Towards multifunctional agricultural landscapes in Europe: Assessing and governing synergies between food production, biodiversity, and ecosystem services – TALE

Deliverable 5.1: Systematic assessment of case study representativeness

Lead author: Emma van der Zanden
(VU University Amsterdam)

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Contributors: Anna Cord, Nina Hagemann, Annelie Holzkämper, Andrea Kaim, Martin Schönhart, Michael Strauch, Peter Verburg, Martin Volk, Bárbara Willaarts.

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1. Introduction

1.1 Background information

Case studies are the central element of the TALE project, as there is a need to improve the understanding and quantitative assessment of the trade-offs between multiple objectives, such as food production, ecosystem services and biodiversity, under different management approaches in agricultural landscapes in Europe. Therefore, an integrative project framework is chosen with five case studies that cover a representative range of ecosystem services over a set of contrasted European agricultural landscapes. Information gained from policy analysis, stakeholder interaction and optimization modelling set-ups at the case study level are aimed to expand the current fragmented knowledge on suitable land management approaches that minimize existing trade-offs to ensure landscape multi-functionality (Schröter et al., 2005; Wilson, 2007).

In general, case studies – sometimes referred to as 'place-based approaches' - allow for a detailed analysis, for instance to understand specific processes. Case studies are rooted in a particular place and context and therefore provide information on the local circumstances, meaning and real-world relevance. One of the advantages of a case study focus, among others, is that this allows for the identification of local trade-offs and associated conflicts and the possibility to use local scenarios as part of management vision development (see Potschin and Haines-Young, 2012 for an overview of characteristics, strengths and weaknesses of place-based approaches). While place-based methods are gaining popularity, for example in landscape ecology and ecosystem services assessments (Potschin and Haines-Young, 2012b; Wu, 2006), a consequence of case study approached is that the unique geographical and historical context provides a limitation to the generalization of results (Flyvbjerg, 2006; Potschin and Haines-Young, 2012b).

There are different methods to integrate and synthesize case study information, depending on the research focus. Often this is done in a formal set-up, for instance by metastudies, but also less formal synthesis approaches are commonly used (Magliocca et al., 2015; van Vliet et al., 2015). In a successful integrated approach based on case study information, the selection of case study areas is a crucial element. For a meaningful comparison, case studies are preferably stratified based on gradients that represent variation in different landscape dimensions: not only in biophysical conditions, but also in other dimensions such as environmental conditions and systems of governance (see e.g. Angelstam et al., 2013a, 2013b). But strict stratification beforehand is not always possible or desired, as case study selection is often based on expert knowledge or previous research projects that established connections with local authorities and other stakeholders.

However, information on the stratification of the case studies over different landscape dimensions as well as explicitly acknowledging the specific landscape dimensions or policy contexts that are not represented by the selected set of case studies is crucial, as limited knowledge on optimum land use strategies and conclusions based on single case studies can lead to biased policy conclusions, especially for a European context (Fischer et al., 2014).

1.2 Aim of Deliverable 5.1

To avoid biased policy conclusions based on single or an unrepresentative selection of case study information, the aim of Deliverable 5.1 is to do an analysis of the case-study representativeness within the TALE project to assess the possible transfer of case study results to other regions. Furthermore, the identification of areas that have similar biophysical and socio-economic circumstances is important, as we make the assumption that these areas face similar policy challenges. Deliverable 5.1 is the first deliverable of WP5 “Synthesis and learning environment” that has as overarching aim to guide the integration process throughout the life time of the project and to package the findings and tools for dissemination outside the project environment.

Chapter 2 gives a general introduction in the selected case studies within the TALE project, including their selection process. The context of the case studies is compared by a ranking of the most important drivers of environmental change as well as the current environmental threats.

Chapter 3 focusses on the case-study representativeness analysis by comparing two different methodologies that are suitable for finding areas that face similar biophysical and socio-economic circumstances. Specific attention is also given to the areas and landscape dimensions that are not well captured by the case study selection. Chapter 4 assess the expert perception on local case study characteristics within a national and European, by testing the differences between expert perceptions of the case study circumstances (on general biophysical characteristics, ecosystem services and environmental status) compared to available datasets on a European and national scale. The expect assessment is driven to explore the answer on two recurring questions in place-based research projects: What is the influence of expert selection of case studies in comparative research projects? How well can local experts rate the case study circumstances within a wider European setting?

2. Case study characteristics

TALE is organized in five successive work packages (WP) which are organized in a way that they jointly deal with the five case study areas (Figure 1). An overview of general case study characteristics is given in Table 1.

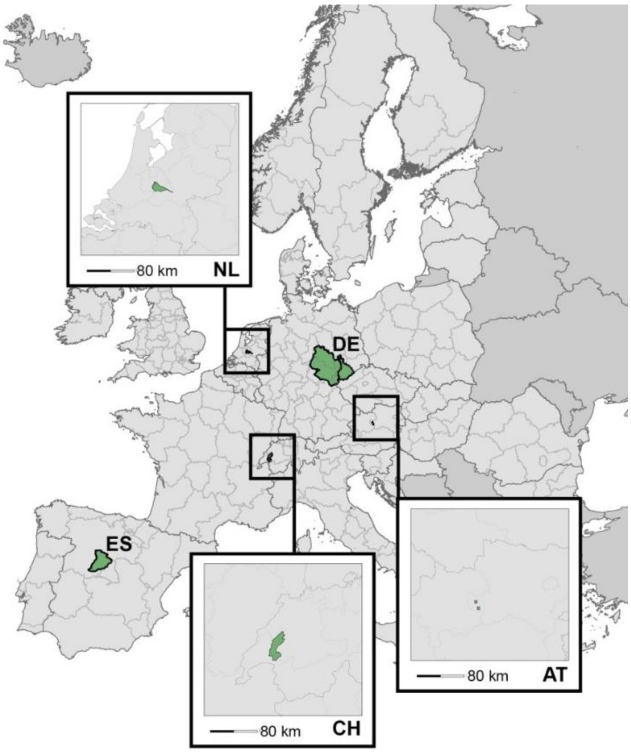

Figure 1. Location and outline of TALE case study areas

The aim of case study selection within the TALE was to select case studies with an agricultural profile, which “cover a representative range of ESS over contrasting case study landscapes” (Volk et al., 2013). When inquiring about the selection process by the partner institutes within the project, it appeared that most of the case study regions that are selected in the TALE project are long-standing research areas of the involved institutes and departments (> 10 years for Germany, Austria, and Switzerland, 3 years for Spain). The selection of long-standing case study areas has as common factor that previously collected information and previously established connections with local authorities and other stakeholders can be used.

Whoever, specific selection was driven by different factors. For the German case study, for instance, the Saale and Mulde basin are key research regions of the department and wider institute because the biophysical characteristics and land use conditions are representative for Central Germany. Conditions beneficial for hydrological modelling led to the selection of a new sub-basin (Ilm basin) in the region, which is a sub-basin of the Saale basin. The selection of a smaller sub-basin also makes the German case studies more comparable in size with the other case study regions within TALE. Suitable modelling conditions also influenced the case study selection for the Austrian case study, as they have set-up a specific data-intensive farm optimization model farm optimization model FAMOS for the Mostviertel for previous studies that will be used again within the TALE project (e.g. see Mitter et al., 2014; Schönhart, M. et al., 2011a, 2011b). The case study area was initially chosen because of the different gradients in the area that led to diverse land use systems, ranging van extensively managed farms dominated by permanent grassland in alpine areas to intensive arable farms. Previous research findings motivated the study selection for Switzerland, as previous studies showed that negative impacts of climate change are expected for various ecosystem services, e.g. decrease in agricultural production (increasing demand for irrigation), increase in soil erosion and leaching (e.g. Holzkämper et al., 2015; Klein et al., 2014). The Spanish case study was selected based on the issues that affect the case study area, which are exemplary for Spanish rural areas in central Spain. Furthermore, previous experience in the area existed due to participation in a previous project in the area on water resources. The Netherlands picked a new case study area for the TALE project, aimed to be used by relevant new projects as well, as the research group was interested in working in a research area that included a per-urban/urbanization gradient with related pressures such as urbanization/housing and recreation pressure, on land use.

