10	
Rising operational costs	Count	-	-	1	3	4	12	15	35	20	42	132
	% of Total			0.7%	2.0%	2.7%	8.2%	10.2%	23.8%	13.6%	28.6%	89.8%
Long working hours and minimal downtime	Count	2	-	3	1	9	7	13	18	17	37	107
	% of Total	1.4%		2.0%	0.7%	6.1%	4.8%	8.8%	12.2%	11.6%	25.2%	72.8%
Labour shortages	Count	1	1	-	2	6	10	15	26	15	27	103
	% of Total	0.7%	0.7%		1.4%	4.1%	6.8%	10.2%	17.7%	10.2%	18.4%	70.1%
Unpredictable weather patterns	Count	-	1	1	2	20	17	29	15	5	5	95
	% of Total		0.7%	0.7%	1.4%	13.6%	11.6%	19.7%	10.2%	3.4%	3.4%	64.6%
Impacts on mental health and wellbeing	Count	-	-	3	-	7	11	17	16	7	14	75
	% of Total			2.0%		4.8%	7.5%	11.6%	10.9%	4.8%	9.5%	51.0%
Unstable milk prices	Count	-	-	1	2	6	8	17	14	6	14	68
	% of Total			0.7%	1.4%	4.1%	5.4%	11.6%	9.5%	4.1%	9.5%	46.3%
Lack of subsidies and grants	Count	-	1	2	3	7	6	15	8	3	8	53
	% of Total		0.7%	1.4%	2.0%	4.8%	4.1%	10.2%	5.4%	2.0%	5.4%	36.1%
Changing consumer demand	Count	-	2	2	5	6	13	11	9	3	1	52
	% of Total		1.4%	1.4%	3.4%	4.1%	8.8%	7.5%	6.1%	2.0%	0.7%	35.4%
Climate change uncertainty	Count	-	1	1	3	9	12	11	10	-	6	53
	% of Total		0.7%	0.7%	2.0%	6.1%	8.2%	7.5%	6.8%		4.1%	36.1%

Table 7. Frequencies and percentages of Australian dairy farmers reporting different challenges (yes), and the levels of concern expressed, from 1, very unconcerned, to 10, very concerned. This table has been evaluated only on frequency and percentage values.

unstable milk prices as a significant issue. Both challenges had high concern ratings, with an average of 7.5 out of 10. Less than half of farmers pointed to the lack of subsidies and grants (36.1%, $n=53$), shifting consumer demand (35.4%, $n=52$), and climate change uncertainty (36.1%, $n=53$) as primary challenges; with moderate to serious levels of concern, reflected in average concern levels of 7.0, 6.2 and 6.6 out of 10, respectively).

In addition, 68.7% ($n=101$) of farmers reported that the challenges they had faced as a dairy farmer had impacted their mental well-being and/or that of their family. However, most (79.6%, $n=117$) believed that the challenges had not impacted the welfare of their cattle (Supplementary Table S3). According to Mann-Whitney U test results, there was a statistically significant relationship between dairy farmers' perspectives on whether dairy farming in Australia is sustainable and the impact of the challenges they face on their and their families' mental health. Farmers who indicated that the challenges they faced as dairy farmers had an impact on their and their families' mental health (i.e., those who answered yes) had less belief in the sustainability of dairy farming ($U=1855.00$, $p<0.05$) (Supplementary Table S4). However, there was no statistically significant relationship between dairy farmers' outlook on whether dairy farming in Australia was sustainable and whether the challenges they faced as dairy farmers affected the welfare of their cattle ($p>0.05$).

Based on the results of the qualitative analysis; the views that dairy farming is not sustainable because it affects their mental health and their families were mostly related to the age of the farmer and the years spent in this profession.

"Yes, it's been a long haul for years, but the risk of collapse is quite stressful." (VIC).

"My father now is a man in his late 80s and the farm has consumed his entire life." (SA).

"It's taking a toll on me at the moment. With my age, I can't do as much as I used to and just trying to cope with the difficulties of the farm can be hard." (QLD).

Concerns about the impact on the mental health of farmers and their families, such as workload and droughts and floods, were as follows:

"*Working 7 days a week take a toll on the body and mind.*" (VIC).

"*Absolutely, all been through pretty dark places at times. Particularly during droughts and floods. Some people have taken their lives, turned to booze.*" (VIC).

"*Had some very dark days, wondering where the end is, all influenced by seasonal conditions and milk prices.*" (NSW).

"*The biggest issue, we live in West Gippsland, and the biggest issue is wet winters. Three months in the wintertime when it is very stressful. We are prone to water logging. This gets very stressful, where to put the cows, how to save your pasture.*" (VIC).

"*When you have prolonged drought or severe flooding, anything that can impact your animals or business is very mentally demanding. It's hard in the household as you spend more time feeding stock and repairing things. It's not an easy industry.*" (NSW).

Financial strains appeared to be particularly problematic and a significant source of stress affecting their and their families' mental health, given the challenges associated with dairy farming.

"*It's definitely stressful, the financial stress is the most influential.*" (VIC).

"*At times yes, with farming if there's a problem (it) can impact the whole family. In terms of what can and can't be done. Farm is the main source of income, if we're having financial difficulties, this can become widespread in the family.*" (VIC).

"*It has a few times, some of my family member have to take medication but no major incidence. The one-dollar-a-litre (milk) campaign was a particular hardship for producers and held down the value of all products, not just milk.*" (NSW).

"*Financial stress and long hours and not spending enough time with the family and certain times of the years.*" (VIC).

Some farmers stated that the challenges experienced in dairy farming affected the mental health of both them and their families and that these situations affected family relationships and needed medical support to overcome them.

"*It has, marriage troubles because of financial stress.*" (NSW).

"*I have been through a divorce which affected my family.*" (NSW).

"*I am on medication all the time, and my mental health has declined and will be for the rest of my life. I got my son training in the industry due to an accident I suffered and didn't get any payment or support.*" (VIC).

"*It's definitely something, I am medicated for stress and my husband probably should be as well, farmers believe that they have to keep getting along with what they do, so any activities that encourage men to get off the farm and have time out and talk should be funded and promoted, we definitely need more help.*" (NSW).

"*I don't mother (my children) how I want to mother because of my stress; we are financially stressed all the time, and it's constant. The dairy farm breaks each week with equipment, and it's constantly being fixed. Taken a huge toll on my mental welfare and my husband's. He no longer smiles, and he's in his thirties but has aged significantly.*" (VIC).

Although they acknowledged the impact of the challenges on their and their family's mental health, some farmers stated that it was part of their job and were trying to cope:

"*It can grind you down, mentally I am fine, but I have to exercise and ensure I have an hour every day to refresh.*" (VIC).

"*No, we're a long-term dairy farming family so we understand the type of industry that we operate in. We're focused on long-term outputs rather than short term gains and losses.*" (VIC).

"*It's challenging, also has its advantages. Look at the glass half full then will be way in front.*" (NSW).

Considering the challenges faced as a dairy farmer, financial challenges appeared to be a factor affecting the welfare of their cattle.

"*Struggle to buy enough feed at times.*" (NSW).

"*They were standing in water due to the flooding and were unable to be fed for a few days.*" (VIC).

"*Mass die-off and disease outbreaks like salmonella, dealing with cold and wet conditions. Sore feet.*" (VIC).

"*Occasionally, me being a farmer I want to be able to feed and look after my cattle to the maximum. However, when your penny pinching some things have to miss out.*" (NSW).

Despite the challenges in dairy farming, animals were always a priority for farmers, who stated that the welfare of their animals was not adversely affected.

"*No, because I make sure that I look after the animals and do all I can to get them through difficult times and keep them healthy. Number one priority.*" (VIC).

"*Always come first in our management, whether it's wet weather or out in the cold, they come first, feed the animal, feed the pasture, then feed us, that's the order.*" (VIC).

"*No, the challenges of dairy farming are more personal to me. We look after the cows and make them the number one priority.*" (VIC).

"*Dairy farming is all about looking after our animals, so it's our top priority on our farm. Tractors can be broken down, but cows will always be looked after.*" (VIC).

Farmers who care about the welfare of their animals stated that despite the challenges in dairy farming, the welfare of their animals was not negatively affected.

"*Our cattle are important to us, we've reared them, we work with them every day. We get attached to them like a pet dog. Animal welfare is important. Have good facilities to feed them as well.*" (TAS).

"*Nope. Impacts on the cattle would impact our mental health and our profitability. The welfare of our animals is the priority.*" (SA).

