1 The production of basic indicators using the LAU2 geometries and the CLC 2006 data

The problem of data integration from the CLC 2006 in the LAU2 frame was already explored in the previous ESPON DB 2013 project, the data being collected for selected countries from the Eastern Europe (Czech Republic, Slovakia, Hungary, Romania and Bulgaria). The methodology involved for analyzing the land use in these countries offered new indicators, such as:
- the surface of any CLC 2006 category at LAU2 level
- the share of the categories in the total surface of the LAU2

The basic steps in order to obtain these values are simple operations involving logical tools of spatial analysis (intersections, surface calculations, summarization by LAU2 code and mapping exercises for verification). As the CLC 2006 layers (categories) are amorphous and administratively independent, we need to intersect theme with the LAU2 frame for obtaining two different codes: a code describing the CLC 2006 polygon of origin and a code for the LAU2 geometry. Obviously, the LAU2 geometry and the CLC 2006 layers need to be properly projected so that the calculated surfaces are as accurate as possible. The surfaces of the intersected objects are summarized using the LAU2 code and attached as new fields in the LAU2 geometry. The only method of validation is to make the sum of the CLC 2006 integrated categories and to verify that this sum is equal to the LAU2 surface. With 44 layers in the CLC 2006 dataset and with few options for automatization, obtaining the indicators implies a large quantity of time. By experience, using a model builder for repetitive steps (intersection and projection) can be used with reasonable geometries that contain less than 20 000 objects. Anyway, even with a functional model builder, the final calculation steps still involve a layer by layer approach. In this case is wiser to execute all the processes for a single country or for a limited number of countries.

To resume, these steps can be synthesized as follows:

1) chose of a LAU2 geometry. As we use CLC 2006 data, we also used a 2006 polygon layer for the LAU2 (extracted from the GISCO database - COMM_RG_2006 with attributes)
2) project the COMM_RG_2006 in a projection appropriate for surface calculation
3) in the same logic, project all the CLC 2006 layers
4) intersect the LAU2 geometry with a layer from CLC 2006 (e.g. Artificial surfaces, "Artificial, non-agricultural vegetated areas", Green urban areas -141 category)
5) calculate the surfaces of the intersected objects. We have made an option for square meters as unit of measure.
6) summarize the surfaces of the intersected objects by LAU2 code and export the output
7) join the output to the COMM_RG_2006 (or to the group of selected and extracted LAU2 objects, when working for a country or a group of countries)
8) map the indicator and verify that its share in the LAU2 is not bigger than 1.
9) verify that the results are reliable (if all the steps were properly implemented, you should not find olive groves in Finland).

Before integration the CLC 2006 for all the LAU2 in the ESPON space, we have tested the methodology on three countries from Western and Southern Europe: Spain, Portugal and France. There are two lessons to be learned from this experience. Some of the indicators are so spatially concentrated (probably due to ecological conditions and agricultural structures) that they cannot be fully exploited. It should be the case, for the CLC 222 category in Spain and Portugal. Aggregating this indicator in a superior class will provide more information about the land use territorial patterns. On the other hand, the share itself (ratio between CLC 222 category and the LAU2 surface) is a limited indicator that might not always suggest the concentration or the localization trends. Considering a new indicator that will take into account the problem of geographical could be more useful, in this context.

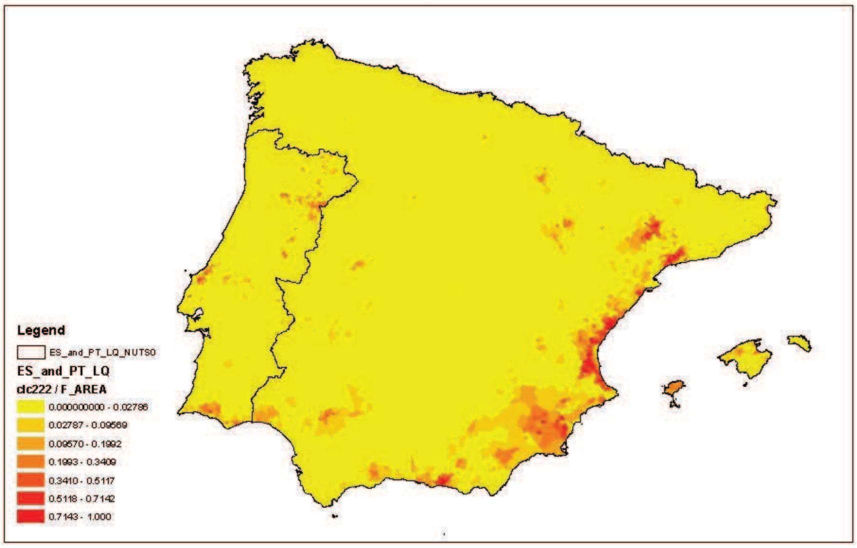

Fig 1 Draft/working map for Spain and Portugal CLC 2006 data integration at LAU2 scale - Permanent crops, Fruit trees and berry plantations.

