Technical sheet

Policy
Europe: *Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021, RDPs (Pillar I and II), CAP; Reg. 1698/05 1974/06 (rural development) Reg. 1306/2013 (cross-compliance). Dir.91/676/EEC (Nitrates Directive), EU Soil Strategy for 2030 COM(2021) 699 final*
Austria, Hungary, Italy: *CAP Greening Payment Requirements and GAEP Cross-Compliance Standards, Austrian Programme of agri-environmental measures (Austria), Act on the Protection of Cultivated Soil (Hungary), Regional RDP; dlgs 18/05/01 no. 227 (Italy)*

First draft

TOOL NITRATE FATE – *Territorial Scale: Regional*

WHY

Agriculture is one of the main production systems and it is strongly supported and regulated by the EU Common Agriculture Policy (CAP). Agriculture is not only responsible for food production but it is also the main responsible of nonpoint source pollution of water, i.e. the nitrate coming from fertilization leached below the soil towards the groundwater. However, agriculture is capable for preserving and safeguarding the environment, e.g. the water bodies, when it is properly managed. The modelling analysis that is performed with the Nitrate fate tool can give clear results about the environmental impact, in terms of nitrate leaching, in a given area in what-if scenarios of field management. The tool operates thanks to the coupling of the process-based dynamic crop-growth model (Armosa) and the TFM-ext transport model, into the LANDSUPPORT geoSpatial Decision Support System (S-DSS).

FOR WHOM

This tool is targeted to Public Authorities (e.g. Regions, Environmental Agencies), and to whom are interested in the quantification of the environmental impact associated to the crop production, namely the nitrate leaching, in contrasting field management options. For instance, the user could be interested in comparing two scenarios (e.g. conventional vs conservation agriculture) and assess the relative groundwater vulnerability to nitrates in a specific region of interest.

HOW – if you want to *select your Region Of Interest (ROI)*[i]

The tool is actually applied to the regional case studies of Marchfeld (Austria), Zala County (Hungary) and Campania region (Italy). It allows the free selection of any region of interest (ROI) following a very simple procedure:

Operational procedure

- Click on the "Draw (Polygon)" button on the top bar, draw the desired area (ROI) and assign it a name[ii].
- Use the "Save" button to store the ROI in the memory of the system. It is then possible to select it whenever necessary.

CROP SOIL MODEL – FULL VERSION

HOW

Operational procedure

The Nitrate fate tool can be selected from the toolbox of the Graphic User Interface: Agriculture > Full version (the button on the bottom) > Regional scale (Campania, Marchfeld, Zala County) > Toolbox > Challenge land degradation and SDG 15.3 > Nitrates and Pesticide directives > Groundwater vulnerability (dynamic modelling) > Nitrate fate.

The interface pops up and here the user finds a long list of crop rotations. These rotations are the most common in the examined area, for both conventional and organic production systems. Different levels of irrigation can be simulated, responding to the aim of restoring 100% or 80% of the maximum crop request. It is possible to simulate the application of mineral and/or organic fertilizer. Tillage offers two options: “conventional”, which means that the Armosa model simulates ploughing at 30 cm soil depth, “Minimum Tillage”, which means that the Armosa model simulates a limited perturbation of the 15 cm topsoil layer with no soil layers mixing. The user can choose whether or not crop residues are retained in the field. Eventually, different climate scenario (current, near and far future under RCP4.5 and RCP8.5) within the dropdown list can be chosen.

After having defined the management, the Armosa model will simulate the nitrogen cycle and produce the nitrate leachate below the root zone depth. This, together with the steady state water flux, will feed the TFM-ext model, which will take care of the transport of Nitrate (considered as a non-reactive solute below the root zone) till the groundwater table depth.

The S-DSS will return the maps of the years for the arrival at the GW table depth of the 50 % root leachate, produced by the Armosa model. Green colour is associated to low vulnerability (>18 years for the 50% arrival), yellow to medium (12-18 years), orange to high (6-12 years) and red to elevated (0-6 years).

Besides, the end-user will have access to the full table with all the info regarding the soils, the groundwater table depth, the selected crop. Eventually, by clicking on the “Action” button in the last column of the full table, a graph shows, for each soil polygon within the ROI, the time evolution of the arrival concentration (mg/l) at the groundwater depth.

Figure 1 shows the scheme of the models coupling, Figures 2 and 3 are screenshots of the results visualization (tables and maps).

