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Monitoring biodiversity: challenges in High Nature Value farming identification

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Abstract. For its relevance to biodiversity conservation, the preservation and development of High Nature Value farming (HNVf) became one of the strategic priorities of Rural Development Policy. HNVf indicators were therefore included into the Common Monitoring Evaluation Framework. This paper illustrates a method aiming at HNVf identification on the basis of the integration of administrative and territorial data, enriched with qualitative information collected through field survey. By providing a higher level of both territorial detail and HNVf characterisation this method refines previous work undertaken by the Italian Network for Rural Development. Results for a pilot Italian region are described and suitability of the method to assess both other agro-environmental indicators and impact indicators is pointed out.

Keywords: High Nature Value farming, biodiversity, environmental monitoring and impact assessment, land cover, field survey.
JEL codes: Q15, Q18, Q51, Q57.

1. INTRODUCTION

The concept of High Nature Value (HNV) farming was introduced during the early nineties (Baldock *et al.*, 1993; Beaufoy *et al.*, 1994) in order to focus the attention on types of farming, particularly low-input farming, and farmed landscapes that are inherently valuable for biodiversity. It was recognised that the conservation of biodiversity in Europe depends on the continuation of low intensity farming practices across large areas of countryside (Bignal *et al.*, 1994; Bignal, McCracken, 1996; 2000).

According to Andersen *et al.* (2003) HNV farmland (hereafter HNVf) refers to «those areas in Europe where agriculture is the dominant land use and where agriculture supports or is associated with either a high species and habitat diversity or the presence of species of European concern or both».

HNV farming concept evolved in the framework of both the integration of environmental concerns into the Common Agricultural Policy (CAP), and the adoption of the European model of multifunctional agriculture (EEA, 2005; Paracchini *et al.*, 2006; Pointereau *et al.*, 2007; Paracchini *et al.*, 2008;

Beaufoy *et al.*, 2008; European Communities, 2010). Within this framework, HNVf and the associated farming systems have increased their policy relevance and in 2006 their protection and enhancement were included among the strategic priorities and targets of the European Rural Development Policy (European Council, 2006). Consequently, in order to monitor and assess impacts of Rural Development Programmes (RDPs) on biodiversity, HNVf indicators have been included in the Common Monitoring and Evaluation Framework (CMEF) of programming period 2007-2013 (European Commission, 2006), and confirmed in the subsequent programming period as well.

In 2007 each Member State was thus required to provide an assessment of the extent and quality of HNVf, based on the CMEF Handbook (DG Agriculture and Rural development, 2006), while facing the lack of both a common understanding of HNVf concept and a standardized common method. Estimates of HNVf were consequently produced by Managing Authorities following different methods and approaches reflecting the wide variety across Member States of agro-environmental characteristics, farming types and data availability (see for a review Peppiette, 2011; Oppermann *et al.,* 2012; Keenleyside *et al.,* 2014).

Over the past ten years, good progress has been made in HNVf identification as a result of both an increasing understanding of the HNVf concept and continuous work by Member States on improving their methods and data collection, supported by the EU Evaluation Expert Network through specific workshops and two guidance documents (European Communities, 2009; 2010; 2016), and drawing on the parallel work carried out by the European Environmental Agency (EEA, 2012), by European and national institutions (e.g. Paracchini *et al.*, 2008; Pointereau *et al.*, 2007; The Scottish Government, 2011), experts (e.g. Beaufoy, 2008; Oppermann *et al.,* 2012) and academy (see Benedetti, 2017 for a review). From the large scientific and technical debate on HNVf it emerged that, due to wide heterogeneity among Member States, a one size fits-all method it is neither appropriate nor feasible, rather it is appropriate to «use methods suited to the prevailing bio-physical characteristics and farming systems, and based on the highest quality and most appropriate data available (DG for Agriculture and Rural development, 2017) (Peppiette, 2011)».

Currently, wide consensus has been reached on the HNVf conceptual framework: HNVf definitions, typology, and common criteria for identification, are now widely accepted. HNV farming is widely understood as resulting from a combination of land use and farming systems which are related to high levels of biodiversity or the presence of certain species and habitats. Three broad types to be understood without being sharply delimited, based on Andersen *et al.* (2003) and subsequent modifications (Paracchini *et al.*, 2008), came into common usage in describing HNV farmland: Type 1. Farmland with a high proportion of seminatural vegetation; Type 2. Farmland with a mosaic of low intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers, etc; Type 3. Farmland supporting rare species, or a high proportion of European or World population.

