Identification of High Nature Value Farmland: a methodological proposal

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Abstract

The concept of HNVF raises thanks to the integration of biodiversity theme into the CAP. The precise definition of the topic and the application of a correct identification procedure deeply affect the assessment needs of European RDPs. Nevertheless, the level of HNVF knowledge is rather limited due to a methodological variability and a structural lack of suitable data. The research aims at overtaking HNVF identification difficulties complying with specific Community requirements and the use of an efficient theoretical framework that allows accurate location and monitoring over time. The methodology results in a characterization and accurate HNVF map for the Apulia Region that can effectively calibrate the implementation of the regional management policies.

Keywords: Biodiversity, Agricultural intensity, Natural value, GIS, Landscape

1. Introduction

1.1 Definition of high natural value and classification of HNVF

The radical changes that have affected agricultural systems and agricultural landscapes in relatively recent years have led agricultural areas to play a key role in the conservation of specific habitats for many animal and plant species. The concept of High Nature Value Farmland (HNVF) was created in response to the need to safeguard biodiversity even outside the habitats placed under special protection regimes (for example those deriving from Habitats Directive), also considering the growing attention of local communities towards the issue of biodiversity and agro-biodiversity conservation programs (Sardaro, et al., 2016). In Europe, the concept of HNVF developed in the early 1990s (Baldock et al., 1993; Beaufoy et al., 1994), focusing attention on agrarian systems characterized by low density of cultivated plants and farmed animals, a reduced use of chemical inputs and a massive use of labour-intensive practices, especially manual (such as sheep-farming). This concept has progressively evolved thanks to the integration of environmental issues within the Common Agricultural Policy (CAP). In this regard, high-nature value farmland are those areas where agriculture represents the main (prevalent) land use and to which is associated the presence of a high number of species and habitats, as well as particular species of Community protection concern. These are areas whose low agricultural intensity matched well with a high presence of semi-natural vegetation or with an agriculture that gives the landscape a mosaic appearance; the latter defined by a diversified ground cover richness in semi-natural and artificial. According to some recent estimates provided by the quantification of the context indicator number 37 of the CMEF[1] (European Commission, 2015), about 32% of European agricultural areas qualify as High Nature Value (mainly concentrated in Eastern and Southern Europe). Particular habitats, such as semi-natural grasslands, steppes and small mosaic areas with numerous landscape elements constitute these areas; HVNFs are also abundantly present in mountain areas. In Italy, these agricultural systems can be mainly associated with semi-natural pastures, permanent meadows, traditional orchards and arable crops (Trisorio et al., 2012).

Specific projects promoted by the European Environment Agency (Andersen et al., 2003) and the European Commission (IEEP, 2007a and 2007b) identified the key features of HNVF. They are identified in low-intensity agricultural systems; semi-natural vegetation; high diversity of land cover. The researches mentioned have shown that the dominant feature of HNVF is the low intensity of the agricultural activity carried out together with the presence of semi-natural vegetation. In the case in which the latter is reduced, however, a high degree of diversity of land cover (mosaic structure) together with a low intensity of production activities can still ensure significant levels of biodiversity, especially in the presence of sufficient elements capable to preserve ecological niches. However, even areas with intensive farming can allow the maintenance of important species of conservation interest (for example, birds), so that the only degree of diversity of land cover does not allow to univocally verify the presence of HNVF.

From the aforementioned works and from the analysis of the literature we can see that a classification in three typologies of the HNVF areas already exists:

[1] Common Monitoring and Evaluation Framework of the Common Agricultural Policy

- Type 1: Agricultural land with a high coverage of semi-natural vegetation;
- Type 2: Agricultural lands dominated by low-intensity agriculture or by a mosaic of semi-natural and cultivated territories;
- Type 3: Agricultural land with rare species or a high proportion of animal and / or plant species of conservation interest at European or world level.

However, even today the level of definition of HNVF, in scientific terms, as well as in relation to their spatial distribution is still rather limited, on both a European scale and, even more, a national and regional scale. The necessary systematization and consequent identification is dictated, in addition to the positive externalities (Madureira, L. et al., 2013), also from the observation that an adequate cognitive system can allow modulating, adequately, effectiveness and efficiency of policies regarding the different types of agricultural areas they are implemented on.

In recent studies, scientists pay attention to the characterization of HNVF from a social and environmental point of view. The main idea is to connect HNVF with ecosystem services provided by agricultural habitat such as carbon storage, flood control or water purification, support services such as oxygen atmospheric production or cultural services where agro-tourism occupies an increasingly relevant role (Dumitrascu, M., *et* al. 2018). In other words, links among traditional farming practices and survival of viable rural communities are investigated. Other researchers deal with micro properties of HNVF: Vigani and Dwyer (2019) propose a characterization of farms in marginal economic and high nature value conditions aiming to help identifying farm-level management and policy options for economic, environmental and social sustainability. Moreover, post 2020 CAP reform confirm the attention towards environmental sustainability, biodiversity and landscape (as well as a fair income for farmers). Main changes of post 2020 CAP concern the way Member States (MS) will determine how to achieve objectives and targets, assuring a more tailored use of CAP support. The 'performance based delivery model' gives much subsidiarity and responsibility to MS who are asked to set objectives and targets also for semi-natural / semi-improved agricultural habitats (not listed in Annex 1) that are declining, or at risk of declining, and their associated farmland species. HNVF will have a key role in future CAP while MS are still developing ways of mapping, targeting and monitoring the location/extent of HNVF (IEEP, 2018). Mapping HNVF at regional or national scale is a complex object of research also because, as with habitat quality indicator (CICES Version 5.1, 2019), HNVF is a non-specific indicator, that needs to be treated with unavoidable assumptions and generalizations.

