Supplementary Material

EO-Based Crop Classification for Rotation Monitoring – Evaluating Temporal Consistency of Operational Models for Sustainable Agricultural Management

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CropRotationViz-Software

The CropRotationViz software is structured into several modular components dedicated to data processing and visualization. The workflow begins with the processing module, which generates standardized output files that can subsequently be utilized by the visualization applications.

For rapid exploratory analysis, the “Fast Visualization” module enables users to display and compare complete administrative units or river catchments, as well as associated crop diversity indicators, without providing interactive manipulation functions. This module is intended for efficient preview and overview analyses.

In contrast, the “Complete Visualization” module provides an extended set of analytical and interactive functionalities. Users can apply customized filters and manipulations, such as excluding specific crops or focusing on selected crop types, optionally combined with the selection of a particular region of interest. Furthermore, the module supports crop rotation ranking across different temporal ranges and allows the export of all generated charts together with the corresponding underlying datasets.

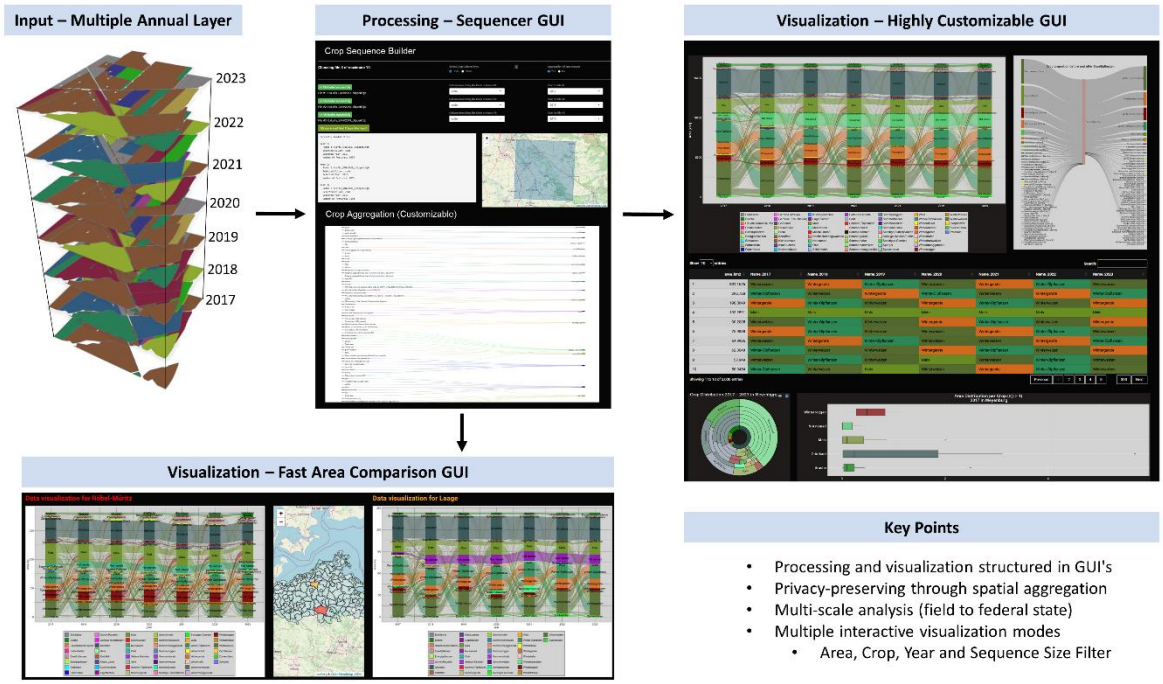

Figure 1: Graphical abstract of the CropRotationViz-software

Thünen Crop Type (v302) – Supplementary Figures

The Sankey chart shows the area-weighted LPIS crop distribution for Saxony-Anhalt from 2017 to