"*The welfare of the stock comes first. We look after them better because we have done well. Give them whatever they need.*" (QLD).

"*The welfare of the cattle is number one always. It's our priority. There is no expense spared on the vet and no expense spared on the feed.*" (VIC).

Hardships from external factors, including costs, drought and floods

Only 56.5% ($n=83$) of respondents answered the question about external factors causing hardship (Question 4 in Supplementary Material). The number of people who said they were experiencing such hardship was substantially more than those who stated they were not. The most common hardship, those who answered yes, was caused by rising costs (39.5%, $n=58$), then drought (14.3%, $n=21$) and floods (12.2%, $n=18$).

Financial strain proved to be particularly problematic, given the unstable pricing of milk, creating a significant discrepancy that challenged the sustainability of their operations.

"*Just with their ongoing costs, just keep going up. Everything is going up, but milk isn't. (after reflection) Milk has gone up but can't make a living with increased costs. Fodder, electricity, etc. all going up. We are treading water currently*." (VIC).

Financial constraints appeared to be impacting optimal operational efficiency across diverse Australian regions. The inability to complete essential tasks was forcing the trimming of vital production processes, further exacerbating challenges in the agricultural sector.

"*It's simply not running as efficiently as it could because you cannot afford to complete the tasks that you would like to*." (SA).

"*Just having to cut back on core essentials to get through, if it continues, it will impact long-term productivity.*" (VIC).

"*Just generally having to deal with the rising costs and having to cut out certain processes*." (SA).

"*It impacts our ability to make a profit and subsequently pay off debt and pay workers*." (VIC).

Some of the dairy farmers pointed to the issue of insufficient profit, which was hindering their ability to reinvest in infrastructure and upgrades.

"*Not enough profit to put back into infrastructure and upgrades.*" (VIC).

"*Reduction in the cash flow on the property.*" (SA).

"*Just basically the cost of running (the farm) has gone up, and the income has gone down. Thus, labour and infrastructure are harder to secure*." (WA).

"*Just capital improvement is lacking. Costs are so high you can't afford to invest in making the job easier, as with labour shortages*." (VIC).

"*Lack of reinvestment and ongoing additional costs affecting cash flow*." (NSW).

The limited profitability was impeding the capacity to reinvest in essential infrastructure and implement necessary upgrades, posing challenges to improvements and modernisation.

"*Because of the extra costs of inputs, we have less money for property development*." (NSW).

"*With (lack of) profit for my property, restricting what I can do and any improvements I can make*." (VIC).

"*Impacted the profitability, less capital to put back in at the end of the month*." (NSW).

Financial and operational hardship were also pointed out in maintaining the workers' salaries.

"*Carry more workload because you've got to keep the wage costs down a bit*." (VIC).

"*Rising costs with our system are labour costs and (there is a) labour shortage. The structure with the amount we need to pay for labour has doubled in the last three years. There are also general running costs and fertiliser costs that have risen significantly, and milk costs have dropped. When looking at the budget, it doesn't look good.*" (VIC).

The stress of exceeding the budgeted operational costs was also causing a significant hardship for many.

"*We just have to make sure that we are not exceeding our power, water and feed costs. Just got to keep an eye on that budget.*" (VIC).

"*Had to prioritise where we spend our allocated funds. (As a) consequence things might require large amounts of capital to get it back up to scratch. Not sustainable*." (VIC).

Issues with operational cost were noted in more concrete examples, such as those mainly attributed to the rising cost of electricity, diesel fuel, irrigation and fertilisers.

"*Primarily with electrical and diesel fuel and fertiliser costs. The added costs have taken away from our bottom line, and with specific regard to fertiliser, in the past 12 months, we had to reduce our fertiliser input.*" (VIC).

"*They are affecting the business because the rising cost of power, fertiliser and operation costs are draining us with taxes imposed by the government and is impacting our business with a cash flow problem. Every time a new idea comes about, it's a cost for the farmer.*" (VIC).

"*Electricity costs, water costs, how many cows we are able to milk, managing farm upgrades and having to put things on hold.*" (VIC).

"*Milk production and rising electricity costs, our biggest problem is water security.*" (NSW).

A substantial reduction of the above-mentioned costs would minimise the overall spending and hardship:

"*Probably spending a bit less on fertiliser and that sort of thing.*" (VIC).

"*Have to spend more money to irrigate, and the costs keep compounding.*" (TAS).

Other issues were different challenges in agriculture production, including increased grain and hay prices, higher labour demands, drought, and a drastic shift in precipitation. Coping with both wet and dry conditions add complexity, emphasising the need for adaptive strategies in the face of changing weather patterns.

"*Grain prices and hay prices have gone up… Probably the main difficulty has been going from 90 inches (of rain) to 18 inches in a year. Our average is 45 inches, so we have had to cope with wet and dry.*" (NSW).

Securing an adequate supply of nutritionally balanced feed for animals, impacted by factors such as drought or financial constraints, was identified as a significant challenge. This highlights the critical need to address the animals' nutritional requirements, emphasising the severity of the problem and its potential impact on their health and well-being.

"*No feed for the animals, both with high costs and drought affecting pasture.*" (NSW).

"*We have a lot less silage and hay on the property at the moment due to drought. Securing feed is going to be a priority and is going to be very expensive. Rising costs as well, any purchases are expensive.*" (TAS).

"*Not enough feed, not enough conserved feed for next winter. There is a winter feed deficit now. It will have a longer-term impact.*" (NSW).

"*There was a rise in input costs due to no paddock feed from flooding.*" (QLD).

Not only the availability but the quality of the feed was of concern to the farmers, especially as the quality was affecting the well-being of their cows.

"*Fodder was poor quality, affected the milking cow's ability to produce.*" (VIC).

"*There has been a downgrade in the quality of feed that has affected production.*" (NSW).

This was mixed with worry about the constantly rising feed prices. This highlights the need for comprehensive solutions, such as price caps on feed and improved feed management practices, incorporating a range of feed sources and cheaper feeding methods, such as grazing, use of legumes etc. Addressing these challenges is crucial for the overall health, productivity and sustainability of dairy farming.

The severe impact of bushfires and other natural calamities is another huge challenge for Australian dairy farmers. Some of them emphasised a reliance on government grants for recovery, but they again stated that another critical challenge was a labour shortage, impeding the swift execution of necessary tasks in the aftermath of such adversities.

"*The bushfire took the whole farm, most of the time the Government comes up with grants but it's a matter of manpower, we can't get things done quickly enough when these hardships affect the property with the lack of workers.*" (VIC).

Other farmers raised the same concerns:

"*90% of our property was under water for a big portion of last year, it was the stress of getting through it and dealing with cow health concerns.*" (VIC).

Due to the drought, there was an insufficient supply of the water most needed for the animals' water and feed.

"*Not enough water, not enough feed.*" (NSW).

"*Very dry conditions, lack of grown feed is the main impact.*" (VIC).

"*At the moment it's very difficult because of the drought. Having to buy hay is enormously expensive.*" (QLD).

Hardship was not only caused by everyday obstacles and challenges on the operational level but also on the psychological level, including issues related to mental health and well-being:

"*Mental health and wellbeing with our workers, rising costs here have affected the ongoing budget of the farm*" (VIC).

"*Loss of production, animal health and mental health from the financial impacts.*" (VIC).

"*Financially, and a mental requirement – the pressure they put people under to make sure they comply with things that are unreasonable, especially the time frames.*" (SA).

"*Some dairy farmers express their desire to look for other business avenues based on their regularly experienced difficulties.*" (SA).

"*We are thinking about getting out since what's the point of working 7 days a week and going bankrupt and being stressed all the time.*" (VIC).

One farmer attempted to explain the root cause of their hardship, explaining it as a cash flow difficulty.

"*Basically, it's a cash flow situation. We make a lot of money but spend a lot of money to keep running.*" (NSW).

Outlook on the sustainability of dairy farming and transitioning away from dairy farming in Australia

More than half of the farmers (62.5%, $n=92$) said that they were optimistic about the sustainability of dairy farming; however, some did not share this optimism, with 25.2% ($n=37$) being unsure and 12.2% ($n=18$) being not optimistic. Additionally, according to the Mann-Whitney U test results, there was a statistically

significant relationship between dairy farmers' outlook on whether dairy farming in Australia is sustainable or not and whether they would consider transitioning away from dairy farming. Farmers considering moving away from dairy farming (i.e. those who answered yes) had less belief in the sustainability of dairy farming ($U = 1576.00, p < 0.01$) (Supplementary Table S4).

