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ANALYSIS

Relating life cycle assessment indicators to gross value added for Dutch dairy farms

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ABSTRACT

Sustainable dairy production requires farms that are economically viable, environmentally sound and socially acceptable. A low environmental impact of milk production is not necessarily associated with an economically viable farm. To gain insight into a possible "trade-off" between economic and environmental sustainability, the relation between the environmental and economic indicators of dairy farms was quantified, and farm characteristics that influence this relation were identified. Economic and environmental indicators were quantified for 119 specialized dairy farms in 2005, based on data from the Dutch Farm Accountancy Data Network (FADN). Economic indicators used were: gross value added expressed per kg fat-and-protein-corrected milk (FPCM) or expressed per unit of labour, i.e. labour productivity. Environmental indicators used were: land use per kg FPCM, energy use per kg FPCM, global warming potential per kg FPCM, eutrophication and acidification potential per kg FPCM or per ha of land. Environmental indicators were deduced from a life cycle assessment. High labour productivity on dairy farms was associated with low on-farm energy use, total and on-farm land use, total and on-farm global warming potential, and total and off-farm acidification potential per kg FPCM. High labour productivity, however, was associated also with high on-farm eutrophication and acidification potential per hectare. From partial least squares regression analysis, it was concluded that relations between economic and environmental indicators were affected mainly by milk production per ha, annual milk production per cow, farm size, and amount of concentrates per kg FPCM. An increase in annual milk production per cow, for example, not only increased labour productivity, reduced energy use and global warming potential per kg FPCM but also, in the case of an unchanged stocking density, increased eutrophication and acidification per ha. To be economically and environmentally sustainable, animal production in the Netherlands, therefore, should focus on high animal productivity, i.e. high annual milk production per cow and efficient use of feed per kg milk, and moderate stocking density, provided that a good animal welfare standard is guaranteed.

1. Introduction

The concept of sustainability was introduced to address concerns about our future livelihood (WCED, 1987). Sustainability is a holistic concept consisting of three domains: economic, environmental, and social, also referred to as the three pillars: profit, planet, and people (Elkington, 1998). Most sustainability assessments of food production, however, address only one domain, e.g., the environmental impact of the production of food. Production of milk by dairy cattle, for example, contributes to nutrient enrichment of the ecosystem, climate change, and acid deposition. Life Cycle Assessment (LCA) is used to evaluate the environmental impact of a product throughout its life cycle (Guinée et al., 2002). Milk production by dairy cattle depends on many inputs, so the LCA method is justified to assess the environmental burden of milk production (Thomassen and de Boer, 2005; Dalgaard et al., 2006).

An LCA of milk production on dairy farms gives us insight into the environmental domain of sustainability or the "planet" pillar. Preferably, however, more than one domain of sustainability should be addressed (Glavič and Lukman, 2007; Ness et al., 2007; Van Passel et al., 2007). Production of milk is not sustainable without economically viable farms or the "profit" pillar (Van Passel et al., 2004). An understanding of the relation between economic viability and environmental impact of milk production, therefore, is a prerequisite for a better insight into sustainability and to contribute to decision making (Norris, 2001; Mouron et al., 2006). To understand this relation, the relation between economic viability (i.e. economic performance) and environmental impact (i.e. environmental performance) of dairy farms needs to be assessed. Such an assessment requires a relatively large number of dairy farms. Most LCA studies of milk production, however, are based on a limited number of farms, because data collection is time-consuming (Cederberg, 1998; Cederberg and Flysjö, 2004; Casey and Holden, 2005;

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Thomassen et al., 2008a). Performing an LCA of milk production for a large number of farms enables us to differentiate results among farms and to study the relation between their environmental and economic performance and their underlying characteristics.

The Farm Accountancy Data Network (FADN) of the Agricultural Research Institute in the Netherlands enabled us to perform an LCA and an economic analysis of milk production for a large number of individual farms (FADN, 2007). The objectives of this study, therefore, were to quantify the relation between the environmental and economic performance of FADN dairy farms, and to identify which farm characteristics influence this relation.

2. Materials and methods

2.1. Farm Accountancy Data Network (FADN)

The economic and environmental performance of specialized FADN dairy farms were analyzed for 2005. The Agricultural Economics Research Institute in the Netherlands continuously collects technical and economic data from a large sample of Dutch farms that are recorded in the FADN. In 2005, data from 271 dairy farms were collected. Organic farms (28) were excluded because this study focused on specialized conventional dairy farms. Conventional farms were selected only when at least 75% of the standardized gross margin of a farm (De Bont et al., 2003) originated from dairy activity and when no pigs and poultry were present. Specialized dairy farms are used in this LCA, because relevant inputs of these farms, such as purchased concentrates, could be allocated easily to the main farm activity, i.e., milk production.

Based on these selection criteria, 80 farms were excluded from the analysis. Lack of data needed to perform an LCA (e.g., grazing system, milk urea content) or inconsistency of data caused another 44 farms to be excluded from the analyses. In total, 119 dairy farms were analysed.