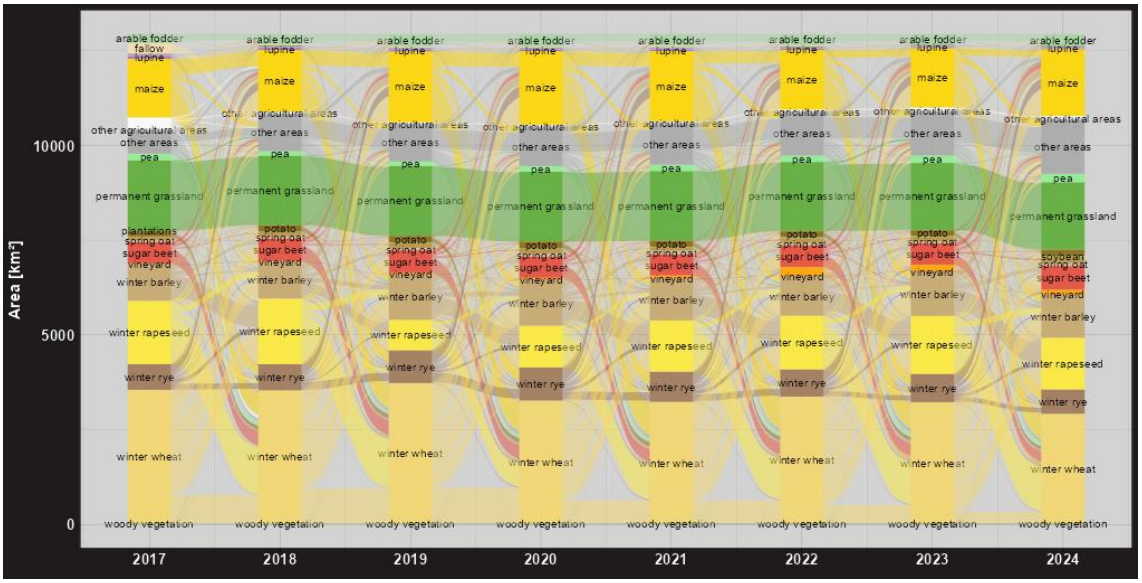

Figure 2: Complete LPIS crop rotation sankey-chart (in Thünen classes) produced by CropRotationViz.

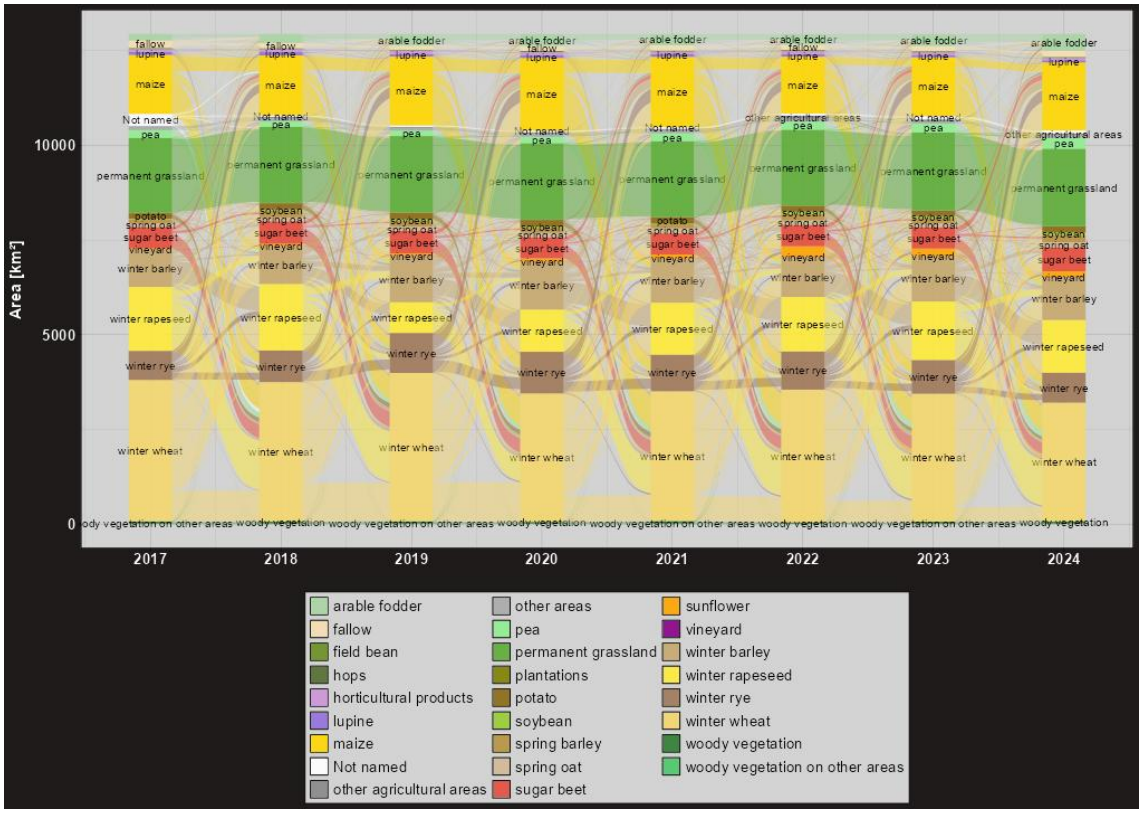

Figure 3: Thünen complete crop roation sankey-chart produced by CropRotationViz.

