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Bridging environmental and financial cost of dairy production: A case study of Irish agricultural policy

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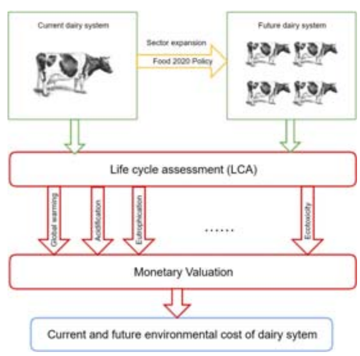
HIGHLIGHTS

- Monetary methods are effective tools to investigate the total environmental impacts in grazing based dairy system.
- The environmental costs of the Irish dairy system are greater than the financial costs.
- Irish 'Food 2020 policy' could reduce environmental and financial cost of milk production.
- Improved herbage and fertilizer management are main factors to reduce environmental costs.

GRAPHICAL ABSTRACT



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ABSTRACT

The Irish agricultural policy 'Food Harvest 2020' is a roadmap for sectoral expansion and Irish dairy farming is expected to intensify, which could influence the environmental and economic performance of Irish milk production. Evaluating the total environmental impacts and the real cost of Irish milk production is a key step towards understanding the possibility of sustainable production. This paper addresses two main issues: aggregation of environmental impacts of Irish milk production by monetization, to understand the real cost of Irish milk production, including the environmental costs; and the effect of the agricultural policy 'Food Harvest 2020' on total cost (combining financial cost and environmental cost) of Irish milk production. This study used 2013 Irish dairy farming as a baseline, and defined 'bottom', 'target' and 'optimum' scenarios, according to the change of elementary inputs required to meet agricultural policy ambitions. The study demonstrated that the three monetization methods, Stepwise 2006, Eco-cost 2012 and EPS 2000, could be used for aggregating different environmental impacts into monetary unit, and to provide an insight for evaluating policy related to total environmental performance. The results showed that the total environmental cost of Irish milk production could be greater than the financial cost (up to €0.53/kg energy corrected milk). The dairy expansion policy with improved herbage utilization and fertilizer application could reduce financial cost and minimize the total environmental cost of per unit milk produced.

1. Introduction

There are many environmental impacts associated with supply of dairy products to market, but the most significant environmental hotspot is the primary production on dairy farms (IDF, 2009;

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González-García et al., 2013; Guerci et al., 2013). Eide (2002) have shown that these impacts can degrade some of the ecosystem services that dairy production depends on, such as provision of feed, biodiversity (Knudsen et al., 2017) nutrient cycling (De Vries et al., 2015), and water purification, all of which can affect future production potential (Ogilvy, 2015). Ecosystem services (including natural resources) (MEA, 2005) and social capital (i.e. human relationships enabling a system to function) (Russell et al., 2013) are key, non-costed elements of agri-food production systems. Any environmental impacts from agri-food production that cause negative effects on these elements can reduce derived benefits and threaten sustainability (Edens and Hein, 2013).

Compared to other European countries, the environmental impact of Irish dairy farming contributes a larger share (approximately 10%) of national GHG emissions (O'Brien et al., 2014). Dairy farming also plays significant social (Läpple et al., 2012) and landscape maintenance (O'Donoghue et al., 2015) roles in Ireland, because of the rotational grazing system used (Fitzgerald et al., 2008). The environmental impacts of the grazing system are likely to be exacerbated, due to the sector transitions to more intensive production (Luo et al., 2013), in response to (i) abolition of EU milk quotas (DAFM, 2010), and (ii) the government policy "Food Harvest 2020" that set a production target of a 50% growth in milk volume by 2020 (DAFM, 2010). The subsequent policy "Food Wise 2025" intends to further increase the economic output of the agricultural sector while considering sustainability. Research has shown that the target could be achieved by improved herbage utilization (DAFM, 2015), and increasing grazing season length could also be beneficial (O'Brien et al., 2015). However, to date, there has been no research to investigate the effect of these agricultural policies on total environmental impacts of Irish milk production, including the non-costed element provided by ecosystem services and social capital (UNEP-SETAC, 2009).

