Carbon footprint of sheep production systems in semi-arid zone of Chile: a simulation-based approach of productive scenarios and precipitation patterns

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Abstract

Grassland based sheep production systems in the semi-arid to sub-humid Central region of Chile are expected to improve technical and economic efficiency, while at the same time decreasing emissions of greenhouse gases (GHG). An existing empirical, stochastic simulation model of grazing sheep production was modified to allow for a cradle-to-farm-gate quantification of GHG under a large number of scenarios. The model includes pasture availability and utilization, supplementation of sheep, milk and lamb production, and carbon sequestration by forages and soils among others. Simulated scenarios included factorial combinations of a range of farm types previously typified and a range of sheep management practices, and their interaction with dry, average, or rainy years that affected grass growth. The carbon footprint (CF) was calculated for 20 runs of each case. Numerous interactions between animal outputs, forage availability and CF, as well as trade-offs, were found. Rainfall patterns had a significant effect on range and sown pastures yields when other factors were kept constant. A decrease of 32% in average rainfall for a dry year resulted in a reduction of forage production of 13%, whereas a rainy year with rainfall 36% higher than average, increased it by 12%, Forage yields had a significant effect on CF. Three different farm types showed CF of 7.4 to 13.3 CO2-eq·kg− 1 LW− 1. Farms that used higher inputs had higher forage production and lower CF, which decreased further if soil C sequestration is accounted for. Large farms that had lower stocking rates than the rest, and that used Merino sheep with high reproductive rates, had lower CF than the smaller farms that make a more intense land use. Reproductive rates had a large and significant effect on CF as they determine the number of ewes required to maintain constant production and overall flock composition. The average CF for lamb production across all scenarios was 14.8 kg CO2-eq·kg LW− 1, and decreased by 2 kg CO2-eq·kg LW− 1 when carbon sequestration was accounted for. The simulated systems were stable in years with average rainfall, but their sustainability seems fragile if faced with a sequence of dry years. It is concluded that the abundant interactions between the rainfall pattern and management variables would be difficult to study in field experiments, and that simulation modelling is a powerful tool to assess the consequences of numerous climate and production scenarios.

Keywords: Climate change||Sheep production||Simulation||Carbon footprint
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