2.2. Environmental performance

The environmental performance of these 119 dairy farms was based on indicators derived from a Life Cycle Assessment (LCA). LCA is a method that evaluates the environmental impact of all processes in the life cycle of an activity, in this case the production of milk (Guinée et al., 2002). The four stages of an LCA are: goal and scope definition, inventory analysis, impact assessment and interpretation of results (ISO, 2006).

2.2.1. Goal and scope definition

The first stage, the goal and scope definition, consists of definition of the functional unit, choice of the method of allocation and the system boundary. An overview of different activities and choices in each stage is in Fig. 1. The functional unit was 1 kg of fat-and-protein-corrected milk (FPCM) leaving the farm gate (CVB, 2008). A cradle-to-farm-gate LCA implies that the environmental impact is assessed for all processes involved up to the moment that milk leaves the farm gate, such as production of concentrates and roughage, bedding material, and rearing of purchased animals. Transport associated with production of purchased inputs also was included. Production of medicines and machinery were excluded, however, because of their small impact (Cederberg, 1998). Buildings also were excluded, because similarity in buildings across farms was assumed (Erzinger et al., 2003).

The environmental impact of a multifunctional production process was allocated based on their relative economic value (Thomassen et al., 2008b). Multifunctional processes were production of feed ingredients and their co-products such as grain and straw, production of feed ingredients being a co-product, such as soy oil and soybean meal, and production of milk, meat and manure on the dairy farm. Furthermore, the impact of milk production on land use, energy use, acidification, eutrophication and climate change was assessed. These so-called impact categories are important when performing a cradle-to-farm-gate LCA of dairy farms (Berlin, 2002; Høgaas Eide, 2002; Thomassen et al., 2008a). Unlike categories of land use, energy use and climate change, which were expressed per kg FPCM, categories of acidification and eutrophication were expressed per kg FPCM or per hectare because they have a regional impact (Halberg et al., 2005). The categories human toxicity, terrestrial and aquatic eco-toxicity, biodiversity, soil quality, and water use were not addressed due to specific reasons. Human toxicity, terrestrial and aquatic eco-toxicity were not taken into account, because detailed data on pesticides and heavy metals of relevant inputs were not available. Biodiversity, soil quality and water use were not included,

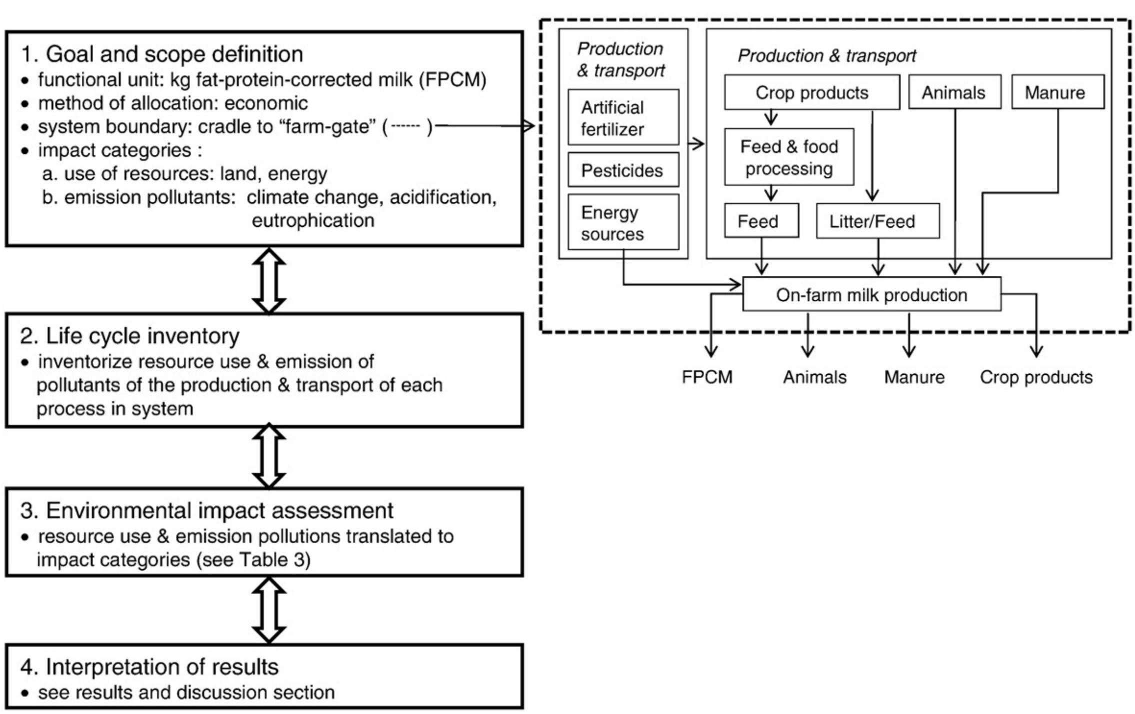

Fig. 1. Overview of specifics during each stage of the life cycle assessment of milk production.