About one-third of dairy farmers said they would consider transitioning away from dairy farming (32.0%, $n = 47$), confirming their concern about the future. The most commonly cited reasons were ageing and health issues (15.6%, $n = 23$) and labour shortages (13.6%, $n = 20$). Of less importance were input costs (12.2%, $n = 18$), declining profitability (8.2%, $n = 12$) and retiring (7.5%, $n = 11$) (see Table 8).

Farmers' qualitative comments revealed that some were contemplating transitions away from traditional dairy farming, driven by a coming together of factors shaping the agricultural landscape. One prominent factor was the economic volatility associated with dairy production, marked by fluctuating milk prices and input costs. Not many were thinking of change at the present time but were considering it more as an action in the long term:

"*Not immediately, because we have a vertically integrated business.*" (VIC).

"*Not immediately, but maybe in about 10 years when I start getting old. Will go beef.*" (VIC).

Sometimes, transition was seen as an inappropriate action, not continuing the family business tradition:

"*Could only transition into beef but it (beef market) has crashed. Also 4th generation dairy farmer so will remain.*" (NSW).

Thus, there was a cautious approach towards transitioning to alternative livestock industries, such as beef or sheep farming. Concerns about market volatility, potential losses and the overall sustainability of these alternatives were mentioned as deterrents.

"*Because currently milk prices are really strong, and that allows us to keep farming through adverse conditions. Plus, the alternatives are less favourable*, e.g., *beef would be a significant downgrade in profitability.*" (NSW).

Many respondents emphasised the stability and profitability of dairy farming. The consistent returns and strong milk prices contributed to a sense of financial security, making dairy farming an attractive option.

"*It's a more a stable return than any other farm type.*" (VIC).

"*Milk prices are really good, probably be the best time to be in the industry. Highly profitable at the moment and has a good outlook.*"

Primary reasons	Group	Frequency	Percent (%)
Ageing or health issues	No	124	84.4
	Yes	23	15.6
	Total	**147**	**100.0**
Labour shortages	No	127	86.4
	Yes	20	13.6
	Total	**147**	**100.0**
Input costs	No	129	87.8
	Yes	18	12.2
	Total	**147**	**100.0**
Declining profitability	No	135	91.8
	Yes	12	8.2
	Total	**147**	**100.0**
Retiring	No	136	92.5
	Yes	11	7.5
	Total	**147**	**100.0**
Market volatility	No	139	94.6
	Yes	8	5.4
	Total	**147**	**100.0**
Improved profitability of alternative practice	No	140	95.2
	Yes	7	4.8
	Total	**147**	**100.0**
Climate concerns	No	141	95.9
	Yes	6	4.1
	Total	**147**	**100.0**
Animal welfare considerations	No	142	96.6
	Yes	5	3.4
	Total	**147**	**100.0**
Other	No	119	81.0
	Yes	28	19.0
	Total	**147**	**100.0**

Table 8. Primary reasons influencing the decision to consider transitioning away from dairy farming.

"*We're in a pretty good area, rainfall is all good. The farm is set up well and things are going well.*" (VIC).

"*I'm happy with the way things are going.*" (VIC).

The family tradition was also a prominent factor for the participating dairy farmers. Numerous farmers mentioned that they come from a long line of dairy farmers and the tradition was deeply ingrained in their family history. This sense of heritage and continuity played a significant role in their decision to remain in the dairy industry.

"*It's profitable at the moment, and we are third generation.*" (VIC).

"*The area that we are in is fortunate for rainfall, so it doesn't compete with other industries, and its 6 generations of dairy farming so it's in us.*" (VIC).

Family ties played a crucial role, with several respondents mentioning that their children or other family members were involved in the dairy farm. Succession planning and the desire to pass the farm to the next generation contributed to their decision to remain in dairy farming.

"*We've got three sons on the farm so it's a family property.*" (VIC).

"*I have a young family that's taking a big interest in getting into the industry.*" (NSW).

"*We like dairy farming, and it works for us, and we are also long-term generational farmers, my daughter just started a dairy farm next door.*" (VIC).

Ownership of land was a key consideration. Some respondents believed that dairy farming is the best way to own and pay off land, making it a strategic financial investment. The idea of leveraging dairy farming for long-term financial security was prevalent.

"*Enjoy what we do and it's the best use of our land.*" (VIC).

"*We are young and want to have a proper crack at the dairy industry and get some good growth, with current land prices, dairy farming is the best way to own the land and pay it off.*" (VIC).

The respondents often highlighted their familiarity and expertise in dairy farming. Having spent several decades in the industry, they felt comfortable with the practices, challenges and day-to-day operations. This expertise served as a barrier to transitioning to less familiar agricultural pursuits.

"*Because I've been doing it for forty-odd years, and I'm used to it.*" (QLD).

Some respondents mentioned that they had diversified their operations by incorporating other enterprises such as beef farming, horticulture or broadacre farming. Diversification was seen as a strategy to mitigate risks and maintain overall stability.

"*I am not going to fully transition but go into diversifying the business.*" (SA).

"*We have always been diversified in our products. For example, we have dairy and beef and used to have sheep. Until recently, each of these commodities has had ups and downs. Sheep and beef are in a downturn, so dairy is keeping us up until the financial year for a reasonable price. We want to keep diversification in these areas.*" (VIC).

Many respondents express a genuine love for the dairy industry. This emotional connection, combined with a belief in the future of dairy farming, reinforced their commitment to staying in the business.

"*I quite enjoy working in the industry, although our industry has a distinct lack of younger farmers.*" (VIC).

"*I have always done dairy farming and enjoy it. We can still make a profit and do okay even with rising costs. There is a future in this.*" (VIC).

Some respondents acknowledged the challenges associated with transitioning to other industries. These challenges included financial constraints, uncertainties about profitability and the lack of suitable alternatives in their specific geographic area.

"*We can't get the same return per hectare doing anything else.*" (VIC).

"*Well because the prices are quite good that keeps me in the industry.*" (VIC).

"*I can't see any other rural industry in this area that would be better.*" (NSW).

Despite the challenges, positive outlooks were often tied to current profitability, market conditions and, for many, the belief that dairy farming would remain a viable and profitable venture worth continuing:

"*Because I am investing in my infrastructure, my existing equipment will be replaced next year. So, we are still investing in dairy operations.*" (VIC).

"*Because I suppose I like farming to start with and at the moment we are making a profit despite the challenges. We just get on with it.*" (VIC).

Considering agricultural alternatives to dairy farming

More than half of respondents (54.4%, $n=80$) said that they were open to exploring agricultural alternatives to dairy farming. A minority of dairy farmers had already integrated dairy farming with other agricultural alternative enterprises, such as horticulture, rather than any other livestock such as beef (6.8%, $n=10$). However, many (63.9%, $n=94$) were not open to transitioning from dairy farming, even if government support and assistance were provided. The remaining farmers (36.1%, $n=53$) were open to transitioning away from dairy farming into a horticultural or other business venture if government support and assistance were provided. Support or incentives from the government were not seen as a major way of driving a transition away from dairy farming. The majority (80.3%, $n=118$) of respondents stated that they would not be encouraged to transition away from dairy farming by government support or initiatives, and the remaining farmers (19.7%, $n=29$) said they would be. A minority of farmers (6.1%, $n=9$) said that grants for infrastructure, land development and technology could be very helpful. Almost half the farmers (45.6%, $n=67$) said that they had other concerns or hesitations about transitioning to a new agricultural model or business.

Dairy farmers' qualitative comments revealed that they were open to exploring any other agricultural alternatives to dairy farming. Many dairy farmers were already exploring alternatives. Among the prominent alternatives were cropping and beef farming.

"*More into cropping and beef cattle.*" (VIC).

"*I'm open to it, if someone came to me with an idea I could be convinced.*" (SA).

"We are open to the idea but are still determining the model we would look into. I know there is a rewilding of blue gums around me, but I am unsure if I would go into that." (VIC).

"Beef cattle, I am venturing into that because younger people will have to taking dairying up." (NSW).

"We're always open to other agricultural alternatives. The most likely would be dairy/beef in a mix farmed operation." (VIC).

The fact that some dairy farmers were open to this idea allowed them to implement other agricultural alternatives in addition to the dairy farming they were already doing.

"We are doing some cropping as well, with grain and pulses for fodder." (VIC).

"Currently we are diversifying into biodiversity stewardship and credits." (NSW).