What for

The results give a clear geospatial quantification of the groundwater vulnerability of the climate-soil-groundwater physical system of the area, under the typical crop systems and related management practices. The tool supports the protected area zoning and the best practice adoption in a varying pedoclimatic and farming conditions.

Figure 1. Coupling of Armosa model and TFM-ext model

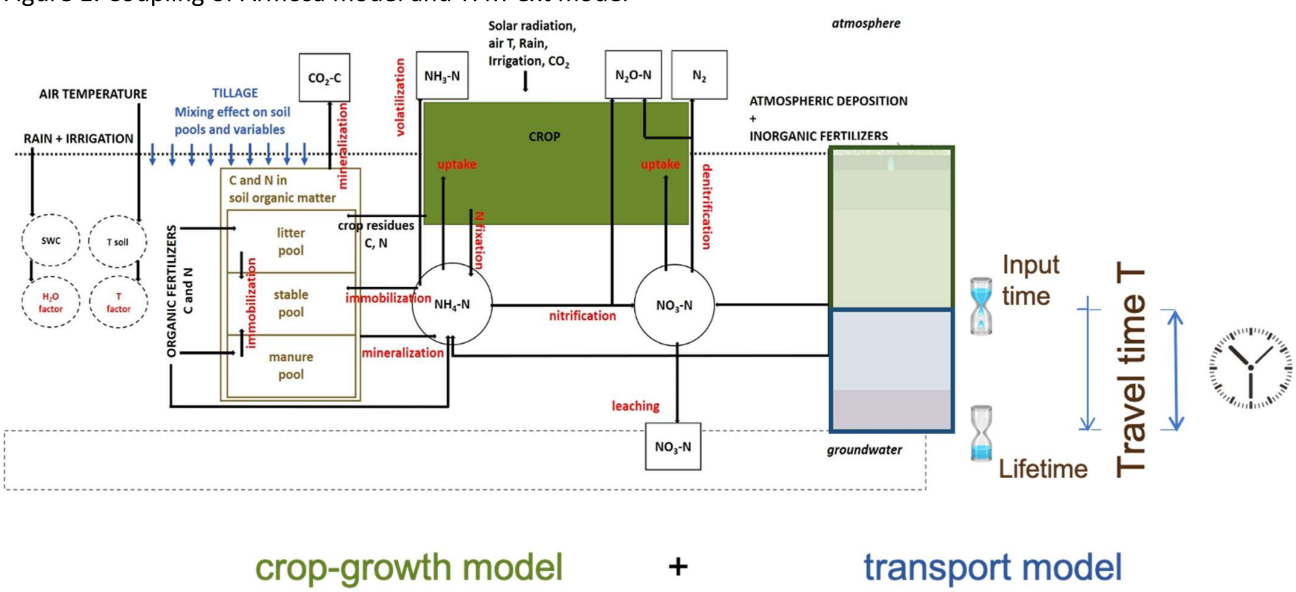

Figure 2. Table of results of the Nitrate fate tool

Results

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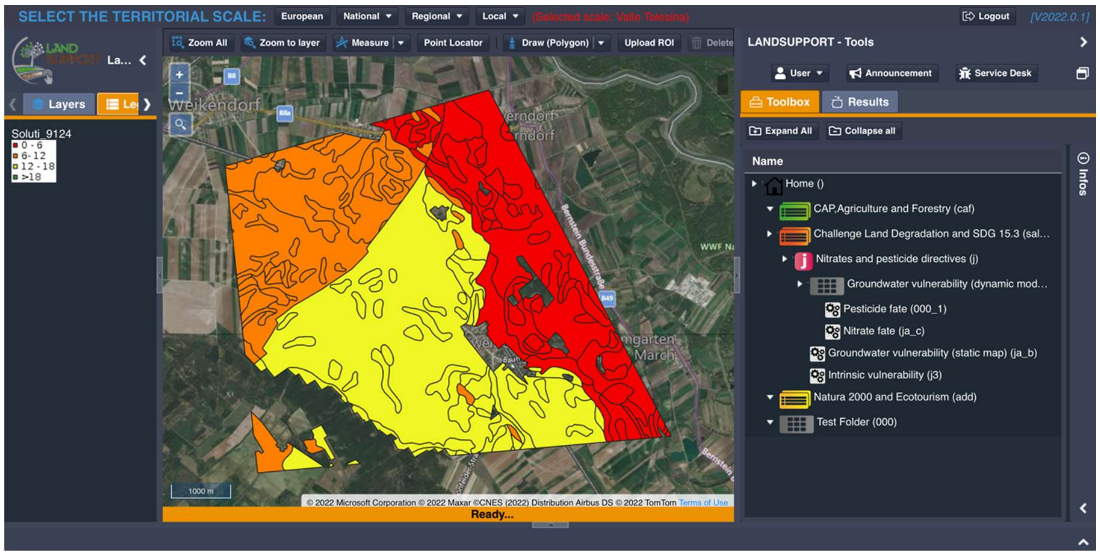
Soil name	Area [ha]	Class USDA	Number of years for 50% of root leachate
raw soil	18.42	Anthrosol	16.00
raw soil	37.18	Anthrosol	10.00
raw soil	4.95	Anthrosol	15.00
chernozem	16.51	chernozem	5.00
chernozem	142.76	chernozem	6.00
chernozem	19.47	chernozem	12.00
chernozem	61.17	chernozem	13.00
chernozem	149.29	chernozem	15.00

