LAND USE PLANNING

Title Assessing the economic marginality of agricultural lands in Italy to support land use planning

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Abstract

Agricultural marginality is a multifaceted issue, being related to place-specific socioeconomic contexts and highly-variable technological conditions. The coexistence of different classification systems of these variables makes hard any attempt to have a general definition of agricultural marginality. Moreover, the spatially explicit identification of marginal lands is still challenging mostly due to the lack of reliable data sources at both country and regional scale. Accordingly, this paper evaluates the degree of economic marginality of agricultural land, using Italy as a representative case study for southern Europe. A spatial analysis of farmland profitability and constraints for agricultural activities (topography and biodiversity conservation) is proposed to identify three classes of agricultural land, namely 'unsuitable', 'supramarginal' and 'marginal' lands. Results show that almost 39% of agricultural land in Italy can be classified as 'marginal'; its spatial distribution and characteristics are also analyzed and discussed in relation to different background conditions. The proposed approach provides a valuable methodology supporting land-use planning and decision-making under restricted geo-spatial data availability.

Keywords: Land values; Farmland profitability; Land abandonment; Economic marginality.

1 Introduction

Although the notion of “marginal land” is frequently used by policy makers, practitioners and researchers, there is not a common, clear and unambiguous definition of marginality (e.g. Dauber et al., 2012). Marginal lands are sometimes intended as a synonym for unused, degraded, abandoned, under-used, fallow and free land, often stimulating an animated linguistic debate and possible misunderstanding (Shortall, 2013). As a matter of fact, the definition of marginal land varies according to the aim for which this term is used and to the given background context to which it is operationally applied (Edrisi and Abhilash, 2016).

There are at least two groups of definitions for 'marginal land': those related to biophysical aspects and those based on socioeconomic conditions which turn out to be constraints for agricultural activity (e.g., Edrisi and Abhilash, 2016). Looking at the biophysical aspects, marginal land features poor and badly drained soils, restricted nutrient and water availability and steep slopes, affecting (more or less intensively) the overall productivity level (Lewis and Kelly, 2014). This notion is consistent with what was proposed by Peterson and Galbraith (1932), which define marginal lands as the “margins of cultivation”, where revenues are equal to (or lower than) the costs of production. Additional definitions have been provided by Rabbinge (1993) and Van Orshoven et al. (2013), respectively based on crop growth and biophysical constraints for agriculture.

Land capability has also been used by earlier studies to identify and characterize marginal lands (Lewis and Kelly, 2014). FAO and UNEP (2010) have classified land supporting a yield of up to 40 percent of its crop potential as marginal. This implies a crop-specific definition of marginality. In addition, the distinctiveness of marginal land from degraded land was emphasized, the latter specifically referring to land/soil degradation phenomena (Salvati and Zitti, 2005) defined as "(…) any decline in ecosystem function and services over an extended period (...)" (MEA, 2005).

From a socioeconomic perspective, marginal lands are considered areas where "cost-effective production is not possible under given conditions, cultivation techniques, agriculture policies as well as macro-economic and legal settings" (Dauber et al., 2012). More precisely, earlier studies have provided a rigorous definition referring to the notion of 'economic sub-marginality' (Cullen and Pretes, 2000) with the aim to outline areas with serious problems of profitability (Cullen and Pretes, 2000; Monti and Cosentino, 2015): submarginal economic land resources would require a substantially higher commodity prices or a major cost-reducing advance in technology and management practices to reach a condition of economic viability. Economically marginal lands are in fact defined by Turley et al. (2010) as "less productive land closer to the break-even economic margin".

Under both biophysical and socioeconomic criteria agricultural marginality is a dynamic condition depending on the considered crop, the technological level and the specific background conditions (e.g. market accessibility, management practices, prices and producers' market power) in a given area (Soldatos, 2015). Therefore, land classified as marginal in a given place or time might be considered as non-marginal in different spatiotemporal conditions (Allen et al., 2016; Edrisi and Abhilash, 2016; Lewis and Kelly, 2014). Hence, a current non-marginal land could be classified as marginal (and vice versa), depending on e.g. commodity prices, market choices, planning regulations and technology development. Based on these premises, the concept of 'marginality' is intuitively referred to transitions from unproductive (unused) to productive (used) land, or from sub-marginal to supra-marginal land along spatially-varying background conditions.

A definition of marginal lands based on three marginality classes has been provided by Shortall (2013), who discriminates between lands unsuitable for food production, ambiguous (lower quality) lands, and economically-marginal lands. The latter class is particularly relevant in order to predict future destination of marginal land, including, for instance, land abandonment and multiple options for a cultivation shift to crop suitable for bioenergy production (Russi, 2008). A low soil production level is reflective of land where significant changes in allocation and use are most likely to be observed.