The identification of farmland exhibiting HNV characteristics can be based on three different criteria: land cover criteria, farming system criteria and species criteria. Ideally a combination of criteria, depending on the type considered, should be used (Beaufoy, 2008). In practice, due to data limitation, this approach has demonstrated to be very difficult at level of entire countries or regions (European Communities, 2010).

Broadly, three main approaches are used, depending on type of data available: the land cover approach, based on land cover data; the farming system approach, based on data reflecting farming practices; the species approach, based on species data (Andersen *et al.,* 2003; European Communities, 2010; Keenleyside *et al.,* 2014; see Lomba, *et al.,* 2014 for a review).

In Italy, at the beginning of programming period 2007-2013, HNVf was identified by each Managing Authority based on different interpretations of the concept and using different methods, making it impossible to obtain a clear and homogenous picture at a national level. Therefore, in order to make available a national framework, the National Institute of Agricultural Economics, within the activities of the Italian Rural Network, provided estimates at a national level based on a common method following the EC Guidance documents, and pursuing, in particular, the land cover approach (Trisorio *et al.,* 2013; Rete Rurale Nazionale, 2014). Existing data (with both national coverage and regional geographical detail) influenced the level of detail of estimates. The analysis was based on various sources of territorial data available on a national scale: sample data derived from AGRIT project[1], Corine Land Cover data and Natura 2000 fact sheets. On these three

[1] AGRIT project is a statistical programme carried out by the Italian Ministry of Agriculture, Food and Forestry Policies (Mipaaf) since 1988. It consists of a Point Frame Survey based on a two-phase stratified sampling design aimed at producing national and regional statistics on the surfaces of the main agricultural crops and on some agro-environmental parameters. This was performed by processing data obtained from in-situ surveys on a sample of points randomly selected from a systematic sample of points (Frame AGRIT-POPOLUS).

themes, a geographic information system was created. The assessment referred on a 10x10 km grid (AGRIT cell.), has been based on the presence of low intensity farming and on three criteria derived from the types identified by Andersen *et al.* (2003) and expressed by three indicators: high proportion of semi-natural land cover; mosaic-like landscape; richness of species of conservation interest. The units of analysis, i.e. the cells, were assigned scores combining the scores obtained for each of the three indicators. Estimates were produced on the extent of both the three types of HNVf and the total HNVf, classified by nature value. The limits of this work can be found in the level of geographical detail of results, and in the limited information on management practices intrinsic to the land cover approach (European Communities, 2010). Particularly, land cover estimates, available for the AGRIT cells and derived from sample surveys, do not allow a precise localization of classes of land cover. The latter would require a further detailed territorial characterisation based on geo-referenced data possibly available at regional level.

The aim of the present study, equally realized within the activities of the Italian Network for Rural Development, is the refinement and enhancement of previous work by providing a higher level of both territorial detail and HNVf characterisation. The land cover approach is integrated with a sampling approach capturing information on farming practices/intensity and quality of HNVf, thus producing more robust and realistic HNVf identification (European Communities, 2010; Lomba *et al.*, 2014; Peppiette, 2011; EEA, 2012).

The method has been tested through a pilot for the Piedmont Region, building a specific database based on the integration of administrative and territorial data stored in the National Agriculture Informative System (SIAN), with particular reference to the data from the Integrated Administration and Control System - IACS (including the Land Parcel Information System), and data derived from the AGRIT project, enriched with qualitative information collected through field surveys on sample points statistically selected. The main stages of the proposed approach and a brief overview of outcomes for the study area are provided. The potential application of the proposed approach to RDPs impact assessment on environment and suitability for additional agro-environmental indicators is illustrated.

2. DATA AND METHODS

The research project has been structured in seven stages: 1) structuring of the reference grid linked with the AGRIT-POPOLUS sampling frame; 2) shaping of the spatial data bases on each unit of the square grid; 3) defining the data set for territorial characterization; 4) classification and stratification of each unit of the grid (and frame points); 5) field surveys; 6) statistical elaborations on management practices, landscape and naturalness parameters; 7) identification of «potential» HNVf.