Figure 3. Map of results of the Nitrate fate tool: the years of 50% arrival are divided in 4 classes (0-6 ->red, 6-12 ->orange, 12-18 -> yellow, > 18 years -> green)



LIMITATIONS

The tool works based on soil properties obtained from the soil map for each of the regions (or subregions). A point scale soil could be different from that one reported on the soil map.

The tool assumes standard practices of agronomic management.

The models underlying the tool (ARMOSA and TFM-ext) have been extensively validated, their coupling not yet.

FUTURE DEVELOPMENT

Model validation;

Improvement of the crop rotation database.

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[i] Special care is required when user draws/select the Region of Interest. In fact, LANDSUPPORT is a multi-scale decision support system. Each of the 15 available tools is designed for a specific application and for a specific scale. Furthermore, the databases using specific standards required for that specific scale. The users of LANDSUPPORT web platform must therefore be well aware of the limitation embedded in the different maps that they require for their specific application. The users must be expert on their specific problem and must understand if the input data offered by the platform are suitable for their problem. In light of the above, the system provides very reliable results only if used appropriately.

[ii] It is also possible to draw a ROI with numerous polygons. In this case, it is possible to assign different values (eg numbers) to each of the drawn polygons.

[iii]Perego, A., Giussani, A., Sanna M., Fumagalli, M., Carozzi, M., Alfieri, L., Brenna, S., Acutis, M., 2013. The ARMOSA simulation crop model: overall features, calibration and validation results. Italian Journal of Agrometeorology 3:23-38. ISSN: 18248705.

[iv]Valkama, E., Kunypiyaeva, G., Zhapayev, R., Karabayev, M., Zhusupbekov, E., Perego, A., Schillaci, S., Sacco, D., Moretti, B., Grignani, C., Acutis, M., 2020. Can conservation agriculture increase soil carbon sequestration? A modelling approach. Geoderma, 369, 114298. https://doi.org/10.1016/j.geoderma.2020.114298

[v]Groenendijk, P., Heinen, M., Klammler, G., Fank, J., Kupfersberger, H., Pisinaras, V., Gemitzi, A., Peña-Harod, S., García-Prats, A., Pulido-Velazquez M., Perego, A., Acutis M, Trevisan, M., 2014. Performance assessment of nitrate leaching models for highly vulnerable soils used in low-input farming based on lysimeter data. Science of the Total Environment 499:463-480.

[vi]Novelli, F., Spiegel, H., Sandén, T., Vuolo, F., 2019. Assimilation of sentinel-2 leaf area index data into a physically-based crop growth model for yield estimation. Agronomy, 9(5), 255.

[vii]Sándor, R., Acutis, M., Barcza, Z., Doro, L., Hidy, D., Köchy, M., Minet, J., Lellei-Kovács, E., Ma, S., Perego, A., Rolinksi, S., Ruget, F., Sanna, M., Seddaiu, G., Wu, L., Bellocchi, G., 2017. Multi-model simulation of soil temperature, soil water content and biomass in Euro-Mediterranean grasslands: uncertainties and ensemble performance. European Journal of Agronomy, 88:22-40 (DOI: 10.1016/j.eja.2016.06.006).

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