2024 in Thünen nomenclature, serving as the agronomic reference. Winter wheat dominates throughout, followed by winter rapeseed, permanent grassland, and maize, with overall composition remaining relatively stable across years. The equivalent chart (Fig. 3) reconstructed from the Thünen satellite classification broadly reproduces the dominant crop structure, but

reveals deviations in minor classes: some crops are partially split across adjacent categories or show inflated and reduced areas compared to the LPIS reference, with discrepancies accumulating across years and affecting rotation reconstruction reliability.

The two bar charts (Fig. 4) show crop-wise mismatch for 5-year sequences: by absolute area (left), winter wheat and permanent grassland dominate due to their prevalence, while the crop-relative rates (right) reveal that minor and structurally complex classes such as woody vegetation on other areas, fallow, and other areas show the highest proportional disagreement with LPIS.

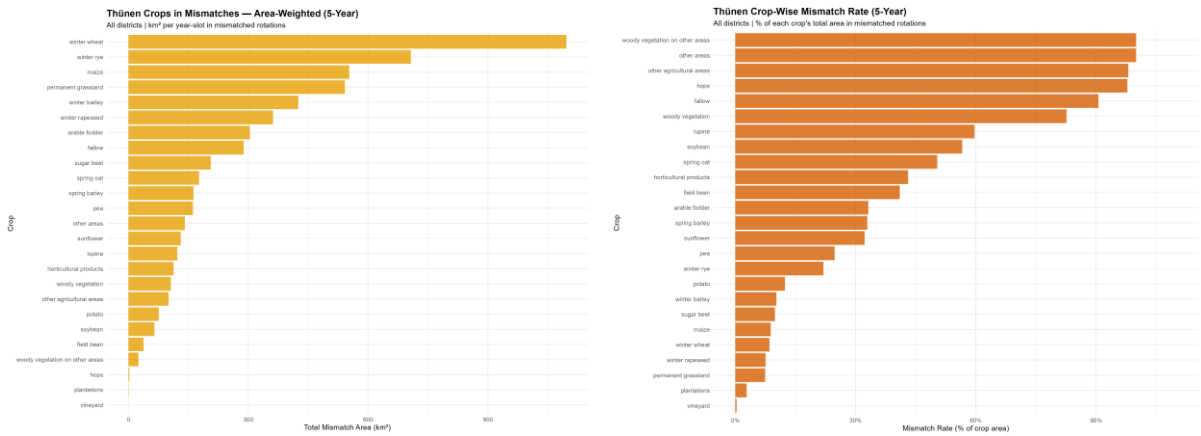

Figure 4: Missmatch rate per crop (5-year rotation) from Thünen-classification against LPIS area weighted and in crop percentage.

The maps of Saxony-Anhalt display area-weighted mean match rates per district for 3-, 4-, and 5-year rotation windows. Agreement is highest in central and northern districts with large homogeneous fields and declines with increasing window length, reflecting the compounding effect of annual classification errors across longer sequences.

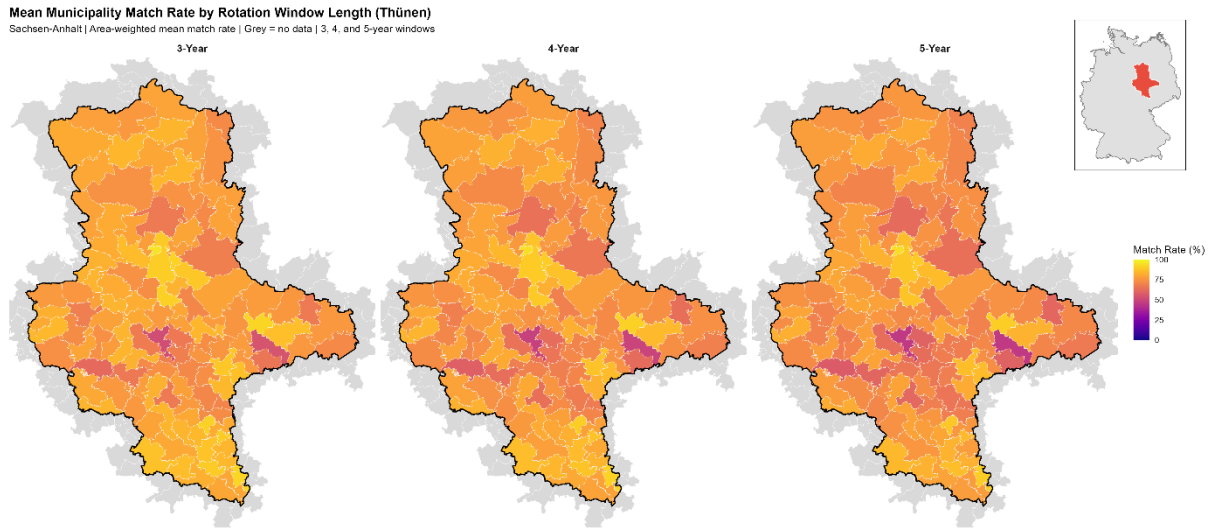

Figure 5: Mean matching rate by district and window length (Thünen classification).