"We run a mixed enterprise. We grow 4000 tonnes of potato. We contract and run beef. We have already diversified." (TAS).

"We look at everything anyway (and) have a mix of dairy and beef cattle. Anything that seems to be able to make you more money for not that much extra work will do. Labour is the main problem." (VIC).

Dairy farmers acknowledged the challenges of transitioning to other agricultural alternatives. These challenges included unsuitable climatic conditions and terrain, or the lack of suitable alternatives in certain geographical areas.

"Open to it but on my farm it would not be viable." (SA).

"Open to, I guess, but we are not really in a cropping suited area." (VIC).

"Horticulture would be interesting because we do have water on the property, but I don't think our soils and temperature would be conducive to it." (VIC).

"I'm on reasonably steep country. Can't crop it, only grazing. Some people do snow peas but not for me. Not at my age. So would (consider) agistment for other dairy farmers in 4- or 5-years' time. Probably will help others as a turnout block. A little beef as well probably." (VIC).

Although some dairy farmers were open to the idea of exploring other agricultural alternatives, they thought that it was not possible to do this. Some thought that dairy farming was better despite trying alternatives, and some saw it more as a possibility in the long term.

"Yes, I am open but unlikely to change." (NSW).

"Horses, part of retirement plan." (VIC).

"We've explored cropping and we've changed previously but pretty happy with dairy." (TAS).

"Beef not immediately but maybe in about 10 years when I start getting old. Will go beef." (VIC).

Although a minority of farmers were open to other agricultural alternatives, they were reluctant to do so because they believed that it would not be profitable compared to dairy farming or that a full transition would not be possible.

"Always looking over the fence." (TAS).

"Who would pay me for rewilding? Yes, I am open." (VIC).

"Open to but haven't seen anything that would provide the same sort of income." (VIC).

"If I could see that it was profitable and sustainable to our business." (VIC).

"Always looking at other things, I wouldn't fully transition but could diversify a little bit. Chasing rainbows is dangerous." (NSW).

Some of the farmers were open to transitioning away from dairy farming and exploring the possibilities of horticulture or other business ventures if support and assistance such as learning tools, infrastructure, appropriate loans or grants, subsidies or incentives were provided by the government. Additionally, profitability was one of the prominent factors.

"Just an easier lifestyle, dairy farming is pretty hard yards." (VIC).

"Probably need some help with infrastructure." (NSW).

"Training in marketing and providing learning tools on how to grow those new products." (VIC).

"Something that has a good financial incentive is always appealing." (VIC).

"I guess if you were transitioning into something I guess that would support you for changing machinery and that sort of thing." (VIC).

Even if government support and assistance were provided to transitioning away from dairy farming and explore the possibilities of horticulture or other business ventures, market guarantee, profitability and sustainability were decisive for farmers' transition.

"Depends on if it was very profitable and we could make the same amount of money. Don't know what it could be, would have to be a big carrot." (VIC).

"It would be a guarantee of success or having a market." (VIC).

"It would have to be 100% compensation for us to switch to another industry." (SA).

"It would need to be support that will ensure my profitability and pay the bank back. No point if it's unsustainable." (VIC).

Transitioning away from dairy farming and exploring the possibilities of horticulture or other business ventures depended on the belief that government support and assistance would be sufficient to achieve this action.

"Governments worry me because they always have agendas." (SA).

"If they were to cover the cost to switch to cropping, I would be very interested to hear that, but I won't think the government will do that for us." (NSW).

"Other countries provide about 50% of the set-up cost. The government could provide more security and support to new businesses." (NSW).

Additional resources for making an informed decision about the future of the farm

When it comes to the future of their dairy farms, only a few (15.0%, $n=22$) felt that they did not need any additional resources to make an informed decision. This indicates that farmers are in need of support to handle the challenges they face. The most commonly cited resources that respondents felt were required to be able to make decisions about the future of the farm were financial and technical advice (respectively 22.4%, $n=33$; 23.1%, $n=34$, finding this very important). Direct government support and, to a lesser extent, sponsored time with a farm management or transition agency were considered quite important, and a significant portion of the respondents reported that these resources should be provided by the government (overall, this was important for 72.8%, $n=107$).

A significant difference was observed in the Kruskal-Wallis test, which was conducted to see whether there was a difference between herds of different size and the need for additional financial resources for making an informed decision about the future of their farm ($\chi 2_{(4)} = 14.649, p < 0.05$). As a result of multiple comparisons made with the Mann-Whitney U test, it was determined that this difference was between the > 700 cows (which had the greatest need) and the 151–300 and 501–700 cow groups (which had less need) (Table 4).

Financial, informational, political, and technical assistance were at the forefront of resources that could be important for dairy farmers to make informed decisions about the future of their farms.

"It would be handy to have some assistance with the new technologies, apps and websites that can be very useful tools, there's just so much technology out there but old farmers aren't being shown how to do it." (VIC).

"Political resources. Politicians at the stroke of a pen can massively impact what we can do. Knowing what they're planning is massively important." (VIC).

"I guess there'd be soil reports and that sort of thing would be helpful especially if you are going into cropping. Analysis of soils and that sort of thing." (VIC).

"Probably agronomy, agronomists, and information from them, I currently use a private source." (SA).

"I think workshops—industry workshops. Keeping up to date with software through online publications." (NSW).

"I suppose better forecasts for milk prices, and further forward pricing. Not very good now, very hard to budget if you don't know the prices. Maybe that's on the milk companies though." (VIC).

"Long-term industry plans and gaining the confidence to invest." (VIC).

For dairy farmers to make informed decisions about the future of their farms, it was important that the resources provided by the state were consistent and sustainable.

"Guaranteed markets maybe." (VIC).

"Would be nice if all states had the same rules. We need Australia-wide consistency with rules. I live on the border, and it is so different on the border. (e.g.) My feed comes from a different state, and they had a public holiday." (VIC).

"No - it's mainly the future of the farm that is up to the council, it is up to the way they allocate land. We are in a high-density area. Rezoning land could be an issue in the next 20 years." (VIC).

"It is more about the guarantees that things will not be taken away, like remaining water licences. Knowing that there will not be change. One of our biggest problems is energy costs." (SA).

Dairy farmers' ability to make informed decisions about the future of their farms also depended on faith in the provision of additional resources by the government.

"If the government wants dairy farmers, they are going to have to help them out. We get nothing." (NSW).

"Government assistance can be important but only when it is done well. And not just for show." (VIC).

"Power policy is bad in our area; government isn't helping us deal with monopolies and exploitation. Incentivizing diesel power production on farms is not helping us with service and dealing with monopolies. Not even letting us feedback power into the grid is a design flaw." (NSW).

Discussion

Pressures on dairy farmers

Our study suggests that dairy farmers can be exposed to various forms of distress and stressors. As found elsewhere, mentally and physically challenging working and living conditions, including a high workload and time pressure, long working hours, limited rest and holiday opportunities, machine malfunctions, climate change, and possible diseases are all factors affecting dairy farmers[33]. As a result, they may experience higher levels of distress compared to those in other occupations. The broad array of difficulties faced by Australian dairy farmers differentiates them from other professional groups in many aspects.

Their wellbeing is a critical factor that is likely to determine the future trajectory of the dairy farming sector. A recent study in Australia conducted by the National Rural Health Alliance (NRHA) revealed that the burden of hardship often leads to distressing outcomes. The alarming findings of an Australian-first study spanning a decade of national coronial data indicates that a farmer dies by suicide every 10 days[50]. The study reveals a staggering 60% higher suicide rate among farmers compared to non-farmers, with key risk factors identified as drought, relationship breakdown, underlying depression and easy access to guns. The most concerning aspect is the reluctance of farmers, as noted by the NRHA, to seek help from professionals, underscoring the urgent need for targeted mental health support within the farming community[50]. Our study also reveals that farmers who state that their mental health is affected by the stressful conditions of dairy farming need support, in line with the literature data stated above.

The complexity of declining profit projected because of climate change impacts[51] makes the situation even more challenging. Unstable milk prices in recent years have affected production, investment volume and trading positions in the dairy sector in many countries, including Australia[52] and the European Union[53], as well as in Iran[54], India[55], and Lebanon[56]. This has increased risk, especially for low-tech producers, making small businesses in this sector unprofitable[52]. Such reasons, combined with epidemics, changing consumer demand, high resource prices and climate change, are forcing dairy farmers to switch to alternative enterprises[15,57]. The

determination that disasters such as droughts and floods caused by climate change have an impact on the mental health of farmers and their families, reveals that uncertainties caused by climate change create pressure on farmers (36.1%, $n=53$) (Table 7). The qualitative and quantitative data supported each other. There are also concerns that securing feed will be a priority due to droughts and floods and that this situation will create financial pressure. Therefore, the mental and financial pressure on dairy farmers created by climate change are important and action needs to be considered.