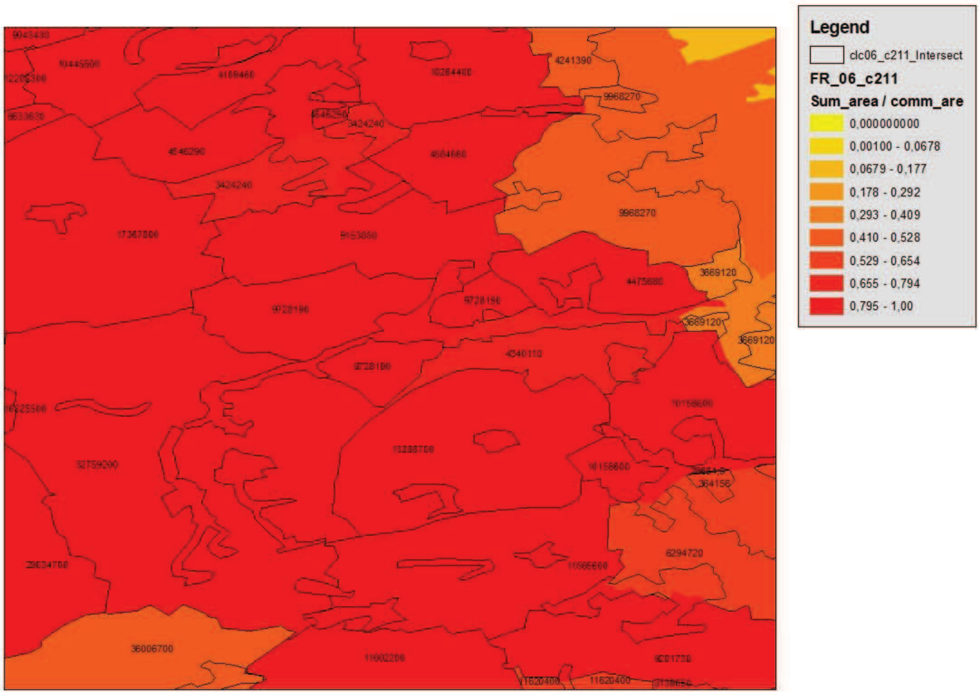

Fig 2 Draft/working map for France CLC 2006 data integration at LAU2 scale - Arable land, Non-irrigated arable land. The map shows the overlay between the LAU2 frame and the intersected CLC 2006 category.

In the methdological and conceptual arsenal of geography there are a lot of tools able to describe the concentration of spatial phenomena or distributions, some of them being inspired by other disciplines (more often economy). There are also some theoretical debates regarding the proper use of these tools, especially when one makes confusion between a concentration index with an indicators of equirepartition (Hoover or Gini). As the ratios are somehow tricky (percentage only refers to the local context), an indicator that will put in relation the relative share of one CLC 2006 category with a macro-spatial context (ESPON space, NUTS0, NUTS2 or NUTS3) will be more efficient.

In the frame of the economic base theory, planners, geographers and practionners developed several methods in order to evaluate the concentration (or the lack of concentration) of employement by economic branch, assuming that this trend will have an impact on the economic perfromance of regions. One of these methods is to calculate the location quotient of employees in the regional economy. The formalization is simple and can be easily implemented in any geographical software or calculus table :

LQ = (R.E.i /R.T.E.) / (N.E.i / N.T.E.)

R.E.i = regional employment in economic branch i (manufacturing, for example)
R.T.E. = regional total employment
N.E.i = national employment in branch i
N.T.E = national employment

The reference value of this ration will be 1. When the value 1 (or very close to 1) appears, we can assume that there is no local pattern of concentration. If the value is larger than 1, we deal with local concentration because the local share is larger than the national one. When the value is less than 1 (0.33 for example) we have a ratio inferior to the national one and we deal with a relative abscence/lack of concentration.