1.2 Aspects concerning the identification of HNVF

The methodological variability described by the literature is usually associated with a structural lack of data and information needed for a correct identification of the HNVF areas. The three typologies identified by Andersen pose different problems about their characterization and individuation. For this reason two complementary approaches have been developed, to which a third is added (although less used in the studies conducted so far). The first, starting from the analysis of the "land cover" is based on the relationships existing between the "agricultural classes" and between these and protected habitats and species. The second considers the study of farm types combining agronomic and economic data. The third considers the effective distribution of wild species in agricultural areas (Figure 1). It highlights how the Institute for European Environmental Policy (IEEP) in the most recent report on the topic (IEEP 2014) encourages individual EU States and the administrations involved to operate at least a joint use of the first two approaches to ensure correct identification of HNVF areas.

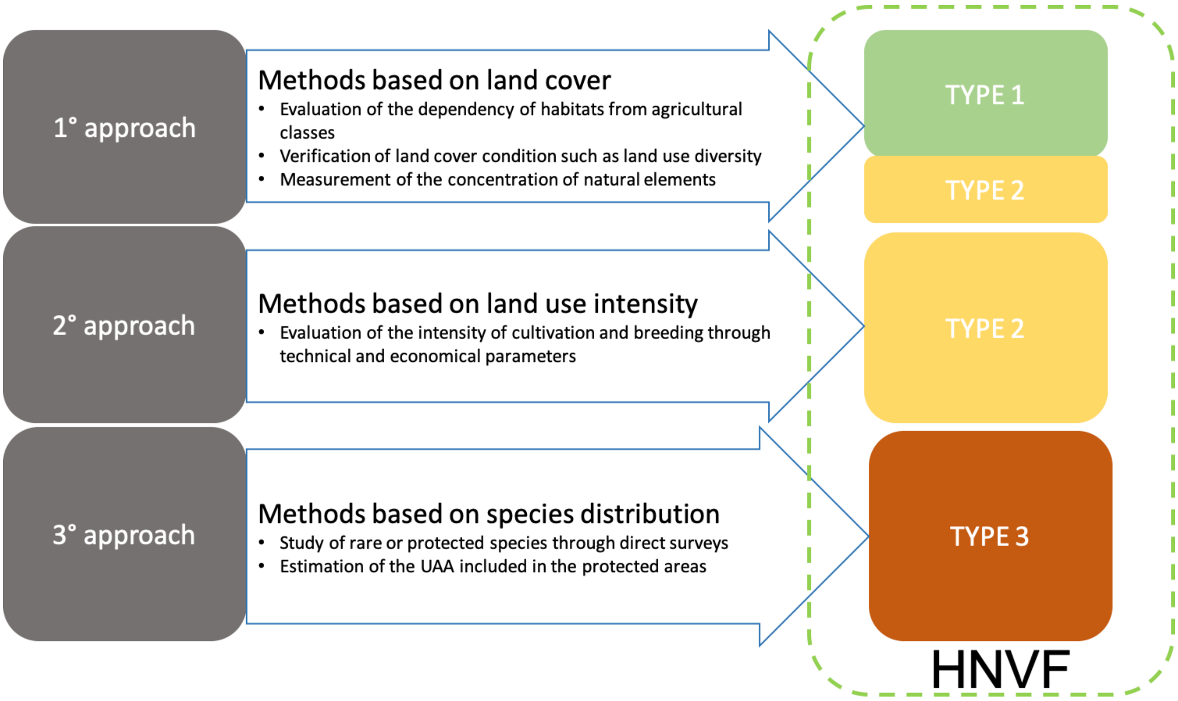

Figure 1 Methodological approaches used in literature by type (Our elaborations)

On an operational level, the work of Andersen et al. (2003) identified the potential HVNF areas on a European scale by combining the cartographic information of the Corine Land Cover (CLC) with the statistical-economic information of the Farm Accountancy Data

Network (FADN). Although useful for an overview, such maps designed and implemented throughout the EU still require more detailed data, taking into account national and, obviously, regional data sets. For these reasons, JRC and EEA carried out a review of the methodological part, concerning the mapping of the land cover, which led to the development of a new map on a European scale in the period 2005-2007.

The work widespread from the Italian National Rural Network (NRN, 2014) follows the land cover approach and uses data from the statistical survey AGRIT2010 of the Ministry of Agricultural and Forestry Policies (MIPAAF) integrated with data derived from CLC and from the database of Italian sites designated at national or European level interest in protecting habitats of community interest. In fact, even if CLC appears today the best available source of land cover data it is clear that its use as an instrument aimed at the localization of HNVF on a regional scale have several limits, such as the greater detail required, the low updating frequency and the absence of elements pertaining to the intensity of cultivation[2]. Another study recently conducted in Apulia (Campedelli et al. 2018) focuses on the analysis of territorial suitability to host species of bird of conservation interest. It therefore follows the third approach to evaluate the HNVF quality starting from NRN identification results.