The LPIS reference (Fig. 6) shows permanent grassland continuity as the most frequent 3-year sequence (~6.9%), followed by cereal-rapeseed rotations. Together the top 20 sequences cover around 60% of total agricultural area, confirming that a small number of rotation patterns dominate the landscape. The Thünen-derived ranking (Fig. 7) broadly matches the LPIS reference, with grassland continuity and cereal-rapeseed sequences leading. Subtle shifts in proportions are visible, and a few rotation types present in the LPIS top 20 are displaced by sequences involving misclassified crops, illustrating how annual errors alter apparent rotation composition.

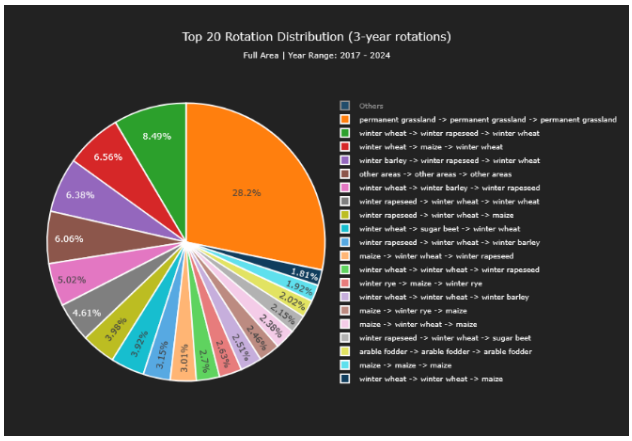

Figure 6: top 20 3-year rotations LPIS (Thünen classes)

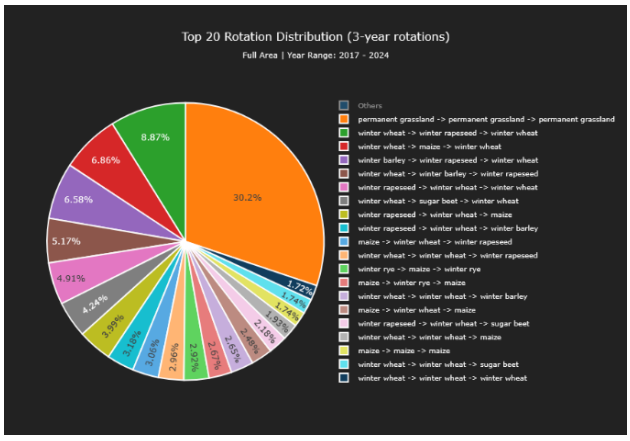

Figure 7: Thünen top 20 3-year rotations

The area-weighted LPIS transition probability matrix (Fig. 8) shows strongly diagonal patterns for permanent grassland and self-succeeding crops, with clear agronomic sequences among arable classes – notably the winter wheat–rapeseed cycle and constrained following-crop distributions for sugar beet and maize. This serves as the reference for evaluating Thünen transition fidelity.

The Thünen-derived matrix (Fig. 9) reproduces the overall diagonal structure and major arable transitions, but shows elevated self-transition probabilities for some crops due to persistent misclassification and more diffuse off-diagonal patterns for minor classes, which is relevant for applications relying on rotation-sequence modelling or diversification compliance.