Among the others, there is a rising interest around marginal land potentially available for bioenergy production, minimizing - as much as possible - the competition between food and non-food land-uses. In this context, identifying and characterizing marginal land according to its best potential in relation to the competitive use for food *vs* bioenergy production, contribute to design policies that may prevent indirect land-use changes (Kluts et al., 2017; Soldatos, 2015). These issues are relevant in Europe, and especially in southern European countries like Italy, where (i) land abandonment is particularly relevant and increasing over time in the last decade (Pagliarella et al., 2016), (ii) national harmonized datasets or maps identifying and classifying marginal land are still missing or covering only small areas of the country (Allen et al., 2016), (iii) assessment of marginal land could effectively support the implementation of policy strategies such as those on the "Less Favored Areas" for the allocation of CAP-RDP (Common Agricultural Policy-Rural Development Policy) incentives, or on the bio-based economy policy of the EU (i.e., the Renewable Energy Directive (2009/28/EC)).

Lewis and Kelly (2014) have described the evolution of marginal land evaluation under continuous improvement in Geographical Information Systems (GIS) and remote sensing techniques, which also allow spatially-explicit identification of land characteristics and estimation of the potential supply of woody biomass (i.e., in Italy, Maesano et al., 2014). Land suitability for biomass production was also investigated through comprehensive approaches based on multiple working hypotheses, criteria and thresholds (Lasserre et al., 2011), at local scale. Particularly, Lewis and Kelly (2014) find differences depending on the scale of application and the aim for which the analysis of land marginality was carried out, which in turn affect data availability and the use of specific criteria and thresholds (i.e., crop specific) hampering data comparability at broader spatial scales (e.g. from regional to country). At the same time, methodological and conceptual constraints to standardized, consistent and reliable approaches to marginal land evaluation have been extensively discussed (Lewis and Kelly, 2014). Accordingly, further research is required to increase reliability and replicability of the proposed operational frameworks (e.g. improving definitions, factors and thresholds used to discriminate among different conditions of land marginality), technical accuracy (e.g. data consistency over time and space, and with the main analysis' objective) and standardization, allowing comparability among empirical studies (Salvati and Zitti, 2011). These improvements will respond to specific demands and needs for which these information are produced.

Based on these premises, the present study evaluates the degree of economic marginality of agricultural land in Italy in a spatially-explicit framework. These information are useful to support land use planning (i.e., the assessment of potential land availability for bioenergy production and for other non-food uses of agricultural biomass). We specifically refer to an economic marginality notion using the Average Value of Agricultural Land (AVAL), a detailed, place-specific information collected and updated by the Italian Revenue Agency at provincial level in Italy for any type of farmland (available at http://www.agenziaentrate.gov.it/wps/content/Nsilib/Nsi/Schede/FabbricatiTerreni/omi/Banche+dati/Valori+agricoli+medi/?page=fabbricatiterrenicitt). These data are used in any official transaction (e.g. compulsory purchases) as reference land values. AVAL is then an official detailed measure of farmland capital values that in our study, are used as a proxy for land profitability, introducing additional evaluation criteria (i.e. topography and protected areas) which allow for a better characterization of land resources under different regulative and physical constraints. We considered Italy a representative case study for southern Europe offering general remarks in order to make the proposed approach replicable in other contexts with limited availability of large-scale harmonized data. Results are discussed according to the peculiar socioeconomic conditions of the investigated land, highlighting the importance to provide reliable maps and spatially-explicit datasets forming a base to decision-making.

2 Methodology

2.1 Economically-marginal land in Italy

Italian territory presents high climatic, topographic, geological, and ecological variability (Falcucci et al., 2007). Italy extends nearly 300,000 km^2, mainly dominated by cropland (33% of the national territory) and forests (32%). Urban settlements covers about 7% of the national territory (Pagliarella et al., 2016), one of the highest percentage within the European Union, still increasing despite the demographic shrinkage recently observed in Italy (ISPRA, 2016) and expanding primarily into high productivity agricultural land (Rivieccio et al., 2017). Mountains cover about 28% of the country's area (Sallustio et al., 2014). However, according to the current national legislation framework - originally referring to mountain areas as "less favorable" (and possibly marginal) areas - the formal definition of "mountain" was extended to nearly 59% of the national territory. This formal definition was adopted in order to assign economic incentives and subsidies to candidate rural districts through dedicated development strategies implemented at national and regional scales (Salvati and Carlucci, 2011). More recently, a National program called "National Strategy for Inner Areas" (Lucatelli, 2015) was implemented with the aim to promote permanence of specific population segments in inland, peripheral rural and mountainous districts (the so called "inner areas"), while promoting their socioeconomic development. Even in this case, the concept of inner areas could be someway referred to that of socioeconomic marginality, but without a specific mention to agricultural land-use. Hence, in this case, the distance from the nearest urban centre with upper functions (a hospital, a secondary school and a train station of national relevance) was used to characterize Italian municipalities: at the end of the selection phase, almost 60% of the country's territory was defined as "inner areas", mostly represented by municipalities in mountain areas and at considerable distance from urban centers.