Table 1. Overview of case studies within TALE project. Based on Volk et al. (2013).

Case study areas	Area (km^2)	Climatic conditions	Landscape structure	Agriculture (% of area)	Expected climate change impacts
Ilm/Mulde river basins, Germany	904 + 1,611	450 mm (fertile dry regions) to 2000 mm (mountains)	Gradient from homogenous to heterogenous	> 60% (partly 70% in the loess areas.	Decrease in productivity; increase of environmental impacts (i.e. erosion, flood damage, aquatic biodiversity)
Broye catchment, Switserland	598	900 mm; 10ºC mean annual temperature difference	Heterogenous	67% (cropland and grassland)	Decrease in productivity; increase in environmental impacts (i.e. erosion, nutrient leaching, aquatic biodiversity).
Kromme Rijn area, the Netherlands	219	750 mm	Gradient from heterogenous to more homogenous. Rich in linear elements.	56% (predominately grassland)	Relatively limited; winters are expected to become milder and wetter; summers are expected to become dryer; weather extremes are uncertain.
Cega-Eresma-Adaja region, Spain	7888	512 mm; 11ºC mean temperature difference	Mediterranean heterogenous landscape; with pine forests, cereal agriculture, pastures, irrigated lands	65% rainfed cereals.45% of irrigated land dedicated to cereals.	Decrease in precipitation; growing number of environmental problems, i.e. aquifer depletion, water quality/quantity problems, with impacts on biodiversity.
Mostviertel region, Austria	19 + 20	900-1300 mm; 8.6-9.7ºC mean temperature difference	Gradient from homogenous to heterogenous	43% (cropland & grassland), gradient from intensive to extensive use.	Increase in average productivity; unclear impacts of extreme events.

Although WP1 has as specific task to analyse and compare the policy settings of the different case study regions regarding policy instruments targeted at agriculture and environment as well as environmental legislation, a short assessment of environmental drivers and pressures is useful is comparing the wider context in which the case study areas are situated.

Table 2. Summary of most important drivers of environmental change in the TALE case study areas for the period 2006 – 2016.

Drivers	Importance[1]	Direction of change[2]	Drivers	Importance[1]	Direction of change[2]
Land use/cover change[3]	**DE, ES**	+ (DE, ES)	Change in population dynamics	**DE, CH, ES**	+ (CH) - (DE, ES)
Structural change in agriculture	**AT, DE, ES, NL**	+ (AT, DE, NL, ES)	Change in urban growth/Residential pressure	**AT, DE, CH, ES, NL**	+/- (DE, CH, NL) + (AT, ES)
Agricultural productivity growth	**AT, DE, ES, NL**	+ (AT, DE, NL)	Change in recreation pressure	**ES, NL**	+/- (DE, ES) + (NL)
Change in food consumption (European or regional)	**DE**	+ (DE)	Change in nature protection legislation	**ES, DE**	+ (DE, Ilm catchment, ES) +/- (DE, Mulde catchment)
Change in agricultural funding	**AT, CH, DE, ES, NL**	+ (DE) - (AT, CH) - (NL) +/- (ES)	Change in water demand by different sectors (including agriculture)	**ES, CH, NL**	+ (CH, ES) +/- (NL)
Change in land use planning policies	**DE, ES**	+/- (DE, ES)	Consequences of climate change	**CH, DE**	+ (AT)
Change in commodity prices on the world market, increased pressure for efficiency	**DE, NL**	+ (DE) + (NL)			

[1]The shading of the country codes indicates the importance (each partner was given 10 points to divide over the answers): 1, **2, 3, 4** and **5**. [2]for "increased", +/- for "no clear direction" and – for "decreased".[3]While being a driver of environmental change, the process itself is often driven by different processes.

Each case study region has assessed the most important drivers of environmental change in the case study area for the period 2006 – 2016. The results show that the case studies vary in the specific drivers of environmental change. While for both the German, Spanish and the Dutch case study many factors play a role, especially regarding the economic aspects of agriculture including structural growth and efficiency/intensification pressure, they are all relatively equal in importance. For Austria, the change in agricultural funding (including demanding funding rules, such as the greening of the CAP), is the most important issue, while economic aspects of agriculture are also important (similarly to DE and NL). As a contrasting case, in Switzerland consequences of climate change and changes in water demand are clearly the most important drives. More precisely, there is an increased (and projected increase for the future) demand for irrigation water, as well more climate-related drought limitations in the lowland section of the catchment. The increase in water demand is also a driver for the Spanish case study.

The current importance of environmental threats for each case study are summarized in Figure 2. The case studies of Germany, Switzerland and Spain indicate a similar pattern of environmental threats, in which only selected threats are not of influence (e.g. marginalization and loss of permanent grassland, for Switzerland also Fragmentation). Unique to Spain is the threat of soil salinization (instead of soil sealing in DE and CH). The case study area of the Netherlands has a very different profile, with a focus on nutrient loading and pollution and the related consequences for water quality. These issues are also related to intensification of agriculture and connected unsustainable agricultural production methods. Austria has, similar to the Netherlands, issues with nutrient loading and pollution and the related consequences for water quality. However, marginalization is also an issue (similar to ES) as well as loss of permanent grassland and landscape elements (unique for AT).

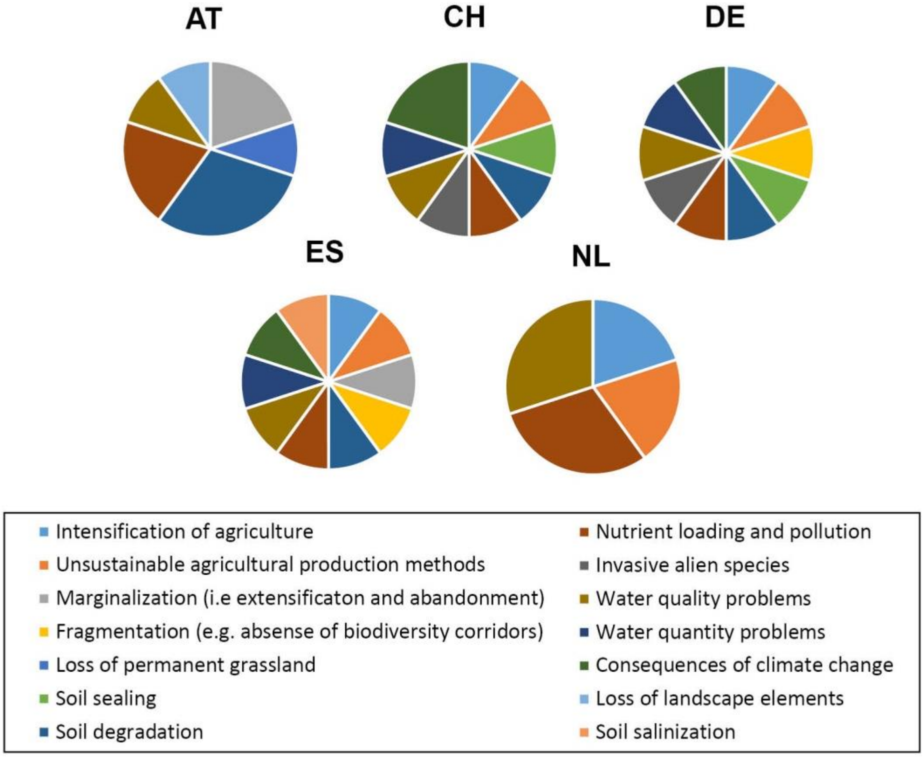

Figure 2. Summary of importance of environmental threats for each TALE case study area.

