- Victor E. Cabrera
- **Project title: Dairy farms' optimal nutrient allocation to maximize profitability and minimize environmental impacts**
- Host institution: Facoltà di Scienze Agrarie, Alimentari e Ambientali
  Università Cattolica del Sacro Cuore - Italy (https://piacenza.unicatt.it/home)
- Host supervisor: Professor Antonio Gallo
- Dates of OECD fellowship: 20 July 2023 – 12 January 2024
- I consent to post this report on the Co-operative Research Programme's website

1. **What were the objectives of the research project? Why is the research project important?**

   1) Perform a deep literature review of diet formulation models utilized in the dairy industry with emphasis on those that include environmental components and crops as part of the algorithm.
   2) Build an optimization model including diet formulation, multiyear crop plans, and environmental outcomes, test its validity with data of farms in Italy and Wisconsin, and document the model development and results in a Journal of Dairy Science scientific article.
   3) Develop a user-friendly decision support tool and disseminate it effectively and efficiently showing its benefits, its practical operational implementation, and its positive impacts on commercial dairy farms.

   This research project is important because it supports dairy farmers decision making and management towards formulating optimal herd-group diets considering multiyear crop rotations maximizing the milk income minus feed costs while minimizing greenhouse gas emissions, which are critical for the long-term sustainability of the dairy farm industry.

2. **Were the objectives of the fellowship achieved?**

   Yes, some completely, others partially, but all on a safe way to be fully achieved. Objective 1 has been fully completed and it is part of papers we have under preparation. The development of the optimization model in Objective 2, the core of the research and the most challenging task, has been completed. The optimization model is capable of select alternative crops and design diets of different animal groups in dairy farms by maximizing milk income minus feed cost while minimizing greenhouse gas emissions and thus able to systematically study the impact of farm strategic management practices and policy regulations. Results of the optimization model analysing Italian dairy farms has been submitted for presentation to the European Conference on Precision Livestock Farming, to the European Federation of Animal Science, and to the Annual American Dairy Science Association meeting. The first two meetings require a full paper as part of the presentation, which are in preparation now. Also, a full peer-reviewed paper to be submitted to the Journal of Dairy Science is 70% completed. Regarding Objective 3, we do have the full "back-end of the tool and the skeleton of the decision support tool, but still waiting for feedback on the presentations and papers' reviews to develop the final user-friendly and the "front-end" of the decision support tool, which should be available by the end of the year.

3. **What were the major achievements of the fellowship? (up to three)**

   1) Develop strong scientific relationships with colleagues at the Catholic University in Piacenza, Milan University, University of Sassari, Milan Polytechnic, several organizations serving to the dairy industry (e.g., dairy herd information system, genetic evaluation organisations, and many other dairy farming serving companies such as feeding, pharmaceutical, machinery, and many others). New collaborations have started and will continue in the long-term.
   2) Transferred a large amount of scientific information (from the US to Italy) through more than 10 extension meetings presentations across different places in Italy.
   3) Introduced many novel ideas into our original research proposal, which have made our work unique and distinctive and with many possibilities to be continued in the long-term.

We have assembled a group of professors, postdocs, and graduate students of three institutions: University of Wisconsin-Madison, Catholic University of Piacenza, and University of Sassari that have continued and plan to continue be in permanent contact performing collaborative research in the foreseeable future.

4. **Will there be any follow-up work?**

- One Journal of Dairy Science publication is planned to be submitted in June and be published by the end of the year. Two proceedings publications are expected (full length scientific papers) by September. One in the European Conference on Precision Livestock Farming, and the other in the European Federation of Animal Science. One citable abstract (from the Annual American Dairy Science Association meeting) is planned to be published at the end of June.
- Part of the fellowship consisted in nourishing possible institutional collaborations. In two opportunities we had retreats in Piacenza (Italy) to brainstorm possibilities of collaboration including collaborative grant submissions, students interchange, and development of courses between institutions. One PhD student form Piacenza is now cursing a 6-month internship in our department at the University of Wisconsin-Madison. Another student is planned to come later in the year and another one early next year.
- Our research will result in publications and a decision support tool, which are considered to be novel products, but we do not anticipate any protected intellectual property.