2.2 Recent land-use changes in Italy

The main trajectories of land-use change over the last decades in Italy include: (i) farmland abandonment, (ii) forest (and other natural and semi-natural land) natural expansion and (iii) urbanization. While the latter phenomenon is particularly evident in flat, coastland and most accessible districts (Marchetti et al., 2014), the former two processes are more likely observed in upland and mountainous districts and, more generally, in less favorable areas such as the inner areas, as previously defined. Particularly, from 1990 to 2013 almost 1.3 million ha of agricultural lands were lost countrywide: 56% in inner areas (Marchetti et al., 2017), as a consequence of the reduced profitability of mountain agriculture and the following trees encroachment (e.g. Cimini et al., 2013), and 44% in lowland because of urban expansion. These evidences outline the urgent need to implement specific policy strategies aimed at increasing the profitability of mountain agricultural activities, e.g. promoting the shift towards alternative – and more remunerative – productions as well as the diversification of products and services offered by farms, especially small owners. In this sense the negotiation of the new EU Common Agricultural Policy (CAP) for the forthcoming decade, also with the introduction of schemes for the payment for ecosystem services, is a relevant challenge for rural development (Longhitano and Povellato, 2017).

In the present study we specifically refer to the notion of 'economically marginal land' (*sensu* Shortall, 2013), intended as a suitable concept for predictive scopes on the future allocation of these lands. With this perspective in mind, we focused on agricultural lands where significant changes are most likely to be observed (i.e. land abandonment) due to their low profitability and the presence of constraints (i.e. legal or topographic) undermining their possible use for new types of production (i.e., bioenergy crops, non-wood forest products).

2.3 Data sources and analysis

2.3.1. Average Value of Agricultural Land and land profitability

According to an earlier study by Italian National Institute of Statistics (ISTAT, 1958), the country's territory was classified into less than 800 Agricultural Homogeneous Districts (the so called "Regioni Agrarie", hereafter AHD). The last version of the AHD was used according to Povellato (1997) and following updates (available at http://antares.crea.gov.it:8080/mercato-fondiario/banca-dati). Each district was derived from spatial aggregation of a certain number of neighboring municipalities (ranging between 5 and 10), which had been identified as homogeneous for agronomic and environmental characteristics, socioeconomic attributes and topography (Recanatesi et al., 2016). This classification system was established in order to acquire aggregate or disseminate statistical data on agriculture, with regards to the farms' structure, the agricultural incomes and the associated economic values. Despite the time and the occurred modifications, these latter could be still useful and appropriate and are expressed using the so-called Average Value of Agricultural Land (AVAL), which are related to the average profitability of a specific crop in a given AHD. Accordingly, the AVAL is strictly dependent on AHD characteristics and crop type. AVALs are normally used for appraisal of farmlands, and can be adopted as indicators of the spatial variability of the agricultural economic value.

The need of a spatially-explicit assessment of land marginality requires conversion of statistical data into geo-spatial databases with the final objective to produce maps. Starting from the map of Italian municipalities, a map of AHDs was created (Figure 1) by assigning a unique numerical code to every AHD. This shapefile map was then overlapped with a CORINE (COoRdination for the INformation on the Environment) Land Cover map (hereafter CLC) dated 2012 and scaled 1:100,000 within a GIS environment (Buttner and Kosztra, 2012; Sambucini et al., 2010). The CLC spatial database represents the more recently full updated land-use/land cover map at the European and national scale, providing high accuracy and a thematic and spatial resolution coherent with the objective of this study. Since this work focused specifically on agricultural land, 14 out of 44 third-level CLC land-use/land cover classes were considered in the following analysis (Table 1).

CLC code	**Description**
2.1.1.1	*Intensive, non-irrigated arable lands*
2.1.1.2	*Extensive, non-irrigated arable lands*
2.1.2	*Permanently irrigated arable lands*
2.1.3	*Rice fields*
2.2.1	*Vineyards*
2.2.2	*Fruit trees and berry plantations*
2.2.3	*Olive groves*

2.2.4	*Forest plantations*
2.3.1	*Pastures*
2.4.1	*Annual crops associated with permanent crops*
2.4.2	*Complex cultivation patterns*
2.4.3	*Land principally occupied by agriculture, with significant areas of natural vegetation*
2.4.4	*Agro-forestry areas*
3.2.1	*Natural grasslands and sparsely vegetated areas*

Table 1. List of the 14 CLC agricultural classes.

The related AHD code was then assigned to each polygon extracted from the general CLC map. Meanwhile, each crop type belonging to the different AHDs, as well as the related AVAL, was referred to each CLC class. In case of CLC classes potentially hosting more than one crop (i.e., 2.4.1., 2.4.2., 2.4.3, 2.4.4. and 3.2.1), the AVAL of the single crops were averaged to estimate a unique AVAL referable to these promiscuous classes. The single AVALs referred to the same CLC class were averaged by AHD, producing a land-use AVAL at the spatial scale of AHD. Finally, the obtained average AVALs were linked to the AHD map through a join function using the AHD-CLC code as primary key.

