Integrated ecological hotspot identification of organic egg production

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Ecological sustainability in agriculture is a concept that contains various environmental problems, which are caused by emission of compounds during different processes along the food chain. A precise ecological analysis of farming systems and food chains is needed in order to suggest and implement effective measures to improve sustainability. Life Cycle Assessment (LCA) assesses the environmental impact along the entire chain. In this research, LCA was used to locate environmental hotspots within the organic egg production chain and explore options that substantially improve ecological sustainability using sensitivity analysis. The environmental impact was expressed per kg of organic egg leaving the farm gate. Five environmental impact categories were included: 1) climate change i.e., emission of CO_2, CH_4 and N_2O, 2) eutrophication i.e., emission of NH_3, NO_x, N_2O and leaching of NO_3^- and PO_4^-, 3) acidification i.e., emission of NH_3, NO_x, and SO_x, 4) fossil energy use i.e., oil, gas, uranium and coal and 5) land use. In case of a multifunctional process, economic allocation was used. We interviewed 20 out of 68 Dutch organic egg farmers to collect farm data for 2006. Data on transport, feed, rearing and hatching were gathered by the conduction of interviews with suppliers and from literature. The Life Cycle Inventories of electricity, natural gas, tap water, transport and cultivation originated from the Eco-Invent V2.0 dataset. A sensitivity analysis was executed for production parameters from the laying hen farm. To identify hotspots, the relative contribution of transportation, feed production, rearing and hatching and the laying hen farm, as well as the contribution of various compounds to each impact category was determined. We identified a chain-compound combination as a hotspot if it contributed to more than 40% of the total of the environmental impact category. Results showed four hotspots. First, 62% of climate change was caused by emission of N_2O from soils during growing of feed. Second, 57% of acidification was caused by NH_3 emission from the laying hen farm. Third, 47% of energy use was oil used for cultivation of feed and fourth, 95% of the land use was arable land required for feed production. We identified no hotspot for eutrophication, but feed production contributed most with 37% nitrogen leaching and 26% PO_4^- leaching. From the sensitivity analysis it appeared that the most sensitive parameters on an organic laying hen farm are the number of produced eggs, the amount of feed consumed and the housing system. An increase in average egg production from 276 with a SD of 39 eggs per laying hen reduced climate change with 13%, acidification with 15%, eutrophication with 13%, energy use with 12% and land use with 12%. A reduction in average annual feed consumption from 42.9 kg with the SD of 7.2 kg per laying hen reduced climate change with 14%, acidification with 17%, eutrophication with 15%, energy use with 14% and land use with 13%. A shift from deep litter housing to an aviary housing with manure drying reduced climate change with 11%, acidification with 53%, eutrophication with 18% and had no effect on land use. The effect on energy use is still being assessed. We conclude that feed conversion and housing are effective ecological optimization options for organic laying hen farmers. However ecological sound feed production also needs attention.