2.1. Structuring the reference grid linked with the AGRIT sampling frame

As mentioned before the method proposed is based on the integration of spatial information, such as administrative and territorial information available from the IACS (i.e. Refresh project[2] and LPIS data, Farm register data) with field surveyed data detected in a sample of geo-referred points in order to collect additional data on management practices and agro-environmental parameters, otherwise undetectable by photointerpretation. The construction of the reference grid had therefore to take into account both the expected level of territorial detail and the point frame adopted for field surveys.

The first stage of the study was, then, the definition of the spatial unit where the information available was to be spatialised, so that the level of geographic detail was higher than previous work based on a square grid of 10x10 km derived from AGRIT project, based on AGRIT-POPOLUS[3] point frame The latter consists of a regular grid covering the entire national territory. Points on the nodes of the grid are spaced 500 meters. Each AGRIT-POPOLUS frame geo-referenced point was stratified according to the following strata: 1. arable land and fodder; 2. permanent crops; 3. permanent grassland; 4. woodland; 5. scattered trees and farm buildings; 6. else (artificial areas, waters, etc.).

For its characteristics the point frame AGRIT-POPOLUS was adopted also in the present study, but, as spatial unit grid, a regular grid consisting of square units of 2x2 km has been adopted as reference. This dimension has demonstrated[4] an acceptable level of detail for

[2] The Refresh project is carried out by the Italian Payment and Control Agency (AGEA). It is aimed at the prior certification of the territorial component of Italian farms and it is based on the photo-interpretation of the land use of the whole national territory. Photo-interpretation is not limited to the parcels declared for agricultural subsidies application, but artificial, natural and forestry is included.

[3] Permanent Observed Points of Land Use Statistics.

[4] The results of the «Pilot Study on the Basilicata Region», funded by the Mipaaf in 2012, show that square units of 2x2 km give an acceptable level of detail for regional level analysis. Aim of the AGRIT – Baseline project was the constitution of a unique baseline, through the integration of the available geographical data, land cover/use data, statistical

regional level analysis. As a result, for the Piedmont Region a grid of 6,692 square units of 2 km per side was obtained. The grid includes 101,516 geo-referred points from the AGRIT-POPOLUS grid.

2.2. Shaping the spatial data bases on each unit of the square grid

SIAN's databases used for integration were:

- Land Cover layer resulting from the Refresh project, consisting in photo-interpretation data of the whole national territory (300,000 sq.km).
- Ecological Focus Areas (EFA) layer of LPIS: landscape features (ponds, groups of trees and groves, ditches and canals, stones walls, hedges and tree row, field margins, terracing, grass margin, isolated trees) detected by photo interpretation;
- Farm register data (farm crops, farm's and farmer's information)
- RDP applications: type of measures applied by farm and associated areas[5];
- Territorial and administrative data (Province boundaries, Municipality boundaries, Natura 2000 areas, etc.).

The «refresh» data were superimposed on the grid enabling the definition of different land cover polygons for each unit of the grid. Subsequently, cadastral parcels falling within the agricultural polygons were identified, allowing the identification of the cultivated crop in each parcel as declared in the farm register. The output of this phase consisted of a database in which for each grid unit the land cover area (possibly detailed at crops level for arable crops) was defined according to the adopted legend[6].

It should be noted that for the boundary units grid the entire area has been considered (400 ha) and not only the area belonging to Piedmont Region.

The reliance on land cover data of high territorial detail made it possible to overcome some acknowledged limitations in HNVf identification (Paracchini *et al.*, 2008; EEA, 2012; European Communities, 2010) improving landscape analysis and the determination of factors of importance particularly in the identification and mapping of HNVf type 2 (Peppiette, 2011).

2.3. Defining the data set for territorial characterization

The characterization aimed to provide an overview of the grid units according to the main classes of land cover (Artificial, Natural and Forestry, Utilised Agricultural Area – UAA, Water) useful for supporting the subsequent process of classification. UAA was further split into sub-classes to be assigned a level of HNV probability (low, unknown, high) according to the peculiarities of local agriculture[7]. Indeed, each territory is characterized by specific types of farming system and cultivated crops that may, or may not, be of potential HNV. Moreover, in the case of the Piedmont Region, we separately considered rice fields, since they are potentially of high nature value (Bogliani, 2008; Travisi & Nunes, 2010; Lupi *et al.*, 2013; Giuliano & Bogliani, 2018). Indeed, under certain farming conditions (to be detected by field survey) they are expected to support a high level of biodiversity

Tab. 1. Data available for each grid unit.