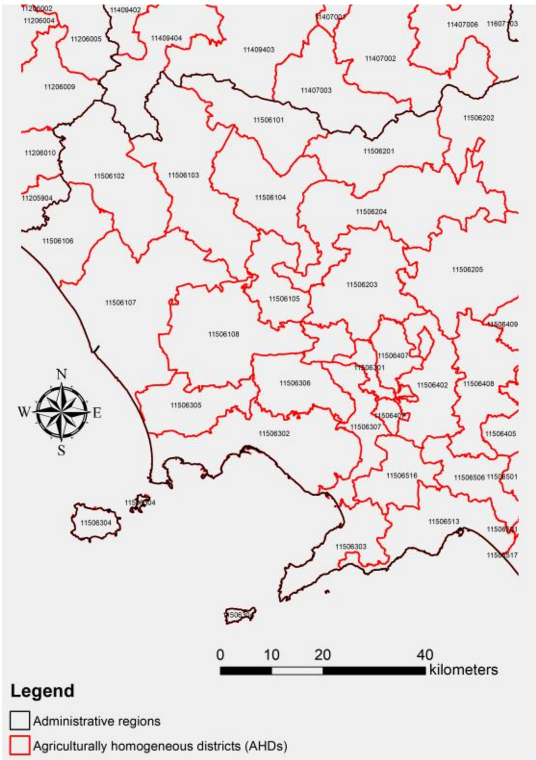

Figure 1. Detail of the Agriculturally Homogeneous Districts (AHD) map in south-western Italy (scene centered in Naples), showing the unique code assigned to each AHD polygon).

2.3.2. Environmental constraints

The choice of the physical thresholds used to identify marginal lands is a crucial aspect in land evaluation (i.e. Lewis and Kelly, 2014). In our case, the physical threshold is determined by soil slope, which can strongly hamper agricultural mechanization thus limiting future farm incomes. A physical threshold that excluded slopes higher than 30% was used in this study (Kang et al., 2013). Slope has been calculated from the National DEM with 75 m resolution using the slope function in ArcGIS 10.1 (ESRI, 2014). An additional constraint is determined by the presence of areas officially designated for nature conservation (i.e. Protected Areas, hereafter PAs), intended as a proxy of land with high provisioning of ecosystem services, according to the National Strategy for Biodiversity Protection approved in 2010 and the Renewable Energy Directive 2009/28/EC (EU RED). The official list of PAs (*Elenco Ufficiale delle Aree Naturali Protette*, EUAP; on line at http://www.minambiente.it/), regulated by the national Framework Law no. 394/91, includes 871 sites, of which 841 classified as terrestrial PAs. In addition, 2,924 sites belonging to the Natura 2000 Network (in compliance with the "Habitats" and "Birds" European Directives Council Directive 92/43/EEC and Directive 2009/147/EC), extending about 58,200 km^2 (19% of the country's territory), were added to the EUAP areas (Figure

2). Considering the existing overlap among the different sites and PAs categories (e.g. a Natura 2000 site can be included in a national park), the overall Italian network of areas officially designated for nature conservation extends about 65,705 km^2, of which 36.5% classified as agricultural lands.

Figure 2. Map of the Protected Areas in Italy (EUAP and Natura 2000 network).

2.3.3. Classification of marginal land

Once obtained the country-wide maps of AVAL, slope and PAs, a stepwise sequence of land exclusion was used to identify four land classes, as follows: (A) unsuitable agricultural lands: land with slope > 30%, considered unsuitable for agricultural production due to mechanization constraints, namely steepness (Kang et al., 2013). In this case the restrictions to mechanization determine higher production costs (labor costs), limiting the affordability of agricultural activities (Lewis and Kelly, 2014);

(B) supramarginal agricultural lands: lands with high profitability for agricultural production (AVAL higher than the mean regional AVAL) and/or nature conservation constraints (land within PA boundaries), being excluded the land category A;

(C) marginal agricultural lands: lands with low profitability for agricultural production (AVAL lower than the mean regional AVAL) which will probably imply their future abandonment, being excluded the land categories A and B. In order to better characterize these lands, they were further distinguished into high (< 30% of the mean regional AVAL), intermediate (30-60% of the mean regional AVAL), and low (60-99% of the mean regional AVAL) marginal agricultural lands.

3 Results

The 14 CLC agricultural classes here considered extend 17,549,028 ha with a total AVAL of about 351 billion € and an average economic value of 20,000 € ha^{-1}, ranging from 5,444 € ha^{-1} to 48,924 € ha^{-1} in Aosta valley and Veneto region, respectively (see Table A.1 for further details on total and mean AVAL per administrative regions). "Intensive, non-irrigated arable land" class provides the greatest value in terms of both AVAL and surface area (respectively 56% and 43%). A particularly high contribution in terms of land surface is also provided by "complex cultivation patterns" (Table 2), "land principally occupied by agriculture, with significant areas of natural vegetation", and "natural grasslands and sparsely vegetated areas" (12%, 12% and 10%, respectively), while only the former classes contribute substantially to the overall AVAL (44 billion €). The highest AVALs per land-use class were found for "Permanently irrigated arable lands", "Vineyards" and "Fruit trees and berry plantations" (42,285 € ha^{-1}, 41,906 € ha^{-1} and 37,204 € ha^{-1}, respectively), while the lowest values were found for "Natural grasslands and sparsely vegetated areas", "Land principally occupied by agriculture, with significant areas of natural vegetation" and "Agro-forestry areas" (3,627 € ha^{-1}, 4,923 € ha^{-1}, 6,239 € ha^{-1}, respectively).