The European Evaluation HelpDesk for Rural Development[3] has published an interesting document to allow the construction of a methodology that responds to specific knowledge and monitoring needs on HNVF areas either at a state or at a region level. An important point concerns the need to define HNVF areas in a spatially explicit form. This requires conducting the analysis in a GIS environment and using geo-referenced data and information. It is also necessary to integrate methods based on land cover (HNVF type 1 and 2) and methods based on cultivation/breeding intensity (HNVF type 2) and possibly methods based on the distribution of species (HNVF type 3). The approach must also be dynamic to allow monitoring of the evolution of the phenomenon. The data used in the analysis must necessarily follow the changes occurring in the agricultural areas and the recording of these variations must take place in a short time to appreciate the changes in the quantity and distribution of the HNVF areas. Data used in the analysis can be secondary or primary. These

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[2] Analysis of the literature shows that the data used in the studies concerning the identification of HNVF areas derive essentially from Corine Land Cover 2012 (IV Level), Regional Thematic Maps, Habitats and Nature Maps with indication of the overall index of ecological value (corine Biotopes), from the hydrography and orography maps.

[3] Directorate-General for Agriculture and Rural Development - Unit E.4 (2016): Working Document Practices to Identify, Monitor and Assessment HNV Farming in RDPs 2014-2020.

may be specific to HNVFs or be part of larger biodiversity and habitat monitoring programs (Oppermann et al., 2012). It is also necessary to record the qualitative variations of the HNVF areas and the steps that can take place from one qualitative status to another, in terms of intraspecific variations (increase or decrease in the level of biodiversity and / or natural value within a typology HNVF) or interspecific (transition from one HNVF type to another). To appreciate the changes, obviously, the use of the same methods and data sources is strongly recommended.

2. Methodology

2.1 Methodological approach

The aim of these researches is to identify a methodology that allows quantifying, localizing and monitoring over time HNVF areas at regional level. It is based on a solid theoretical framework developed by Andersen (2004) and on the criteria proposed by the European Evaluation HelpDesk for Rural Development.

The theoretical framework allows structuring the methodology adopted through a cascade process highlighted in the following steps:

- identification of the most appropriate single or multiple criteria to break down the three types;
- choice of the indexes that return the types and choice of the aggregation methods between indicators;
- selection of indicators measuring the phenomenon defined by the index and corresponding to the chosen criteria;
- choice of data sources;
- choice of the format of the analysis and the geographical scale of the survey;
- selection of spatial analysis tools for data conversion.

2.2 Description of the methodology

Starting from the above mentioned framework, the concept of HNVF can be considered from two points of view: the naturalness of the areas and the type of management of the agricultural systems. The territorial naturalness is determined by the predominant land cover within each agricultural system, with reference to the agricultural land use, to the types of semi-natural vegetation, to the elements of biodiversity, to the landscape elements and the historical-cultural value. Instead, the component of the management of agricultural systems is determined on a farm scale, with reference to the cultivation models and the intensity of use of fertilizers, plant protection products, irrigation and mechanization. In order to select the indices and the indicators used for satisfy the criteria of HNVF areas, a check was made on the naturalness elements and on the type of management of the agricultural systems. Figure 2 describes the criteria adopted to allow, as mentioned, the decomposition of the three types or to allow the re-composition of the indices (and the indicators) in a way that guarantee the satisfaction of the prescriptions of the theoretical framework. Furthermore, based on the criteria, the indices and the most appropriate aggregation methods are defined. The choice of the indices also derives from their ability to directly measure the phenomenon that defines the type, as in the case of types 1 and 3, or the possibility of being able to aggregate them in a logical manner, as in the case of type 2[4].

