Transform Dairy Net

D4.2 Resource flow diagrams

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Revisions

List of Acronyms

CCC	Cow-calf contact
EU	European Union
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
NNF	National Network Facilitator
NIP	National Innovation Practice Hubs
TDN	TransformDairyNet

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Keyword list

- Cow-calf contact systems
- Sustainability
- Carbon footprinting
- Water modelling
- Worker satisfaction
- Animal welfare

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1. Executive summary

There is increasing pressure on farmers to deliver high quality food with a low environmental impact. This concept is embedded in the European Union's Farm to Fork Strategy and is a key part of the European Green Deal. In regard to cow-calf contact (CCC) dairy systems, the lack of suitable models and methods that incorporate the important features of CCC systems is a major barrier to understanding the environmental, social and ultimately the economic impact of this new livestock farming system. The aim of this part of this deliverable was to produce resource flow maps (flowcharts, interpretive lists and diagrams) to explore the key differences between cow-calf contact systems and conventional dairy farms. This exercise will facilitate the modification of existing models and the collection of data. We aimed to assess carbon, water, antibiotic use, worker satisfaction (as an aspect of social sustainability) and animal welfare.

To this end, we consulted with NNFs, key stakeholders and TDN partners to identify the models currently used for carbon and water footprinting in dairy systems, and what are the key differences between CCC and conventional systems. Lists of key differences were compiled. Models were screened for relevance, opportunity to access the background coding to allow modifications and compliance with international standards (e.g., IPCC).
Key changes that must be implemented in models for carbon and water, and areas where CCC and conventional systems are likely to differ in antibiotic use, worker satisfaction and animal welfare were identified. These data can now be used to create new models and methods to characterise CCC systems in a fair and transparent way.

2. Introduction

Sustainability is at the heart of the of the European Union’s Farm to Fork Strategy and the EU Green Deal, due to the increase in societal pressure on livestock farmers to produce food in an environmentally sensitive manner, whilst safeguarding key attributes such as animal welfare and biodiversity.

The three pillars of sustainability are considered to be economics, environment and society. While the level of greenhouse gas emissions is typically viewed as the primary environmental concern, more recently sustainability has become more of a holistic concept, with water use, and cross-pillar concerns such as antibiotic use, animal welfare and worker satisfaction being included (Broom, 2023). In this project we use this broader vision of sustainability, because it allows the multi-faceted features of cow-calf contact systems to be considered. Cow-calf contact systems have the potential to deliver on a number of these sustainability themes. However, a key challenge for this system of dairying is that many of the models and methods created, particularly for assessing environmental impact, do not take into account key aspects of CCC systems. In particular, the models do not account for the reduction in saleable milk, where instead the ingestion of this milk by the calves allows them to be reared on the farm of origin, for veal or beef. For instance, most models of greenhouse gas emissions consider dairy and beef production separately.

This aim of Task 4.2 in the TransformDairyNet (TDN) project is to create new models or modify existing models to allow relevant sustainability metrics to be fairly and appropriately measured. The key areas to be addressed are carbon, water, antibiotic use, societal impacts and animal welfare. The first step in this process was to determine what models and methods are currently used in the European partner organisations. In the case of the models (i.e. for greenhouse gases and water), we also needed models that we could have access to the background coding so that we could alter them as required to take account of the CCC system characteristics. Once this was completed, we use flow diagrams to identify the key features that differentiate CCC systems from conventional dairying systems. By firstly identifying these characteristics, we can then build new or amended models and methods to hem into existing models.

3. Methods

To identify what GHG and water models are currently used by TDN project partners across Europe, we consulted with the NNFs (who asked their NIPs about the use of models), key stakeholders and TDN partners. We reviewed systems for assessing on-farm usage of antibiotics. Some countries have these data recorded on national databases, while in others, the data will need to be collected from farm management software or herd health books directly. We considered the appropriate methods for quantifying societal benefits such as animal welfare and worker satisfaction. The following sections show the outcomes of this work.