3.1 CLC class	***Relative contribution to AVAL***	***Relative contribution to total surface***
Intensive, non-irrigated arable lands	55.8%	43.3%

Extensive, non-irrigated arable lands	1.7%	2.9%
Permanently irrigated arable lands	0.5%	0.2%
Rice fields	2.5%	1.7%
Vineyards	6.9%	3.3%
Fruit trees and berry plantations	4.5%	2.4%
Olive groves	7.1%	6.9%
Forest plantations	0.3%	0.3%
Pastures	2.3%	2.4%
Annual crops associated with permanent crops	0.7%	1.2%
Complex cultivation patterns	12.6%	12.5%
Land principally occupied by agriculture, with significant areas of natural vegetation	3.0%	12.1%
Agro-forestry areas	0.3%	1.0%
Natural grasslands and sparsely vegetated areas	1.8%	9.9%

Table 2. Percent contribution of each land-use class to AVAL and total surface area in Italy.

Figure 3 illustrates the spatial distribution of the AVALs in Italy, with the highest values found in Po Valley (Northern Italy) and in the north-western part of Campania. Generally speaking, the highest AVALs are observed in lowlands and sparse districts along the sea coast; conversely, the lowest AVALs are observed in the Alps and Apennines mountains as well as in dry and less productive land in the major islands, Sardinia and Sicily.

The spatial distribution of the AVALs is illustrated in a summary map classifying land into three classes based on the empirical assessment of economic marginality (Figure 4). Unsuitable and supramarginal agricultural lands are mostly located along the Alps and in valleys and plains all over Italy, with a gradual shifting towards marginal conditions along the elevation gradient. Empirical results of this study indicate that nearly 0.87 million ha of agricultural lands in Italy are classified as unsuitable while 9.89 million ha as supramarginal. Marginal agricultural lands amount to 6.77 million ha, of which 47% with low marginality, 33% with intermediate marginality and 20% with high marginality conditions (see Table A.2 in Appendices for further details). In absolute terms, Apulia has the largest extent of supramarginal lands (1.06 million ha), Trentino-South Tyrol of unsuitable lands (0.16 million ha), and Sicily of marginal lands (1.04 million ha).

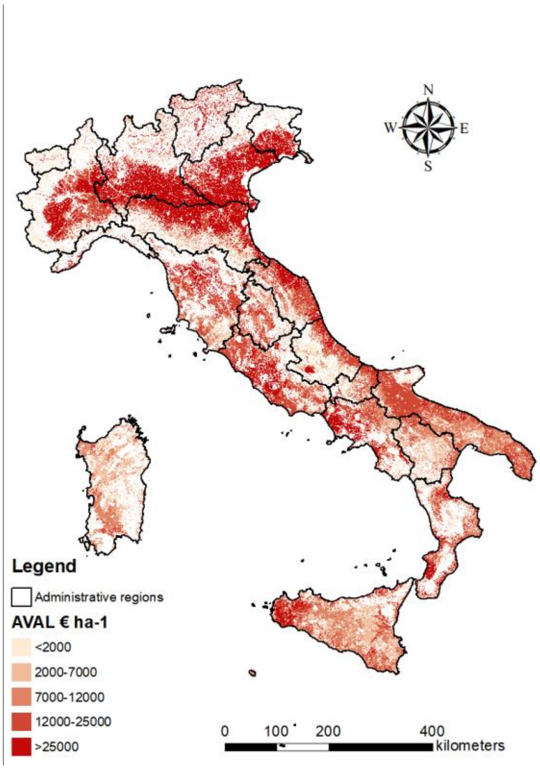

Figure 3. Spatial distribution of the Average Value of Agricultural Land in Italy.