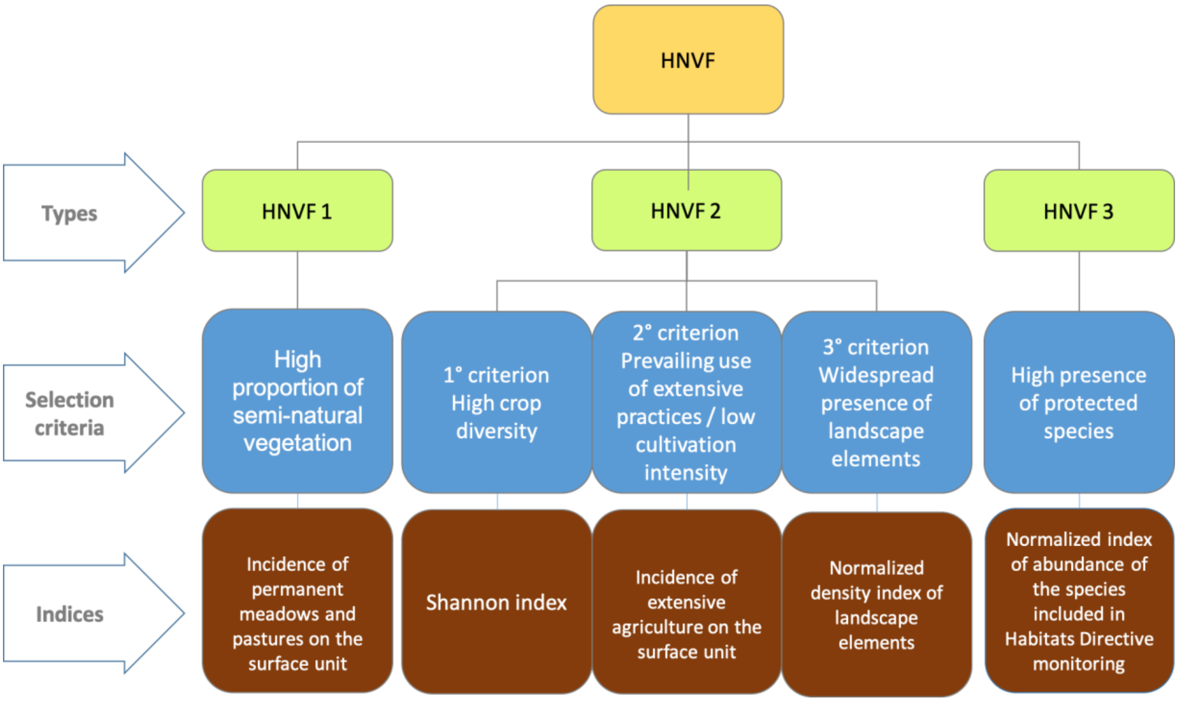

Figure 2 Scheme for the identification of HNVF area types based on criteria and relative indices (Our elaborations)

HNVF type 1 areas are identified starting from territories where agriculture is the predominant use and where it is carried out with the concomitant high presence of natural or semi-natural spaces. Several sources (for example the comparison between the land use map and the Nature Map[5]) show a frequent overlap between the agricultural areas belonging to the classes of meadows, natural and uncultivated pastures with habitats of significant

[4] For type 2 HNVF areas, a non-compensatory aggregation of the 3 indices was chosen to allow compliance with the criteria
[5] ISPRA, 2004 and 2009

naturalistic value. The correct identification of natural meadows and pastures is therefore of fundamental importance for the identification of type 1 HNVF areas.

The second type of agricultural areas with a high naturalistic value is identified by the presence of three aspects of the agricultural territory attributable to the low intensity of cultivation in support of biodiversity. In particular, the crop diversity requires a limited specialization of production and greater complexity of the agricultural landscape, benefiting the spread of wild species. Moreover, the presence of extensive practices is defined by a poor use of agricultural inputs, therefore a limited disturbance for biodiversity. Finally, agricultural landscape elements constitute an important refuge and territorial connection features for the wild species.

As mentioned, the logical process and the consequent elaborations are crucial to define the second type of HNVF areas, strongly linked to the following criteria:

- 1st high crop diversity;
- 2nd prevalent use of extensive practices;
- 3rd diffuse presence of agricultural landscape elements.

In the first case, the presence of an identifiable agro-ecomosaic is assumed with a sustained diversity of the crops present in the analysis unit. The employment of a diversity index can represent the richness of the agro-ecomosaic. Shannon's diversity index (Shannon and Weaver, 1949; Pielou, 1975; Magurran, 1988; McCarigal and Marks 1995; Crimella et al., 2001; Turner et al., 1989, 2001) is able to measure diversity of the agricultural landscape in terms of agro-ecomosaic richness. The greater the value, the greater the degree of diversity registered in the unit of analysis.

The second criterion related to the identification of the second HNVF type requires that areas of the investigated territory are identified where agriculture is extensive or where the agricultural practices used are extensive. In the literature, the intensity of agricultural land (Turner, BL, & Doolittle, WE 1978; Temme, AJAM, & Verburg, PH 2011; Teillard, F., et al., 2012) refers to the level of use of input (water, mechanization, fertilizers and plant protection products). The greater the application of them, the higher the level of intensity of agricultural activity carried out in those agricultural systems.

Finally, it should be noted that the structural elements of agricultural landscape are important features as these elements represent, in a predominantly agricultural land, the ecological corridors that are decisive for shelter, for food search and for movement needs of wild animal species as well as important ecotones for wild plant species. The density of these elements on the surface unit represents, quantitatively, the capacity of the agricultural territory to provide benefits deriving from the presence of ecological corridors. The three criteria, if satisfied simultaneously in a defined territorial unit, give rise to a HNVF area of the second type, highly representative of the capacity of agriculture to conserve animal and plant biodiversity[6].

The third type of HNVF areas may seem apparently simple and easy to understand. Instead, even in the presence of a conventional type of agriculture (and in the absence of particular elements of widespread naturalness) it is necessary to consider the presence of animal and plant species of non-agricultural interest. The abundance criterion of species of conservation interest can define these areas.

According to the framework steps described, Table 1 contains the overall synoptic table, which, starting from the indices, proposes the indicators that are able to measure every single phenomenon included in the index. Each choice complies with the theoretical framework. In fact, all the indicators can be calculated by using one or more alternative data sources, each of which is evaluated in terms of the possession of specific requisites (spatial detail, dynamism, updating). These requirements determined the choice of data sources[7].

Table 1 Evaluation of indicators and data sources

Source: Our elaborations

[6] Operationally this means that a non-compensatory aggregation method has been adopted.
[7] For example, the CLC was considered unsuitable because it did not meet the requirement of dynamism, or frequent update.