3. Case study representativeness

Generalisation and transferability of case study approaches is limited by their specific local (geographic) context and complex drivers and processes (Václavík et al., 2016). Furthermore, the outcomes are the result of a complex interaction between different conditions (e.g. economic, political or cultural), especially with so-called social-ecological systems (Liu et al., 2007). Recently, the topic of case study representativeness and synthesis gained more attention, as it is stated that one of the current challenges in landscape studies is to better link the different scales of research (global, regional and local), for instance by comparative and collaborative approaches (Plieninger et al., 2015). An example of such an collaborative approach within the land science domain is the establishment of the GLOBE project (http://globe.umbc.edu), which is an online collaborative platform that that facilitates the synthesis of case studies, by comparing local or regional studies with global data to assess the global relevance of these studies (Ellis, 2012).

In general, there are different methods to integrate and synthesize case study information and to assess their relevance beyond the study areas. While a formal set-up for comparison can be used, for instance in the form of meta studies, other approaches have also gained popularity (Magliocca et al., 2015; van Vliet et al., 2015). Land system approaches, such as landscape typologies are aimed to synthesize regions that have comparable characteristics and are therefore a useful starting point for comparison. While traditionally many of these typologies lacked information on land use and land management, recent efforts have included information on human-landscape interactions, landscape management and landscape structure. Examples on a global-scale are, for instance, the Land System by van Asselen & Verburg (2012) and the land system archetypes (LSAs) by Václavík et al. (2013). For Europe, landscape structure and management intensity are included in a agricultural landscape typology by van der Zanden et al. (2013), while Pinto-Correia et al. (2016) developed two typologies that focus on the multi-functionality and societal demands of rural zones.

Different methodologies for typology development exist, with the largest difference between top-down expert-based typologies and bottom-up approaches, which group locations with similar characteristics with the help of statistical clustering methods. The advantage of a bottom-up data-driven approach is the flexibility, as the classification is based on major structures and clusters of data without an a priori hypothesis (Agarwal and Skupin, 2008). However, transferring the current statistical solution to another dataset, e.g. representing future conditions, is challenging (van der Zanden et al., 2016). A clear critique towards bottom-up data-driven approaches is also that data-driven typologies are often poor in terms of explanatory capacity (Pinto-Correia et al., 2016). Data-driven typologies are based on clustered information based on the statistical distance. Instead of defining groups based on similar statistical distance as in a typology, this information can also be used to perform a "similarity index" (GLOBE, 2012) or a "transferability analysis" (Václavík et al., 2016). Within the GLOBE project, the "similarity analysis" is based on the statistical distance (normalized Euclidean distance) between the case study and selected global variables. Václavík et al. (2016) developed a similar approach, but used a different statistical distance (absolute distance) and a raster-based analysis. GLOBE includes another measure, their so-called "representativeness analysis", that aims to assess the degree to which a given collection of study sites represents an unbiased sample of a specified global extent, by analysising the principle that an unbiased samples of study sites should cover the variation in a global variable to the same degree that a random sample of the same size would.

To compare between different approaches that are suitable for case study comparison based on comparable characteristics, we will use two methodologies for the case study representativeness analysis. First, we use commonly-used and suitable agricultural and biophysical typologies. While some of these typologies are expert-based, others have a more data-driven approach, although the latter also have been assessed by experts. However, all typologies are defined by distinct groupings of information. Secondly, we use the transferability analysis as applied by Václavík et al. (2016), as a data-driven approach without clear thresholds. The results from both methods are compared and their differences are discussed.

3.1 Agricultural and biophysical typologies

3.1.1 Typology selection

For the representativeness analysis based on agricultural and biophysical typologies, we have selected five typologies which capture different aspects of agricultural landscapes, including climate and biophysical dimensions. We selected the typologies based on the fact that they are widely used and/or key dimensions that are important to differentiate agricultural landscapes, such as land management or landscape structure. A criterion for typology selection was the coverage of Switzerland.

To incorporate different intensity and structural dimensions of agricultural landscapes, we have included the expert-based agricultural landscape typology by van der Zanden et al. (2016) that consists of 19 classes. This typology is based on the dimensions land cover (dominant land use), land management (using nitrogen application rates) and landscape structure (using on field size and linear landscape element density).The typology by van der Zanden et al. (2016) did not cover Switzerland in the original version, but is extended for this purpose using the original data sources. For nitrogen application rates, information regarding Switzerland from Hürdler et al. (2015) is used. A recently developed typology by Tieskens et al. (*in review*) is also based on landscape structure and management intensity, but has extended the typology by van der Zanden et al. (2016) by including information on value and meaning in order to establish a “cultural landscape index”. Value and meaning of landscapes are based on information regarding social media usage and registered traditional food products. For agricultural areas, the dimensions land management and landscape structure are based on more recent versions of the proxies used by van der Zanden et al. (2016), but extended with information on economic farm size for management intensity. The typology has also been developed to include information on forestry, but this is not included in our analysis. We compare these recent agricultural typologies with the “classic” analogue and qualitative classification of traditional European landscapes developed by Meeus (1995; 1990) as digitized in Stanners and Bourdeau (1995).

To capture climate and biophysical dimensions, we have selected the climate-focussed Environmental Stratification of Europe (EnS; Metzger et al., 2005) and the Landscape Map

(LANMAP) classification, which has four separate levels (Mücher et al., 2010). The EnS has a climatic focus and is based on 21 variables that capture different aspects of altitude, slope, latitude, oceanicity, temperature, precipitation and percentage sunshine. These have been aggregated using Principal Component Analysis (PCA) and ISODATA clustering into 13 Environmental Zones. The LANMAP classification aimed to give an overall classification of landscape types in Europe, based on quantitative spatial analysis and a consistent classification framework. The classification consists of four separate layers that can be overlaid to get an area-specific coding. LANMAP includes the dimensions climate, altitude, parent material and land cover. The dominant typology values for each TALE case study is summarized in Table 5.

A method to assess the relationships between different typologies is MapCurves, a goodness-of-fit test for the spatial concordance of categorical maps (Hargrove et al., 2006). The test indicates the degree of spatial overlap, or positive spatial correlation between maps with the same spatial extent. The final score ranges between 0 and 100, with 100 being a perfect correspondence. The results of the MapCurves analysis on our selected typologies clearly show that each typology captures very different dimensions as compared to the other datasets, as the concordance with the included datasets is low to very low (Hargrove et al., 2006).

Table 3. Goodness-of-fit scores using MapCurves (Hargrove et al., 2006)

	Agricultural landscape	Cultural landscape index	EnS	LANMAP1[1]	LANMAP2[1]	LANMAP3[1]	LANMAP4[1]
Meeus	9.3	13.8	18.1	20.9	34.5	9.6	9.8
Agricultural landscape		12.3	16.8	18.8	33.0	7.2	9.3
Cultural landscape index			17.0	18.5	33.7	11.7	11.8
EnS				20.7	34.8	15.6	15.7
LANMAP1					41.6	24.6	31.2
LANMAP2						43.2	53.6
LANMAP4							22.6

[1] Mücher et al. (2010) with four levels: climate (1), altitude (2), parent material (3) and land cover(4).

Table 4. Dominant typology categories for each TALE case study region.