- Natural and forestry areas surface and percentage ratio on the surface of the grid unit
- Natural and forestry areas surface and percentage ratio on the surface of the grid unit
- Artificial areas surface and percentage ratio on the surface of the grid unit;
- UAA surface and percentage ratio on the surface of the grid unit
- EFA surface and percentage ratio on the surface of the grid unit and on the UAA of the unit
- UAA with high probability to be of HNV and percentage ratio on the grid unit
- UAA with unknown probability to be of HNV and percentage ratio on the grid unit
- UAA with low probability to be of HNV and percentage ratio on the grid unit
- Area under rice cultivation and percentage ratio on the UAA
- Surface for which an RDP application has been submitted and share on the surface of the tile
- Average slope
- Surface falling within Natura 2000 areas and percentage ratio on the surface of the unit grid

Figure 1 shows the geographical distribution of the UAA according to the different levels of probability (low, unknown, high) to be of HNV.

data and climatic data to be used as reference for agro-environmental analysis.

[5] Data provided by the Piedmont Region.

[6] The legend derived from a combination of Refresh and farm register classes of land cover.

[7] The assignment of the level of HNV probability was related to the intensity of farming of type of crops based on the usual farming systems occurring in Piedmont Region.

Fig. 1. Distribution of UAA by level of probability of being of HNV (share of UAA of the grid unit).

2.4. Classification and stratification of each unit of the grid (and frame points)

The aim of the stratification was to classify the unit grid according to its level of probability of including HNVf. This, in turn, guided the subsequent selection of the AGRIT sample units characterized by unknown probability of being of HNV (that is, of possible, but uncertain nature value) to be field surveyed in order to detect additional field data useful for assessing the actual nature value of grid units.

The parameters and rules described in Table 2, led to the classification of each grid unit into five categories aimed at guiding the sampling process.

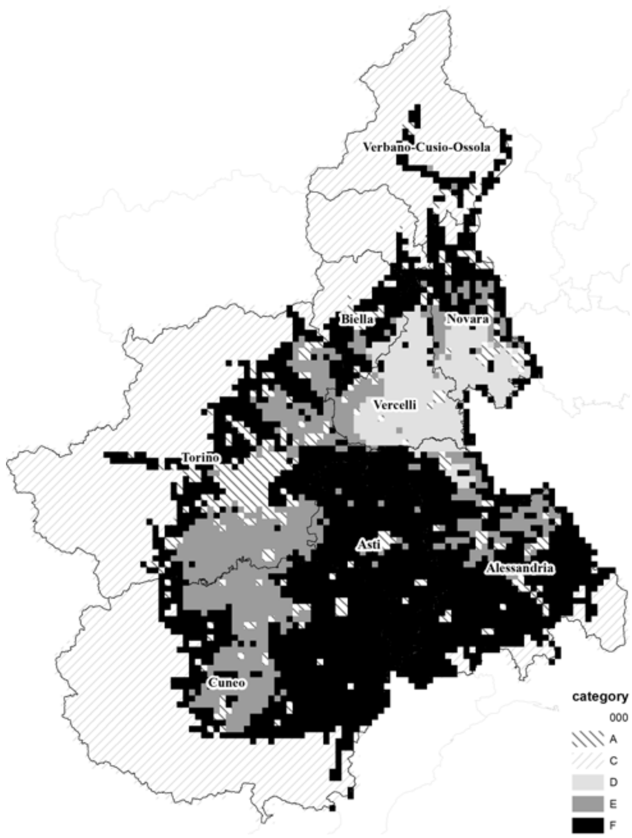
Tab. 2. Categories and respective conditions.

Category	Condition
A	Units where the percentage of artificial areas is greater than *33%* («low probability» to be HNVf)
C	Units above an elevation where UAA is «substantially» of HNV[8]. The elevation was established by the Piedmont Region experts («high probability» to be HNVf)
D	Units where the percentage of rice fields is greater than *33%*
E	Units where the percentage of «low probability» to be HNVf is greater than *33%*
F	Units where the percentage of «low probability» to be HNVf is less than *33%*.

[8] Based on HNVf definition, this category mainly includes permanent grasslands and pastures (farmland with a high proportion of seminatural vegetation), and farmland with a mosaic of low intensity agriculture.

The sample was extracted from the grid units of category D (rice fields % > 33%) and F (percentage of Low probability of HNVf < 33%), which mainly include areas of uncertain, but potential HNV, thus requiring further investigation in order to assign the actual probability of HNV.

Fig. 2. Grid units by category.



