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Farmland abandonment in Europe: Identification of drivers and indicators, and development of a composite indicator of risk

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ABSTRACT

Accounting for more than half of the European Union's (EU) territory, agriculture ensures food production, manages important natural resources and supports socio-economic development of rural areas. Moreover, it is estimated that 50% of all plant and animal species (including some of that are listed in the EU Habitat Directive) depend on agricultural practices. The continuation of appropriate agricultural land management is essential to ensure these primary functions. Avoidance of farmland abandonment is therefore an important rationale for the EU's Common Agricultural Policy which requires improved knowledge of this phenomenon at the European level. This study assesses the risk of farmland abandonment in the 27 EU Member States. It summarizes the work performed by an expert panel of European scientists and national representatives which aimed to identify the main drivers of farmland abandonment in Europe, to define indicators for assessing its risk of occurrence and to test the value of European-wide data sources to achieve these aims. Drivers were identified under two rationales: low farm stability and viability, and negative regional context. Indicators were defined using recent socio-economic farm data and geospatial datasets. Some indicators were then combined to make a composite risk indicator. Regions with higher risk of farmland abandonment are located in Portugal, Spain, Italy, Greece, Latvia, Estonia, Finland, Sweden and Ireland. This paper demonstrates the challenges of performing a European-wide assessment of a phenomenon influenced by drivers whose effects vary at local levels. Other problems encountered are data heterogeneity in terms of spatial resolution and quality, as well as access to microdata (local level data). High spatial resolution European datasets measuring farmland abandonment are needed to validate the defined indicators as well as to benchmark the methodology. Furthermore, such data could be used to establish a weighting system for the drivers.

1. Background

Accounting for almost half of the European Union's (EU) territory, agriculture plays an important role in the conservation of the EU's environmental resource (EC, 2006). It interacts with a wide range of valuable habitats, and the maintenance of a number of ecosystems that have emerged from agricultural cultivation

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depends on the continuation of appropriate land management practices (Benayas et al., 2007). Even though a cessation of land management can have a positive influence on biodiversity (rewilding), the abandonment of agricultural land may also threaten farmland biodiversity (Sirami et al., 2008; Plieninger et al., 2014; Zakkak et al., 2014), in particular functional diversity (Peco et al., 2012) associated with anthropogenic landscapes of high nature values. The concept of high nature value farming (HNV) recognizes that low-intensity farming systems are crucial for the conservation of biodiversity in some settings (Oppermann et al., 2012).

Besides its influence on biodiversity, land abandonment has a range of consequences for ecosystem functions and the provision of ecosystem services (Benayas et al., 2007). This influence is often context-specific, e.g., wildfire frequency and intensity, nutrient cycling, carbon sequestration, cultural landscape values, and water balance.

Moreover, food security being one of the major challenges for the future, the EU has a justified strategic interest in keeping its agricultural production potential, in view of short and long term needs such as foods, feed, fiber and biomass production (Kastner et al., 2012). Furthermore, agricultural activity underpins important aspects of the rural economy in many parts of the EU (Terluin et al., 2010).

During the past decades, European farming has changed (EC, 2006): specialization, intensification and technological developments have made farming more competitive but have also increased negative impacts on the environment. At the same time, the abandonment of farming is of concern because of negative social, economic and environmental effects (EC, 2006; Moravec and Zemeckis, 2007). Environmental and social problems related to abandonment include: (1) the reduction of landscape heterogeneity and promotion of vegetation homogenization (often associated with increased fire risk); (2) soil erosion and desertification; (3) the reduction of water stocks; (4) biodiversity loss and reduced population of adapted species; and (5) the loss of cultural and aesthetic value (Benayas et al., 2007).

Land abandonment can occur everywhere, even in areas with good yield potential, during satisfying general economic situations (Strijker, 2005) or outside marginal areas (Hatna and Bakker, 2011). In western Europe, the problem of land abandonment tends to be minor, whilst in southern and central Europe it is more important (Moravec and Zemeckis, 2007). In central and eastern European countries the change of political system from 1990 onwards, which triggered land privatization and the dismantling of collective farms, may have led to land abandonment because the conditions for profitable and commercial farming had become difficult (Vranken et al., 2004). This phenomenon can evolve rather quickly, especially in the new EU Member States (Moravec and Zemeckis, 2007). Drivers vary between regions and countries, and this potentially influences the definition or importance given to it (Strijker, 2005).