Indices	Indicator	Source	Spatial detail	Dynamicity	Update
Incidence of permanent meadows and pastures on the surface unit	Incidence of permanent meadows and pastures on the surface unit	Sentinel 2	Raster with a 10m cell	yes	5 days
Shannon index	Incidence of the arable lands on the surface unit	Sentinel 2	Raster with a 10m cell resolution	yes	5 days
	Incidence of the woods on the surface unit				
	Incidence of the permanent crops on the surface unit				
	Incidence of the vines on the surface unit				
	Incidence of permanent meadows and pastures on the surface unit				
	Incidence of inland water on the surface unit				
Incidence of extensive agriculture on the surface unit	Area covered by arable lands with low use of agricultural inputs	RICA data on the use of water, fertilizers, plant protection products and mechanization per hectare	Punctual data from RICA sample survey (necessary interpolation)	yes	annual
	Area covered by vines with low use of agricultural inputs				
	Area covered by permanent crops with low use of agricultural inputs				
	Incidence of the woods on the surface unit	Sentinel 2	Raster with a 10m cell resolution	yes	5 days
	Incidence of permanent meadows and pastures on the surface unit				
Normalized density index of landscape elements (aggregated index)	Agricultural point elements density (trees outside forest or isolated trees)	Regional technical map	Punctual geometries	partly	10-15 years
	Agricultural line elements density (trees outside forest or isolated trees)	Regional technical map	Linear geometries	partly	10–15 years

	Incidence of the woods on the surface unit (polygonal elements)	Sentinel 2	Raster with a 10m cell resolution	yes	5 days
Normalized index of abundance of the species included in Habitats Directive monitoring	Number of species on the surface unit included in Habitats Directive monitoring	Habitats Directive monitorin g	Shapefile with a 10 km polygons	yes	6 years

According to the table 1, the geographic information system was prepared and developed by using the following information layers:

- Sentinel-2 Multiband Satellite Data.
- FADN Database.
- Species distribution maps from Habitat Directive monitoring program.
- Apulia Regional Technical Map.

With regard to the data source, the need to identify a dynamic and at the same time speedy instrument that does not involve the high costs of direct investigations, let it look with particular care to the use of Sentinel 2 satellite images. Sentinel-2 is the newest generation Earth observation (EO) satellite of the European Space Agency (ESA) for land and coastal applications included crop and forest classification. The satellite, launched in June 2015, is part of Europe's Copernicus program aiming at independent and continued global observation capacities. Compared to Landsat satellites, Sentinel-2 offers an increased spectral and spatial resolution with 13 spectral bands of 10 to 60 m spatial resolution (Vuolo, F. *et al*. 2016). Moreover, in terms of temporal resolution, Sentinel-2 give an adequate update possibility with a combined constellation revisit frequency of 5 days. In comparison, Corine Land Cover, commonly used for such purposes, precisely identifies the land use classes that represent the starting point for the calculation of indexes. It has a good thematic resolution not supported by a time resolution (about 5 years) and a spatial resolution (Minimum Mappable Unit of 25.000 square meters), able to provide adequate disposing of the transformations taking place on agriculture landscape. Moreover, in the same way, National Agricultural Census has a too long updating period and a geographical detail unit too large (Municipality).

The use of satellite images requires the application of appropriate methods for remote sensing such as supervised classification methods or automatic ones. Recognition techniques has been evaluated among a few other for its large application in studies concerning land cover maps production from satellites images, computation efficiency and reliability of the algorithm. Maximum Likelihood Classification (MLC) was preferred in consideration of large use of the technique and the simplified land cover map obtaining procedure. Moreover, MLC is included in the Semi-Automatic Classification Plugin (SCP), a free open source plugin for QGIS, used in many studies and promoted by ISPRA (Institute for Environmental Protection and Research – Italy).

The derived land cover map from Sentinel 2 data forms the basis on which to carry out the subsequent processing operations. Indeed, it has an immediate relevance in the calculation of type 1 HNVFs, through the isolation of the class of meadows and natural pastures and, in the calculation of the index of crop diversity, by calculating the incidence of each of the classes per unit area and the application of the Shannon diversity index formula.

$$H' = -C\sum_{j=1}^{s} p_j \ln p_j$$

where:

- C: constant equal to 1;
- Pj: percentage incidence of the class J surface compared to the total;
- s: number of classes of crop types;
- J: J-th class of crop type.

Although the description of indicators is not the main objective of this article, on the other hand, it is important to explain further the way the process is carried out. We focuses on data sources, on the way spatial data are returned and on the territorial scale analysis is referred to.

The modality of data restitution (set the use of georeferenced spatial data as a direct constraint) has conditioned the choice of the calculation methods to be perform in the GIS. This is a crucial step to prepare the methodology. It is important to pointing out that results of the calculation of indicators on a spatial basis can be returned in raster or vector format. The former format requires sizing the fictitious reference cell as an elementary unit of analysis while the latter one presuppose the choice of the elementary territorial minimum figures such as particles, map sheets, farms or municipalities. Each of the two outputs has positive and negative elements that have been carefully evaluated both for the effect they have on analytical choices, and on the outcome they may have regarding the use of results for public decision maker use. Of course, while territorial figures like cadastral data are more understandable for decisional and political purposes, the use of raster cells, for which we have opted, albeit fictitious, is a flexible tool with a wide possibility of use. However it is not excluded the possibility to re-project the results in a discrete form such as cadastral parcels.

Specific spatial elaborations appropriately modified each layer in order to (i) prepare a dataset for our research analysis and (ii) make it compatible with a geographic result as a raster format with a 1000 meters cell (1 square kilometer). The scale of analysis, then the width of the fictitious reference cell for the calculation of the indicators, was chosen opting for a solution that would allow a fair compromise between time ease of calculation and effective appreciation of the phenomenon to be measured.