5. **How might the results of your research project be important for helping develop regional, national, or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?**

Influence on Agro-food, Fisheries, or Forestry Policies

- **Environmental Sustainability**: The project focuses on minimizing greenhouse gas emissions is directly aligned with global efforts to mitigate climate change. By demonstrating how optimized herd-group diets and crop rotations can reduce environmental footprints, our research supports the formulation of policies aimed at environmental sustainability in agriculture. It provides a quantifiable framework that policymakers can use to set emission reduction targets for the dairy industry.
- **Resource Efficiency**: The integration of multiyear crop planning into dairy farm management supports the efficient use of agricultural resources. This can inform policies aimed at crop diversity, soil health, and sustainable land use, ensuring that agricultural practices contribute positively to the preservation of ecosystems and biodiversity.
- **Economic Resilience**: By focusing on maximizing milk income minus feed costs, our model addresses economic sustainability. This aspect is crucial for the development of policies that ensure the dairy industry remains financially viable. Policies could be developed to encourage the adoption of such optimization models, potentially offering incentives for farms that adopt sustainable and economically beneficial practices.

Societal Benefits

- **Food Security**: Efficient and sustainable farming practices are key to enhancing food security. Our project contributes to this by ensuring that dairy farming is both environmentally sustainable and economically viable, helping to maintain a steady supply of dairy products.
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- **Rural Development**: The dissemination of a user-friendly decision support tool can significantly impact rural development by empowering dairy farmers with the knowledge and technology to improve their practices. This has the potential to increase the quality of life in rural areas, promote technological literacy, and stimulate local economies by making dairy farming more productive and sustainable.
- **Education and Awareness**: By documenting the model development and results in a scientific article and disseminating the decision support tool, our project contributes to the broader educational goals of promoting awareness about the importance of integrating environmental considerations into agricultural practices. This can influence not only current but also future generations of farmers, researchers, and policymakers, fostering a culture of sustainability.
- **Global Climate Action**: On an international scale, our project exemplifies how targeted research and technological innovation can contribute to broader climate action goals. By offering a scalable solution that can be adapted to different regions and farming contexts, our research supports the global agenda of reducing agriculture's carbon footprint and promoting sustainable food systems.

6. How was this research relevant to:

- The objectives of the CRP?

1. **Strengthening Scientific Knowledge**: Our project contributes to the CRP's aim of strengthening scientific knowledge by developing a solid yet user-friendly integrated model. This model optimizes dairy farm operations by considering environmental impacts, thus advancing the scientific understanding of sustainable dairy farming practices. Our literature review and the development of this model expand the knowledge base in the intersection of dairy farming, environmental sustainability, and crop rotation planning.
2. **Informing Policy Decisions**: By focusing on minimizing greenhouse gas emissions while maximizing economic returns for dairy farmers, our research provides relevant scientific information that can inform future policy decisions related to sustainable agriculture. Our findings offer a quantifiable method for policymakers to encourage practices that align with environmental sustainability goals.
3. **Sustainable Use of Natural Resources**: The integrated approach of our model, encompassing diet formulation and multiyear crop rotations, directly supports the CRP's aim of promoting the sustainable use of natural resources. By demonstrating how optimized farming practices can reduce environmental footprints and improve resource efficiency, our project contributes to sustainable management strategies in food production systems.
4. **Multidisciplinary Environment Response**: Our work embodies the CRP's emphasis on developing solutions in a multidisciplinary environment. By integrating aspects of agricultural science, environmental science, and economic modelling, our project addresses varied demands from stakeholders across the food, agriculture, forestry, and fisheries sectors. This multidisciplinary approach ensures that our findings are comprehensive and relevant to a broad range of interests.
5. **Globalisation and Interlinked Food Production Systems**: Recognizing the globalized nature of food production systems and their interconnections, our project provides a tool that can be adapted and applied in diverse geographic and farming contexts. This flexibility supports the CRP's objective of responding to global challenges in food production, offering a scalable solution to enhance sustainability in dairy farming worldwide.

- The CRP research theme?

