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Pesticide use under the influence of socio-economic and climate change: Pest-Agri-SSPs

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Pesticide use is a crucial human-driven change in the Anthropocene that negatively impacts the environment and ecosystems. While pesticides are essential to agriculture to sustain crop production and ensure global food security, they also lead to significant environmental impacts. The export of pesticides after application from the agricultural fields threatens the soil, groundwater and surface water quality in many world regions. Pesticide use is constantly increasing globally, driven mainly by agricultural intensification, despite stricter regulations and higher pesticide effectiveness. To enhance the understanding of future pesticide use and emissions and make informed farm-to-policy decisions, we developed Pesticide Agricultural Shared Socio-Economic Pathways (Pest-Agri-SSPs) in six steps. The Pest-Agri-SSPs are based on an extensive literature review and expert knowledge, considering significant climate and socio-economic drivers from farm to continental scale in combination with multiple actors impacting them. In the literature, pesticide use is associated with farmer behaviour and agricultural practices, pest damage, technique and efficiency of pesticide application, agricultural policy and demand for agricultural products. Here, we developed Pest-Agri-SSPs upon this understanding of pesticide use drivers and relating them to plausible sectoral developments, as described by the Shared Socio-economic Pathways for European agriculture and food systems (Eur-Agri-SSPs).

The Pest-Agri-SSPs present European pesticide use in five scenarios with low to high challenges to climate change adaptation and mitigation up to 2050. The most sustainable scenario (Pest-Agri-SSP1) shows a decrease in pesticide use owing to sustainable agricultural practices, technological advances and a pro-environmental orientation of agricultural policies. On the contrary, the Pest-Agri-SSP3 and Pest-Agri-SSP4 show an increase in pesticide use resulting from high challenges from pest pressure, resource depletion and relaxed agricultural policies. Pest-Agri-SSP2 presents a stabilised pesticide use resulting from strict policies and slow transitions by farmers to sustainable agricultural practices. Pest-Agri-SSP5 shows a decrease in pesticide use for most drivers, influenced mainly by rapid technological development and the application of sustainable agricultural practices. However, Pest-Agri-SSP5 also shows a relatively low rise in pesticide use driven by agricultural demand, production, and climate change. Our results highlight the need for

a holistic approach to tackle pesticide use and emissions, considering the identified drivers and future developments. The storylines and qualitative assessment provide a platform to make quantitative assumptions for numerical modelling and evaluating policy targets.

Keywords: Farm characteristics, pest damage, technology, policy, socioeconomic, agriculture and food systems

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