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5s2: The environmental and economic consequences of adoptig circularity at different spatial scales

The impacts of a collective biogas unit on circularity of nutrient and energy flows for a group of dairy farms

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Improving the circularity of nutrient flows beyond the farm scale is a recognized alternative pathway for agriculture to reduce its environmental impacts. Circularity involves closing gaps in nutrient flows and improving the efficiency of nutrient use with a system approach. However, enhancing circularity at the territorial scale requires a multi-objective, multi-actor approach. Biogas production through anaerobic digestion is one such technology that can partially address these challenges of circularity of nutrient flows combined with renewable energy production. Yet, it is essential to understand the impacts of the implementation of a biogas unit on the cropping system and material flows of the farms involved. The installation of a biogas unit impacts farmers who must adapt their cropping system practices to both supply the plant with feedstocks and receive a share of the biogas digestate in return. The article examines the environmental impacts of a collective biogas unit for a group of dairy farming systems. Using spatially explicit plot-level survey data, we construct a nitrogen and energy budget for the group of farms involved and highlight changes in flow circularity after the installation of the collective biogas unit. We build scenarios that take into account the technical and environmental regulations constraints of the main farmers and the biogas producer. With an integrative modeling approach, we characterize in each scenario the indicators of nutrient circularity and the energy return on energy invested. We also design a framework incorporating the gradual learning curve of farmers over several years to adapt their cropping system practices with the new biogas unit. This framework highlights the various effects on farming practices and production orientations - associated with the replacement of nitrate-fixing intermediate crops with energy crops and the substitution of livestock manure with biogas digestate. The case study is a biogas plant project involving a group of ten farmers on 744 hectares in a context of a dairy production area in Brittany, France. Our results show that, on average, each farm's nitrogen use efficiency could improve by 20% and that the group of farms would reduce their dependence on industrial nitrogen fertilizers by up to half. The biogas produced is 40,000 GJ per year. This is more than the energy invested in the farms before the plant. However, the plant needs additional feedstock from the local agri-food industry and excess digestate from the biogas plant must be exported for land spreading outside the dairy farm group.

Keywords: