WP 5: Sustainability of agricultural management strategies at the catchment-scale

Agricultural production in Europe has significantly increased food security but has simultaneously damaged soil and water resources as well as ecosystem biodiversity, and has contributed to climate change (EEA, 2015). This is in part due to elevated inputs of nitrogen (N) and phosphorus (P) to the soil (Pretty, 2008; Tonitto et al., 2006), the migration of pesticides from agricultural fields into surface waters (EU, 2013; Reemtsma et al., 2013), and increased mechanization. Furthermore, declining soil organic carbon (SOC) and increasing soil compaction are recognized as major soil threats in Europe (European Commission, 2012; Van-Camp et al., 2004), and understanding carbon dynamics in agricultural soils is important for mitigating carbon losses (Dawson and Smith, 2007).

Sustainable intensification of agriculture is needed to increase crop production while also managing natural resources sustainably and minimizing environmental impacts. This requires the integration of technologies, practices and natural processes to manage pests, nutrients, and soil and water quality. WP5 focuses on the development of decision support tools to analyze agricultural management impacts related to (1) pesticide use, (2) soil fertility (focusing on soil organic carbon as well as the nutrients N and P), (3) soil compaction, (4) water quality (focusing on N, P and pesticides), and (5) trade offs with crop production. Two separate PhD projects collaborate on these aspects with the idea of creating integrated or complimentary decision support systems (DSSs).

ESR 14 Madaline Young, Wageningen University (NL): Developing a decision support framework to evaluate the impacts of agricultural management on crop yield, soil quality, and environment

Numerous management strategies already exist to improve nutrient use efficiency, profitability, and environmental impact. However, there is a gap in knowledge on the combined impacts of these management approaches on crop yields, soil quality and environment as well as on optimal combinations of practices given those impacts. DSS science has existed for decades (Power, 2007) and can be used to assess the integrative impacts of agricultural measures, with multi-criteria decision-making being an important development for evaluating agricultural land (Parsons, 2002). Addressing the complexity of management interactions on soil systems and available win-wins and trade-offs, as well as focusing on the dependency of management impacts on local agro-ecosystem properties will ultimately boost long-term agricultural sustainability (Lin, 2011). A user-friendly decision support tool integrating both environmental and agronomic issues within a spatially explicit framework can guide farmers, local and regional policymakers, and fertilizer industry and advisory companies in developing high-impact management strategies.

Madaline will develop a decision-making framework to evaluate the impacts of nutrient, soil and crop management measures on both agricultural production and environmental impacts to maximize crop yields and minimize environmental impacts. Impacts will focus on the soil balance of C, N, and P and on soil compaction, while integrating spatial and temporal scales. A set of sustainability indicators will be used, linked to nutrient, soil, and crop management practices and informative on yields as well as soil organic carbon, nutrient use efficiency and compaction. Using a combination of meta-analysis and process-based modelling, she will quantify the various effects of management practices on the impacts in question, using the indicators as a metric. The second stage of the project will involve creating a DSS tool for evaluating management practices in terms of soil functionality, nutrient budgets, and related environmental impacts. Multi-criteria analysis will be used to assess multiple goals, trade-offs, and management-impact relationships, based on the distance of sustainability indices to target or critical values. The final step is validating the DSS on long-term experimental data and testing its use for farmer stakeholders as well as for providing management recommendations for typical farms in north-western Europe.