Case study region	*Meeus*[1]	*Agricultural landscape*[2]	*Cultural landscape index*[2]	*LANMAP*[2]	*EnS*[1]
'Mostviertel region', Austria	Continental open fields, Atlantic semi-bocage	Very-intensive mosaic land use, Open large-scale intensive grassland	Low CLI, Structure	Continental – Hills – Sediments (Soft loam) - Heterog. agr. areas	Continental (CON)
Broye catchment, Switzerland	Atlantic semi-bocage	Medium-scale intensive arable land, Open large-scale intensive grassland	Low CLI, Value/meaning	Continental – Mountains – Sediments (glaciofluvial deposits), Rocks (Crystalline rocks and migmatites) - Heterog. agr. areas	Continental (CON)
Ilm/Mulde river basin, Germany	Continental open fields, Atlantic semi-bocage, Collective open fields	Large-scale very intensive arable land, Large-scale extensive arable land	Low CLI, Value/meaning	Continental, Alpine – Hills, Mountains – Sediments (Soft loam), Rocks (Crystalline rocks and migmatites) – Arable land, Forest	Continental (CON), Atlantic North (ATN), Alpine South (ALS)
Cega-Eresma-Adaja (Duero Basin), Spain	Mediterranean open land	Medium-scale intensive arable land, Large-scale extensive arable land	Intensity, Structure & Intensity	Mediterranean – Mountains – Rocks (detrital formations, Crystalline rocks and migmatites) – Arable land, Shrubs & herbaceous vegetation	Mediterranean North (MDN), Mediterranean Mountains (MDM)
Kromme Rijn, the Netherlands	Kampen, Polder	Small-scale intensive grassland, Enclosed intensive mosaic land use	Structure & value/meaning	Atlantic – Lowland – Sediments (River alluvium) - Pastures	Atlantic Central (ATC)

[1] All categories overlapping case study areas are listed, dominant categories are underlined. [2] If applicable, two most abundant categories are listed, dominant categories are underlined.

2.1.2 Case study comparison based on typologies

Figure 3 shows the overlay of dominant typology classes for each TALE case study. Based on these patterns, there is a clear overlap visible between the Austrian, Swiss and German case studies. All three case studies have a distinct pattern of high values in Eastern Germany as well as in Eastern Europe (with exception of North-West Poland and the Baltic States). This overlapping pattern is mainly the result of similar climatic zones and low cultural landscape values, but also with regards to agricultural landscapes there are clear similarities: predominantly open landscapes, defined by intensive to very intensive arable or mosaic land use. For the very intensively used arable land in the German case study, there is also a close similarity with the “production agriculture” and parent material in the Paris basin (France). Both the Dutch and the Spanish case study have more distinct patterns with little overlap with the other case studies. Both case studies also are spatially more restricted with high values. For the Netherlands, the high values are located in the Atlantic region (excluding Spain). High values are for instance found for North-West Germany and Western Denmark, which have comparable pasture dominated Polder and enclosed Kampen landscapes. The Atlantic Central Zone is also rich in cultural landscapes that are defined by structure and value/meaning. The high values for the Spanish case study reflect the Mediterranean location, with the highest values around the case study location in Central Spain. The highest comparability can further be found along the Adriatic coast of Italy, which has comparable land cover (Mediterranean open land, with medium-scale intensive arable use) and climatic conditions.

When assessing the maps, it is clear that almost all areas in Europe are covered by at least one dominant typology class. Figure 4 shows that most of the more distant areas are based on the land cover and geomorphology layer of LANMAP. Interestingly, some areas that are located near the case study areas have little overlap based on biophysical and land system characteristics, as they are only covered by broad landscape type (Meeus) or a cultural landscape type (see e.g. Switzerland).

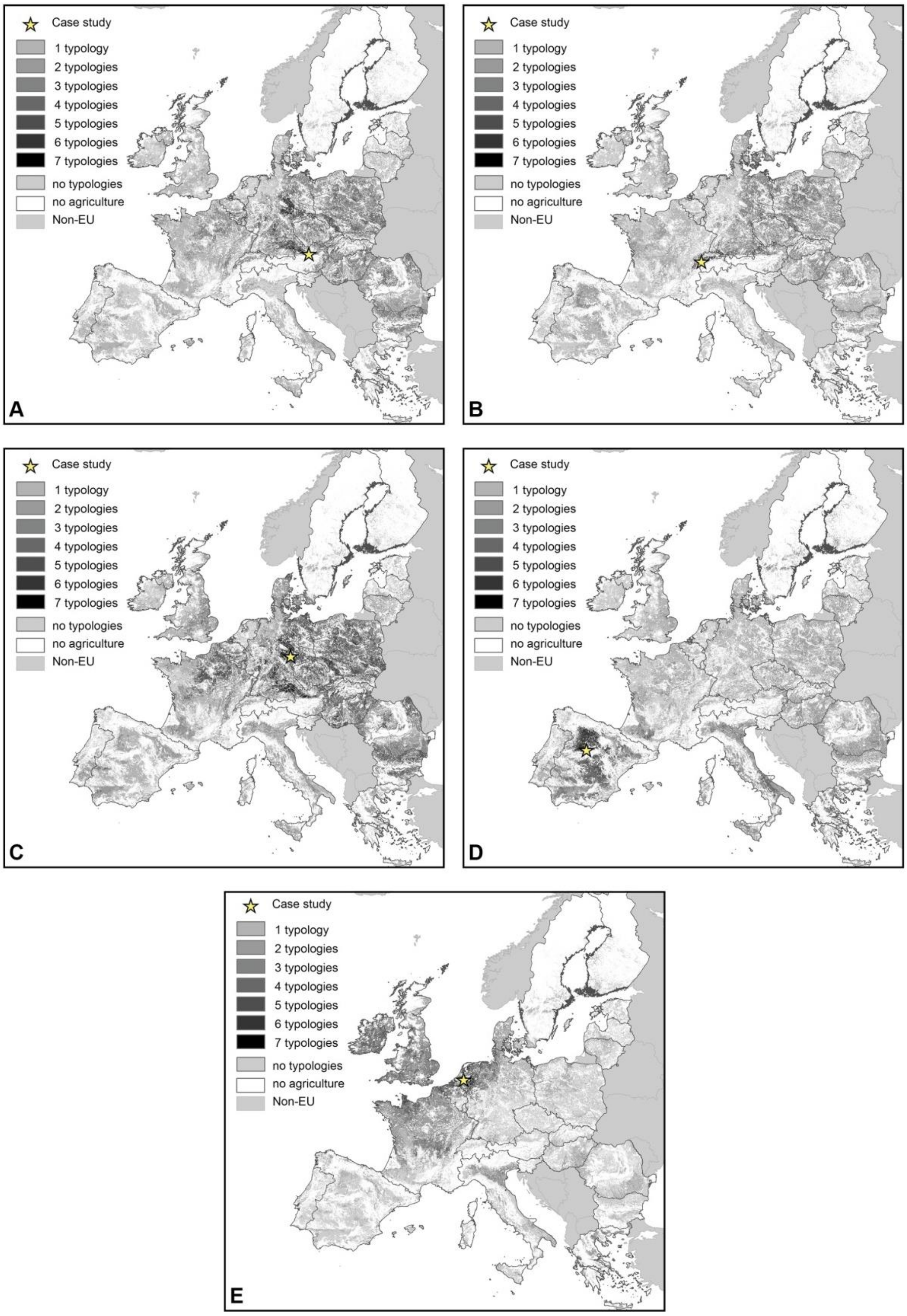

Figure 3. Summary of the spatial distribution of the dominant typology classes (summed) for the five TALE case study areas: A) Mostviertel, Austria; B) Broye catchment, Switzerland; C) Ilm/Mulde basin, Germany; D) Cega-Eresma-Adaja, Spain; E) Kromme Rijn, the Netherlands.