The feedback from the stakeholder groups and a review of key literature identified key features that differentiate CCC from conventional systems. Below we show the resource flow diagrams that outline the key points that differentiate the systems and allow the capture of relevant data.

4. Resource flow modelling outcomes

4.1 Carbon

Because of the importance of understanding the contribution of livestock farming systems to global warming, a number of tools for ‘carbon footprinting’ have been developed. Different countries often create their own models that reflect the characteristics of the local farming systems. However, each model must follow the Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC 2006, 2019), meaning that the underlying assumptions and key calculations are the likely the same for all models. A number of carbon footprinting models were considered including HolosNor (from Norway), BEK (Germany), a model under construction in Austria (from the CowTalk project) and AgreCalc (United Kingdom).

Figure 1 shows a typical flowchart for greenhouse gases within a livestock production system. Modelling carbon flows firstly requires that a ‘boundary’ is set to define the extent of the modelling. This can be at at the level of the farm (‘farm gate boundary’) or take into account inputs that originate outside the farm such as fertilizers, fuels, non-home grown feed and bedding. Consideration of this flow model shows that the key differences between conventional and CCC systems likely lie in the ‘livestock module’ and in the milk, animal and manure outputs.

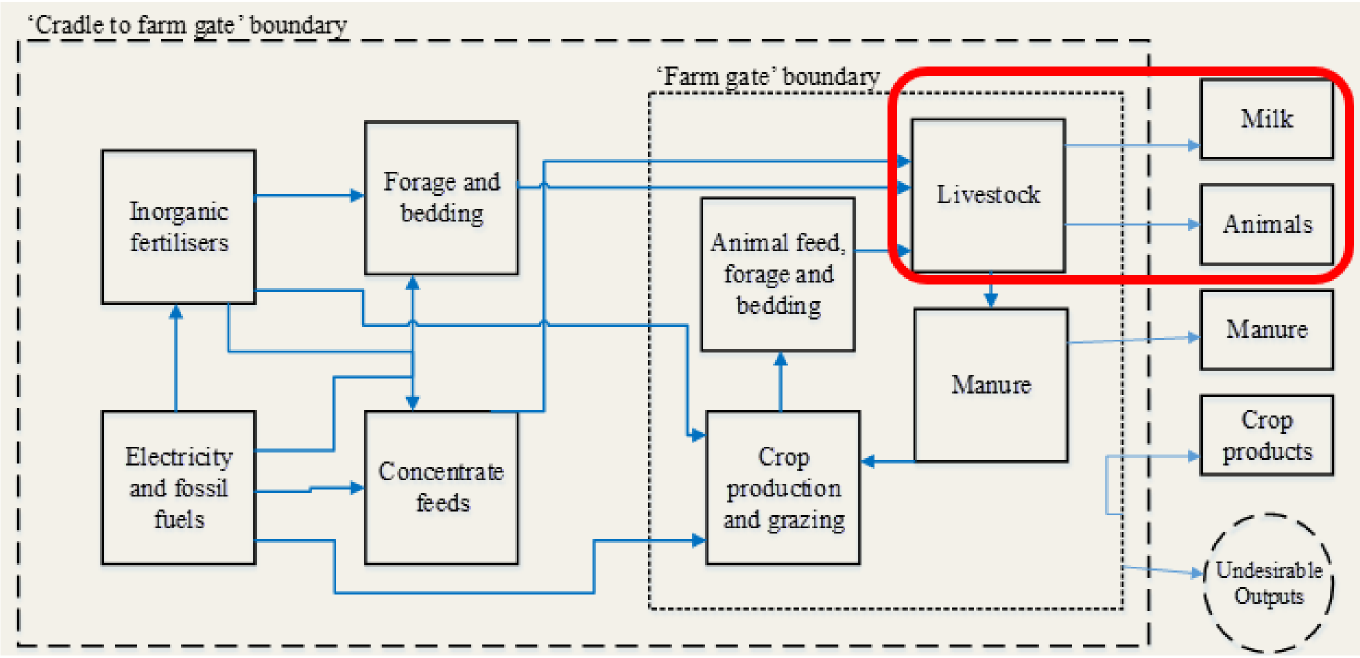

Figure 1. Diagram of carbon flows though a dairying system. System boundaries are shown with dotted lines. The models and outputs likely to differ between CCC and conventional systems are outlined in red.