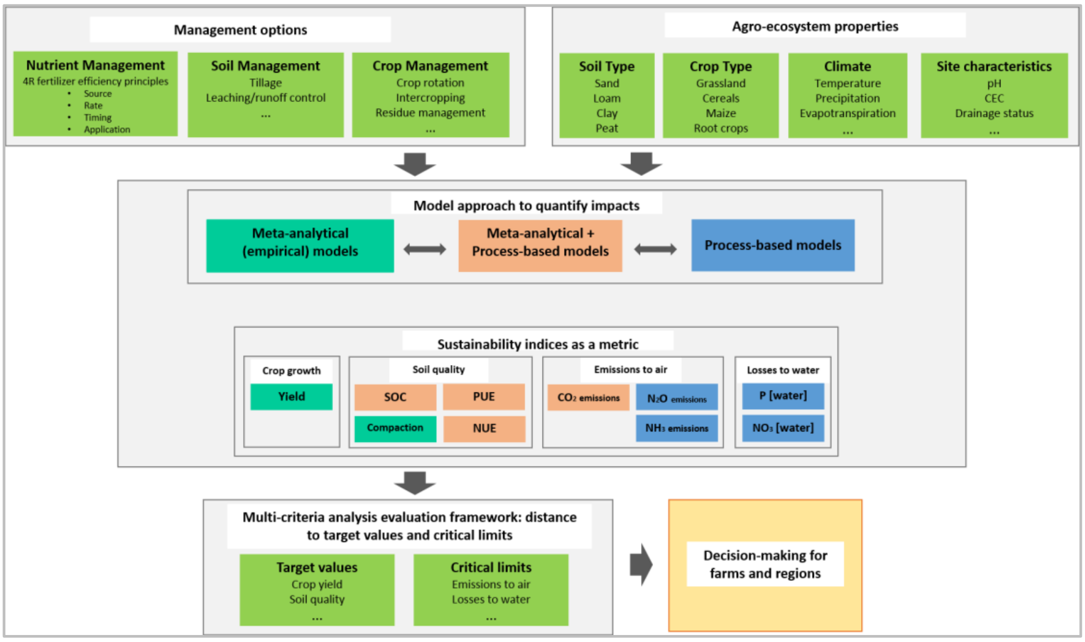

Figure 1 DSS development approach

ESR 15 Gisela Quaglia, Flemish Institute for Technological Research (BE): Developing a framework to establish cost-effective measures to reduce pesticide impacts on a catchment-scale

The use of pesticides during agricultural production negatively influences water quality and is a major threat to aquatic ecosystems (Bereswill et al., 2014; EU, 2013). Without treatment or targeted mitigation, pesticide pollution is diffused into the environment (Gregoire et al., 2009). Therefore, there is an increased interest in the implementation of agricultural mitigation measures to reduce the environmental impact of pesticides and to reach desired water quality levels (European Commission, 2009, 2000).

There is no perfect unique solution to deal with pesticide input to water bodies (Reichenberger et al., 2007). Consequently, a holistic catchment-scale approach is required for implementing measures (Babut et al., 2013; Brack et al., 2009). Integrated evaluation is needed at the catchment scale, focusing on the combined effects of several mitigation strategies rather than an isolated measure as well as quantifying the effectiveness in reducing pesticides losses towards surfaces water. This has scarcely been attempted altogether. Field experiments under realistic and representative conditions need to be conducted to validate the models and measure the effectiveness of the applied measures.

Gisela focuses on developing targeted pesticide mitigation strategies, monitoring their impact on water quality, and developing an assessment framework to select cost-effective measures to reach a pesticide reduction goal, all at the catchment scale. This study will lead to a practical tool to monitor the pesticide management implementation process and will support good practice in linking science to the farm sector and increasing farmer awareness. Furthermore, other win-win strategies or co-benefits that can be established for topics such as erosion control and nutrient abatement will be taken into account in this study.

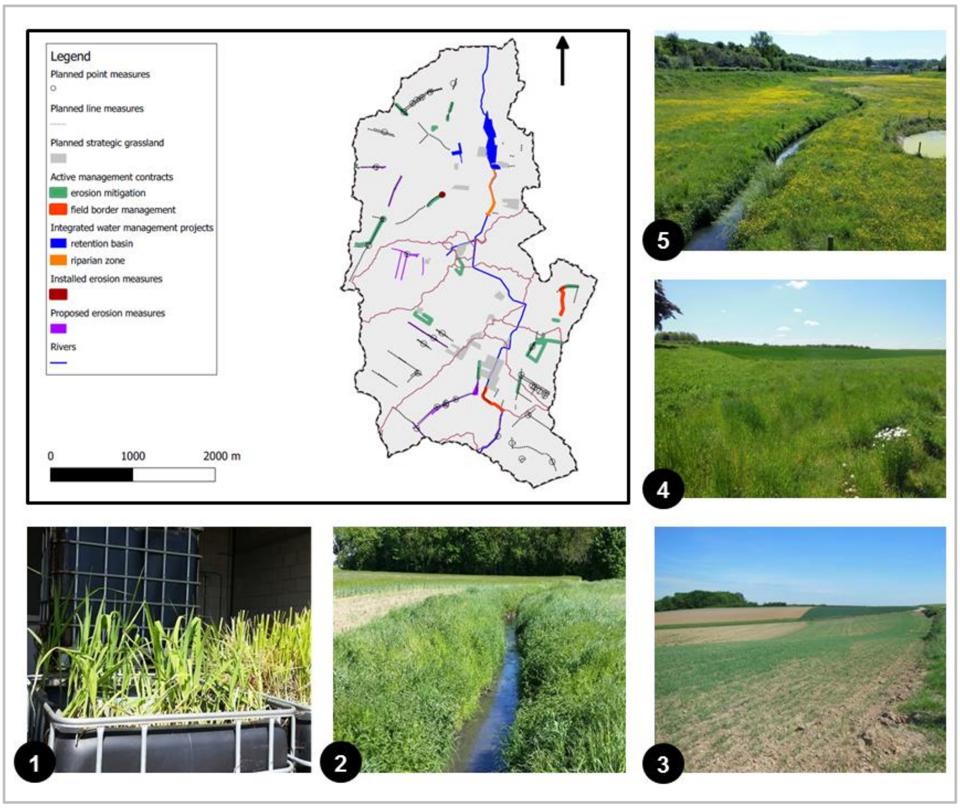

Figure 2 Catchment spatial setting for mitigation measures for pesticides. 1) Biofilter to reduce point losses 2) riparian grass strips 3) strategic grassland areas 4) Grass buffer strips in field borders 5) retention basin