The abandonment of farmland has long been a contentious issue within Europe (e.g., see Baudry, 1991; Brouwer et al., 1997; Pointereau et al., 2008) in part because this phenomenon is difficult to define and measure (Keenleyside and Tucker, 2010; Moravec and Zemeckis, 2007). In fact, there is no single definition and, depending on the discipline, different interpretations exist (Moravec and Zemeckis, 2007). Despite the acknowledged importance of the phenomenon (e.g., EC, 2006), there is no consistent measurement across the EU and as a consequence the current extent of abandonment is not well known (Pointereau et al., 2008). Several studies have demonstrated the loss of agricultural land in (parts of) the EU through comparison of land use data (Hatna and Bakker, 2011; Keenleyside and Tucker, 2010; Müller et al., 2009) or using farm statistics (Corbelle-Rico et al., 2012; Pointereau et al., 2008). A number of studies have also analyzed the issue under a range of future scenarios (e.g. Elbersen et al., 2013; Helming et al., 2011; Nowicki et al., 2007; Verburg et al., 2010) and these results suggest that farmland abandonment in Europe will continue over the next 20–30 years. The highest projected levels of abandonment are simulated for scenarios with strong levels of global competition in agriculture and low levels of Common Agricultural Policy (CAP) support for extensive farming (Renwick et al., 2013). Some abandonment is also projected under scenarios with reduced global competitiveness, high levels of support for agriculture and the environment as well as strong regulations. As related by Renwick et al. (2013) there is furthermore a fear that trade reforms will reduce the economic viability of farming in Europe and lead to further abandonment of the more marginal agricultural areas.

Given the importance of the CAP in EU policies and its various objectives, the risk of farmland abandonment was included in the list of 28 agri-environmental indicators that are used to assess the integration of environmental concerns into the CAP (EC, 2006). As the indicator is not fully operational yet and requires conceptual and methodological improvement, a panel of European experts was commissioned with the methodological development of the indicator. This paper summarizes the first results of the panel's work which covered the identification of principal farmland abandonment drivers and the definition of indicators for measuring its risk of occurrence for the EU-27. Further to this thematic objective, this study also aimed to assess the suitability of available European-wide datasets including the identification of gaps and limitations. The work started with the identification of drivers which is summarized in the following Section 2. This was the basis for the definition of indicators in Section 3 and their analysis in Section 4. Conclusions and perspectives for future work on the indicator development are provided in Section 5.

2. Definition and driving forces of farmland abandonment

For this study, farmland abandonment was defined by the expert panel as a cessation of land management which leads to undesirable changes in biodiversity and ecosystem services. As the indicator will be used to assess the integration of environmental concerns into the CAP, the definition was steered towards potential threats to the environment, which in this case are linked to loss of biodiversity (Sirami et al., 2008; Plieninger et al., 2014; Zakkak et al., 2014; Peco et al., 2012) and ecosystem services (Benayas et al., 2007). The indicator to be developed addresses the risk of farmland abandonment (probability of occurrence), not the consequences or the extent to which farmland abandonment actually happens.

The reasons for farmland abandonment are multidimensional, and there is no clear-cut division among drivers as it rather depends on the result of their co-occurrence and interactions (Bethe and Bolsius, 1995; Coppola, 2004). Drivers are usually grouped into either natural constraints, land degradation, socio-economic factors, demographic structure, and the institutional framework (FAO, 2003) or ecological, socio-economic reasons and reasons related to unadapted agricultural systems (Benayas et al., 2007). In this study driving forces are classified into unsuitable environmental conditions, low farm stability and viability, and the regional context.

2.1. Unsuitable environmental conditions

Amongst the biophysical factors often mentioned as unfavorable to agriculture, low soil productivity, poor climate, steep terrain and significant altitude are the main natural constraints to agriculture and may therefore increase the risk of farmland abandonment. There is a large literature analyzing these drivers and their negative impacts on agricultural production, economic profits and land use management opportunities. Mottet et al. (2006), Müller et al. (2009) and Sys et al. (1991) assessed elevation and slope effects on agriculture conditions. Farming difficulties due to unfavorable soil chemical and texture properties were documented by the FAO (1983, 1988) and Thomasson and Jones (1989), while limited soil drainage and excessive soil moisture were found responsible for crop production reduction (Schulte et al., 2005) and for farming restrictions (Earl, 1997; Fitzgerald et al., 2008; Jones and Thomasson, 1993). Adverse climate for agriculture in Europe can either occur due to low temperature limiting crop growth, short growing season (Fischer et al., 2007), or to dry conditions and water stress affecting crop physiological processes (Hassan and Dregne, 1997; Le Houerou, 2004).

The above biophysical criteria are currently under evaluation in the EU-27 for the delimitation of areas with natural constraints to agriculture as part of the new Rural Development regulation for the programming period 2014–2020. Consequently, these drivers will not be directly adressed in this study.