Key differences between CCC and conventional systems:

1. *Milk drunk by calf vs milk harvested through the milking parlour:* an obvious key difference between CCC and conventional systems is that on CCC farms, the calf will drink milk from the dam or foster cow, so less is harvested in the milking parlour. This means that less milk is available for sale, but that does not mean that it is 'lost' as such, as it is consumed by the calf and contributes to its growth and development. This has a number of implications in terms of modelling the greenhouse gas output of the farm, including how to calculate emissions from the cow, and including calf growth (and health), and ultimately the meat as part outputs of the farm.
2. *Herd structure is different:* in CCC systems, calves are retained on the dairy farm of origin, and are reared and sold for rosé veal or beef. This means that there are more youngstock on the CCC farm than on a similar conventional farm. This has a number of implications including accounting for the emissions of the youngstock destined for beef on the dairy farm of origin.
3. *Percentage of milk fat:* It is well recognised that the percentage of fat delivered to the parlour is lower in CCC systems than in conventional systems (Barth, 2020). *This may affect mod*
4. *Milk replacer:* The calf on a conventional farm is fed on artificial milk replacer, which consists of milk replacer powder and water, with electricity used to deliver the milk in systems using automatic calf feeders.

5. *Cow and calf health*: it has been reported that calves are healthier on CCC systems than on conventional systems, and that cows may show lower incidences of udder disease. This will affect milk wastage and productivity. This will be further considered in the section on antibiotic use.
6. *Bedding*: it is possible that the bedding material used to house calves with cows may be different to that used when calves are housed alone.

4.2 Water modelling

Water use in livestock systems is a comparatively understudied area. The model developed by Hörtenhuber et al (2014) represents one of the few that is tailored to the dairy farm. As partners in this WP, it was an opportunity to use this model. Green, blue and grey water streams are differentiated and considered. The model uses that same inputs as carbon footprinting models, which will make data collection more efficient. Considering the flows in this model, it is likely that the inputs and outputs from animals and milk, and the forage, manure and bedding will differ between CCC and conventional systems.