The number of dairy farms in Western countries has been decreasing in recent years, at the same time as their individual acreage and the size of the herds has been increasing. In Australia, the number of registered dairy farms has been consistently decreasing, a falling from 6770 in 2012 to 4420 in 2022[58]. The number of dairy farms in the European Union has decreased by 62% since 2005, with no corresponding decrease in the number of dairy cows. This indicates that dairy farms are disappearing, and the number of dairy cows is increasing in the remaining farms[59]. This puts additional pressure and responsibilities on the farmers who continue in this business. As determined in our study, as the herd size increases, financial pressures increase (Table 4), as it brings with it the pressures created by an excessive workload, long working hours and labour shortages.

Economic viability

For farmers to be economically competitive in the near future, farms with increasing herd sizes need to cope with an increasingly complex business environment and develop operational and strategic management skills to do so. Long-term planning is therefore very important, and the ways to support this are by using future forecasting methods and identifying needs[60]. Therefore, it is important to focus more on the needs and expectations of farmers in providing the necessary technical and support structures[61]. Our study found that farmers choosing to receive financial and/or other support to remain in the industry reduced the likelihood of considering transitioning away from dairy farming ($p<0.01$) (see Table 2). A significant proportion of them (58.5%, $n=86$) wanted to receive financial and/or other support to remain in the sector, and this finding was supported by qualitative data. We also determined that as herd size increased above 700, the need for additional financial resources to make an informed decision about the future of the farms increased ($p=0.05$) (Table 4). According to Zweigbaum et al. (1989), feed intake, labour, interest, and energy consumption all increase for large herds[62]. In our study, it is clear that as herd size increases, financial needs and expectations increase, and therefore additional financial resources are an important requirement. Also, given the expected negative impacts of challenges like climate change on the dairy industry[34], such an expansive approach might prove to be only a temporary measure. The challenges from plant-based milk alternatives did not feature strongly in farmers' responses, despite there being a general recognition of the need for more sustainable food choices. When it comes to the role of government, however, an important policy decision would be whether to support dairy farmers or their rivals producing alternative milks.

Trends towards large dairy farms have gradually increased over the past few decades, while also ensuring that dairy farmers remain competitive in the evolving global market. This intensification in the dairy production system (fewer dairy farms and a larger herd size per farm) is aimed at increasing total milk production and improving the efficiency of using feed, labour and land inputs[63]. If these trends continue, global dairy production is expected to increase by approximately 22% over the next decade[64]. A significant part of this increase in milk production (80%) is expected to be from developing countries, while the production from developed countries is expected to decrease from 48 to 43% in the period from 2017 to 2027. The low sales prices of dairy products will probably limit the increase in supply, especially in developed countries[3]. Even in the current situation, there is an increase in production costs while the market price of milk decreases due to overproduction and retailer control of supply chains[65]. High costs are an effective factor in the exit planning of farms[3]. In our study, many farmers were concerned about rising operational costs (89.8%, $n=132$), and with those concerned about rising costs in their dairy farming operations showed lower levels of job satisfaction ($p<0.05$) (see Tables 3 and 7 and Supplementary Table S1). For this reason, 12.2% ($n=18$) were not optimistic about the sustainability of dairy farming, and 25.2% ($n=37$) were unsure. In addition, about one-third of them were considering transitioning away from dairy farming (32%, $n=47$), and the fact that labour shortages were among the most frequently stated reasons (13.6%, $n=20$) (see Table 8) suggests that the current conditions in dairy farming make the lives of producers and their viability in this sector difficult.

Transitioning to other enterprises

The many challenges associated with dairy farming are forcing some dairy farmers to switch to different production systems such as horticulture. This requires a better understanding of potential transition routes and farmer demands in this process to support smooth transitions. Economic difficulties and the feeling of compassion for animals are powerful incentives to give up animal husbandry and switch to another agricultural alternative such as horticulture[66]. Despite this, in our study, farmers indicated that animal welfare did not suffer as a result of these challenges. The need for change is undeniable, as it is not sustainable to achieve high productivity with animal husbandry under the current conditions.

Better integration of crop and livestock systems is recommended to achieve sustainability and high efficiency in economic, ecological and energetic terms[67]. In our study, dairy farmers who believed that dairy farming was not sustainable in Australia were considering transitioning away from dairy farming ($p<0.01$) and are open to exploring any other agricultural alternatives ($p<0.05$) (Supplementary Table S4). In addition, the study determined that openness to exploring any other agricultural alternatives to dairy farming increased the likelihood of considering transitioning away from dairy farming ($p<0.05$) (see Table 2), and more than half of farmers were open to exploring any other agricultural alternatives to dairy farming (54.4%, $n=80$). A preference for financial and/or other support to transition into a different form of farming or business also increased the likelihood of considering transitioning away from dairy farming ($p<0.05$) (see Table 2), with about one-fifth

of farmers being open to transitioning away from dairy farming and exploring the possibilities of horticulture or other business ventures if support and assistance were provided by the government (19.7%, $n=29$). It is likely that well-being and profitability in dairy farming can be a decisive criterion in deciding whether to move away from the dairy sector. A minority of dairy farmers had already integrated dairy farming with any other agricultural alternatives, such as horticulture (6.8%, $n=10$). Therefore, to ensure a smooth transition, there is a need to better understand what type and the extent of support and assistance needed by dairy farmers who are open to transition.

Dairy farmers' satisfaction with their work

Satisfaction with farm work significantly and greatly impacts satisfaction generally and quality of life. Farm-level factors such as working hours, age of assets, farm finances, and social participation significantly influence farmers' satisfaction with farming[68]. Long working hours and low financial returns create a difficult situation for farmers, which also reduces the level of job satisfaction. This situation particularly concerns the younger generation because of the impact of long working hours on their social lives. In addition, family life is under extreme pressure due to the workload and long working hours[69]. Farms that require a large workforce with paid employees have a more intense working environment and a high mental workload. There is a correlation between high working hours, less free time, and lower satisfaction levels. The average working time for farmers who are satisfied with their working conditions is almost 1.5 h shorter than for dissatisfied farmers[70]. Considering that, the satisfaction level of farmers could make a great contribution to the sustainability of livestock farming[71]. In our study, it was determined that the degree of satisfaction is an important parameter for the continuation of dairy farming (43.5% positive, 19% negative, 36% neutral) (see Supplementary Table S1), with an increase in satisfaction reducing the possibility of considering transitioning away from dairy farming ($p<0.01$) (see Table 2, Supplementary Graphic S1). In addition, our qualitative data showed that farmers believed that they do not spend enough time with their families due to their busy working hours, and that their family dynamics were badly affected, revealing the challenging nature of dairy farming and the importance of work-life balance. Participants' responses indicated that regional differences in satisfaction may be influenced by factors such as climate, labour shortages, economic conditions, inadequate information about government policies, grants and financing, and issues with local agricultural practices and weather conditions (see Tables 7 and 8). Therefore, the complexity of farmers' perspectives is important as it demonstrates the need for specific approaches to address changing concerns and challenges in different regions. It also reveals the need for follow-up research.

In parallel with these developments, the concept of the farmer's well-being, which reveals the individual's satisfaction with different aspects of their life, has begun to attract more attention in dairy farming. This may affect farmers' perspectives on moving away from or continuing in dairy farming[32]. The concerns for farmers' welfare are particularly important in light of the prevailing trend of an aging population in the agricultural sector. The issue is also intensified by the documented low income reported in rural areas[72]. Since the risk of abandonment of farms[73] poses substantial obstacles and restrictions for young or new farmers seeking entry into the sector[74], farmers' satisfaction levels appear to be an important element of welfare in dairy farming. In a study investigating the relationship between farmer welfare and their intention to leave the farm, although farmers' satisfaction with their working situation was generally high, many complained about the high workload on weekends. The wellbeing of farmers who are determined to continue dairy farming is generally higher than the welfare of those who are considering quitting[32]. Sabillon et al. (2022) recommend that social metrics on farmers' well-being should be included in agricultural monitoring systems to ensure social sustainability[38]. Our study identified that the impact of dairy farming created a primary challenge to the mental health and well-being of Australian dairy farmers (51.0%, $n=75$); with those experiencing mental health and well-being issues reporting less satisfaction ($p<0.01$). A significant number of them stated that the challenges they faced were affecting their own and/or their family's mental health (68.7%, $n=101$) (see Table 3 and Supplementary Table S3). This result from our study parallels previous literature[75] and stands as a significant challenge contributing to the continual shrinking of the number of dairy farmers.

