Department of Agriculture, Food and the Marine
An Roinn Talmhaíochta, Bia agus Mara

Research Stimulus Fund

Final Report

SMART INTEGRATED LIVESTOCK FARMING (SILF)

DAFM Project Reference No: 13/RD/ICT-AGRI/1

Start date: 01/06/2013

End Date: 31/05/2016

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Collaborating Research Institutions and Researchers: *None for Irish component*

Please place *one* "x" below in the appropriate area on the research continuum where you feel this project fits

Basic/Fundamental			Applied			Pre Commercial
1	2	3	4 X	5	6	7

Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	Sustainable Food Production and Processing

Key words: *(max 4)*
Lameness; dairy; life cycle assessment; ICT

1. Rationale for Undertaking the Research

This section should outline the rationale for carrying out the research and identify the need / problem to be addressed

There is a growing global demand for livestock products that has to be met by farmers producing more from the same or less resources (land area and inputs) causing fewer impacts. The ERA-NET ICT-Agri collaborative project SILF (*Smart Integrated Livestock Farming*) had the objective of 'develop[ing] an evaluation platform that demonstrates through research the potential for an Internet of Things (IoT) enabled farm management information system with animal-centric ICT, production databases & best practice standards to assist farmers to optimise sustainable livestock production' There is a belief that the use of ICT and smart systems will improve livestock management. One area where such technology has great potential is precision livestock management, which is the use of sensors, networks, data, models and decision support to allow animal, site and time specific management to optimize the use of resources and minimize the impact of production. The UCD involvement in SILF addressed two main problems: (1) whether managing lameness could have meaningful environmental benefits for the Irish dairy sector and (2) whether it is possible to detect lameness using sensors in a grazing dairy herd before clinical symptoms are seem by stock handlers. The investment in lameness ICT will be justified if it provides advantages not seen from other means of management. In addition, the impact of energy regulation and carbon neutrality for building design was considered as another area of livestock management where ICT could play a role.

2. Research Approach

Specify the research methodologies employed, emphasising novel techniques and also outline any modifications from the original approved project proposal

A number of sustainability indicators were initially identified from a review of literature. These were to be used to create a framework for evaluating the benefits of ICT systems by a wider European consortium, but were not central to the Irish research.

Motion sensors were mounted on the legs of two herds of dairy cows that were managed using rotational grazing. The accelerometer data were analyzed to identify baseline movement data for each animal and whether the data changed in response to lameness. Each animal was regularly assessed for locomotion score and monitored daily by stock handlers for signs of lameness.

A finite element model of an typical Irish animal house was linked to LCA to establish whether a zero carbon building could be designed. The energy balance component was less important for Ireland than for other parts of Europe because of local climate.

A life cycle assessment model was constructed that included a specific component that accounted for the impact of lameness of dairy productivity at the individual cow level. This was used to evaluate the impact of severity and prevalence on the carbon footprint of milk produced by a typical Irish dairy farm. Eurtophication and acidification impacts were also

assessed. The LCA model was used as the basis for a life cycle costing analysis to quantify the non-costed or environmental cost of dairy production.

3. Research Achievements/Results

Outline main results achieved

Eight key indicators were identified: energy efficiency, nitrogen surplus, nitrogen use efficiency, land use efficiency, soil structure, carbon footprint, biodiversity score, water use efficiency and water quality. There are all related to key legislation and globally recognized environmental impacts.

While the movement behavior of lame cows was different to that of healthy cows, the technology could not detect a difference any sooner than stock handlers, therefore it would be of little advantage for pre-clinical symptom intervention. However, as herd sizes increase and milking becomes robotic, it is likely that human interaction will be reduced so the sensor technology would be a valuable investment to maintain economic return from milk production and to minimize the environmental impact per unit milk produced.

It was found that the severity of lameness was more important than prevalence and could increase environmental impact of milk production by 7-9% compared to a healthy herd (at the herd scale, not the cow scale).

4. Impact of the Research

The research provided the first evaluation of the impact of lameness on the environmental performance of Irish milk production. It has clearly demonstrated the importance of herd health from more than an economic perspective, i.e. the non-costed environmental impacts. In addition it has show that there are potentially significant non-costed benefits derived from using the Irish environment to produce milk; including the ecosystem services provided by the natural environment and the cost of human health impacts via the modelled environmental mechanisms. Given these findings, there is a strong case to consider investment in ICT to enhance farm management at the animal scale.