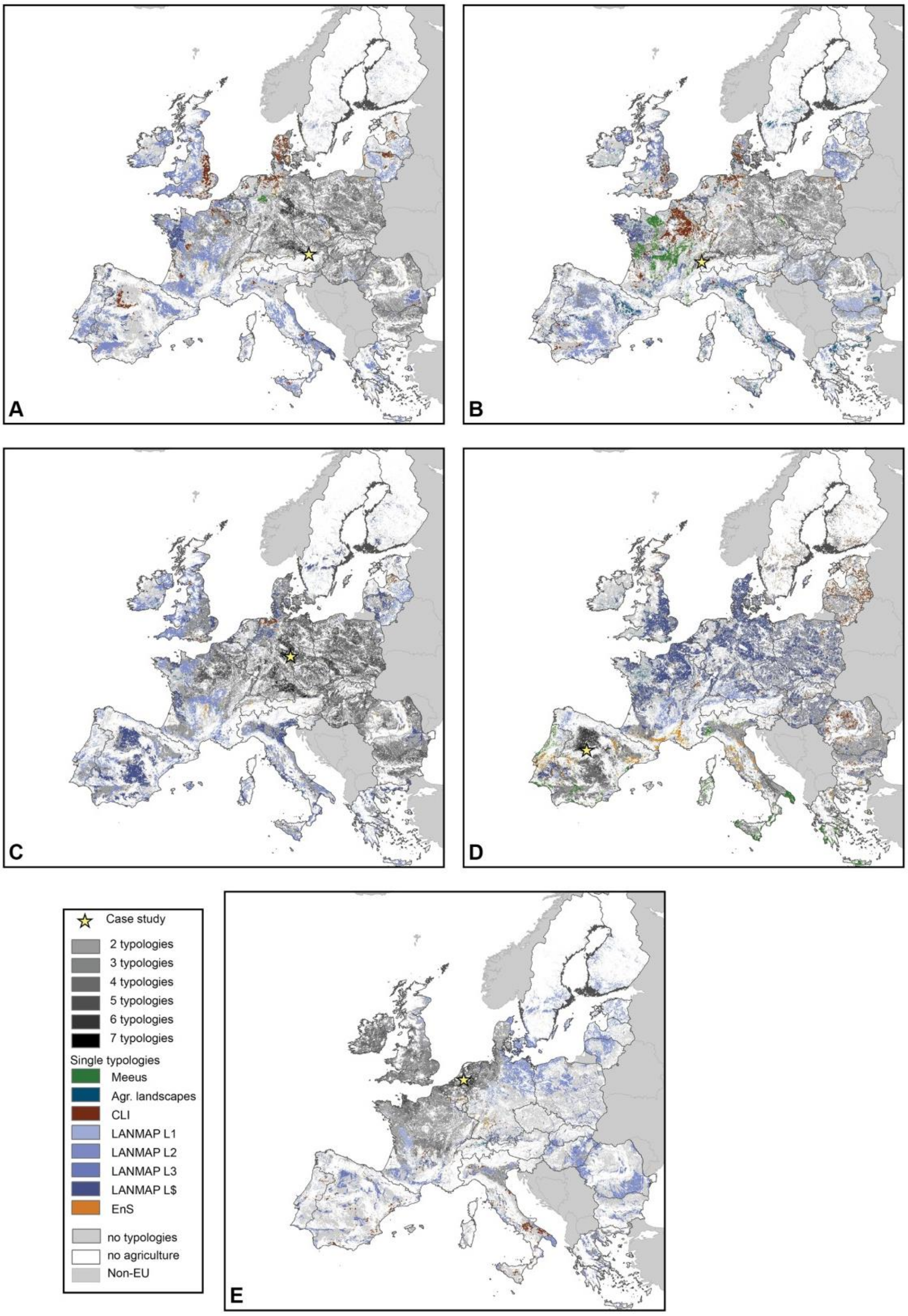

Figure 4. Summary of the spatial distribution of the dominant typology classes (summed) for the five TALE case study areas. The areas that are covered by a single typology class are indicated. The five TALE case studies: A) Mostviertel, Austria; B) Broye catchment, Switzerland; C) Ilm/Mulde basin, Germany; D) Cega-Eresma-Adaja, Spain; E) Kromme Rijn, the Netherlands.

2.2 Transferability analysis

2.2.1 Methodology and variable selection

We apply the transferability approach (Václavík et al., 2016) to calculate the statistical distance between the centroid (average) of each study region with a selected list European-level variables. Based on the experiences by Václavík (pers. comm.), we believe that a centroid-based approach is suitable for our purpose. However, as the German case study covers two distinctly different river basins, we have calculated the statistical distances for each river basin separately and averaged the values afterwards. The basis for the transferability approach is based on the absolute distance (D) as a measure for similarity (see Equation 1):

$$D = \frac{1}{g \times v} \sum_{i=1}^{v} \sum_{m=1}^{g} \left| x_{i,n} - x_{i,m} \right|$$

The inverse distance is consequently mapped as the gradient of transferability. For better visualisation, we have divided the gradient of transferability potentials into four classes, based on the average distribution of the transferability over all case studies. Using this approach, each class covers approximately the same area. We have used the same thresholds for each case study, so the levels of transferability potentials are comparable among the projects. This method differs from Václavík et al. (2016) as their method of equally divided classes of the transferability gradient is not suitable on a European scale, as the distances are much smaller overall. We performed the transferability analysis based on information with a resolution of 1 km^2.

We have selected the list of indicators to represent important variables that characterize the land system as well as the biophysical characteristics of the case study areas (See Table 6). We have tried to match the majority of the datasets or indicators that also serve as data-input/information for the agricultural and biophysical typologies. Only parent material (LANMAP; Mücher et al., 2010) and specific climatic variables used in the EnS (Metzger et al., 2005; latitude, oceanicity and percentage sunshine) are not included. The qualitative Meeus map (1995) is not possible to represent based on specific indicators.

Table 5. Selected indicators on a European scale that represent land system and biophysical characteristics. The spatial resolution of the indicators is 1km^2.

Indicator	*Indicator specification*	*Temporal coverage*	*Source*
Land system			
Arable land	% of agricultural area	2006 (Greece 2000)	CORINE 2006 for all countries except Greece, for which CORINE 2000 was used (EEA, 2012)
Grassland	% of agricultural area	2006 (Greece 2000)	CORINE 2006 for all countries except Greece, for which CORINE 2000 was used (EEA, 2012)
Permanent Crops	% of agricultural area	2006 (Greece 2000)	CORINE 2006 for all countries except Greece, for which CORINE 2000 was used (EEA, 2012)
Economic farm size	St gross margins in ESU[1] (1,200 €)	2007-2009	European Commission (2012). For Switzerland we used the averaged equivalent of ESU[1] per Kanton for the years of 2007 to 2009 (Bundesamt für Statistik, 2009). Areas without information are based on the focal mean of the neighboring areas.
Field size	In hectare	2012	EUROSTAT (2012), processed using ordinary kriging (van der Zanden et al., 2016)
Nitrogen Application	N-input in kg/ha	2000-2006	Temme and Verburg (2011), for Switzerland we used Hürdler et al. (2015)
Abundance of linear landscape elements	Density (Nr. of GLE intersections at 250m transect)	2012	EUROSTAT (2012), processed using ordinary kriging (method: van der Zanden et al., 2013)
Panoramio (2015)	Nr. of geotagged photos per km^2	2015	Panoramio (2015)
Product of Designated Origin (PDO)	Nr. of PDOs	2014	European Commission (2014)
Biophysical system			
Elevation	Mean altitude	2003	Derived from 1000 m DEM from SRTM3 data, NASA (2003)
Geomorphology	Average height difference	2003	Derived from 1000 m DEM from SRTM3 data, NASA (2003)
Precipitation	Yearly rainfall (mm)	1950-2000	Based on Worldclim (http://worldclim.org), Hijmans et al. (2005)
Temperature	Mean yearly temperature (˚C)	1950-2000	Based on Worldclim (http://worldclim.org), Hijmans et al. (2005)

[1] European Size Unit

2.2.2 Transferability analysis results

Figure 5 clearly show that most areas within Europe are in relatively close statistical distance. As with the typology analysis, in general the pattern indicates that the closer a area is to the case study, the smaller the statistical distance is (or the higher overlap with respect to typologies. The positive spatial autocorrelation, e.g. the degree of which a set of spatial features and associated data values are clustered together in space, is therefore high.