Financial stress

Investments in technology and depreciation expenses are important parameters impacting farmers' overall income[35]. Farmers in the early or middle stages of their careers are more likely to leave the farm due to financial stress, which is one of the most important challenges[74]. In addition, economic issues such as irregular and uncertain income, financial debts and high interest rates jeopardize the sustainability of dairy farming, as they increase the stress experienced by dairy farmers[33]. In our study, the sustainability of dairy farming was interpreted mainly as economic viability, with financial stress posing a substantial threat. Additionally, some specific challenges confronting Australian dairy farmers have been identified, shedding light on factors affecting both the viability of the farm and the livelihoods of those involved.

Physically and mentally challenging working conditions such as high costs, intensive labour and working hours[76], time pressure, climate change, machine malfunctions and possible epidemics also make it difficult for farmers to balance their social lives[33]. In our study, the biggest challenges faced in dairy farming operations included rising operating costs as the primary concern, with the main challenges being the demanding nature of the profession, long working hours, minimal downtime and labour shortage (see Table 7). These highlighted challenges were consistent with literature data and demonstrated the challenging nature of Australian dairy farming and the need to support farmers mentally and physically.

Family farms represent nearly all (99%) of dairy farming in Australia[35]. Exit rates are higher in regions with smaller farms and are closely related to production structure. By comparison, exit rates are lower in regions where part-time farming is common, subsidy payments are high and relative price increases for agricultural outputs are high[16]. While factors such as difficulty in farm management, lack of experience and low equity

capital reduce the entry of young farmers into this sector, they may also negatively affect their decisions to stay in the profession[74]. While increasing herd size reduces the probability of leaving the farm, ageing increases the probability of leaving the farm[77]. However, in our study, herd size and ageing did not have any statistically significant effect on exiting the farm.

It was shown in the study that these challenges faced by dairy farmers have a significant impact on the sustainability of dairy farming, as the biggest problem in dairy farming was increasing costs (39.5%, $n=58$), followed by drought (14.3%, $n=21$) and floods (12.2%, $n=18$), and most farmers experienced such difficulties (overall 72.1%, $n=106$). Financial distress proves to be particularly problematic when considering the unstable pricing of milk, creating a significant inconsistency that complicates the sustainability of dairy operations. In addition, an inability to complete basic tasks due to financial constraints challenges vital production processes and further increases the difficulties in the agricultural sector. Financial constraints affect optimum operational efficiency in key dairying regions of Australia.

The financial burden on farm income, concerns about animal diseases and animal welfare, and environmental problems caused by agriculture are interrelated within the scope of sustainability[78]. Also, farmer wellbeing is directly related to animal welfare, as productive farms are often associated with positive farmer wellbeing. The strong relationship between animal welfare, human wellbeing and the environment reveals the importance of the concept of One Welfare[79]. Natural disasters, the majority of which are climate change-related, are one of the main triggers for deteriorating mental health[80,81]. A National Farmers' Federation report reveals an alarming situation, with two-thirds of Australian farmers experiencing anxiety, 45% having felt depressed, and 30% having attempted self-harm or suicide[82]. Therefore, in our study, sustainability was also evaluated in terms of farmer wellbeing, animal welfare and the environment. Our study indicates that a significant portion of the farmers (7 out of 10) grappled with wellbeing and mental health issues. Farmers who reported that the challenges they faced as dairy farmers had an impact on their own and their family's mental health had less belief about the sustainability of dairy farming ($p<0.05$) (Supplementary Table S4). However, in our study many of them did not see this as affecting the welfare of their cattle. Given the strong connection between the farmer's wellbeing and the welfare of their livestock, farmers' claims that cattle welfare was not affected may not be realistic.

Climate change

Although the farmers in our sample also expressed concerns about the impact of climate change uncertainty on their businesses, there was no acknowledgement in the qualitative comments that the cattle themselves are contributing high levels of greenhouse gas emissions[83]. Only one farmer stressed that he wanted to see "more government funding in emissions reduction in the dairy industry". There seemed to be a lack of recognition of the link between livestock and climate change and the benefits of plant-based choices, which could potentially influence dairy farmers' interest in transitioning to other businesses.

According to the study of Lane et al. (2019), although dairy farmers expressed concerns about climate impacts, other business pressures such as profitability, market conditions, government regulations and workforce availability were often more critical issues influencing their decision-making processes. It has been suggested that the risk of climate change should be framed as a risk multiplier that increases the severity and/or frequency of some existing threats, rather than as a new independent risk factor for the stability of farm systems[84]. There are significant differences between countries in farmers' reactions to changing agricultural conditions, so shaping individual policies for the dairy sector in different countries and a more specific approach related to local conditions may help farmers to cope with the changes better[85]. About one-fifth (1/5) of farmers in our study identified climate change uncertainty, lack of or insufficient subsidies and grants, and changing consumer demand as major challenges, with moderate levels of concern expressed regarding these issues.

Government incentives

In our study, some of the participating farmers thought they missed out on government incentives due to insufficient information. Therefore, an absence or inadequacy of government support in the form of subsidies and grants (reported to be a challenge by 36.1%, $n=53$) (see Table 7) can hinder the ability of farmers to run their businesses and invest in modern technologies, more sustainable practices and infrastructure improvements to counter climate change. A multifaceted, comprehensive approach is required to improve farmers' mental health and well-being and offer them opportunities. This could include policy interventions, technological advances and support systems. By strategically integrating these elements, the industry can explore potential pathways for transitioning towards more sustainable products and resilient practices. However, the industry must respond to market demand, and if this is transitioning away from dairy products to plant-based alternatives, dairy farmers will also have to transition to alternative enterprises to meet this demand.

Conclusions

The majority of dairy farmers did not express positive levels of satisfaction with the industry. However, some dairy farmers gave strong support to their industry, which reduced the likelihood of them considering transitioning away from dairy farming. All farmers recognised that there were significant challenges, in particular rising costs, which represented a major strain on their mental health. As a result of this situation, although a significant proportion of farmers were open to transitioning away from the dairy industry, especially to alternative agricultural businesses, and would value government support in making such a transition, they were not ready to take this risk because they believed that it would not be profitable compared to dairy farming or that a full transition would not be possible. More were interested in financial and technical advice to make decisions about the future of their business. In addition, even if they were not satisfied with the dairy farming sector, some of the land they owned was not suitable for other agricultural alternatives, and also the considerable number of cows they owned was among the reasons why dairy farmers believed they could not easily leave the sector. However, it

was also clear that many dairy farmers considered this change as a long-term action, showing that transitioning away is a long process, but that it is possible over time if done gradually.

Addressing both current and future challenges to ensure the sustainability and resilience of Australian farmers demands a multifaceted approach that builds not only on the current position of dairy farmers but also on changing consumer preferences and impacts of climate change. This approach should incorporate more research to integrate the transition to plant-based alternatives with strategic policy interventions that result in robust support systems for farmers, particularly those who are worst affected by the challenges. With policy support, the industry can also forge a path toward greater adaptability and long-term sustainability, allowing diversification and transition to alternative enterprises where appropriate. For this reason, it is very important to understand the concerns of dairy farmers regarding the risk factors for the transition to agricultural alternatives and to provide the support they need from the government, and to carry out the planned changes, including the transition to alternative agricultural business, in a controlled manner under the supervision of government and industry experts. Such a comprehensive strategy is essential for navigating the complexities of the dairy sector, fostering innovation and positioning farming for sustained success in the face of evolving economic, environmental and market dynamics.

Data availability

Data is provided within the manuscript and supplementary information files. The datasets used and/or analyzed during the current survey also available from the corresponding author on reasonable request.