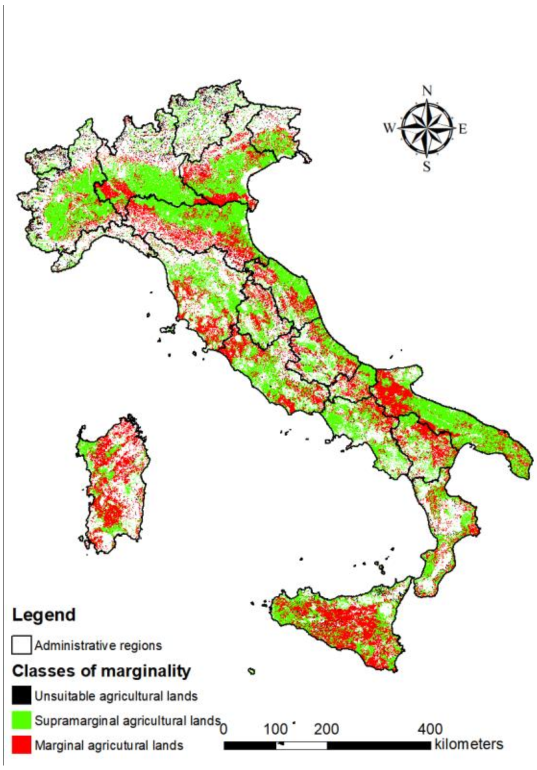

Figure 4. Map showing the spatial distribution of the three land types classifying agricultural land in Italy.

Looking at the relative distribution of the marginality classes within the Italian administrative regions (Figure 5), Aosta valley and Trentino-South Tyrol have the highest percentage of unsuitable lands due to the abundance of steep slopes (48.5% and 38.4%, respectively), while the lowest was observed for Apulia (0.1%). Otherwise, the highest percentage of supramarginal lands were observed in Campania and Piedmont (69.6% and 69.1% of total agricultural land, respectively), the lowest in Aosta valley and Sardinia (35.5% and 33.7%, respectively). The highest percentages of marginal agricultural lands are situated in Sardinia, Basilicata and Sicily (64.1%, 50.9% and 53.5% of their agricultural lands, respectively).

The highest percentage of land with high marginality was found in Piedmont, where almost 85% of the marginal land showed a high degree of marginality, while the lowest value was observed in Molise and Umbria (0.1% in both cases) (Table A.2 in Appendices). These differences indicate how, in spite of indicators and criteria operating through discrete values/classes/thresholds to define marginal lands (i.e., the AVAL), a variety of background conditions can be found within a country, revealing the importance of classification and indicators using continuous values and scales with the aim to increase effectiveness in land-use planning and decision making.

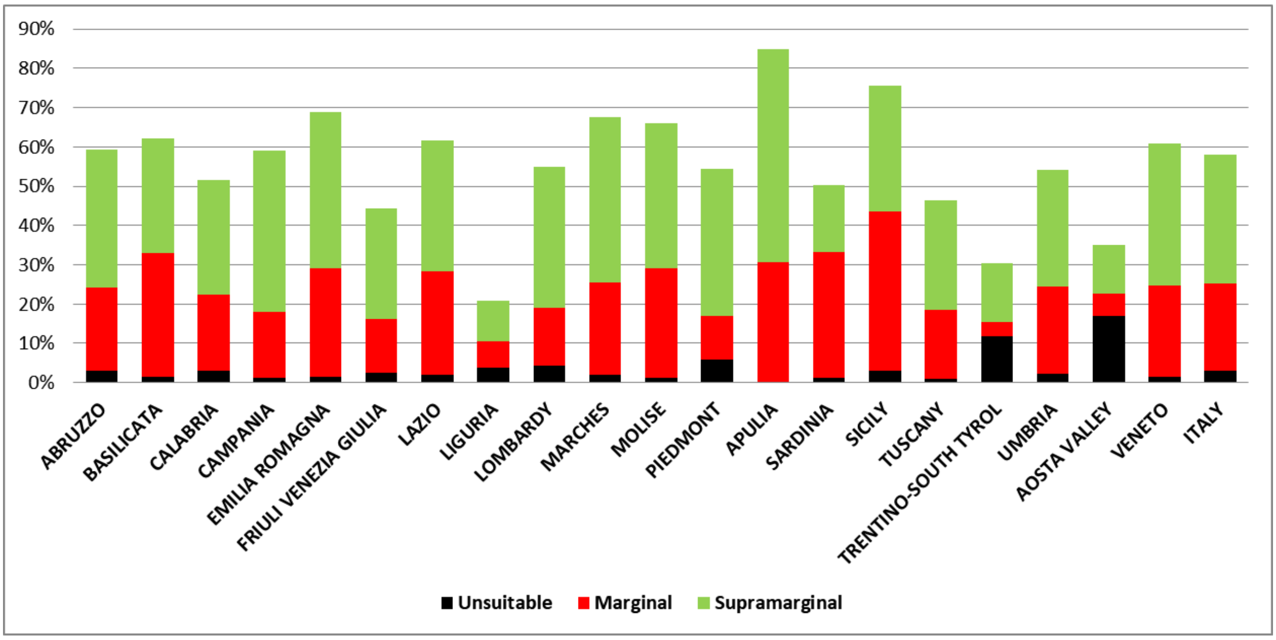

Figure 5. Percent share of the three classes of economic marginality in total surface area of Italian administrative regions.