Although the threshold for the class division in Figure 6 was adjusted from the global analysis of Václavík et al. (2016), the question remains what would be an appropriate distance within Europe to regard as having a “high transferability”. Although the Austrian, Swiss, German and Spanish case study all have areas throughout Europe within the high transferability class, these are all linked to areas that are defined by arable land. An exception is the Netherlands, which covers a smaller area in the high transferability class and only has the highest values for the North Atlantic region, areas in North-West Germany and West-Denmark and grassland areas in France.

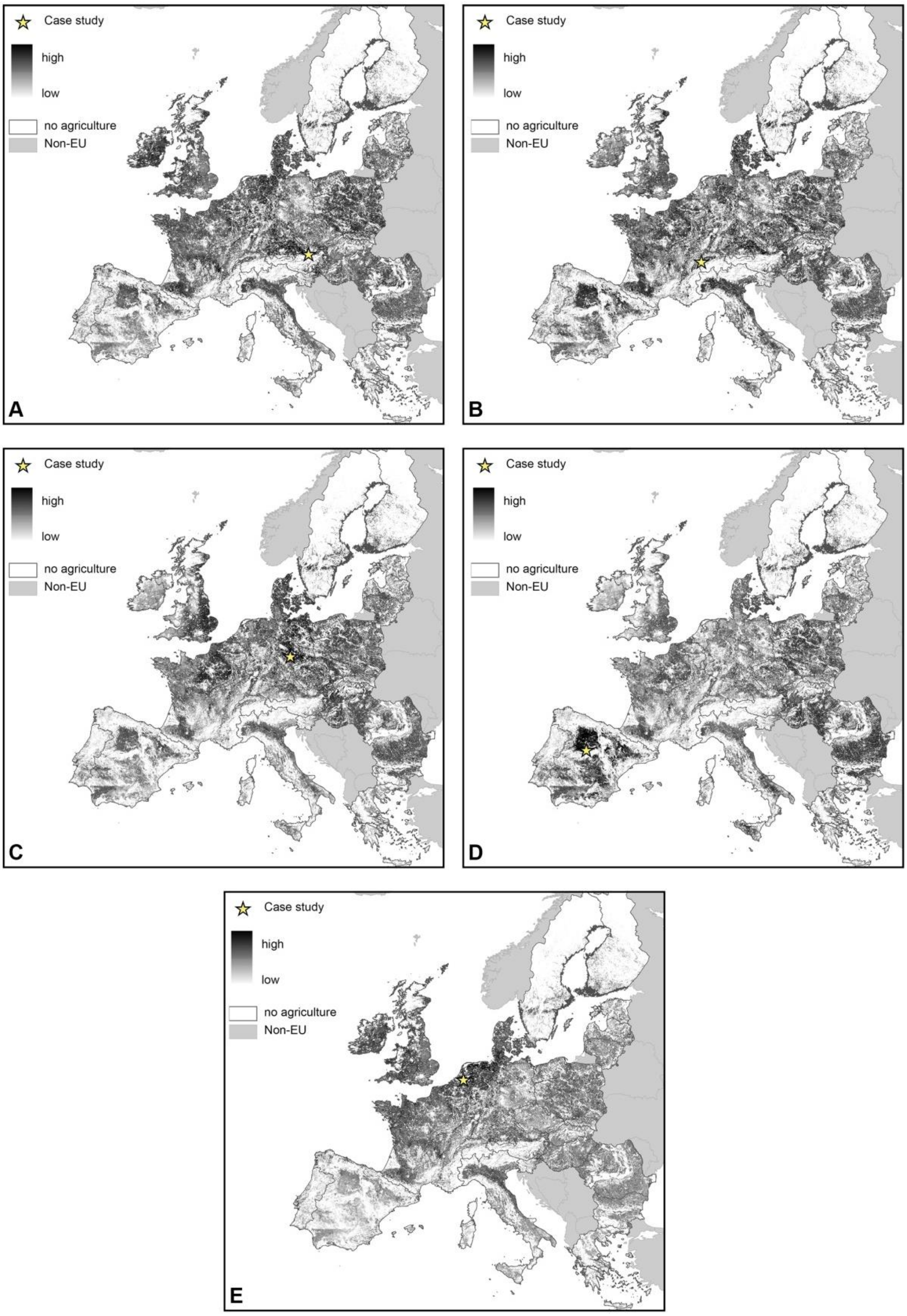

Figure 5. Mapped transferability potentials for the five TALE case study areas: A) Mostviertel, Austria; B) Broye catchment, Switzerland; C) Ilm/Mulde basin, Germany; D) Cega-Eresma-Adaja, Spain; E) Kromme Rijn, the Netherlands.