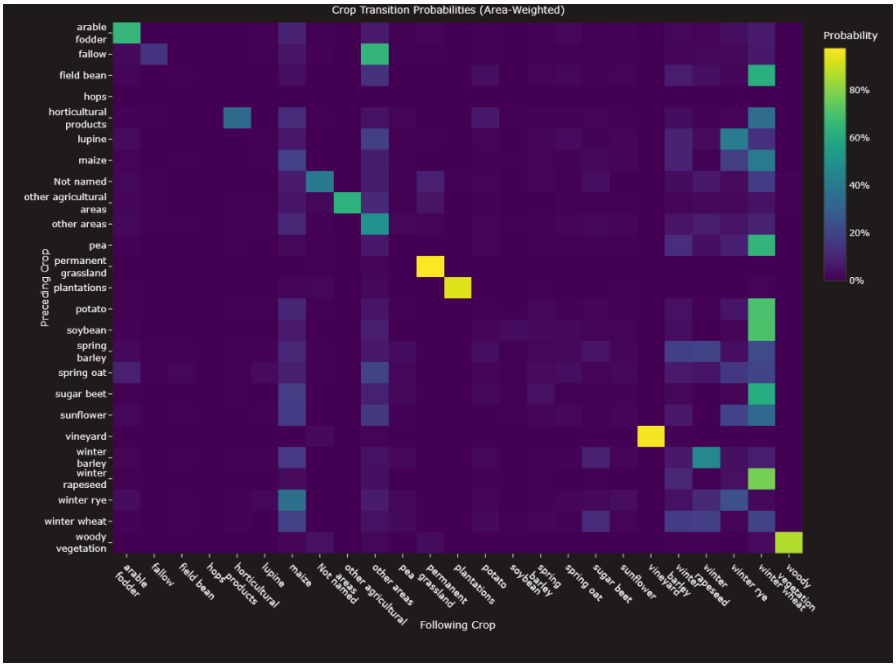

Figure 8: LPIS transistion probability (in Thünen classes) produced by CropRotationViz.

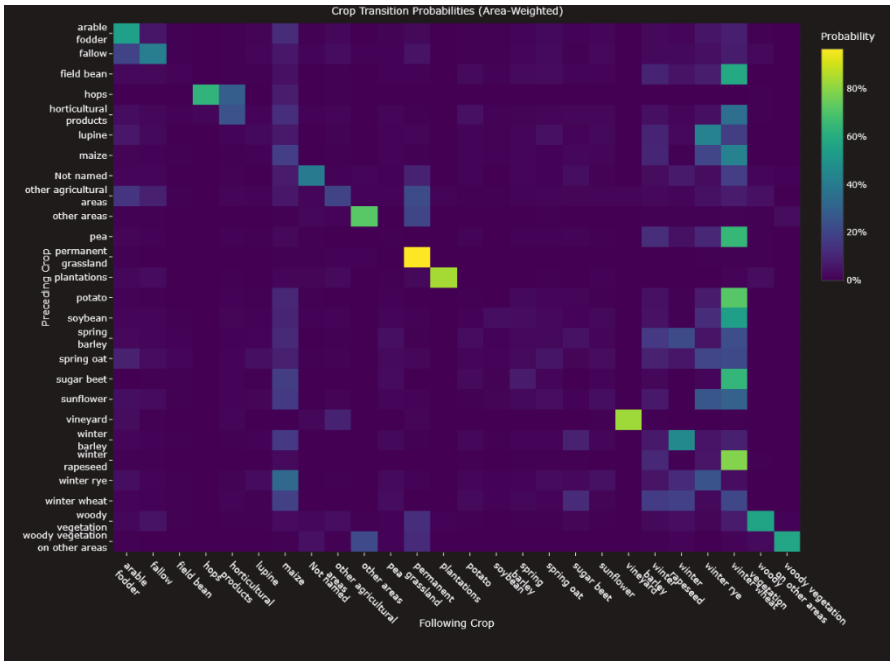

Figure 9: Thünen Probability produced by CropRotationViz.

DLR CropTypes – Supplementary Figures

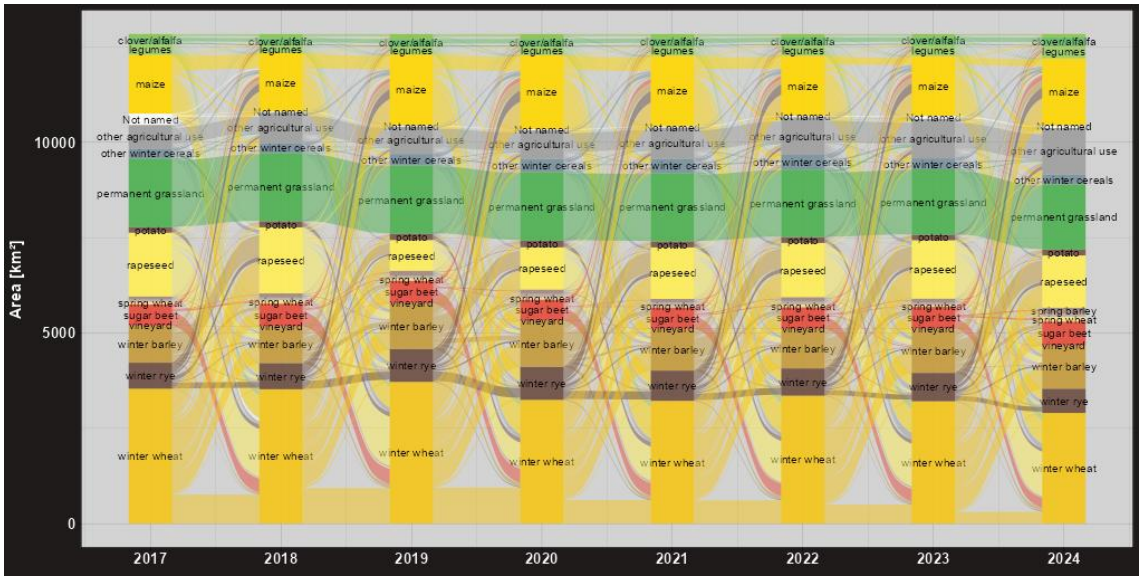

Figure 10: Complete LPIS rotation sankey-chart (DLR classes) produced by CropRotationViz.