4 Discussion

Although discourses about marginal land have stimulated a thorough scientific and normative debate at European and national scales at least since the last three decades, poor spatial data and statistics on the consistency and location of marginal land were limiting effective analysis and approaches to policy-making, particularly in Italy. The high subjectivity underlying the economic marginality concept, its definitions and the multiple indicators and approaches adopted for land evaluation hinder effective comparisons with other studies, both for Italy and abroad, where, due to the lack of coordinated surveys and data-gathering activities, no quantitative studies on this topic have been carried out so far at the national scale (Allen et al., 2016). Abbate et al. (1989) outlined the intrinsic difficulty in land evaluation due to the inherent differences in operational definitions and lack of reliable data. In their work, they generally referred to marginal lands as "lands with low profitability", thus more likely prone to land abandonment. Based on this general definition and using socioeconomic data (without a spatial-explicit approach) provided by national agricultural censuses, about 2 million ha of marginal lands were identified, that were extended up to 10 million ha considering lands with a certain "inclination to marginality", which were represented by hilly lands. Trying to compare these data with our results, unsuitable and highly marginal lands (2.2 million ha) have a similar extension with marginal lands, while extending the 'marginality' concept to all lands having different degrees of marginality, there is a difference of about 2.3 million ha (7.6 million ha in this study, 10 million ha in the former study). This difference can be easily explained considering the vastly different approaches and definitions adopted in the two studies as well as the lost of about 1.4 million ha of agricultural lands occurred from 1990 to now, mostly due to land abandonment (e.g. Pagliarella et al., 2016).

From the economic point of view, the land-use class contributing the most to marginal agricultural lands are the "Intensive, non-irrigated arable lands" and the "Land principally occupied by agriculture, with significant areas of natural vegetation" (3.4 and 1.7 million ha, respectively). While the contribution of the latter class remains high even in percent terms (about 78% with respect to the total surface area), the relative contribution of the former class decreases due to the high percentage of supramarginal agricultural lands (about 55% of the class area). The land-use classes with the highest percentages of marginal agricultural lands are the "Agro-forestry areas" and the "Annual crops associated with permanent crops" (82% and 81%, respectively). "Olive groves", "Fruit trees and berry plantations" and "Vineyards" show the highest percentage of supra-marginality (96%, 94% and 92% of their total surfaces, respectively), mostly due to their high profitability. Surprisingly, only 23% of "Natural grasslands and sparsely vegetated areas" is classified as marginal instead their low AVAL (3,627 € countrywide), due to the large presence of PAs (almost 50% of class area), which drives their classification as supramarginal land, and their location on steep slopes determining unsuitable conditions to farming. Almost 26% of "Natural grasslands and sparsely vegetated areas" is classified as unsuitable, which is the highest percentage of unsuitable agricultural lands observed in Italy, being followed by "Pastures" (14%), reflecting a rural landscape possibly associated with a high rate of land abandonment. Moreover, "Natural grasslands and sparsely vegetated areas" show the highest percentage of lands with high marginality (67% of the marginal lands), followed by "Land principally occupied by agriculture, with significant areas of natural vegetation" (60%).

Concerning the relationship between marginal districts and protected areas, our results show that agricultural lands within PAs boundaries are less profitable than outside PAs, with an average AVAL of 14,317 € ha^{-1}. Hence, if not considering the PAs existence in these areas, only 24% of their agricultural lands could be considered as supramarginal, with respect to 48% outside PAs. This difference is mostly explained by the larger extent of land-use classes with lower profitability within PAs, such as the "Natural grasslands and sparsely vegetated areas" (37% of the agricultural lands within PAs, 10% outside). Notably, the statistical distribution of the AVAL by land-use class is relatively stable within and outside PAs. The highest difference is found for "Intensive, non-irrigated arable lands”, and specifically for those lands within the boundaries of National Parks, which have almost 43% of the average national AVAL of this land-use class.

5 Conclusions

The present study has assessed economically-marginal lands with constraints on biophysical and economic marginality in Italy (Kang et al., 2013), using available information and a simplified methodology addressing data constraints at national scale. Innovation and advantages of our approach deal with the updated provision of statistics and mapping methodologies approaching marginal land classification. Future research has to evaluate the impact of other types of constraints in the assessment of AVAL and considering more complex frameworks in the analysis of marginality (e.g. biophysical marginality considering soil data or specific values linked to high added value production such as wine and oil with a recognized or formal geographical specificity). Our approach could be improved assuming variable conditions of the level of profitability and hence of the AVAL due to e.g. the impacts of CAP reform with a reduced level of agriculture product price support and the effects of Rural Development Programs. Earlier studies (Keenleyside and Tucker, 2010; Renwick et al., 2013) have provided empirical evidence that these ongoing policy reforms will increase the extension of economically-marginal lands in European countries. Renwick et al. (2013) gave special evidence to the hot-spots of land abandonment that will involve Italian mountain areas. By contrast, while there is a general consensus that the EU renewable energy policy may have relevant impacts on increased imports needed in meeting the EU targets for biofuels (Edwards et al., 2010;