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References

1. Gerber, P. J. et al. *Tackling Climate Change through Livestock: A Global Assessment of Emissions and Mitigation Opportunities* (FAO, 2013).
2. Alexandratos, N. & Bruinsma, J. World agriculture towards 2030/2050: the 2012 revision. In *ESA working paper No. 12–03*FAO, (2012).
3. MacDonald, J. M., Law, J. & Mosheim, R. *Consolidation in U.S. Dairy Farming. ERR-274* (U.S. Department of Agriculture, Economic Research Service, 2020).
4. Knips, V. Developing countries and the global dairy sector part I: Global overview. PPLPI Working Papers 23768, Food and Agriculture Organization of the United Nations, Pro-Poor Livestock Policy Initiative (2005).
5. Nam, K., Lim, H. & Ahn, B. I. Analysis of consumer preference for milk produced through sustainable farming: the case of mountainous dairy farming. *Sustainability* **12**, 3039 (2020).
6. Headey, D. Can dairy help solve the malnutrition crisis in developing countries? An economic analysis. *Anim. Front.* **13**, 7–16 (2023).
7. Loughrey, J., O'Donoghue, C. & Conneely, R. Alternative measures of family farm viability–incorporating gap measures. *J. Rural Res.* **89**, 257–274 (2022).
8. Gebeyehu, M. N. Recent advances and application of biotechnology in the dairy processing industry: A review In *Intensive animal farming-a cost-effective tactic: A cost-effective tactic* (ed. Abubakar, M., & Manzoor, S.) (BoD–Books on Demand, 2023).
9. Hernandez-Patlan, D., Tellez-Isaias, G., Hernandez-Velasco, X. & Solis-Cruz, B. Technological strategies to improve animal health and production. *Front. Vet. Sci.* **10**, 1206170 (2023).
10. Parzonko, A., Parzonko, A. J., Bórawski, P. & Wicki, L. Return on equity in dairy farms from selected EU countries: assessment based on the DuPont Model in years 2004–2020. *Agriculture* **13**, 1403 (2023).
11. Britt, J. H. et al. Invited review: learning from the future—a vision for dairy farms and cows in 2067. *J. Dairy. Sci.* **101**, 3722–3741 (2018).
12. Salokhe, S. Problems and prospects of dairy farming in pune district. *J. Crit. Rev.* **6**, 2838–2849 (2019).
13. Duguma, B. Farmers' perceptions of major challenges to smallholder dairy farming in selected towns of Jimma Zone, Oromia Regional State, Ethiopia: possible influences, impacts, coping strategies and support required. *Heliyon* **8**, e09581 (2022).
14. Krampe, C. & Fridman, A. Oatly, a serious 'problem' for the dairy industry? A case study. *Int. Food Agribusiness Manag Rev.* **25**, 157–171 (2022).
15. Khan, N., Fahad, S., Naushad, M. & Faisal, S. COVID-2019 locked down impact on dairy industry in the world. Preprint at SSRN: (2020). https://ssrn.com/abstract=3616325
16. Breustedt, G. & Glauben, T. Driving forces behind exiting from farming in Western Europe. *J. Agric. Econ.* **58**, 115–127 (2007).
17. Cardoso, C. S., Von Keyserlingk, M. A. & Hötzel, M. J. Brazilian citizens: expectations regarding dairy cattle welfare and awareness of contentious practices. *Animals* **7**, 89 (2017).
18. Jackson, A., Doidge, C., Green, M. & Kaler, J. Understanding public preferences for different dairy farming systems using a mixed-methods approach. *J. Dairy. Sci.* **105**, 7492–7512 (2022).
19. Schulze, M., Kühl, S. & Busch, G. We have some calves left! Socially accepted alternatives to the current handling of male calves from dairy production. *Food Ethics*. **8**, 11 (2023).
20. Slade, P. & Markevych, M. Killing the sacred dairy cow? Consumer preferences for plant-based milk alternatives. *Agribusiness* **40**, 70–92 (2024).
21. Izmirli, S. & Phillips, C. J. The relationship between student consumption of animal products and attitudes to animals in Europe and Asia. *Br. Food J.* **113**, 436–450 (2011).
22. Çelik, E. & Yaşar, A. An evaluation on food ethics. *Erciyes Üniv Vet. Fak Derg.* **18**, 129–136 (2021).
23. Stone, A. The relationship between attitudes to human rights and to animal rights is partially mediated by empathy. *J. Soc. Psychol.* **163**, 367–380 (2023).
24. Hansen, B. G. & Østerås, O. Farmer welfare and animal welfare-exploring the relationship between farmer's occupational well-being and stress, farm expansion and animal welfare. *Prev. Vet. Med.* **170**, 104741 (2019).
25. Robichaud, M. V. et al. Associations between on-farm cow welfare indicators and productivity and profitability on Canadian dairies: II. On tiestall farms. *J. Dairy. Sci.* **102**, 4352–4363 (2019).
26. Spigarelli, C. et al. Animal welfare and farmers' satisfaction in small-scale dairy farms in the Eastern Alps: A One Welfare approach. *Front. Vet. Sci.* **8**, 741497 (2021).
27. Hendricks, J. et al. Public perceptions of potential adaptations for mitigating heat stress on Australian dairy farms. *J. Dairy. Sci.* **105**, 5893–5908 (2022).
28. Malliaroudaki, M. I., Watson, N. J., Ferrari, R., Nchari, L. N. & Gomes, R. L. Energy management for a net zero dairy supply chain under climate change. *Trends Food Sci. Technol.* **126**, 153–167 (2022).