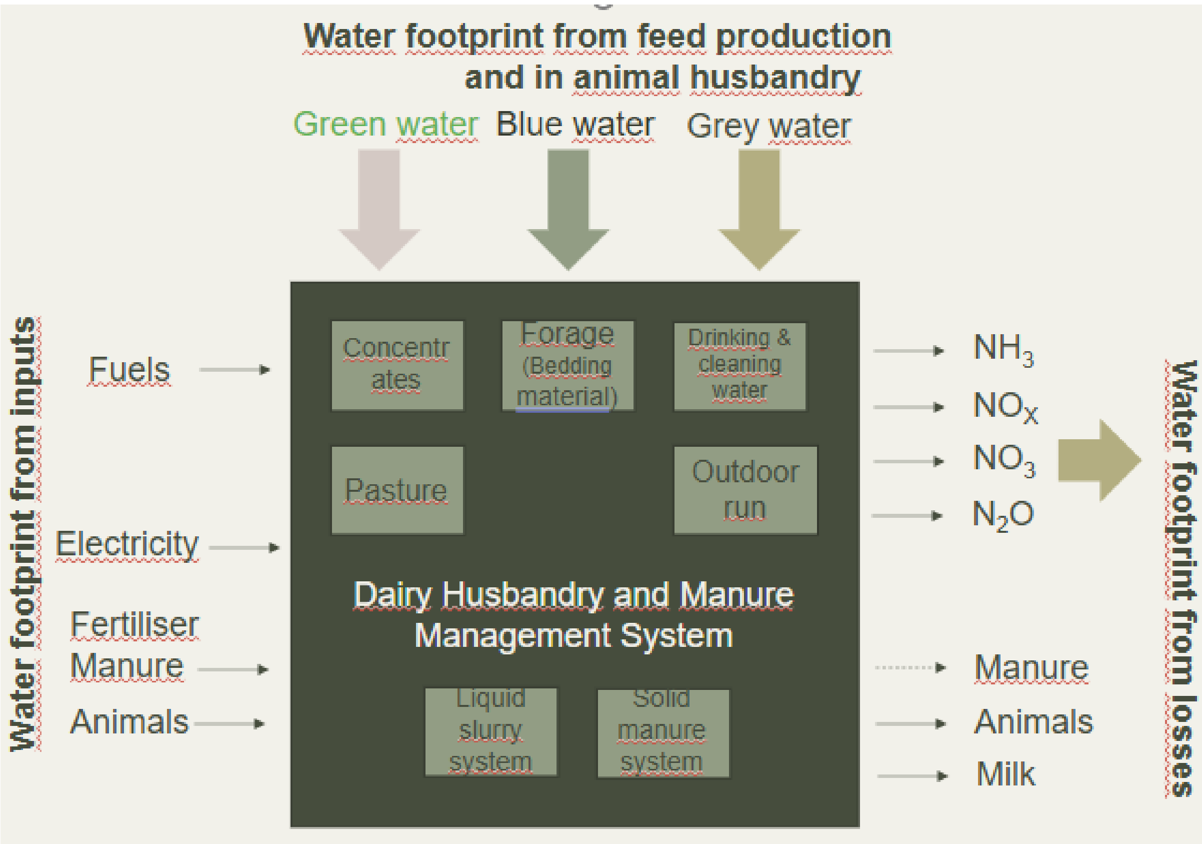

Figure 2. Diagram showing inputs and outputs of water and other resources (after Hörtenhuber et al., 2014).

Key differences between CCC and conventional systems:

1. *Herd structure:* as above, if calves are retained for rearing for beef, there will be larger numbers of youngstock retained on the dairy farm. This has implications for the amount of water used for aminal rearing.
2. *Water usage in feeding of milk replacer to calves:* in conventional systems, calves are fed milk replacer, which consists of powdered milk replacer mixed with water. Water is also used to wash equipment in a bucket rearing system.
3. *Water usage in the milking parlour:* cows are typically milk once per day in a CCC system whilst the calf is in the suckling phase. Less water is therefore needed to clean the milking parlour.

4.3 Antibiotic use

The use of antibiotics is typically calculated by using the farm inventory, farm management software or health logbook to determine the number of disease cases treated and the type and volume of antibiotics used. There are key areas where cow-calf contact systems may differ from conventional systems particularly for young calves and udder health in cows (Beaver et al., 2019; Wenker et al., 2022).

