

PhD School on Agriculture, Environment and Bioenergy

http://sites.unimi.it/dottorato_aab/

(XXXIX cycle, 2023-26)

Project draft

1. Field of interest

AGR19 Zootecnia Speciale

2. Project title

Innovative methods for assessing and improving environmental sustainability and animal welfare in dairy farming

3. Tutor L. Bava

- **Eventually:** co-tutor/s

4. Relevance of the topic and state of the art:

In recent decades, environmental sustainability, animal welfare and the study and development of new technological tools for precision livestock farming have emerged as the most significant research areas in the field of dairy science. Regarding the evaluation of environmental sustainability, the most widely used method is the Life Cycle Assessment (LCA) which has been proven to be the most effective and commonly used approach for determining the environmental impact of milk production at farm gate (Castanheira et al., 2010; Bava et al., 2014). However, as reported by many authors (among others Berton et al., 2021), there are limitations to this method that are still being debated. For example, the LCA methodology usually fail to include the complex connections within the food system, for instance posing the competition between feed and food production (Van Zanten et al., 2018). In addition, the LCA method does not consider the ecosystem services which include the management of renewable natural resources, the socio-economic viability of many natural areas (Kiefer et al., 2015), climate regulation, protection from natural disasters, recreation and support for biodiversity. Ecosystem services represent an important added value particularly in extensive dairy system. Therefore, it is desirable to combine the LCA analysis with other methods to better define the environmental sustainability of milk production system. In addition, the implementation of new sensors and precision systems in both intensive and extensive farms can provide precise information about the animal responses to different management and husbandry techniques. This information can be useful in identifying the best strategies in terms of both environmental sustainability and animal welfare. The last issue is becoming more and more important not only for consumers but also for farmers and technicians. The current practices in dairy farming, as for example with regards the lifespan of cows (De Vries et al., 2020) or cow-calf separation (Meagher et al., 2019), are required to evolve to better respond to the demands of society and multiple stakeholders.

5. Layout of the project (draft)

5.1. Materials & Methods:

The project aims to evaluate the environmental sustainability of milk production and to assess animal welfare across different dairy farming systems (intensive and extensive), with different level of precision technology implementation (high or moderate use of sensors) and in different geographical areas (plain and mountain regions), using an LCA approach as well as other methods

to explore the different aspects of sustainability. The final aim is to identify the more sustainable farming strategies and to study the relationships among the different dimensions of sustainability. The LCA analysis will be conducted starting from a detailed collection of primary data from farmers and regional databases. Moreover, the LCA will be performed following the IDF (2015) guidelines for milk and, the equation of IPCC (2019) and EEA (2019) will be used for quantifying the emissions from animals and manure. The impact categories will be evaluated with the support of a specific software (SIMAPRO).

At the same time, the feed/food competition will be evaluated using different approaches: the first analysed the feed ration of animals to calculate the human-edible feed conversion efficiency, proposed by Ertl et al., (2015), the second is the Land Use Ratio (LUR) that evaluates the land use efficiency considering the potential protein obtainable from directly cultivated crops compared to the protein obtained indirectly from the feed cultivated for farm animals as proposed by van Zanten et al. (2016). The agroecosystem services related to milk production in the different farms located in different regions will be evaluated using the method proposed by Augstburger et al. (2018).

The data collected by precision instruments in the studied farms will be used both for the evaluation of environmental impact and for the evaluation of animal welfare. Animal welfare will be assessed also through conventional protocols (Welfare Quality, 2009; AWIN, 2015).

All the data obtained will be statistically analysed using the statistical package SAS.

5.2. Schedule and major steps (3 years):

The three year programme can be summarized below:

- literature review on the definition and methods of evaluating environmental sustainability of dairy farming (months 1-6)
- identification of dairy farms suitable for the study (months 3-5)
- collection of primary data (months 4-12)
- evaluation of sustainability using the different approaches and methods proposed (months 12-24)
- assessment of animal welfare in the selected farms through both indicators from precision tools and conventional protocols (12-24)
- statistical analysis of data and integration/comparison among the results obtained from the different methods applied (months 18-25)
- publication of the results in national and international journals (months 24-36)
- participation and co-organization of public events to communicate the results at regional, national and international levels (months 18-36)

6. Available funds

- PNRR – AGRITECH Tasks 5.1.2 e 5.2.3 304.000€
- OPERAZIONE 16.1.01 – “Gruppi Operativi PEI” Nuove pratiche gestionali per l'allevamento intensivo sostenibile – VISION” 152.000€

7. Literature:

1. AWIN. 2015. AWIN welfare assessment protocol for goats.
2. Bava L., Sandrucci A., Zucali M., Guerci M., Tamburini A., 2014. How can farming intensification affect the environmental impact of milk production? *Journal of Dairy Science* 97:4579–4593

3. Berton, M., Bovolenta, S., Corazzin, M., Gallo, L., Pinterits, S., Ramanzin, M., Ressi W, Spigarelli C, Zuliani A., Sturaro, E. (2021). Environmental impacts of milk production and processing in the Eastern Alps: A “cradle-to-dairy gate” LCA approach. *Journal of Cleaner Production*, 303, 127056.
4. Castanheira, É. G., Dias, A. C., Arroja, L., & Amaro, R. (2010). The environmental performance of milk production on a typical Portuguese dairy farm. *Agricultural Systems*, 103(7), 498-507.
5. de Vries, A. (2020). Symposium review: Why revisit dairy cattle productive lifespan? In *Journal of Dairy Science* (Vol. 103, Issue 4, pp. 3838–3845).
6. Ertl, P., Klocker, H., Hörtenhuber, S., Knaus, W., & Zollitsch, W. (2015). The net contribution of dairy production to human food supply: the case of Austrian dairy farms. *Agricultural Systems*, 137, 119-125.
7. Kiefer, L. R., Menzel, F., & Bahrs, E. (2015). Integration of ecosystem services into the carbon footprint of milk of South German dairy farms. *Journal of Environmental Management*, 152, 11-18.
8. Meagher, R. K., Beaver, A., Weary, D. M., & von Keyserlingk, M. A. G. (2019). Invited review: A systematic review of the effects of prolonged cow–calf contact on behavior, welfare, and productivity. *Journal of Dairy Science*, 102(7), 5765–5783
9. Van Zanten, H.H., Herrero, M., Van Hal, O., Röö, E., Muller, A., Garnett, T., Gerber, P.J., Schader, C., De Boer, I.J.2018. Defining a land boundary for sustainable livestock consumption. *Global Change Biol.* 24 (9), 4185e4194
10. Welfare Quality®. 2009. Assessment Protocol for Cattle; Wageningen Academic Publishers: Wageningen, The Netherlands