The sample was calculated, according to each stratum of the AGRIT-POPOLUS frame points, as described in Table 3.

Tab. 3. Sample calculus.

20% of the AGRIT-POPOLUS frame points classified as stratum 1 (arable crops) included in the grid units of Category D
40% of the AGRIT-POPOLUS frame points classified as stratum 1 (arable crops) included in the grid units of Category F
40% of the AGRIT-POPOLUS frame points classified as stratum 2 (permanent crops) and stratum 5 (Trees out of forest) included in the grid units of Categories D and F
20% of the AGRIT-POPOLUS frame points classified as stratum 3 (permanent grassland) included in the grid units of Categories D and F

The final sample was made up of 9,049 geo-referenced points.

2.5. Field surveys

The purpose of the field surveys was to gather additional information on management practices, landscape and natural characteristics useful to assess the intensity of farming and the level of naturality of farmland, making it possible to detect HNV characteristics linked to farming or farmland.

Parameters to be collected were identified taking into consideration the characteristics of the Piedmont Region's agriculture and so that data can be easily detectable in a quick visit carried out by agricultural engineers/technicians. Parameters to be collected include land cover/land use information as ground truth to qualitatively validate the land cover classification based on SIAN's databases.

Field surveys on the sample points were carried out between April and May 2017. Field surveyors were equipped with an Android-based software package, installed on a tablet, which enabled them to navigate and reach the sample points, enter the data and transmit it in real time.

Quality control of the data collected was performed to assess the survey results and the adequacy of the data for the supporting documentation.

The sampling approach enriched the analysis with information on management practices, landscape and naturalness of vegetation, thus enabling informative gaps of land cover approach to be reduced (European Communities, 2010; EEA, 2012).

Tab. 4. Information collected from field surveys.

All crop classes	Land cover/land use and coverage according to the AGRIT project classification
	presence of stone walls and their maintenance state
	presence of terraces
	presence of hedges and/or tree rows
	presence of water management
Permanent crops	planting pattern (density, regularity)
	management activities: crop conditions (managed/unmanaged); green cover (>50 cm or ≤50 cm) or ploughing
Grasslands	grade of naturalness of vegetation through the identification of key species
Rice fields	state of the land (in dry/submerged)
	presence of water furrows
	presence of grass margins

2.6. Statistical elaborations on management practices, landscape and naturalness parameters

For each square unit land cover types were defined according to combinations of farming intensity, landscape and naturalness parameters.

For this purpose, for all the sampling points, the data of each parameter were generated as follows:

- if at the coordinate point xi (xi represents the coordinate pair of the adopted reference system) the parameter was detected, the observed data was associated with it (value between 0 and 1);
- if at the coordinate point xi the parameter was not found, a null value was associated with it.

The combinations of the different parameters detected for each main land cover class were thus estimated.

To estimate the extent of the area associated with any possible combination of parameters, in the regular blocks of 4 km^2 (square blocks of side 2 km) a local estimation algorithm was used. The applied linear estimator used the information detected in the sampling points around each square unit.

2.7. Identification of «potential» HNV farmland

The identification of potential HNVf was based on land cover agricultural sub-classes associated with specific combinations of landscape, naturalness and farming intensity parameters believed[9] to be favourable to biodiversity, thus conferring HNV features to farmland.

[9] According to literature (Andersen *et al.,* 2003; European Communities, 2010; Oppermann *et al.,* 2012; Lomba *et. al.,* 2014) and expert opinion.

Examples of combinations of field-detected parameters considered for qualifying as HNV the associated land cover classes, are listed below: a) presence of terracing, presence of EFA, low intensity farming (irregular planting distance, no tillage, unmanaged crops) and the presence of green cover for permanent crops; b) presence of water furrows and of grass margin for rice fields; c) the presence of terracing or EFA for cereals, dry pulses and fallow land; while permanent grasslands were considered HNVf regardless of parameters detected.

The presence of irrigation was not given a «a priory» assessment, since its effect on biodiversity is not unique, but it can vary according to the territorial context and the crop considered.

Farmland thus identified, together with the areas previously assigned a «High probability» of being of HNV (thus including permanent grassland), has been used to construct the preliminary database of the potential HNVf in the Piedmont Region.

3. PRELIMINARY RESULTS AND FURTHER STEPS

All the data acquired and processed were structured in a final data base in which for each of the 6,692 unit grids the following data were available:

- land cover data deriving from the SIAN databases (Refresh + farm register);
- land cover surface estimates as a function of the agro-environmental and farming intensity parameters.