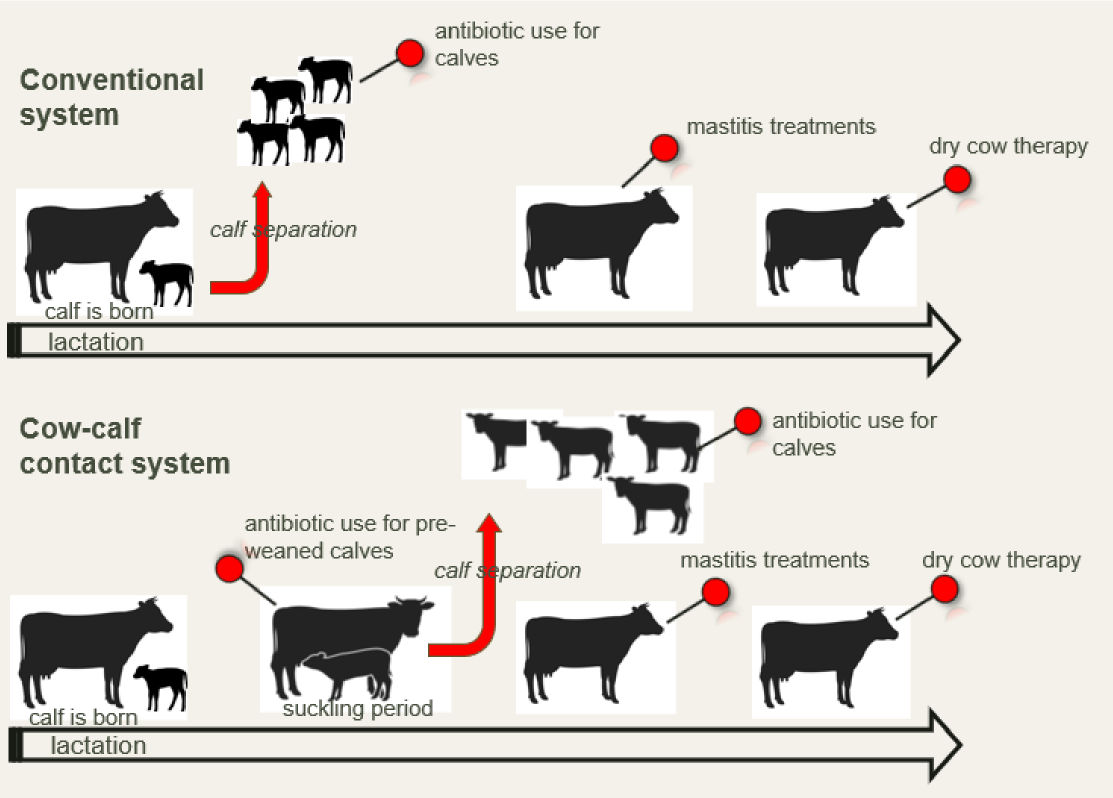

Figure 3. Diagram illustrating key differences between conventional and CCC systems for antibiotic use

Key potential differences between CCC and conventional systems:

1. *Use of antibiotics to treat calves:* there may be differences in the amount of antibiotics used to treat calf disease.
2. *Treatments for udder disease in cows:* there is some evidence that there are differences in incidence of mastitis between CCC and conventional systems (Beaver et a., 2019).

3. *Use of selective dry cow therapy:* there may be differences in use of selective dry cow therapy between CCC and conventional farms.

4.4 Worker satisfaction

The mental and physical experience of working on a CCC farm vs a conventional farm is an interesting but often overlooked aspect of sustainability. Satisfaction with the job itself and its effects on other aspects of life, influences the mental and physical health of farm staff and ultimately affects staff retention (Broom, 2021). Anecdotally, a notable aspect of CCC farming is the positive engagement of farmers and farm staff with the animals and the management system, but the reduction in saleable milk is not something that suits all farmers' expectations.

A worker satisfaction survey has been created by Rademann, Waiblinger and colleagues at VetMedUni (Vienna, Austria) and has been used in other projects to understand attitudes to work and its wider effects. This survey investigates the following domains: job satisfaction, free-time satisfaction, physical and mental load and workplace satisfaction. This will allow a comprehensive analysis of the experience of work while also capturing its effects on physical and mental health and flow-over effects on free-time.