4(a)Summary of Research Outcomes

(i) Collaborative links developed during this research

- ERA-net partners: CERETETH Greece; IVLO, Belgium; KUL Blegium; MTT, Finland; AU, Denmark.
- LCA links: Harvard.

(ii) Outcomes where new products, technologies and processes were developed and/or adopted

- Lameness component of dairy production LCA model
- Environmental cost model

(iii) Outcomes with economic potential

- None directly

(iv) Outcomes with national/ policy/social/environmental potential

- Animal welfare; implications for Origin Green farm carbon calculator

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.

Chen, W, White, E, and Holden, N. M. (2016) The effect of lameness on the environmental performance of milk production by rotational grazing. Journal of Environmental Management Vol 172 pp. 143-150

Chen, W, White, E, and Holden, N. M. (2017) Social life cycle assessment of average Irish dairy farm. International Journal of Life Cycle Assessment (DOI 10.1007/s11367-016-1250-2)

(ii) Popular non-scientific publications and abstracts including those presented at conferences

Chen W, Nicholas M. Holden (2014) spatial and temporal scale of eco-labels for agricultural products- case study of milk production. Poster Presentation / 9th International conference on LCA in the agrifood sector, San Francisco

Chen, W and Holden N. M. (2016). Social life cycle assessment of an average Irish dairy farm. Poster Presentation / Fifth International Seminar on Social Life Cycle Assessment, Harvard USA

(iii) National Report

None

(iv) Workshops/seminars at which results were presented

None

(v) Intellectual Property applications/licences/patents

None

(vi)Other

Chen, W and Holden N. M. Improving farm management using Information and Communication Technology for lameness detection on Dairy farms. UCD Biosystems Engineering Research Review 19, May 2014

Chen, W and Holden N. M. Economic tool for sustainability assessment. UCD Biosystems Engineering Research Review 20, May 2015

5. Scientists trained by Project

Total Number of PhD theses: _1__

W. Chen, University College Dublin, Life Cycle Sustainability Assessment of Irish Dairy Farming. (to be submitted May 2017).

Total Number of Masters theses: _0__

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (person years)
UCD	1	0.05
Total	**1**	**0.05**

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates/Contract Researchers	2	1.8
PhD students	1	2.7
Masters students		
Temporary researchers		
Other		
Total	**3**	**4.5**

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
None	

9. Project Expenditure

Total expenditure of the project: € 195,443

Total Award by DAFM: € 222,772

Other sources of funding including benefit in kind and/or cash contribution(specify): € 0.00

Breakdown of Total Expenditure

Category	UCD	Name Institution 2	Name Institution 3	Name Institution 4	Total
Contract staff	70,586.02				70,586.02
Temporary staff					
Post doctorates					
Post graduates	58,666.61				58,666.61
Consumables	9,862.72				9,862.72
Travel and subsistence	7,114.12				7,114.12
Sub total	146,229.47				146,229.47
Durable equipment	3,635.33				3,635.33
Other	1,709.71				1,709.71
Overheads	43,868.84				43,868.84
Total	**195,443.35**				**195,443.35**

10. Leveraging

Summarise any additional resources'/funding leveraged by this award from other sources e.g. Additional Staff, National/EU funding secured, EI Commercialisation Fund, etc.

The SILF project was the foundation for developing a research programme that expanded environmental LCA to include social LCA and life cycle costing (LCC). A draft method for integration as a life cycle sustainability assessment tool was developed. This work has been leveraged to secure two H2020 projects: H2020: AgriChemWhey (H2020-BBI-JTI-2016) and H2020: Valumics (H2020-SFS-2016-2). The work has also been central to a SFI centre proposal (BEACON), and if funded will be at the heart of the 'sustainability' platform for this centre.

11. Future Strategies

Outline development plans for the results of the research.

The social LCA and Life Cycle Costing methods developed are being used in three H2020 projects: Agrocycle, AgriChemWhey and Valumics and the combined approach is being leveraged as part of a platform within a proposal for an SFI Bioeconomy Research Centre (BEACON), which is in the second stage of review at the time of writing.