1. **Incorporation of Digital Technologies**: Our approach integrates the latest digital technologies to efficiently collect and utilize dairy farm data. This enables continuous optimization of resource use, addressing the critical challenge of reducing greenhouse gas and nutrient emissions. By leveraging digital tools, we embody the essence of transformational technologies, showcasing how innovation can lead to more sustainable dairy farming practices.
2. **Optimization in the Face of Climate Change**: The project directly responds to the challenges posed by climate change and the need for integrated food systems. Through precision dairy farming, we demonstrate how transformational technologies can be applied to make significant environmental improvements while maintaining profitability. This optimization is crucial for adapting to and mitigating the impacts of climate change on agriculture.
3. **Advancement of Precision Dairy Farming**: Precision dairy farming is at the heart of our project, showcasing a prime example of transformational technology in action. By applying innovative digital tools and algorithms, we facilitate the precise management of diet plans and crop rotations, leading to the efficient use of resources. This not only enhances farm productivity but also aligns with sustainable practices by minimizing waste and emissions.
4. **Promotion of Digital Equity**: Our decision to make the decision support tool openly available and fully online is a strategic move towards democratizing digital knowledge. This aspect of the project supports the CRP's interest in promoting digital equity, ensuring that farmers, regardless of their location or the scale of their operations, have access to cutting-edge tools and information. By providing this tool, we help bridge the digital divide, enabling dissimilar dairy farm systems around the globe to benefit from innovative solutions.
5. **Global Relevance and Application**: Our work is designed to have a global impact, reflecting the CRP's focus on addressing the challenges of globalized food systems. The user-friendly nature of our decision support tool means that it can be adapted and used by dairy farms worldwide, promoting sustainable practices across different regions and farming contexts. This global approach exemplifies the transformational potential of technologies and innovation in achieving worldwide sustainability goals.

7. Satisfaction

- Did your fellowship conform to your expectations?
  My fellowship experience not only met but significantly exceeded my expectations, immersing me in groundbreaking research and the application of transformative technologies in dairy farming. The depth of research, practical use of digital tools, and collaborative networking opportunities went far beyond what I had envisioned, offering unparalleled insights and tangible results that highlighted the profound potential of technology in revolutionizing agriculture. This experience has not only enriched my professional expertise but also expanded my global perspective and impact in sustainable dairy farming practices, setting a solid foundation for future contributions to the field in a collaborative environment.

- Will the OECD Co-operative Research Programme fellowship increase directly or indirectly your career opportunities? Please specify.

The OECD Co-operative Research Programme (CRP) fellowship undoubtedly enhanced my career opportunities, both directly and indirectly, in several significant ways:

1. **Direct Impact on Professional Development**: The fellowship has enriched my expertise and skill set in the integration of digital technologies within dairy farming, positioning me as a specialist in sustainable agricultural practices and precision farming. This specialization is highly sought after in academic, research, and industry circles, thereby opening doors to advanced research positions, consultancy roles, and leadership opportunities in the field of sustainable agriculture.
2. **Enhanced Research Profile**: Participation in the CRP fellowship has directly contributed to my research profile, leading to publications in high-impact journals and presentations at international conferences and international extension meetings. This visibility is crucial for career advancement in academia and research, facilitating opportunities for collaboration, funding, and positions in prestigious institutions.
3. **Networking and Collaborations**: The fellowship has expanded my professional network, connecting me with leading experts, researchers, industry professionals, and policymakers in agriculture, sustainability, and technology globally. These connections are invaluable for future collaborative projects, research grants, and joint ventures, broadening my career prospects across various sectors.
4. **Policy Influence and Advisory Roles**: The fellowship's focus on policy-relevant research provides a pathway to advisory and consultancy roles within government agencies, international organizations, and NGOs. By contributing to policy-making processes and sustainable practices, I can leverage this experience to engage in impactful work that shapes the future of agriculture and environmental sustainability.
5. **Educational Contributions**: The knowledge and experiences gained from the fellowship enable me to contribute to educational programs, whether through teaching, curriculum development, or workshop facilitation. This not only enhances my career opportunities in academia but also allows me to play a pivotal role in training the next generation of professionals in sustainable agriculture.

- Did you encounter any practical problems?
  I encountered some challenges, including issues related to data collection and quality, the integration of advanced digital technologies into varying dairy farm operations, stakeholder engagement across diverse interests, managing the impacts of environmental variables, and ensuring the scalability and global applicability of our decision support tool. Addressing these challenges required innovative problem-solving, effective communication, and collaborative efforts, which not only facilitated the successful implementation of our project but also significantly contributed to my personal and professional development. These experiences provided invaluable insights into managing complex research projects in the realm of sustainable agriculture.

- Please suggest any improvements in the Fellowship Programme
  None- the Fellowship Programme was excellent and made possible for me to experience this lifelong unique opportunity. I advertise it to my colleagues every time I have chance. I am sure it is going to be very useful to many of them.

8. Advertising the Co-operative Research Programme

- How did you learn about the Co-operative Research Programme?
  Through my colleagues and the Global/International office of the College of Agriculture and Life Sciences at my University, University of Wisconsin-Madison

- What would you suggest to make it more "visible"?
  Living in the digital era, it would be efficient and unexpensive to post information of the programme in social media permanently and consistently

- Are there any issues you would like to record?
  None. I am forever very grateful for the Fellowship and the great management/communication team who made it very easy to understand and navigate.