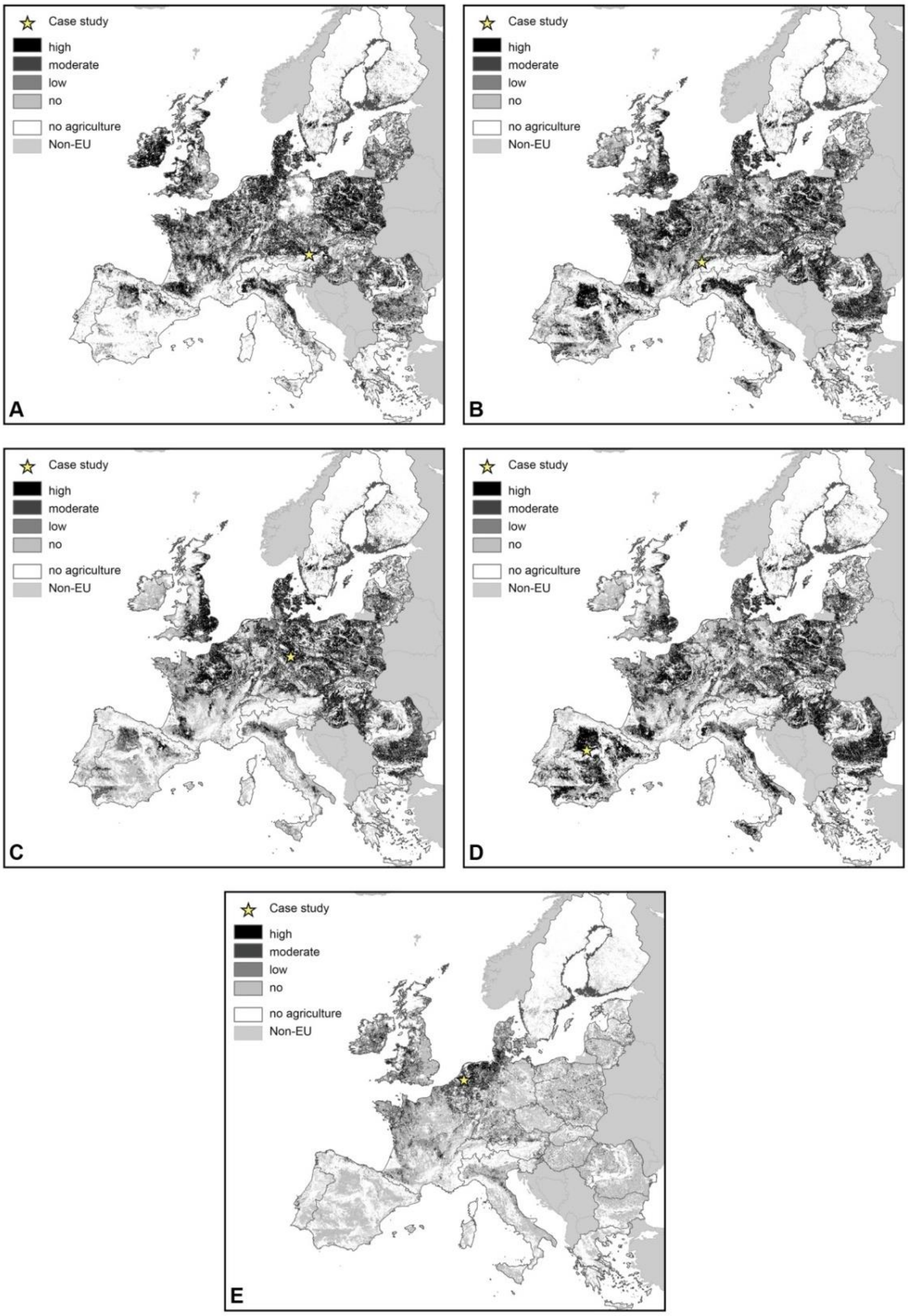

Figure 6. Mapped transferability potentials for the five TALE case study areas: A) Mostviertel, Austria; B) Broye catchment, Switzerland; C) Ilm/Mulde basin, Germany; D) Cega-Eresma-Adaja, Spain; E) Kromme Rijn, the Netherlands. The gradient of transferability potentials is divided into four classes based on the average quantile distribution of the transferability potentials. For all case studies, the same thresholds are used.

2.3 Under-represented areas

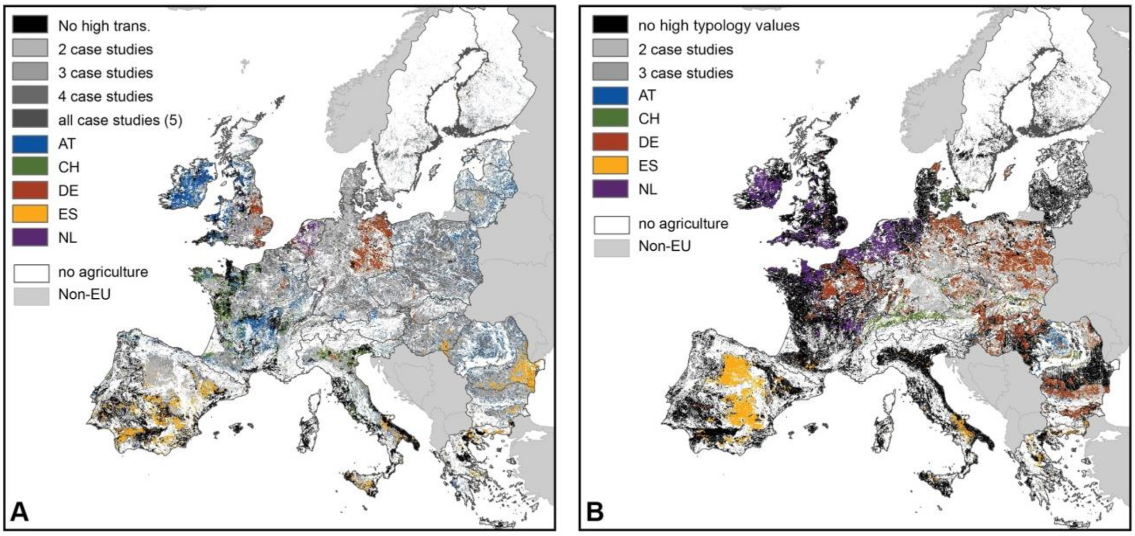

Figure 7. Areas of under-representation by TALE case studies: A) spatial overlay of areas with high transferability potentials, B) spatial overlay of high typology classes (each area covered by at least 4 of the 8 included typologies). Areas that are only covered by the high transferability potentials or high typology values of one case study are indicated by the country code.

A spatial overlay of the areas with high transferability potentials (~25% of all values) gives an indication of the areas in which areas of Europe the results of the TALE case studies are most relevant. This analysis can also be used to see the areas that are under or not-well represented in TALE. The results in Figure 7 show that the majority of Europe is covered by at least one case study high transferability value. Detailed values show that most areas in Europe are covered by two or three different case study areas. The largest areas is covered by a combination of four case studies (CH, AT, DE and ES; 325.896 km^2). However, the analysis clearly shows areas in pre-dominantly Southern Europe that are not represented by the high transferability classes (a total of 380.432 km^2). More specifically, this refers to areas in South Eastern France (Normandy, Loire region, Auvergne and Languedoc-Roussillon), Spain except for the Central-North (Castilla-Leon and surroundings) and almost all agricultural areas of Portugal. Also large areas of Italy and Greece are not part of the analysis. Outside the Mediterranean region, also the Eastern coasts of the UK and Ireland are not well represented.

To compare the high transferability class with the typology results, we have done a similar overlay for typology classes. To match high transferability, we have chosen for a threshold of ≥ 4 typologies. Four was chosen with the aim to ensure a mix of both biophysical and land system typologies in each high value. Although the threshold choice was a bit arbitrary, the resulting pattern closely mimics the result of the transferability analysis with a more distinct pattern of unrepresented areas.

From both results in Figure 7, we can conclude that the Mediterranean region is not well represented by our case study selection, especially the more extensive regions and areas with permanent crops. Specific regions of France (Atlantic coast, Auvergne and Languedoc-Roussillon) as well as the West-coast of the UK are not well represented, with is possibly a result of the limited inclusion of grassland dominated landscapes and extensive areas within the case study selection. Several areas have a limited representation, as they are represented by a specific case study (e.g. Netherlands and Belgium only represented by the Dutch case study, Central/North Germany solely represented by German case study) or on broad characteristics (e.g. Baltic States, overall low representation mainly based on Intensity and Arable land).

2.4 Discussion

Although we compared two different approaches that are suitable for case study comparison based on different methodologies, the results are highly comparable. This clearly has to do with the similarity in input indicators, which were mainly different by the difference in processing (expert and threshold based or data-driven and continuous). An advantage of the typology method is the clearer interpretation of the results and the more distinct patterns. However, a limitation is that almost similar classes or values beyond the dominant classes are not taken into consideration (which do have influence on the statistical distance calculation). Despite the different approaches, the overall patterns of case study representativeness show positive autocorrelation, indicating that the the closer an area is to the case study, the smaller the statistical distance is (or the higher overlap with respect to typologies). Furthermore, the case studies of Austria, Switzerland and Germany show comparable transferability patterns, while Spain and Netherlands represent both distinct biophysical and land system characteristics. Clear un-represented areas by the TALE case study areas are the Mediterranean region, specific regions of France as well as Western UK. Thematically, this is mainly the result of the low representation of grassland, permanent crops and extensive systems.

A general comment on the interpretation of the transferability and typology results is that both analysis make the assumption that similarity of land systems constitutes the potential for transferability, i.e. the more similar two sites are in terms of land use, environmental and socio-economic conditions, the higher the probability that methods, results and conclusions from a project site prove applicable at a similar side. This, however, should be always threated carefully. Furthermore, the comparison is limited by the information included. Specific information, such as information on GDP, population density or on political systems, could therefore clearly alter the results and consequently the interpretation of representativeness.