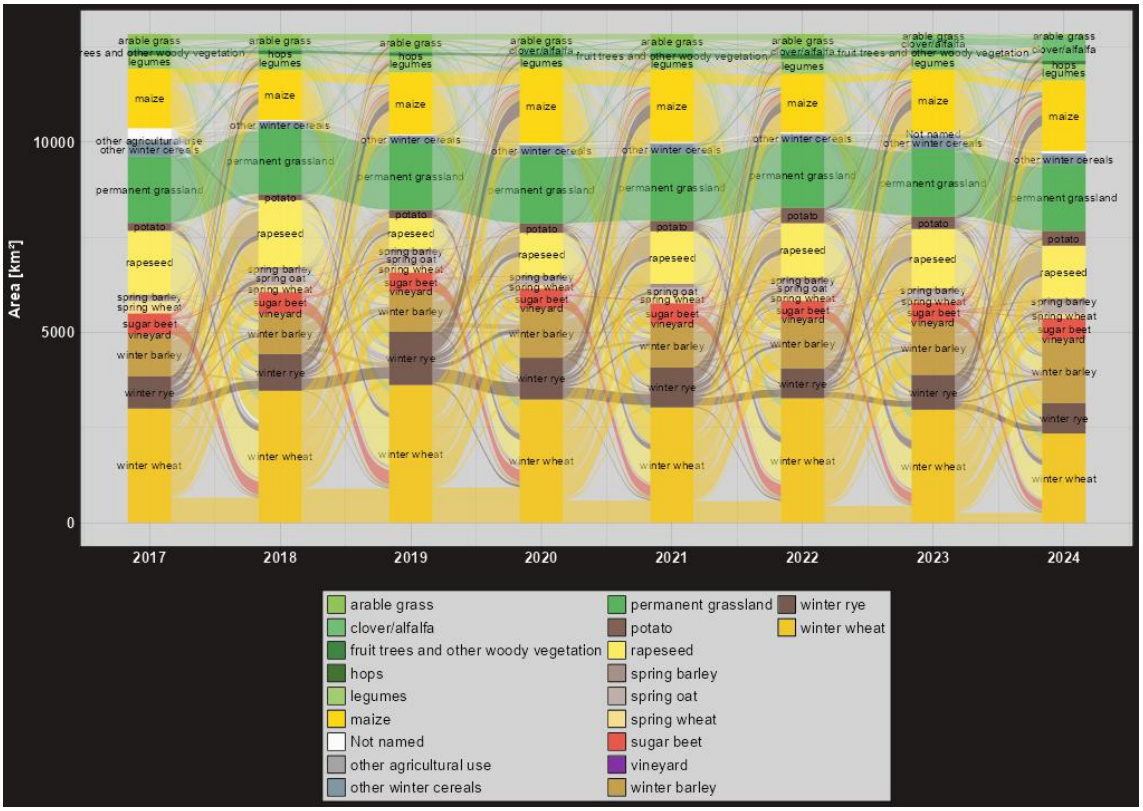

Figure 11: DLR complete crop rotation sankey-chart produced by CropRotationViz.