In this logic, we can use the CLC 2006 categories integrated in the LAU2 frame to measure concentration trends for land use. Replacing the employment with different CLC 2006 categories, the national employement with the national surfaces give us a more accurate measure of spatial patterns of land use. Substracting 1 from the result replaces the limits of the indicator to -1 for complete abscence, 0 for no concentration trends (similar to the national share) and positive values - concentration of one CLC 2006 category.

Two suplimentary steps are compulsory in order to calculate the location quotient: summarizing the national and the ESPON space CLC 2006 surfaces and the effective implementation of the formula. A double join of tables to the initial files is needed. All these steps and methodological points create huge table files, difficult to manage, if we take into account the large number of spatial units involved. Different tests on different hardware platforms were performed, hoping that an optimization of the calculus will be found. For the moment, the results of these tests are not very encouraging.

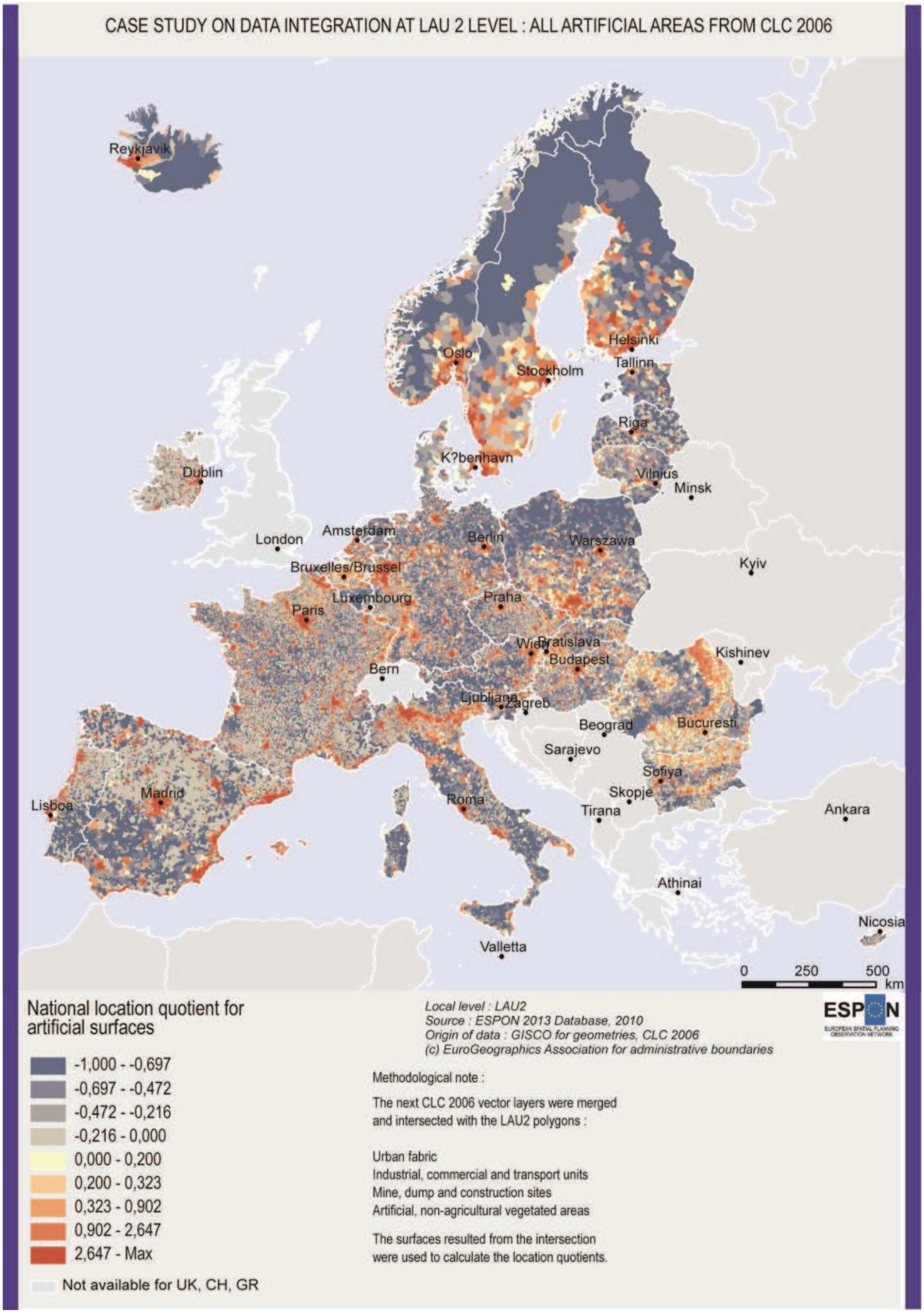

Fig 3 Location quotient of the artificial surfaces in 2006 - national reference

The first test and the first integration of data concern the artificial surfaces. Excepting three countries (UK, CH, GR), all the other ESPON states were included in the analysis. The next layers were merged in a single spatial reference and intersected with the LAU2 frame :

111, Artificial surfaces, Urban fabric, Continuous urban fabric
112, Artificial surfaces, Urban fabric, Discontinuous urban fabric
121, Artificial surfaces, "Industrial, commercial and transport units", Industrial or commercial units
122, Artificial surfaces, "Industrial, commercial and transport units", Road and rail networks and associated land

123, Artificial surfaces, "Industrial, commercial and transport units", Port areas
124, Artificial surfaces, "Industrial, commercial and transport units", Airports
131, Artificial surfaces, "Mine, dump and construction sites", Mineral extraction sites
132, Artificial surfaces, "Mine, dump and construction sites", Dump sites
133, Artificial surfaces, "Mine, dump and construction sites", Construction sites
141, Artificial surfaces, "Artificial, non-agricultural vegetated areas", Green urban areas
142, Artificial surfaces, "Artificial, non-agricultural vegetated areas", Sport and leisure facilities