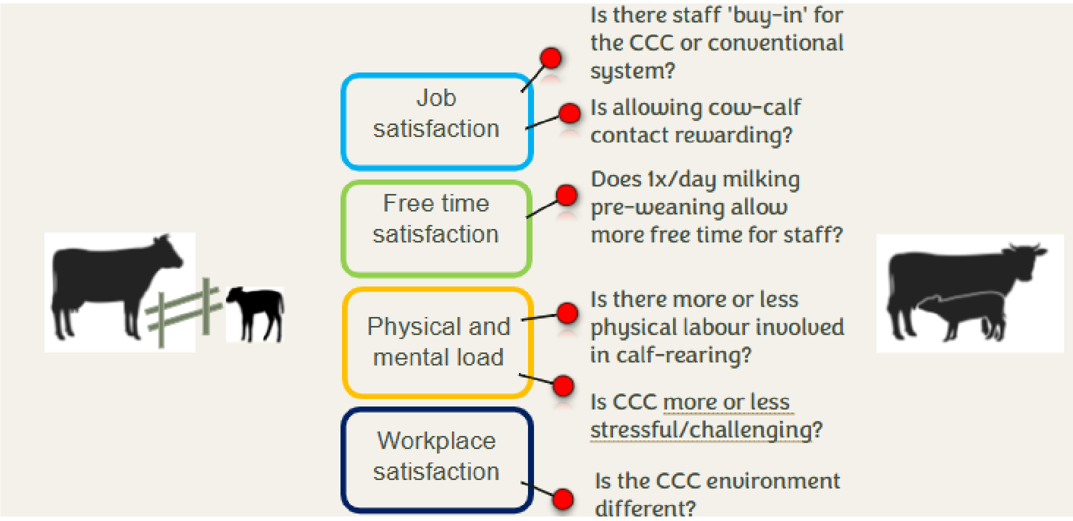

Figure 4. Diagram illustrating potential key differences between CCC and conventional systems for worker satisfaction

Key potential differences between CCC and conventional systems to be addressed by the survey:

1. *Work satisfaction:* Is work satisfaction on CCC farms different that that shown on conventional farms? Is there something inherently rewarding about CCC systems?
2. *Free-time satisfaction:* Is the work-life balance different?

3. *Physical and mental load:* Is working on a CCC vs a conventional farm stressful (negative) or engaged and challenging (positive)?

4.4 Animal welfare

A key aspect of the sustainability of CCC systems is the potential to deliver high standards of health and welfare. However, separation at weaning may be more stressful for cow and calf due to the strong bond created by the extended period together. The diagrm below illustrates key areas of positive and negative welfare impact.