2.2. Low farm stability and viability

Farm viability mainly depends on the farm's economic situation. Farmland is typically abandoned as an economic resource when it ceases to generate a sufficiently high income (MacDonald et al., 2000). Although this is not a sole cause, and although it can be triggered by a number of factors, there is a strong link and farm income plays a prominent role in farmers' strategy regarding land use (Strijker, 2005).

However, in the agricultural sector, the rule of profit maximization is not always true and one cannot only refer to strictly economic variables to explain farmland abandonment (Coppola, 2004). Schmitt (1997), quoted by Strijker (2005) notes that farmers will only leave agriculture when their income becomes very low since there are many reasons for not leaving the sector. Some are the strong preference for being a farmer or the lack of gainful alternatives for their land, machines, buildings, and labor.

Some agricultural policy instruments link public support to land management commitment and are consequently reducing abandonment (e.g., farmers committed for at least five years in the agri-environmental measures etc.). This was confirmed by Renwick et al. (2013) through modelling various policy scenarios.

New investments on the farm could be a relevant indicator of farm dynamism, its adaptation capacity and forward-looking strategy. This can be a proxy for the willingness to continue farm activity, while low level of investments might indicate a farming activity in decline (De Stefano, 1985).

Farmers' age is generally acknowledged in the literature as an important driver for land abandonment (Kristensen et al., 2004; Mishra et al., 2010; Potter and Lobley, 1992). Information published by the EC (2010) confirms the structural holding difference between young and elderly farmers. Younger farmers tend to be above the EU average with respect to economic size, utilized agricultural area and labor force. Kristensen et al. (2004) highlighted the relationship between farmer's age and landscape changes. In particular, other factors being constant, farmland extensification and abandonment are more likely to occur when the farmer is old and close to retirement. The number of farmers nearing retirement age may reflect the expected transition of the land and its structure in a period of ten years (Baldock et al., 1996). Additionally, this proxy can become more meaningful if information about succession is known (percentage of successor farmers). Potter and Lobley (1992) identified a direct effect of farm management. The investment indicator could, in this regard, be a proxy for succession probability. Moreover, if the holding has a low economic viability and inappropriate structure, the succession possibility will be low.

Training and information are important to be able to adapt to changing economic circumstances and to guarantee the integration of the different functions of agriculture at farm level (Baldock et al., 1996; Labarthe, 2009). The use of a farm advisory system is a proxy for the professionalism of the farm, and the willingness to invest in terms of human capital and knowledge with a sufficient time horizon (Mishra et al., 2010). In some examples (e.g., Ireland), Member States have introduced voluntary educational schemes with the stated objective of protecting against land abandonment.

Finally, farm physical structure can also be a handicap for farm viability. Small and scattered plots can constitute an obstacle to succession. Small parcels located far from the farm, are more likely to be abandoned than those that are larger or more accessible, due to higher transportation and labor costs. Moreover, small farms are more likely to have difficult access to credit and other institutional services required to increase their competitiveness (Rahman and Takeda, 2007). Generally, larger holdings can benefit from lower production costs and are more competitive for farm practices (use of machinery or a better input use efficiency). They are more frequently associated with innovation and usually more competitive and viable in economic terms (e.g., Bojnec and Latruffe, 2013; Lange et al., 2013).

2.3. Regional context

At regional or national levels, imbalanced economic development between sectors (agriculture, industry and services) may increase the transfer of labor forces. Risk of farmland abandonment may increase when agricultural income is substantially below that of the rest of the economy (regional or national income). This tendency would be reinforced with the increase of opportunities outside the agricultural sector.

Alternative employment opportunities in other sectors, as well as a low proportion of full-time farms are factors which increase the probability of abandonment (Rickebusch et al., 2007). However, there could also be areas with a well-established and stable system where farmers are employed part-time in other sectors. For instance, in their analysis of marginalization in Denmark, Bethe and Bolsius (1995) stressed that part-time employment was often a factor of stability.

Several studies have analyzed the relationship between farmland abandonment and proximity to settlements and roads (e.g., Corbelle-Rico and Crecente-Maseda, 2014; Corbelle-Rico et al., 2012; Gellrich and Zimmermann, 2007; Lange et al., 2013). In general, proximity to both, and the related accessibility of opportunities, activities or assets existing close by, reduces the risk of farmland abandonment. Indeed, distance to agricultural infrastructure (retailers, inputs suppliers, slaughterhouse, etc.), as well as to social infrastructure such as schools and hospitals, are identified as strong drivers (Mottet et al., 2006; Nordström Källström, 2008). Proximity to urban centres also makes it possible to combine farm-work with a second job (Terluin et al., 2010).