Two indicators were created for this category : a location quotient at national scale and a location quotient for the ESPON space. The two of them are positevely strongly correlated (r = 0.83 and R2 = 0.69). The map shows a classic pattern of the European space with the metropolized core highly artificialized spaces (the Pentagon) and with the regions where the relative abscence of artificial surfaces is very prononced (Northern Poland, Central and Northern parts of the Scandinavian countries or areas in Spain, Portugal and Italy). This spatial repartition is partially (and arguably) explained by the natural and ecological features of the European territory. Internal (national) logics of planning would explain to a certain extent the distribution of the values : rural migration, diffusion of economic practices, volontarist interventions in some states - Hungary or Romania.

The second map is based on the integration of agricultural data - the arable areas. Much more dependent on the natural and ecological constraints, the arable land concentration is a sensitive subject for agricultural policies. It also indicates how rural territories functions or if they are monospecialized. In this case, the map has a double interest - allowing comparations at national scale and between states. Three layers from CLC 2006 were merged and integrated in order to produce this map:

211, Agricultural areas, Arable land, Non-irrigated arable land
212, Agricultural areas, Arable land, Permanently irrigated land
213, Agricultural areas, Arable land, Rice fields

The third map deals with the problem of the agricultural heterogeneous areas, emphasiying European regions with possibly fragmented landscapes (Western France, Northern Spain or Central Transylvania in Romania). The next layers were merged in a single spatial reference and intersected with the LAU2 frame:

241, Agricultural areas, Heterogeneous agricultural areas, Annual crops associated with permanent crops
242, Agricultural areas, Heterogeneous agricultural areas, Complex cultivation patterns
243, Agricultural areas, Heterogeneous agricultural areas, "Land principally occupied by agriculture, with significant areas of natural vegetation
244, Agricultural areas, Heterogeneous agricultural areas, Agro-forestry areas

The two maps are partially completing each other in certain regions like the North-West of Spain or in Latvia and Lithuania, where the border regions present a completely different pattern of spatial organization regarding the agricultural areas. One notable association appears between the distribution of the heterogeneous agricultural land and the low-mountain areas - the

Subcarpathian regions in Poland and Romania, the Central Massif in France present positive values of the indicator. One solution to better observe these relations is to cross the values of the location quotient with different regional frames/geometries, using the OLAP cube. The results could be used in order to refine typologies of land occupation at different scales of analysis. It could also be usefull in order to better seize the geographical specificities of regions.