In order to evaluate the total environmental impact of a system, suitable weighting methods are required for aggregating different midpoint level impacts. The most widely used weighting methods can be classified into two groups: non-monetary weighting and monetary weighting (Ahlroth, 2014). The proxy method is a non-monetary tool that weights selected environmental impacts according to specific criteria (e.g. scale and significance of environmental impacts). The scope of this approach is often limited to certain environmental impacts, for example, cumulative fossil energy demand (Huijbregts et al., 2006), or ecological footprint (Wackernagel et al., 1999). Panel weighting generates weighting factors for multi-criteria analysis using a panel of experts and stakeholders. However, the values from panel weighting can be influenced by the socio-economic status of the people in the panel (Govindan et al., 2015). The distance-to-target method may seem more objective, as it evaluates the distance between current and target environmental performance, but in many applications, the weights of different targets are assumed to be equal (Castellani et al., 2016). These drawbacks of non-monetary valuation methods make them difficult to apply across different regions and for aggregating into a comprehensive environmental impact indicator. Compared to non-monetary weighting methods, monetary valuation is an approach to aggregate impacts across the non-costed elements in a consistent manner (Ahlroth et al., 2011). The results of monetary valuation of environmental impacts have the same unit as financial accounting (e.g. $, € and other local currency), so producers and other stakeholders can easily identify the sustainability hotspots in production chains to understand the "real cost" of production. Suitable monetary valuation methods should be able to capture the hidden cost of environmental impacts on ecosystem, human well-being and natural resources (Weidema, 2006).

There are a number of monetary valuation methods available that can be grouped into three categories (Nunes, 2014): market demand approaches (market prices, travel cost, hedonic pricing), cost approaches (replacement cost, mitigation or averting expenditure, avoided damage cost) and non-market demand approaches (contingent valuation, choice experiment). These methods all suffer from deficiencies making no one approach ideal. Approaches founded on the contingent valuation method 'willingness to pay' principles (WTP) (Ahlroth et al., 2011), can be influenced by variation in social factors between different societies, and thus cause uncertainty when comparing the same environmental impacts for different social groups (Boyd and Banzhaf, 2007). To reduce uncertainty from social factors, some researchers have suggested that decoupling social costs from full environmental costs (Weidema, 2006) by focusing on natural capital consumption (e.g. resource productivity and ecosystem service) (Othoniel et al., 2015). Ecosystem services are especially important for agricultural systems. Nguyen et al. (2012) found that EU pork production systems had the most significant impacts on ecosystem service, and the impact on the natural capital of degraded ecosystem systems is not normally captured in financial accounting systems. In addition, to capture all environmental impacts from a system, a life cycle approach should be adopted (ISO, 2006). However, because of the difference in methodologies, not all monetary valuation approaches are compatible with life cycle assessment (Bagstad et al., 2013; Pizzol et al., 2015). And due to lack of international consensus on the value of environmental impacts, monetary methods are developed using various environmental cost values. In order to obtain robust and trustworthy results that can reflect the different values and views of nature and society, a mixed valuation approach has been suggested (Ahlroth et al., 2011; Weidema, 2015).

Iribarren et al. (2011) combined life cycle assessment and data envelopment analysis to evaluate the operational efficiency of a dairy farm from environmental and economic perspectives, but this included few impact categories. Weidema and Eder (2008) and Nguyen et al. (2012) are the very few studies that have attempted to use monetary valuation to aggregate the environmental impacts of livestock system. However, both studies had less focus on economic cost of system. And there is no attempt to capture the change of financial cost and environmental cost at the same time as the 'total cost' of production system. Although Weidema and Eder (2008) investigated the environmental cost of milk production systems in EU-27, they did not differentiate between confinement or grazing systems, which is known to be significant in terms of the impacts of dairy systems (O'Brien et al., 2012). In addition, it is known that agricultural policy can affect the specification of a dairy production system and its associated economic costs (O'Donoghue and Hennessy, 2015), but the effect of agricultural policy on environmental costs and economic costs remains poorly understood. Therefore, the aim of this work was to investigate the total environmental cost of a grass based, rotational grazing dairy system and the effect of the Irish agricultural policy 'Food Harvest 2020' on the total cost (financial cost + environmental cost) of milk production in Ireland, which could be used to formulate suitable policy for dairy sector expansion.

The structure of the manuscript is: (1) characterization of the average Irish dairy farm for baseline (2013) and projected (2020) systems; (2) an economic analysis of baseline and 2020 systems; (3) quantification of the environmental impacts of each system; (4) monetization of the environmental impacts using three LCA-compatible monetary valuation methods and evaluation of the uncertainty of the results by each method; and (5) analysis of total environmental cost and projected financial cost for baseline and 2020 to identify relationships and estimate the 'real cost' of Irish milk production.

2. Material and methods

2.1. System description and characterization of baseline scenario

Irish dairy production is dominated by grass-based rotational grazing system, which was modelled in Chen et al. (2016). This LCA model was used as basis for developing the system model for baseline scenario.