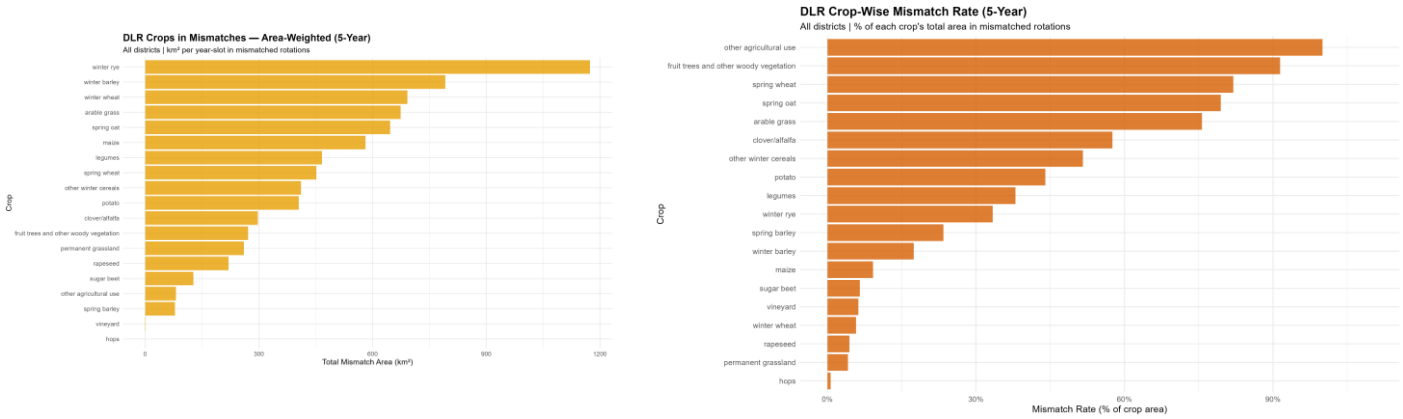

Figure 12: Missmatch rate per crop (5-year rotation) from DLR-classification against LPIS area weighted and in crop percentage.

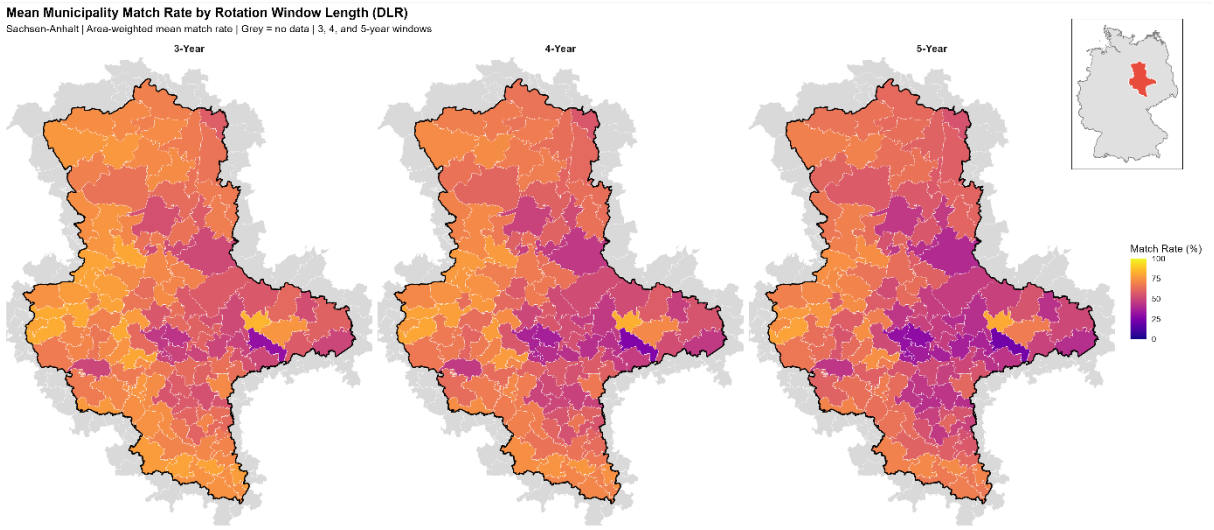

Figure 13: Mean matching rate by district and window length (DLR classification).

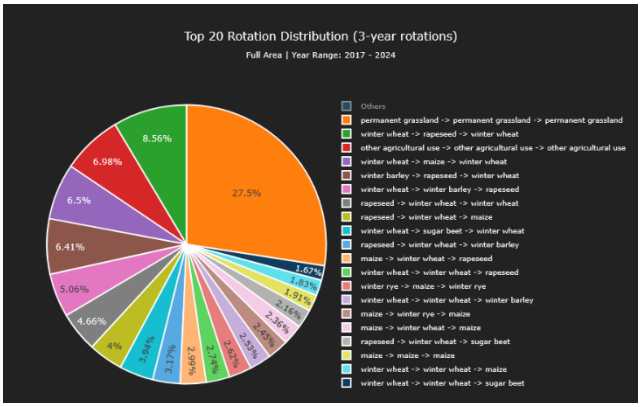

Figure 14: top 20 3-year rotations LPIS (DLR classes)