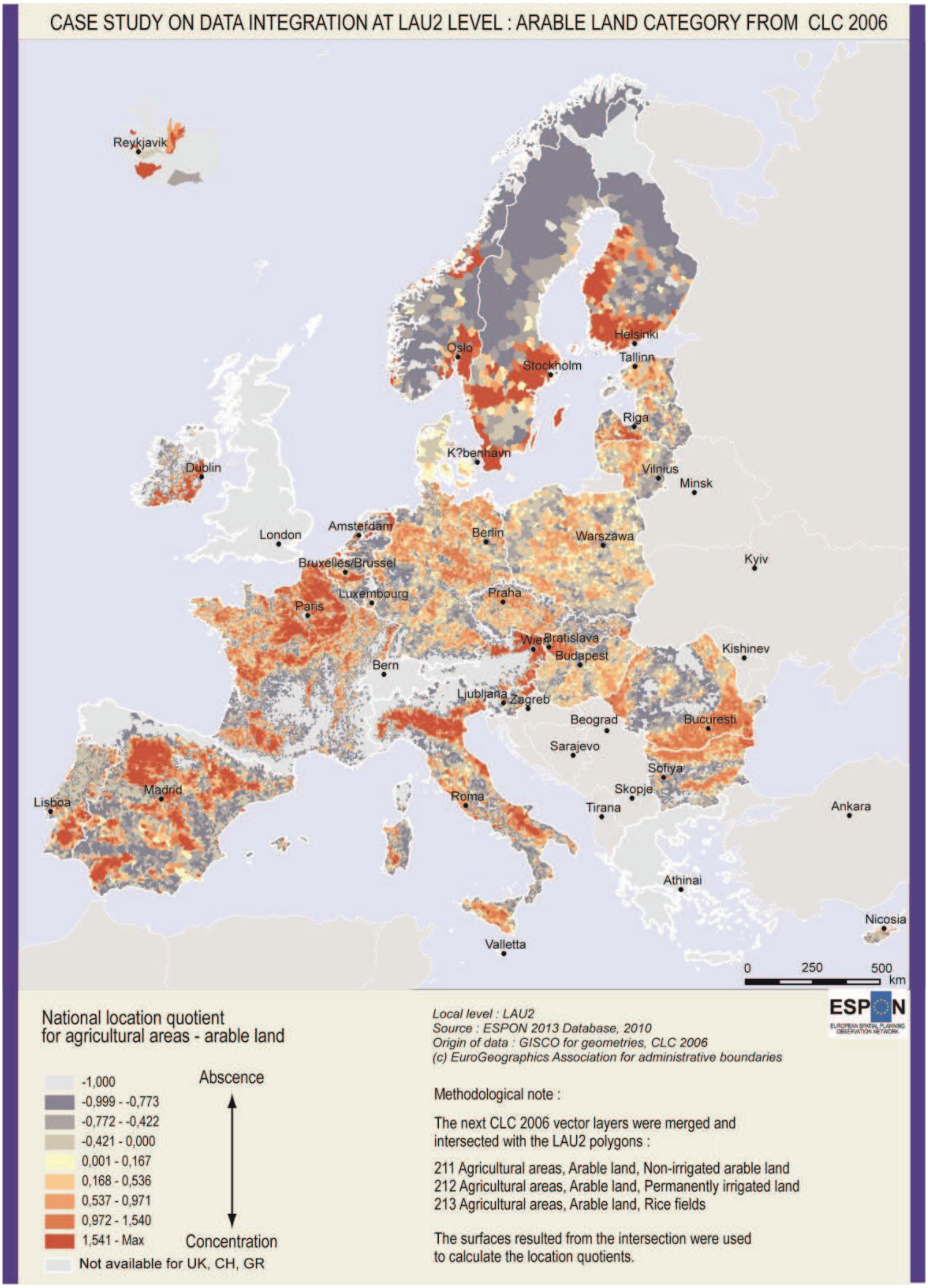

Fig 4 Location quotient of the arable land in 2006 - national reference

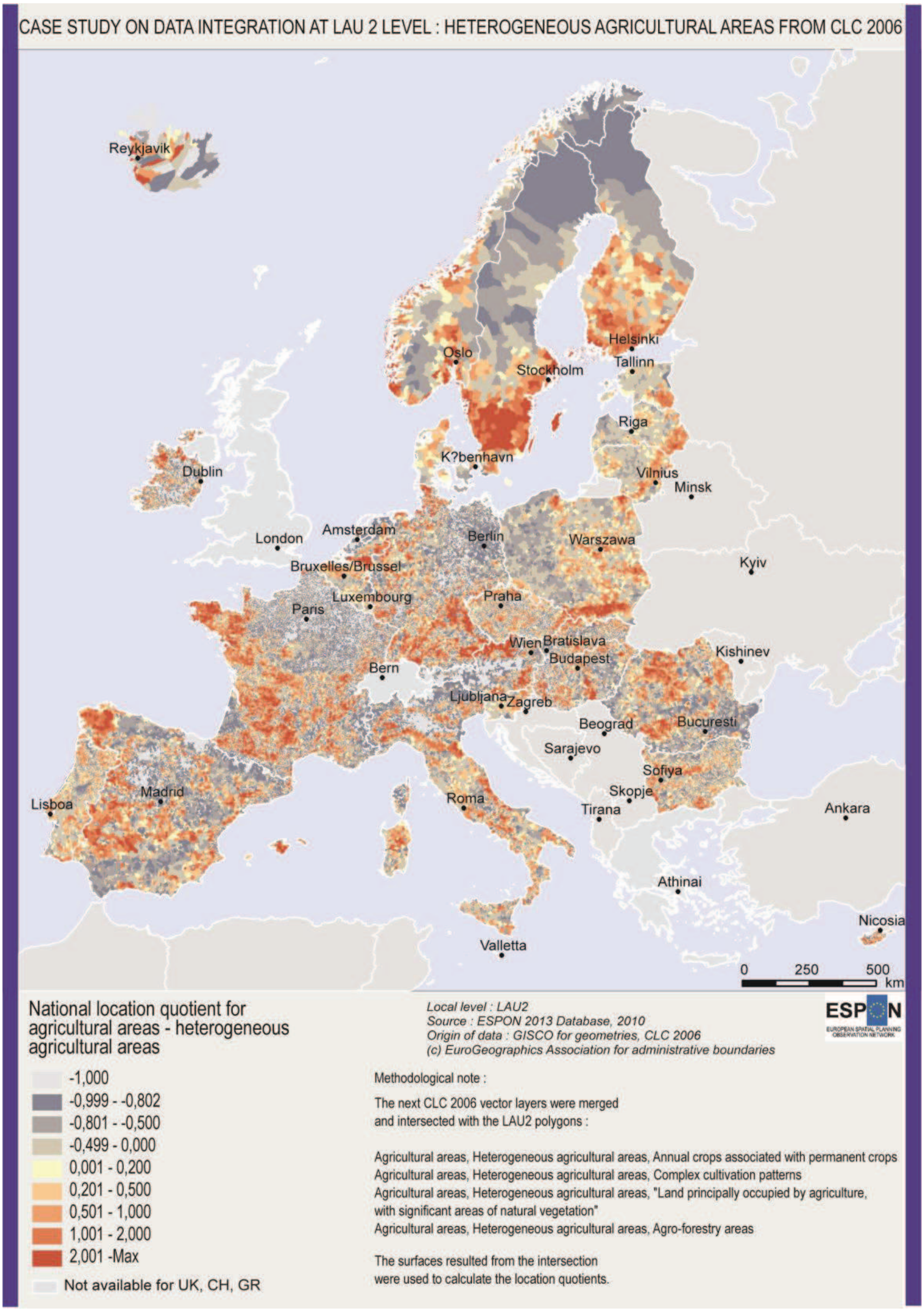

Fig 5 Location quotient of the heterogeneous agricultural areas in 2006 - national reference

The issue of the permanent cultures has multiple stakes because their spatial repartition is not only a matter of natural conditions. Territories specialized in permanent cultures are socially structured by traditions in this agricultural practice, at least in theory. This specialization is definitely market oriented, creating economical linkages between territories and functioning as an engine of extrovertion. Some of the regions involved in this analysis are easy to locate and associate with their specialization : Bordeaux, Côte de Rhone, Vallée de la Loire in vineyards, some other in Spain or Italy are more difficult to label. These generally rural spaces should be regarded as regions where the territorial competitiveness functions as a pre-condition for the economic performance, some of the well-known European brands being produced or located (Champagne). The next layers were merged in a single spatial reference and intersected with the LAU2 frame:

221, Agricultural areas, Permanent crops, Vineyards
222, Agricultural areas, Permanent crops, Fruit trees and berry plantations
223, Agricultural areas, Permanent crops, Olive groves