The available data for the Piedmont Region made it possible to build a preliminary dataset of potential HNVf in the region identified within the classes of UAA land cover. Graphs and images below show the preliminary results.

As regards the total surface, it should be noted that the databases are built on the entire surface of the unit grid (see § 2.2), therefore for the grid units on the border between two Italian regions, the surface considered was that of the unit grid and not of the regional limit. Vice versa, for the unit grid on the national border, only the surface belonging to the national territory was considered.

It can be seen from Figure 3 that almost half of the UAA exhibits HNV characteristics. The prevailing land cover of HNV is arable crops classifiable as HNVf type 2 «Farmland with a mosaic of low intensity agriculture and natural and structural elements», which are very widespread indeed in the Piedmont Region. It's followed by permanent grassland, classifiable as HNVF type 1 «Farmland with a high proportion of seminatural vegetation».

These results broadly confirm the extent of HNVf and types identified in the previous work (Rete Rurale Nazionale, 2014), but they display greater territorial detail, overcoming one of the main limits encountered in the application of the landcover approach, i.e the coarse spatial resolution of maps produced (e.g. Beaufoy, 2008; European Communities, 2010; Peppiette, 2011). They also incorporate information on the diversity of crops, on management practices and naturalness of vegetation. The first refines the HNVf identification taking explicitly into account the intensity of land management, the second taking into account its conditions.

The method proposed therefore makes it possible to monitor HNVf over time not only in their extent but also in their quality.

The more refined identification of HNVf enables the support of better targeting and tailoring of RDPs measures aimed at maintaining or enhancing biodiversity.

Nevertheless, these preliminary results are subject to further improvement after a process of fine tuning that implies expert opinion based on a careful analysis of maps and parameter combinations. Indeed, HNVf has been identified with a cautious approach, thus providing enough flexibility to allow possible refinements.

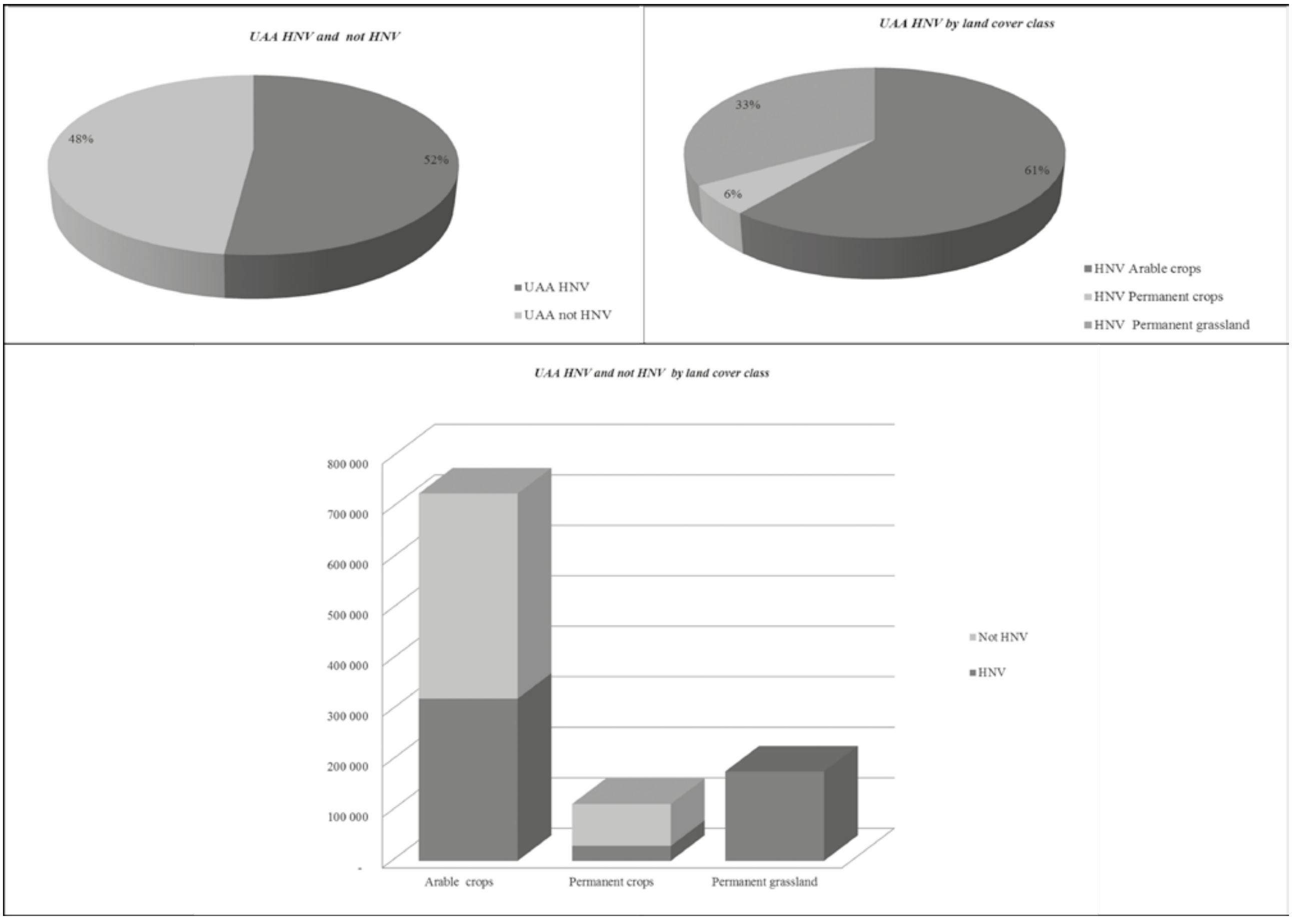
The process of fine tuning will be followed by the classification of HNVf according to different levels of nature value depending on the relevance for biodiversity of each grid unit.