The analysis of agricultural systems through FADN and RICA[8] databases presents several positive aspects to identify HNVF areas (especially type 2). These data are regularly updated, which increases their usefulness for monitoring purposes. However, the possible non-representativeness of all agricultural systems potentially affected by HNVF can be observed. The data from the Agricultural Accounting Information Network, RICA, updated annually by CREA[9], however, provide useful information on the location of the companies subject to the sample survey and the indication of the levels of each input included in the analysis for each crop. The use of RICA microdata, however, requires a first phase of georeferencing and aggregation on a company basis of agricultural input data by crop type and then an interpolation phase that returns a continuous data on the use of inputs on the investigated agricultural territory. The point data of the farms from RICA survey have been aggregated according to crop types consistent with the Sentinel 2 land use classes. Afterwards these point database have ben interpolated through a deterministic technique, the Inverse Distance Weight (IDW), in order to obtain a continuous surface covering the complete regional agricultural territory (Green, S., & O'Donoghue, C. 2013; Fais, A. et al. 2005).

The landscape elements from Regional Technical Map instead are subjected to spatial analysis aimed at converting punctual, linear or polygonal vector data into raster. Data used for the calculation of the density of the agricultural landscape elements are represented by the Regional Technical Map in which are highlighted in particular the punctual features

[8]Agricultural accounting information network

[9] CREA: Consiglio per la Ricerca in Agricoltura e l’Analisi dell’Economia Agraria - Council for Research in Agriculture and the Analysis of Agricultural Economics.

(trees outside forest or isolated trees), linear features (dry stone walls, hedges and tree-lined rows) and the polygonal features (wooded areas). The vicariate nature of these elements imposes the selection of a compensatory aggregation method of the density indexes, since it is presumable an abundance of maximum one of the feature types.

Moreover, the abundance of species of conservation concern is measured through the wild species distribution maps deriving from the monitoring of Habitats Directive. It is a 6 years update monitoring, consisting in the distribution of each species in indicative areas with a 10 kilometers greed.

The application of the proposed methodology with GIS on a regional scale requires the use of specific spatial processing techniques and conversion procedures to transform satellite images, point databases or geometrically discrete vector data in continuous raster formats. The aforementioned techniques such as MLC for classification of satellite images and IDW for interpolation of point data found in the literature among the most effective and available on commercial and open source software used for the intended purpose.

Finally, as in the most common multi-criteria analyses, the choice of thresholds represents a crucial, often criticized, topic. In HNVF identification, being an aggregated non-specific index, it is difficult to identify optimal and efficient values, indicative targets or even predetermined thresholds that satisfy the choose criteria. Therefore, we opted for the application of an ordinariness principle, well known in appraisal and used because of its geographical relativity. Each classification of data and information took place in such a way as to represent the ordinariness of the diffusion of phenomena and the cases of particular specificity (high natural value).

Figure 3 shows the operational process performed for the processing of spatial data in order to produce the HNVF types map. These maps can be overlaid to understand the respective distribution, to distinguish the percentage of typological coexistence as well as the qualitative differences between the different areas.

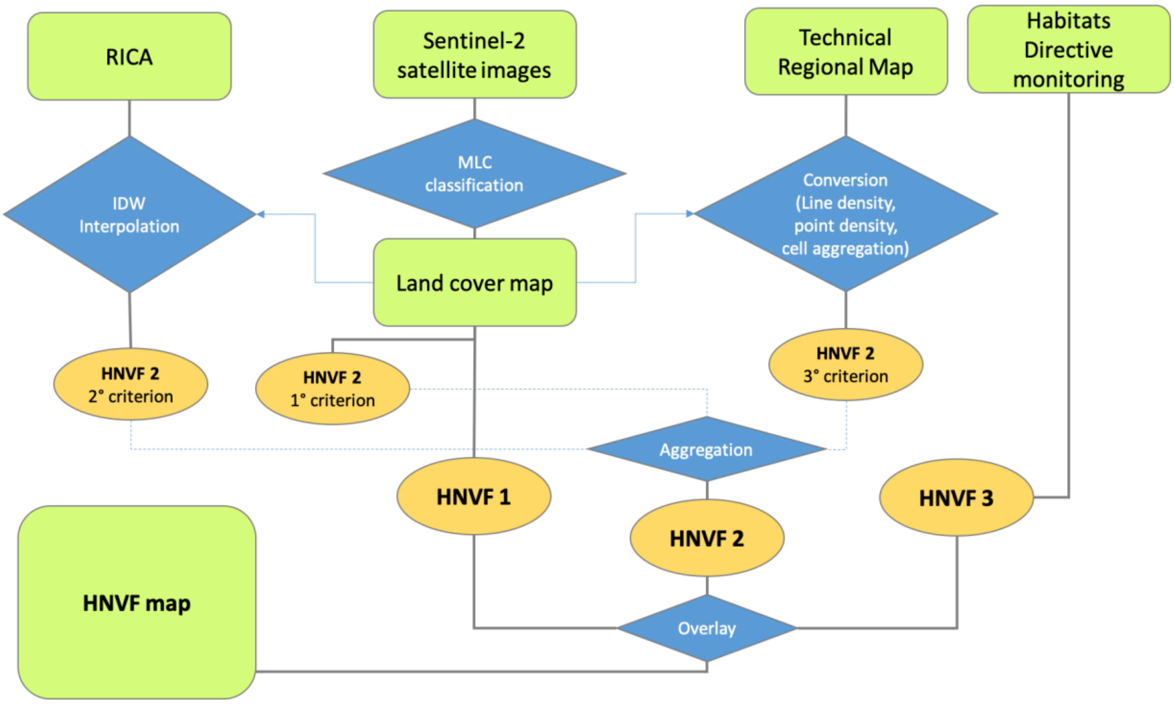

Figure 3. Processing operations (Our elaborations)

The theoretical framework and the methodology adopted (through a cascade process) have been detailed. Although each passage could be debated or even changed, the framework and the set of choices described have undebatable advantages. It has an instrumental value, built to satisfy a specific need of RDP's: mapping HNVF, tailored to be used over time, systematic way to guide decision makers and stakeholders towards the goal of determine the solution that best solves the problem.