Özdemir et al., 2009) - highlighting the role of bioenergy for sustainable development and green growth (Goetz et al., 2017) - studies on the potential impact of increased biofuel consumption in reducing land abandonment and economically-marginal lands provide mixed and sometimes contrasting results for both Italy and other EU countries (Banse et al., 2011; Demirbas, 2009; Fischer et al., 2010). This turns out to be particularly relevant in Italy, which till recently has been the first producer of more advanced liquid biofuels in EU (EUROSTAT, 2016), and where a political awareness and interest on these topics is already existent (see the recently approved Decree no. 369 of 16/1/2017). Furthermore, the identification of marginal lands is particularly relevant for the implementation of innovative and sustainable production systems based on the so called “smart-intensification” principles, which turn out in offering a wide range of novel products (i.e., non-wood forest products, organic foods, short food supply chain) and services (i.e., structured recreational activities, ecosystem services etc.) (Schröder et al., 2018; Weltin et al., 2018). Hence, even according to Schröder et al. (2018), the detection of hotspots of marginalities represents one of the first steps in order to unlock such lands transforming them into productive lands, thus able to effectively contribute to emerging environmental, societal and economic challenges towards sustainability.

Finally, the availability of such data on land marginality is particularly relevant in Italy, where a rising interests on land use strategies and policies to promote their recovery, thus hindering land abandonment, has emerged during last years, as demonstrated, for example, by the establishment of 'land bank' initiatives (i.e., 15 of the 20 Regions have recently established their land banks), or by the constructive introduction of these topics in the political debate and legislation on forestry, agricultural and rural development issues. An improved analysis under different policy scenarios may contribute to define and monitor marginality conditions, justifying the use of regional thresholds and considering land marginality as a relative and spatially-varying concept. Further steps to move technical framework from marginality evaluation to, for example, land availability for bioenergy and other non-food crops include the implementation of a suitability evaluation specific for different bioenergy crops, using spatially-explicit approaches possibly considering e.g. the optimal location of bio-refineries and other geographical constraints.

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Appendices

Table A.1. Extension, total and mean AVAL for all the 14 CLC classes per administrative regions.

Administrative region	Surface (ha)	Total AVAL (€)	Average AVAL (€ ha^{-1})
ABRUZZO	643,128	8,251,351,466	12,830
BASILICATA	627,034	6,789,451,544	10,828
CALABRIA	785,205	11,462,484,440	14,598
CAMPANIA	808,787	14,917,907,511	18,445
EMILIA ROMAGNA	1,522,633	36,087,460,526	23,701
FRIULI VENEZIA GIULIA	348,033	10,031,457,875	28,823
LATIUM	1,060,572	20,798,592,600	19,611
LIGURIA	113,146	1,193,414,805	10,548
LOMBARDY	1,312,520	45,058,709,368	34,330
MARCHE	658,702	11,452,504,854	17,386
MOLISE	293,950	3,544,662,233	12,059
PIEDMONT	1,381,784	25,713,499,119	18,609
APULIA	1,660,024	30,196,868,996	18,191
SARDINIA	1,209,150	10,731,947,150	8,876
SICILY	1,949,088	29,956,961,821	15,370
TUSCANY	1,066,579	18,773,453,391	17,602
TRENTINO-SOUTH TYROL	412,954	4,603,774,085	11,148
UMBRIA	457,382	6,010,384,474	13,141
AOSTA VALLEY	114,363	622,607,977	5,444
VENETO	1,119,843	54,786,750,241	48,924
ITALY	**17,549,028**	**351,016,221,849**	**20,002**

Table A.2. Percent contribution of each marginality class per administrative regions.

ADMINISTRATIVE REGION	Unsuitable agricultural lands	Marginal agricultural lands			Supramarginal agricultural lands
		High marginal lands	Intermediate marginal lands	Low marginal lands	
ABRUZZO	5%	2%	17%	16%	59%
BASILICATA	2%	1%	26%	24%	47%
CALABRIA	6%	3%	19%	16%	57%
CAMPANIA	2%	8%	7%	12%	70%
EMILIA ROMAGNA	2%	18%	5%	17%	58%
FRIULI VENEZIA GIULIA	6%	11%	0%	20%	64%
LAZIO	3%	15%	2%	26%	54%
LIGURIA	18%	0%	31%	0%	50%
LOMBARDY	8%	8%	5%	14%	65%
MARCHES	3%	9%	4%	21%	62%
MOLISE	2%	0%	21%	21%	56%
PIEDMONT	11%	17%	0%	3%	69%
APULIA	0%	1%	10%	25%	64%
SARDINIA	2%	1%	29%	35%	34%
SICILY	4%	7%	31%	15%	42%
TUSCANY	2%	13%	5%	21%	60%
TRENTINO-SOUTH TYROL	38%	2%	10%	0%	49%
UMBRIA	4%	0%	15%	26%	55%
AOSTA VALLEY	49%	3%	0%	13%	36%
VENETO	3%	6%	16%	16%	59%
ITALY	5%	8%	13%	18%	56%