Babut, M., Arts, G.H., Barra Caracciolo, A., Carluer, N., Domange, N., Friberg, N., Gouy, V., Grung, M., Lagadic, L., Martin-Laurent, F., Mazzella, N., Pesce, S., Real, B., Reichenberger, S., Roex, E.W.M., Romijn, K., Röttele, M., Stenrød, M., Tournebize, J., Vernier, F., Vindimian, E., 2013. Pesticide risk assessment and management in a globally changing world-report from a European interdisciplinary workshop. Environ. Sci. Pollut. Res. 20, 8298–8312. doi:10.1007/s11356-013-2004-3

Bereswill, R., Streloke, M., Schulz, R., 2014. Risk mitigation measures for diffuse pesticide entry into aquatic ecosystems: Proposal of a guide to identify appropriate measures on a catchment scale. Integr. Environ. Assess. Manag. 10, 286–298. doi:10.1002/ieam.1517

Brack, W., Apitz, S.E., Borchardt, D., Brils, J., Cardoso, A.C., Foekema, E.M., van Gils, J., Jansen, S., Harris, B., Hein, M., Heise, S., Hellsten, S., de Maagd, P.G.-J., Müller, D., Panov, V.E., Posthuma, L., Quevauviller, P., Verdonschot, P.F., von der Ohe, P.C., 2009. Toward a Holistic and Risk-Based Management of European River Basins. Integr. Environ. Assess. Manag. 5, 5. doi:10.1897/IEAM_2008-024.1

Dawson, J.J.C., Smith, P., 2007. Carbon losses from soil and its consequences for land-use management. Sci. Total Environ. 382, 165–190. doi:10.1016/j.scitotenv.2007.03.023

EEA, 2015. State and Outlook 2015 the European Environment. European Environment Agency, Copenhagen. doi:10.2800/944899

EU, 2013. Rural development in the European Union – Statistical and economic information – Report 2013.

European Commission, 2012. JRC Reference Reports: The State of Soil in Europe. Publications Office of the European Union, Luxembourg. doi:10.2788/77361

European Commission, 2009. Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. Off. J. Eur. Union. doi:10.3000/17252555.L_2009.309

European Commission, 2000. Directive 2000/60/EC Framework for Community action in the field of water policy.

Gregoire, C., Elsaesser, D., Huguenot, D., Lange, J., Lebeau, T., Merli, A., Mose, R., Passeport, E., Payraudeau, S., Schütz, T., Schulz, R., Tapia-Padilla, G., Tournebize, J., Trevisan, M., Wanko, A., 2009. Mitigation of agricultural nonpoint-source pesticide pollution in artificial wetland ecosystems. Environ. Chem. Lett. 7, 205–231. doi:10.1007/s10311-008-0167-9

Lin, B.B., 2011. Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change. Bioscience 61, 183–193. doi:10.1525/bio.2011.61.3.4

Parsons, J., 2002. Agland Decision Tool : A Multicriteria Decision Support System for Agricultural Property 181–186.

Power, D.J., 2007. A Brief History of Decision Support Systems. DSSResources.COM.

Pretty, J., 2008. Agricultural sustainability: concepts, principles and evidence. Philos. Trans. R. Soc. B Biol. Sci. 363, 447–465. doi:10.1098/rstb.2007.2163

Reemtsma, T., Alder, L., Banasiak, U., 2013. Emerging pesticide metabolites in groundwater and surface water as determined by the application of a multimethod for 150 pesticide metabolites. Water Res. 47, 5535–5545. doi:10.1016/j.watres.2013.06.031

Reichenberger, S., Bach, M., Skitschak, A., Frede, H.G., 2007. Mitigation strategies to reduce pesticide inputs into ground- and surface water and their effectiveness; A review. Sci. Total Environ. 384, 1–35. doi:10.1016/j.scitotenv.2007.04.046

Tonitto, C., David, M.B., Drinkwater, L.E., 2006. Replacing bare fallows with cover crops in fertilizer-intensive cropping systems: A meta-analysis of crop yield and N dynamics. Agric. Ecosyst. Environ. 112, 58–72. doi:10.1016/j.agee.2005.07.003

Van-Camp, L., Bujarrabal, B., Gentile, A.R., Jones, R.J.A., Montanarella, L., Olazabal, C., Selvaradjou, S., 2004. Reports of the Technical Working Groups Established Under the Thematic Strategy for Soil Protection. Office for Official Publications of the European Communities, Luxembourg.