3. Results

As result of the application of the above-mentioned methodology, elaborations in Apulia (Italy) are described as follow. The three types of HNVF areas identified by applying the proposed methodology have a respectively territorial extension of 828,00 square kilometre, 2.454,00 square kilometre and 1.721 square kilometre, with a respective territorial incidence of 4.28% of 12.69% and of 8.90%. Overall, considering also the areas where two or more types overlap, we reach a total regional endowment of 4,302 square kilometre that represents approximately 22.2% of the regional area classified as HNVF. As shown in the figure (Fig. 4), a prevalence of type 2 emerges, followed by 3 and 1. Among the most widespread forms of overlapping, the areas in which type 2 and 3 coexist is 5.70% while 1 and 3 overlap in 4.50 % of the classified areas.

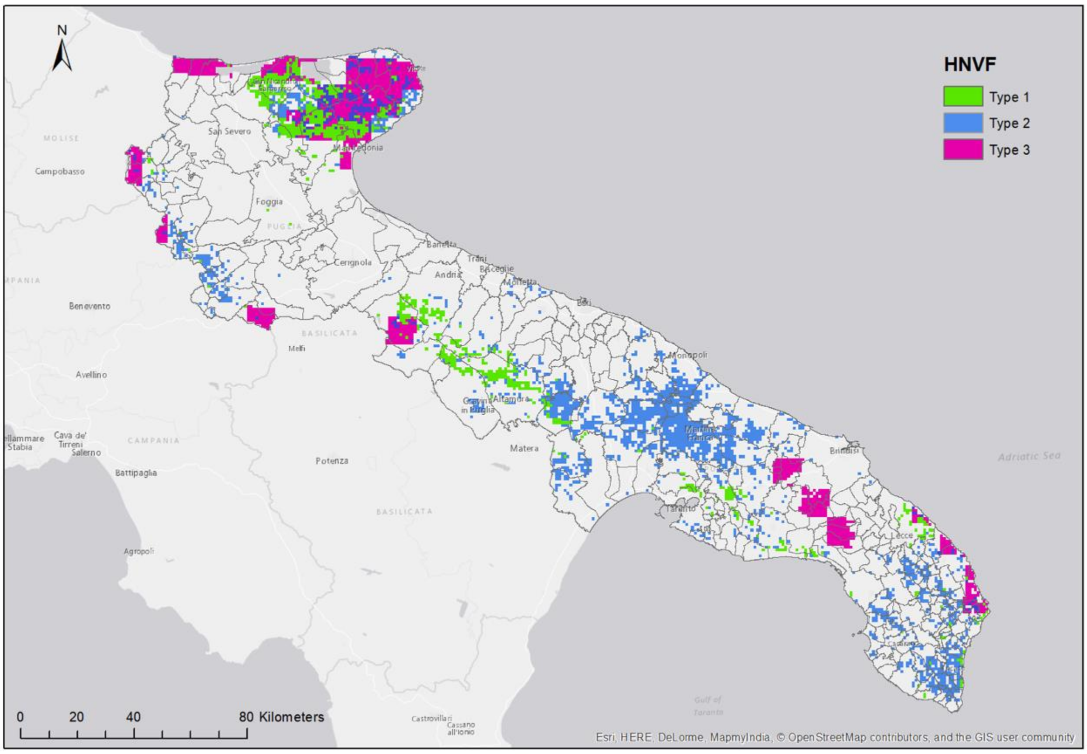

Figure 4 Overlay of HNVF maps (Our elaborations)

The selection process identifies some specific core territories where HNVF concentrate, showing an agricultural landscape and cultural system specialization. Central part of the region, known as “Alta Murgia”, is prevalently type 1 classified. In the North West area, “Monti Dauni” have been classified as type 2 as well as “Murgia dei Trulli”, “Vallle d’Itria” in the middle south area and inland Salento in the South. A mixture of typologies, instead, characterize different territories. Gargano in the upper east part of the Region is a complex of all typologies represented, while coast Salento is predominantly type 1 and 2 with a few hot spot of type 3, especially near wet retro-dunal areas. Some other zones have been excluded by the methodology. Indeed, results highlight how many characters contribute to the effectiveness of the analysis. Some of the excluded areas are affected by agriculture specialization such as olive groove monoculture (central Apulia). Some others reflect the predominance of intensive agricultural systems. As emerges from RICA data analysis, in those specific areas, intensity index associated to the arable lands that represent the prevalent agricultural typology is decisive.