The identification of type 3 «Farmland supporting rare species, or a high proportion of European or World population» will be part of a further stage in the project. It will be based on the integration of appropriate data on biodiversity such as species and habitats (Natura 2000), meadows and permanent grassland species and farmland birds.

4. CONCLUDING REMARKS

HNV farming, resulting from a combination of land use and farming systems which are related to high levels of biodiversity or the presence of certain species and habitats, is region-specific. It follows that the identification and monitoring of HNVf ideally require data with a high level of territorial detail (European Communities, 2010). The operationalisation of the concept has proved problematic for the multiple aspects it comprises (i.e. land use, farming system, species) and subsequent technical and data needs (Beaufoy, 2008; European Communities, 2010). During the last two decades approaches and methods have been driven mainly by type of information categories and data availability, thus only par-

Fig. 3. HNV and not HNV UAA (share and classes of land cover).



tially highlighting HNVf's inherent characteristics (see for a review Oppermann *et al.,* 2012; Peppiette, 2011; Keenleyside *et al.,* 2014; Lomba *et al.,* 2014).

The method proposed relies on the integration of in-situ data, such as LPIS and national orthophotos from the Refresh project, with other administrative and territorial data, providing a detailed characterisation of territory. A further in-depth analysis is provided using qualitative information collected through field surveys on statistically selected sample points. The latter, in turn, made it possible to qualify the territory and, specifically, to detect HNV characteristics exhibited by land units concerning both farming intensity and farmland ecological conditions.

The integration of a land cover approach, based on data of high territorial detail such as the orthophotos from the Refresh project and on a powerful and relevant dataset such as LPIS (Beaufoy, 2008; European Communities, 2010), with a sample approach made it possible to overcome relevant limitations acknowledged in many HNVf identification and mapping exercises (Lomba *et al.,* 2014) and increased the robustness of estimates.

The geodatabase, structured as described above, is suitable for further data integration according to data availability. For example, it can be further enriched by ecological data making it possible to identify type 3 HNVf. The latter will be part of a further stage in the project.

The flexibility of the method presented is such as to enable the integration of additional data layers, thus allowing the improvement of results as new data become available. Most agro-environmental indicators are strictly dependent on land cover and land use features. The characteristics of the proposed method also make it suitable for the development of additional agro-environmental indicators by allowing a detailed characterisation of the territory followed by a field data collection on a statistically selected sample of points to detect the appropriate[10] parameters. Indeed, it allows us to direct the analysis towards the indicators to be developed.

Additionally, the integration of administrative data (including RDP applications and farm registers) with territorial data, would make the proposed method also suitable for implementing rural development policy impact indicators and assess the effectiveness of specific RDP measures.

Multiple use shows the potential for agro-environmental monitoring and evaluation of the proposed method.

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[10] The parameters to be collected are specific to the agro-environmental issue to be investigated.

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