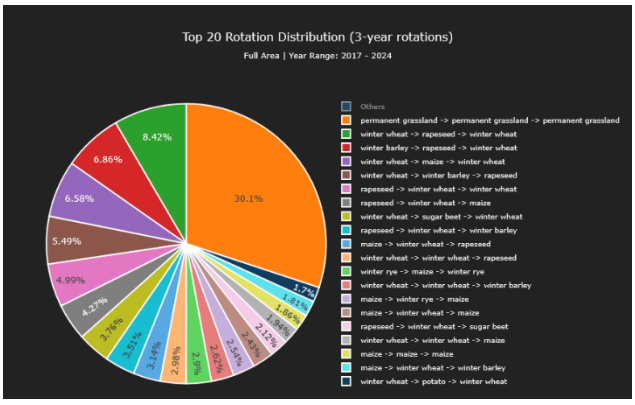

Abbildung 15: DLR top 20 3-year rotations

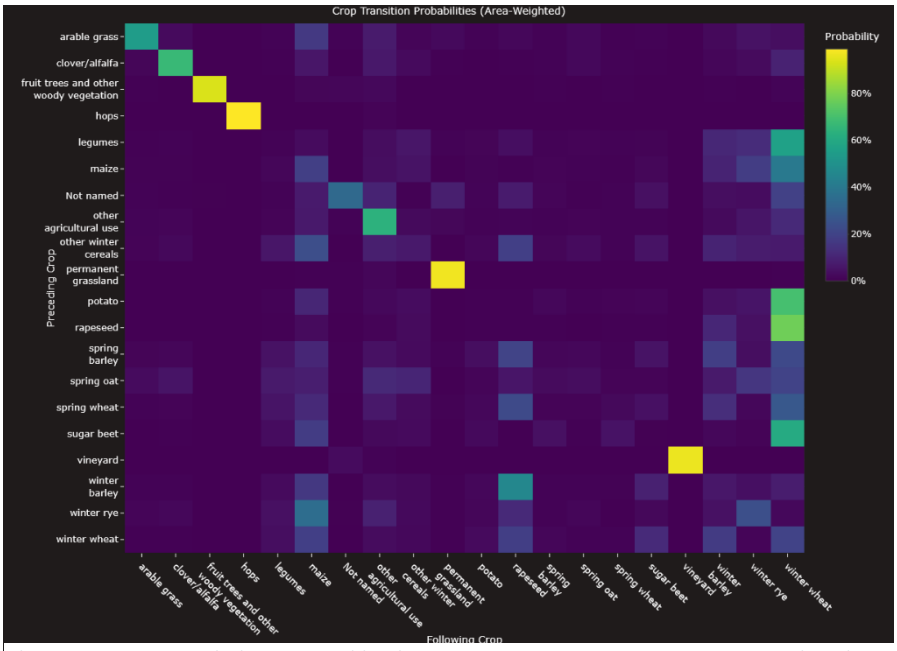

Figure 16: LPIS transistion probability (in DLR classes) produced by CropRotationViz.

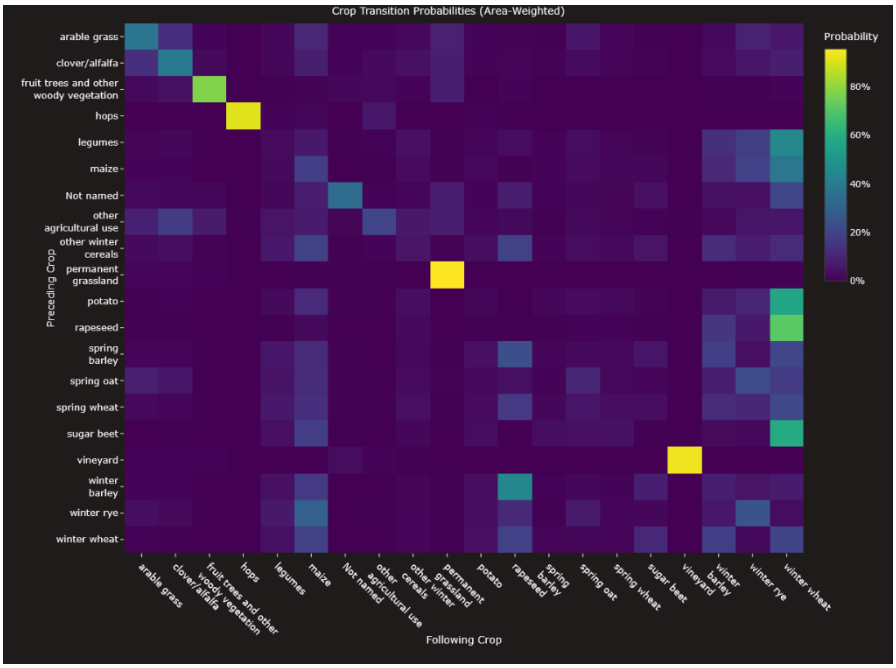

Figure 17: DLR transistion probability produced by CropRotationViz.