4 Discussion

The study shows an application of an original methodology that derives from the implementation of a theoretical framework with strong connections to Andersen definitions of HNVF and the specific Community guidelines. Results reflect the multidimensional concept underlying HNVF. It let us reaching a likely amount of areas with high natural value, also coherent with those results obtained in studies analysed as follow and with an internal consistency due to a representativeness of the territories classified in the landscape planning tools used at regional level.

Comparing this methodology with that applied by the study officially used by regions for identifying HNVF (National Rural Network 2014), many advantages can be underlined. It is clear how the initial difficulty of combining land-use and cultivation intensity approaches on an adequate and homogeneous scale has been overcome. Furthermore, results from the cited study shows that maps only have the function of summarily representing the distribution of the HNVF areas in the territory, while the matching numerical value corresponds to the estimate of SAU of each cell divided by the different degrees of natural value. In the National Rural Network study, a research on the different degree of membership to HNVF, at a national scale, has been conducted. Starting from the results of this work, our analysis focuses on a regional scale. It allows and at the same time deserves a more detailed assessment of such kind of agricultural areas. Moreover, the results obtained in the work of Campedelli et al. 2018 try to validate the report of the National Rural Network, showing attention only towards bird species, leaving behind other animals (mammals and reptiles) or plants. It focuses especially on HNVF type 3 while advances a criticism towards approach on land cover and farming system. Our methodology, instead, aims at including and integrating different approaches. This can guaranteeing a greater accomplishment of the Helpdesk requests, trying to address each typology with a specific and adequate approach, aware that land cover is essential for type 1, farming system is crucial but not exhaustive for type 2 and species distribution for type 3.

Results appear to be coherent with Apulia territorial characteristics. In particular, a clear division between areas known and classified as separate landscape areas in the Regional Territorial Landscape Plan (PPTR Puglia) have been confirmed. Indeed, territorial characterization deriving from both natural value and type of agriculture conducted in those areas can be easily recognized and overlapped with HNVF typology found with the application of the methodology.

The geographic area known as “Alta Murgia” is prevalently dominated by pastures and poor grassland as well as arable dry land. Here a clear abundance of HNVF type 1 is recorded. Moving from this area to south-est, we encounter a more diversified cultural system, where pasture gives way to orchards, olive grooves and vineyards as well as a heavier presence of woods, hedges and anthropic agricultural landscape elements, such as dry walls. This area is well recognized as “Murgia dei Trulli”, characterized by the typical agrimosaic of “Valle d’Itria. The application of the methodology in this context is accomplished with a massive selection of areas classified as HNVF type 2, suggesting an appropriate use of thresholds and parameters used in the analysis.

In the north part of the region, two areas were identified as HNVF cores. Passing the “Tavoliere” area, where monoculture and intensive agriculture have been taken into account, leading to a clear exclusion of HNVF concept, as recorded in the results, “Gargano” and “Monti Dauni” are, rightly, subject to selection. In the former area a net dominance of HNVF type 2 is observed, especially in the southern part. Here, there is a marginal agriculture, typical of mountain and inland areas. The same characteristics can be found in the Gargano promontory where also an abundance of mountain and hilly pastures is recorded.

Ultimately, this preliminary application of the methodology leads to a comforting result since the extension of HNVF in Apulia is consistent with what can be found although in the scarce literature. The overall HNVF area is slightly below the results obtained by Trisorio et al (2013) in which areas potentially classified as HNVF were estimated for Apulia in 40% of the total regional extension, equal to 5,960,00 square kilometre (areas where medium and low potential are also included). The work of the JRC (2008) conducted on the NUTS2 scale; on the other hand, returns lower values, reaching a percentage of 15.9% and a total extension of 2,667.00 square kilometres.

4. Conclusions

HNVF areas have a rising strategic value for the CAP. In fact, the themes of conservation of agricultural systems with low environmental impact and biodiversity have become an essential part of the Community Agricultural Policy. The multiple references of the Regional, Italian and European Rural Development Programs to the need to rely on a sure data concerning the quantification of HNVFs require particular attention to this topic. With this aim, therefore, a modular instrument that allows identifying HNVF areas has been proposed, based on statistically rigorous methodologies and on data that can be updated over a short period in order to be useful to the public decision-maker. An objective that clashes with two problems of "structural" nature: the scarcity of data that at the same time respect all the requirements suggested by the HelpDesk and the difficulty of integrating geographically surveys with analysis of cropping systems. Technologies behind remote sensing and spatial interpolation have overcome these difficulties, with promising results. Despite the well approved significant role in crop classification and crop monitoring (Steven, M. D., & Clark, J. A. 2013), remote sensing for the assessment of agricultural coverage in order to quantify CAP indicators is still an innovative topic. The EU Regulation no. 746/2018, strongly encourages the use of satellite image interpretation instead or in combination with traditional "on-site" checks, while supporting different methodological alternatives for CAP surface measurements. Furthermore, the combination of satellite data with crop data from RICA sampling survey makes it possible to integrate an approach based exclusively on land use with aspects concerning the management of agricultural inputs in order to identify agricultural systems with different intensities. Finally, the research comes to the mapping of the different types of HNVF in Apulia showing a high adaptability for other regions and, using data from different years, to compare the evolution over time. A global amount of about 4.000 square kilometres of farmland areas with High Natural Value have been identified, corresponding to about 22% of regional surface. The work carried out leads to results that are consistent with those found in the relevant literature and is consistent with landscape plan (PPTR, 2015), the main policy tool for managing territorial transformation at regional scale.

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