3. Expert assessment

The information in the expert assessment was collected by asking the case study teams within TALE to rate the expected values of selected key characteristics of their local case study area, based on their expert knowledge (but without checking for values within literature). These values are compared in Table 6 and 7 with calculated ranking based on spatial explicit information of each indicator (see Appendix for average values per class). This comparison is intended to lead to an exploratory reflection on the following questions: What is the influence of expert selection of case studies in comparative research projects? How well can local experts rate the case study circumstances within a wider European setting? We think these questions are relevant, as most case studies are selected based on expert assessment. Furthermore, although much research is data driven, certain assumptions about the position of the case study within a wider context will influence decision making (e.g. comparison between regions, assumption about case study uniqueness).

The results show the difficulty expert judgement regarding the positioning of a case study within a European and a national context. For the European values, 44% of the quartiles are estimated correctly. In two cases, value and the expert estimation were in the opposite quartile (AT precipitation and CH economic farm size). Experts also mentioned that it is difficult to assess the values in the case study within a European context, because they are often not aware of the European “baseline” values. For the national values, 56% of the quartiles are estimated correctly, with none of the values and estimates in the opposite quartile. Again, experts mentioned that it was difficult to estimate the values, but also mentioned that they are more familiar with the national situation which makes it easier to assess the situation and provide a contextualisation of the case study.

The results from this exercise clearly illustrate the difficulty of experts to judge the case study circumstances within a wider European setting. Although the case studies are often taken as an exemplary case for a national process, it is often assumed that the case study selection within a research project also provides a representation of the variation in Europe. While this is often done based on expert assessment, this exercise also shows that it is not so straightforward to have good assessment of the position of the case study within a wider context. One method to avoid this bias, which could e.g. influence decision making for instance due to assumptions about the case study uniqueness, is to do a general data-driven assessment of the case study regions at the start of the project. Within the TALE project, the values in Table 7 and the Appendix, as well as the mismatches between Table 6 and 7 can therefore be used during the further course of the project as a learning tool, to modify different “intuitive” assumptions about the position of the case studies.

Table 6. Data-based (value) and expert-based assessment of the rank of biophysical and land system characteristics compareed to European values. The colors indicate quartiles: red indicates the lowest 25% of the data (lower quartile), yellow indicates the middle range (25-75%) and green indicates the highest 25% of the data (upper quartile). This data division is often used in hotspot analysis, with the lower quartile indicating a “coldspot“ and the upper quartile indicating a “hotspot“.

Biophysical/Land systems		Compared to European values									
Indicator	*Indicator specification*	**AT**		**CH**		**DE**		**ES**		**NL**	
Land system		Value	Expert	Value	Expert	Value	Expert	Value	Expert	Value	Expert
Arable land	% of agricultural area	🟥	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟥	🟨
Economic farm size	St gross margins in ESU (1,200 €)	🟨	--	🟩	🟥	🟩	🟨	🟨	--	🟨	🟩
Field size	In hectare	🟥	🟥	🟨	🟥	🟩	🟨	🟨	🟥	🟥	🟨
Nitrogen Application	N-input in kg/ha	🟩	🟨		🟨	🟨	🟨	🟨	🟨	🟩	🟩
Abundance of linear landscape elements	Density	🟨	🟥	🟨	🟩	🟨	🟨	🟨	🟥	🟨	🟩
Biophysical (whole case study area)*											
Elevation	Mean altitude	🟩	🟨	🟨	🟨	🟨	🟨	🟩	🟨	🟥	🟥
Geomorphology	Average height difference	🟩	🟨	🟨	🟥	🟨	🟨	🟨	🟨	🟥	🟥
Precipitation	Yearly rainfall (mm)	🟩	🟥	🟥	🟥	🟨	🟨	🟥	🟥	🟩	🟨
Temperature	Mean yearly temperature (˚C)	🟥	🟩	🟨	🟨	🟥	🟨	🟩	🟩	🟨	🟨

Table 7. Data-based (value) and expert-based assessment of the rank of biophysical and land system characteristics compareed to national values. The colors indicate quartiles: red indicates the lowest 25% of the data (lower quartile), yellow indicates the middle range (25-75%) and green indicates the highest 25% of the data (upper quartile). This data division is often used in hotspot analysis, with the lower quartile indicating a “coldspot“ and the upper quartile indicating a “hotspot“.

Biophysical/Land systems		Compared to national values									
Indicator	*Indicator specification*	**AT**		**CH**		**DE**		**ES**		**NL**	
Land system		Value	Expert	Value	Expert	Value	Expert	Value	Expert	Value	Expert
Arable land	% of agricultural area	🟥	🟨	🟨	🟩	🟨	🟨	🟨	🟨	🟥	🟨
Economic farm size	St gross margins in ESU (1,200 €)	🟥	🟨	🟨	🟨	🟩	🟨	🟨	🟨	🟥	🟨
Field size	In hectare	🟨	🟨	🟨	🟨	🟩	🟨	🟨	🟨	🟨	🟨
Nitrogen Application	N-input in kg/ha	🟨	🟩	🟩	🟨	🟨	🟨	🟨	🟩	🟨	🟨
Abundance of linear landscape elements	Density	🟨	🟥	🟨	🟨	🟨	🟨	🟨	🟥	🟨	🟩
Biophysical (whole case study area)*											
Elevation	Mean altitude	🟨	🟨	🟨	🟨	🟨	🟨	🟩	🟨	🟨	🟨
Geomorphology	Average height difference	🟨	🟩	🟨	🟨	🟨	🟨	🟨	🟥	🟨	🟨
Precipitation	Yearly rainfall (mm)	🟨	🟨	🟨	🟨	🟨	🟨	🟥	🟨	🟨	🟨
Temperature	Mean yearly temperature (˚C)	🟨	🟨	🟨	🟨	🟥	🟨	🟥	🟨	🟥	🟨

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5. Appendix

Average indicator values

Biophysical/Land systems				National averages					Case study average				
Indicator	*Indicator specification*												
Land system		Source	EU average	AT	CH	DE	ES	NL	AT	CH	DE	ES	NL
Arable land	% of agricultural area	(EEA, 2012)	63.72	50.53	53.39	70.72	60.09	43.51	91.30	90.92	80.74	92.06	14.28
Economic farm size	St gross margins in ESU (1,200 €)	European Commission (2012), (Bundesamt für Statistik, 2009).	59.80	35.91	45.86	172.23	34.87	154.21	27.06	61.98	336.13	27.85	81.16
Field size	In hectare	EUROSTAT (2012)	7.61	5.90	8.75	6.81	8.39	5.43	5.12	7.81	9.32	8.26	3.97
Nitrogen Application	N-input in kg/ha	Temme and Verburg (2011), Hürdler et al.	2.50	3.04	3.28	3.17	1.63	4.02	4.11	2.25	3.14	1.67	4.45

		(2015)											
Abundance of linear landscape elements	Density	EUROSTAT (2012)	0.46	1.32	0.29	0.24	0.55	0.60	1.13	0.24	0.10	0.25	0.35
Cultural Landscape value	Index	(Tieskens et al., n.d.)	0.33	0.32	0.27	0.26	0.37	0.34	0.31	0.24	0.23	0.32	0.35
Biophysical (whole case study area)*													
Elevation	Mean altitude	NASA (2003)	359.54	656.71	1309.08	263.02	676.90	7.05	442.14	643.61	396.84	914.35	3.35
Precipitation	Yearly rainfall (mm)	Hijmans et al. (2005)	695.23	890.43	1090.45	717.98	543.72	780.67	899.30	993.48	636.57	422.67	796.66
Temperature	Mean yearly temperature (˚C)	Hijmans et al. (2005)	9.83	7.60	7.47	8.03	13.51	8.79	7.55	7.55	7.05	11.06	9