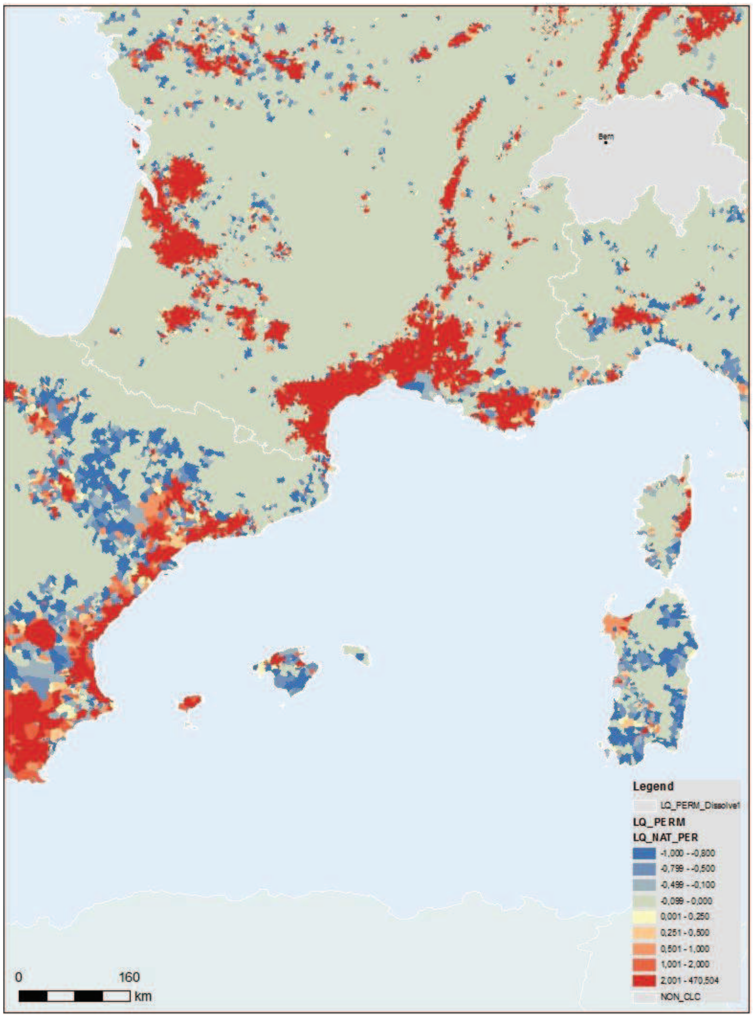

Fig 6 Location quotient of the permanent crops in 2006 - national reference. Draft/working map.

The last map we present as an illustrative output of our methodological approach integrated the forests and the semi-natural areas. Theoretically, this map should closely follow the natural limits or the ecological constraints in the development of these natural areas and be less spectacular. Consequentely, it is no surprise that the map emphasize mountain areas or regions with genuine natural potential. What is more interesting on the map is the repartition of areas that are practically deforested, despite their potential. Some LAU2 situated in Central Germany, in France, in Italy, in Hungary or in Romania are the signs of the deep impact of economic activities in the territory. Better understanding their spatial distribution should be a matter of interest, relevant for policy decision and scientific analysis.