29. Markets and Markets. *Dairy Alternatives Market* (2023). https://www.marketsandmarkets.com/Market-Reports/dairy-alternatives-market-677.html
30. Eshel, G., Shepon, A., Makov, T. & Milo, R. Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *Proc. Natl. Acad. Sci. U S A*. **111**, 11996–12001 (2014).
31. Giller, K. E. et al. The future of farming: who will produce our food? *Food Secur.* **13**, 1073–1099 (2021).
32. Hansen, B. G. Stay in dairy? Exploring the relationship between farmer wellbeing and farm exit intentions. *J. Rural Stud.* **92**, 306–315 (2022).
33. 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).
34. Dairy Australia. *Dairy Businesses for Future Climates* https:// (2016). cdn-prod.dairyaustralia.com.au/-/media/project/dairy-australia-sites/national-home/resources/2020/07/09/dairy-businesses-for-future-climates-national/dairy-businesses-for-future-climates-national.pdf?rev=50adcefdbe874ae1b4f4df8031f9cb9e
35. Wallis, A. & Dollard, M. F. Local and global factors in work stress-the Australian dairy farming examplar. *Scand. J. Work Environ. Health*. **34**, 66 (2008).
36. Statista *Share of Households Buying Milk or Plant-Based Milk Alternatives in Australia as of March 2023*. (2023). https://www.statista.com/statistics/1393662/australia-breakdown-of-households-buying-milk-or-milk-alternatives/#:~:text=Over%20one%20third%20of%20households,milks%20during%20the%20survey%20period
37. Dairy Australia. *Our Regions* (2023). https://www.dairy.com.au/our-industry-and-people/our-regions
38. Sabillon, B. H., Gerster-Bentaya, M. & Knierim, A. Measuring farmers' well-being: influence of farm-level factors on satisfaction with work and quality of life. *J. Agric. Econ.* **73**, 452–471 (2022).
39. Beggs, D. S., Jongman, E. C., Hemsworth, P. H. & Fisher, A. D. The effects of herd size on the welfare of dairy cows in a pasture-based system using animal-and resource-based indicators. *J. Dairy. Sci.* **102**, 3406–3420 (2019).
40. The Senate. *Rural and regional affairs and transport references committee. Performance of Australia's dairy industry and the profitability of Australian dairy farmers since deregulation in 2000* (Parliament of Australia, 2021).
41. KG2. *Data Driven Sales & Marketing for Farmers and Agribusiness* (2024). https://kg2.com.au/
42. Australian Government. *Dairy Cattle Farmers* (2024). https://labourmarketinsights.gov.au/occupation-profile/Dairy-Cattle-Farmers?occupationCode=121313
43. Dairy Australia. *Workforce: The Power of People in Australian Dairy Farms in 2020* (2021). https://thepeopleindairy.org.au/wp-content/uploads/2021/08/3353-Workforce-The-Power-of-People-on-Aust-Dairy-Farms-2020.pdf
44. Morse, J. M. Principles of mixed methods and multimethod research design In Handbook of Mixed Methods in Social & Behavioral Research (eds Tashakkori, A. & Teddlie, C.) 189–208 (Sage, (2003).
45. Moffatt, S., White, M., Mackintosh, J. & Howel, D. Using quantitative and qualitative data in health services research–what happens when mixed method findings conflict? [ISRCTN61522618]. *BMC Health Serv. Res.* **6**, 1–10 (2006).
46. Giannakaki, M. S. Using mixed-methods to examine teachers' attitudes to educational change: the case of the skills for life strategy for improving adult literacy and numeracy skills in England. *ERE* **11**, 323–348 (2005).
47. Bryman, A. Integrating quantitative and qualitative research: how is it done? *Qual. Res.* **6**, 97–113 (2006).
48. Can, A. *Quantitative Data Analysis with SPSS* 9th edn (Pegem A Publishing, 2013).
49. Gargiulo, J. I., Eastwood, C. R., Garcia, S. C. & Lyons, N. A. Dairy farmers with larger herd sizes adopt more precision dairy technologies. *J. Dairy. Sci.* **101**, 5466–5473 (2018).
50. Condon, M. Farmers still face higher rates of suicide with one death every 10 days in Australia, ABC News. Preprint at (2021). https://www.abc.net.au/news/rural/2021-12-07/farmers-still-face-higher-rates-of-suicide/100679652
51. Dairy Australia. *Dairy's Climate Changing Future* (2022). https://landcareaustralia.org.au/project/dairys-climate-changing-future/
52. Kashtanova, E. Global trends in milk production and trade: the impact on the European milk market. *Biotechnol. Anim. Husb.* **26**, 129–134 (2010).
53. O'Connor, D., Keane, M. & Barnes, E. Measuring volatility in dairy commodity prices in *113th EAAE Seminar 'A Resilient European Food Industry and Food Chain in a Challenging World', Chania, Crete, Greece* (September 3–6, (2009).
54. Roustaee, R. et al. Challenges and obstacles to dairy consumption in Iran from stakeholders' perspectives using a food system approach. *Sustainability* **15**, 12568 (2023).
55. Martin, S. & Joshi, A. Comparative study of retail prices of milk and green vegetables in Gujarat. *J. Surv. Fish. Sci.* **10**, 4201–4210 (2023).
56. Khairallah, L., Chedid, M., Jaber, L., Martiniello, G. & Hamadeh, S. K. Traditional dairy goat value chain in Lebanon: an uneven distribution of values. *J. Agribus Dev. Emerg. Econ.* **13**, 555–569 (2023).
57. Miller, B. A. & Lu, C. D. Current status of global dairy goat production: an overview. *Asian-australas J. Anim. Sci.* **32**, 1219–1232 (2019).
58. Statista *Number of Registered Dairy Farms in Australia from Financial Year 2012 to 2022* (2024). https://www.statista.com/statistics/1297010/australia-registered-dairy-farms/
59. Barbeta-Viñas, M. & Requena-i-Mora, M. The paradoxes of dairy farmers in Catalonia (Spain): Crisis and 'double bind'. *Sociol. Ruralis*. **62**, 91–111 (2022).
60. Lahnamäki-Kivelä, S. Coping with uncertainty: exploring the foresight actions' role in supporting growth-orientation among Finnish dairy farmers. *Futures* **135**, 102870 (2022).
61. Palczynski, L. J., Bleach, E. C., Brennan, M. L. & Robinson, P. A. Youngstock management as the key for everything? Perceived value of calves and the role of calf performance monitoring and advice on dairy farms. *Front. Anim. Sci.* **3**, 835317 (2022).
62. Zweigbaum, W. H., McGilliard, M. L., James, R. E. & Kohl, D. M. Relationship of management and financial measures among dairy herds in Virginia. *J. Dairy. Sci.* **72**, 1612–1619 (1989).
63. Clay, N., Garnett, T. & Lorimer, J. Dairy intensification: drivers, impacts and alternatives. *Ambio* **49**, 35–48 (2020).
64. FAO. Dairy and dairy products. In OECD-FAO Agricultural Outlook 2018–2027 14th edn. (OECD Publishing, (2018).
65. MacDonald, J. M., Cessna, J. & Mosheim, R. *Changing Structure, Financial Risks, and Government Policy for the US Dairy Industry* (ERR-205, U.S. Department of Agriculture, Economic Research Service, 2016).
66. Salliou, N. Quitting livestock farming: transfarmation pathways and factors of change from post-livestock farmers' accounts. *Front. Sustain. food syst.* **7**, 1122992 (2023).
67. Lemaire, G., Franzluebbers, A., de Faccio Carvalho, P. C. & Dedieu, B. Integrated crop–livestock systems: strategies to achieve synergy between agricultural production and environmental quality. *Agr Ecosyst. Environ.* **190**, 4–8 (2014).
68. Herrera, B., Gerster-Bentaya, M. & Knierim, A. Farm-level factors influencing farmers satisfaction with their work in *30th International Conference of Agricultural Economists* (July 28-August 2, (2018).
69. Glover, J. Doctoral dissertation Loughborough University,. Why do dairy farmers continue to farm? Can Bourdieu's theory aid our understanding and suggest how farmers could regain some control in their industry? (2008).
70. Beguin, E. et al. Working conditions in large French dairy farm: differences and similarities between working groups in *2nd International Symposium on Work in Agriculture. Thinking The Future of Work in Agriculture*. (2021).
71. Flores, C. & Sarandón, S. Limitations of neoclassical economics for evaluating sustainability of agricultural systems: comparing organic and conventional systems. *J. Sustainable Agr.* **24**, 77–91 (2004).
72. Eurostat. Final report of the expert group on quality of life indicators: 2017 edition. In European Union: Statistical Reports. (2017).

73. Terres, J. M., Nisini, L. & Anguiano, E. *Assessing the risk of Farmland Abandonment in the EU: Final Report* (Publications Office of the European Union, 2013).
74. Gale, H. F. Age-specific patterns of exit and entry in US farming, 1978–1997. *Appl. Econ. Perspect. Policy*. **25**, 168–186 (2003).
75. Marie, J. & Nichols, J. Australia's shrinking dairy industry continues to wither as milk is trucked across the country. ABC News. Preprint at (2023). https://www.abc.net.au/news/rural/2023-12-04/dairy-industry-shrinks-in-australia/103171644
76. van der Lee, J., Zijlstra, J., Wouters, A. P. & Van Vugt, S. M. Wageningen,. Milking to potential: Strategic framework for dairy sector development in emerging economies. Discussion paper. Centre for Development Innovation and Livestock Research, Wageningen UR (University & Research centre) (2014).
77. Dong, F., Hennessy, D. A., Jensen, H. H. & Volpe, R. J. Technical efficiency, herd size, and exit intentions in US dairy farms. *Agric. Econ.* **47**, 533–545 (2016).
78. Calker, K. J. V., Berentsen, P. B., Giesen, G. W. & Huirne, R. B. Identifying and ranking attributes that determine sustainability in Dutch dairy farming. *Agric. Hum. Values*. **22**, 53–63 (2005).
79. Pinillos, R. G. et al. One Welfare–a platform for improving human and animal welfare. *Vet. Rec.* **179**, 412–413 (2016).
80. ABC Rural. *Link Between Climate Change, Youth Mental Health Concerns Highlighted by New National Survey* (2023). https://www.abc.net.au/news/2023-04-20/climate-change-impacts-young-peoples-mental-health-survey-finds/102240226
81. Walinski, A. et al. The effects of climate change on mental health. *Dtsch. Arztebl Int.* **120**, 117–124 (2023).
82. Honan, K. Alarming report on farmer mental health prompts peak body to call for urgent action. ABC Rural. Preprint at (2023). https://www.abc.net.au/news/rural/2023-03-29/calls-for-government-action-on-farmer-mental-health/102133810#
83. Marinova, D. & Bogueva, D. *Food in a Planetary Emergency* (Springer Nature Singapore Pte Ltd., 2022).
84. Lane, D., Murdock, E., Genskow, K., Rumery Betz, C. & Chatrchyan, A. Climate change and dairy in New York and Wisconsin: risk perceptions, vulnerability, and adaptation among farmers and advisors. *Sustainability* **11**, 3599 (2019).
85. Kuipers, A., Malak-Rawlikowska, A., Stalgienė, A., Ule, A. & Klopčič, M. European dairy farmers' perceptions and responses towards development strategies in years of turbulent market and policy changes. *Agriculture* **11**, 293 (2021).

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Author contributions

Conceptualisation, all authors; methodology, C.J.C.P., E.C.; collection of data, investigation and data curation, KG2, D.B, E.C.; writing-original draft preparation, E.C., D.B., C.J.C.P.; writing-review and editing, all authors. All authors have read and agreed to the published version of the manuscript.

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Declarations

Competing interests

Clive Phillips declares that he is on the grant-advisory committee of Voiceless. Other authors declare no conflict of interest.

Additional information

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Correspondence and requests for materials should be addressed to C.J.P.

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