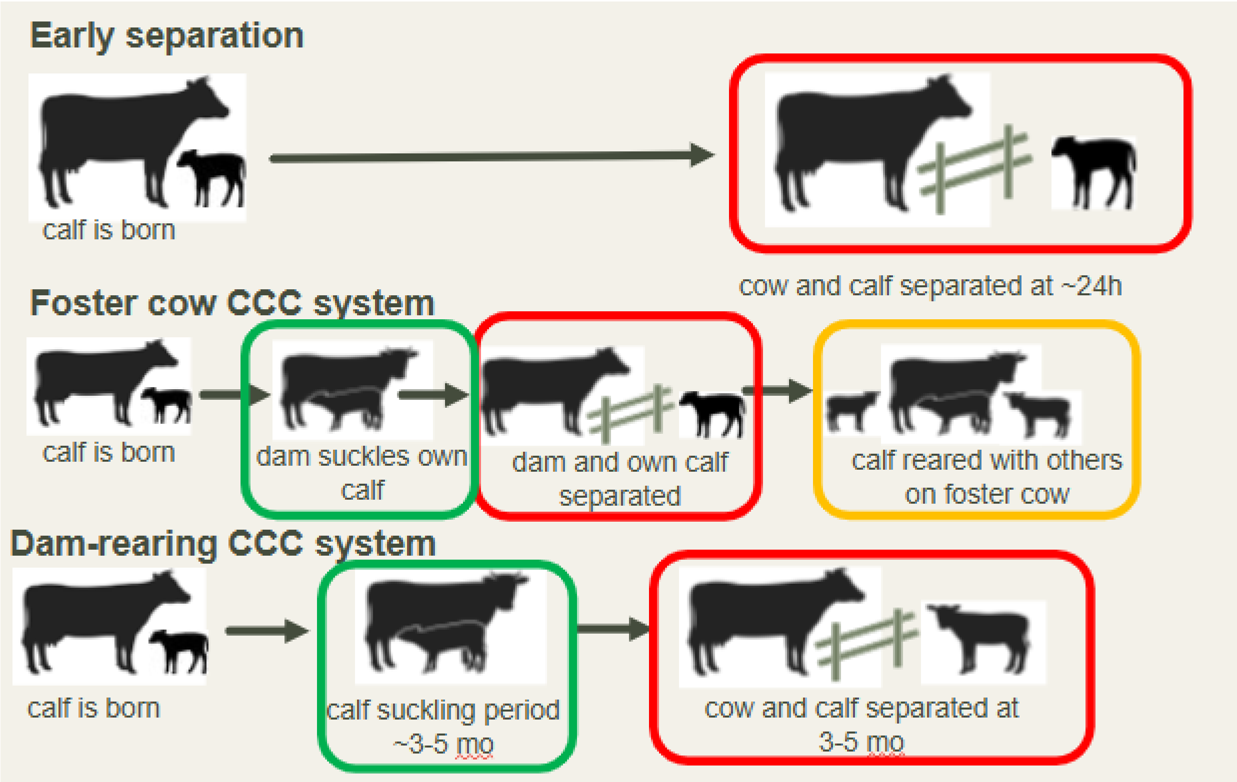

Figure 5. Figure illustrating the key periods with positive (green boxes), negative (red boxes) and mixed (orange box) impacts on welfare.

Key points where CCC systems may differ from conventional systems:

1. *Opportunity for prolonged social contact:* in a CCC and foster cow system, the cow and the calf have the opportunity to stay together over a period of weeks or months, depending on the farm strategy with regards

to weaning time. This has positive benefits for calf growth and social behaviour (Waiblinger et al., 2020, Foske-Johnsen et al., 2021)

2. *Weaning:* Early separation results in distress in cows and calves. However, separation after a prolonged period of contact is considered very distressing for both cow and calf (Eriksson et al., 2022; Whalin et al., 2025)
3. *Foster cow systems:* is the welfare experienced by foster cows and the calves fostered the same as in dam-rearing systems? Does it differ from conventional systems? These questions will likely be addressed as part of the wider TDN project.

5. Conclusions

A consideration of the models and methods used to assess carbon, water, antibiotic use and societal acceptance and worker satisfaction was carried out. Examination of the models allowed us to identify the key points that need to be considered to allow CCC systems and all of their attributes to be modelled appropriately.

To adjust existing models for carbon and water, we must take into account differences in herd structure, the allocation of milk to calf intake rather than being harvested by the milking parlour and the use of different types of bedding. Clearly in CCC systems, the saleable milk entering the bulk tank is less due to calves ingesting milk in the pre-weaning phase. Current carbon models use cow milk yield to calculate the methane emissions of the cow, therefore an estimate of total yield will be needed to allow this estimate to be meaningful. The milk ingested by the calves also contributes to their growth, and this should be adjusted in the model inputs. The use of milk replacer to feed calves, and requires water for mixing and for cleaning, which can be taken into account for the water model. The presence on the farm of calves being reared for veal or beef production are a major difference between CCC and conventional systems, and a major source of emissions and water use for the origin dairy farm. Accounting for these animals separately may be needed so that the emissions from the dairy and beef enterprises from CCC and conventional systems can be compared fairly.

Evidence suggests that the health of cows and calves may differ between CCC and conventional systems. The use of antibiotics in livestock system is believed to be associated with anti-microbial resistance, which has serious and negative implications for human health. We have identified that the use of antibiotics to treat calf disease primarily in the period post-weaning period, and for treating and preventing udder disease in the cows are keys issues to address.

In terms of societal sustainability, understanding the impacts of CCC and conventional systems on worker satisfaction is important. The importance of understanding the perceived levels of stress and positive outcomes have been identified, as well as the wider effects of work on life outside of work. Because cow-calf contact systems are primarily driven by a desire to improve animal welfare, including a consideration of this topic is central to this analysis. We have identified the key impacts for consideration here.

In future work, each of these features will be considered when re-designing models and creating data collection protocols for the next tasks within the project.

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