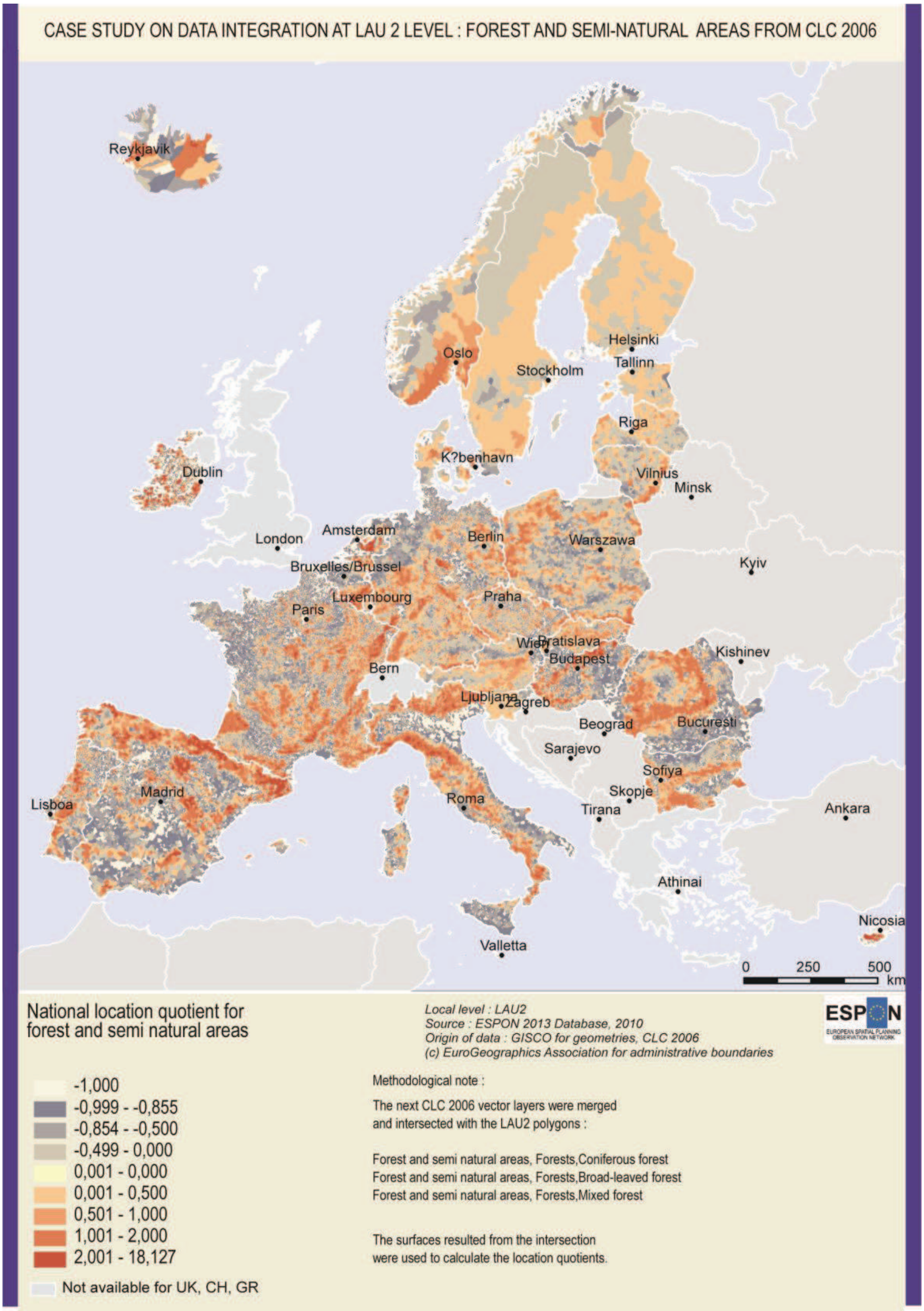

Fig 7 Location quotient of the forest and semi-natural areas in 2006 - national reference

The next layers were merged in a single spatial reference and intersected with the LAU2 frame:

311, Forest and semi natural areas, Forests, Broad-leaved forest
312, Forest and semi natural areas, Forests, Coniferous forest
313, Forest and semi natural areas, Forests, Mixed forest

The CLC 2006 data integration in the LAU2 frame produced 20 indicators grouped by three major categories : artificial surfaces, agricultural land and forest. The coverage of the ESPON space is almost complete, excepting three countries where data is not available.

Indicators	Total surface	Share of in %	LQ_NAT	LQ_EUR
Artificial surfaces	1	1	2	2
Arable land	1	1	2	2
Permanent crops	1	1	3	3
Heterogeneous agricultural areas	3	1	2	2
Forest and semi natural areas	1	1	2	2
Legend				
1	Easy to calculate			
2	Complex to calculate			
3	Reserved to interpretation			

Tab. 1 Synthetic table - degree of difficulty in the indicators construction

As the construction of the CLC 2006 vector layers is a matter of photo-interpretation, some of the information should be precautiously regarded, especially the category heterogeneous agricultural areas. In the case of the permanent crops, another reference for the location quotient could be considerent as relevant (NUTS2 scale), taking into account the very limited presence of this category in the North of the ESPON Space. The size difference between the LAU2 included in the data integration process is also a problem. The geometry of France is difficult to compare with the LAU2 frame of Poland and may influence the results, especially for the calculated ratios. However, this problem of scale is partially solved by the superior reference layer (national or ESPON Space) in the construction of the location quotients. One question that also deserves to be explored is how mobile in time is the land use and what transfers are realized between these categories. For the moment what we have is almost a complete picture of the ESPON Space land occupation in 2006.