Land tenure status could influence investment and farm holder dynamism if the long-term perspective for land as a factor of production is unclear. A large proportion of tenant-farmed agricultural areas can sometimes indicate a tendency for instability if property rights are insecure or land tenancy laws are weak (Swinnen et al., 2006). In the IRENA operation (Indicator Reporting on the Integration of Environmental Concerns into Agriculture Policy) the price of the land was also considered as a good supplementary indicator of marginalization, as it expresses the demand for land. A low demand for land usually translates into low transaction prices (selling or renting) and a weak land market is a good proxy for a higher risk of land abandonment (Ciaian and Swinnen, 2009). However, this should be considered in a regional/national context as property laws and local usage vary between Member States (Deininger, 2003).

The transition period of the new Member States was accompanied by major changes in agricultural structure in most of these countries, sometimes involving the break-up of large collective or state farms and the privatization of land. The FAO (2003) stressed that central European countries in the transition phase face difficulties regarding land ownership (registration), insufficiently defined property rights, and the lack of operational land sales markets (Swinnen et al., 2006). This prevents the reconstitution of viable farming units through land consolidation. Because of the absence of any type of land market during this phase, parcels remained fragmented and led to a massive co-ownership situation. This occurred for example in Bulgaria, creating imperfect property rights on land, inefficient land allocation among farm structures, and farmland abandonment (Vranken et al., 2011).

Finally, previous trends in farmland abandonment might influence its future evolution, assuming that regions facing the phenomenon are more fragile and therefore prone to further land abandonment (Pointereau et al., 2008).

3. Data and methods

3.1. Datasets

As indicated in the previous section, this study focuses on the drivers of farm stability and viability from the regional context, not those related to environmental conditions. Therefore, mainly information on the structure of agricultural holdings was required. Pre-conditions for these data were (i) availability for the entire territory of the European Union and (ii) comparability between Member States. We used the two European datasets farm accountancy network (FADN) and farm statistical survey (FSS) which fulfill both conditions. The collection of FSS and FADN data is harmonized throughout the Member States but with differences. FADN focuses on collecting economic information. FSS collects economic information, but also collects information on the demographic and environmental characteristics of farms. FADN data are collected in annual surveys from a sample of agricultural holdings above a minimum size in order to include the most relevant part of the agricultural activity (commercial farms). Instead, FSS data are collected for almost all farms (or almost the entire utilized agricultural area) during agricultural censuses that are performed every ten years with intermediate sample surveys every two or three years. Compared to FSS, FADN data exclude small farms and as a consequence cover only a percentage of all farms in the EU (39% in 2007). The FADN sample of holdings is representative for the so called FADN regions which correspond in most of the cases to the administrative NUTS2 regions (NUTS, nomenclature of territorial units for statistics). FSS data are collected at individual holding level but are available only at aggregated administrative unit level. FSS data provide the basis for extrapolating FADN data.

An initial quality check of the annually available FADN data revealed ambiguities in the 2009 data. As a consequence, data from the period 2006–2008 were selected for this study and the average of those years was calculated. For indicators requiring FSS data, one indicator was only available from the 2000 census; other indicators were available in the FSS intermediate surveys.

Table 1 shows for both datasets the variables that were used for calculating the indicators (for more information see the database web links at the end of the paper).

Other statistical datasets used are the national accounts provided by DG Eurostat (for gross national product) and population numbers from the infra-regional information system (SIRE).

Furthermore, Corine land cover from 2006 (CLC) was used to locate agricultural areas. Missing data for Greece in CLC 2006 were complemented with the respective CLC 2000 data. Urban areas were also identified from CLC and completed by the urban morphological zones (UMZ) and city statistics from the urban audit.

Table 1
Variables from the FADN and FSS datasets used to build the indicators on drivers of farmland abandonment (UAA utilised agricultural area).

Database (provider)	Data/variable used (unit)
Farm accountancy data network (FADN)	• Rent paid, including rent for buildings, quotas, etc. (Euro)
(DG Agriculture and Rural Development)	• Rented UAA (ha)
	• Farm net value added per annual working unit FNVA/AWU (Euro)
	• Total investment before deduction of subsidies (Euro)
	• Total UAA (ha)
	• Weight of the farm in the sample (non-dimensional)
Farm structure survey (FSS)	• Holder's being a natural person: age 65 years and over (number of persons)
(DG Eurostat)	• Agricultural training of farmer (% of farmers with practical experience only, basic training, or full agricultural training)
	• Percentage of farms with a UAA under 50% of the NUTS3 holding's average UAA and by farmtype (%) (special data request)
	• Area of certified organic farming (ha), total UAA (ha)

Features from the EuroRegionalMap (ERM) were used for the road network.

Reference units for data processing were the administrative (or statistical) units as defined in the EuroBoundaryMap (EBM) version 2.2 from 2006. These units are the NUTS with NUTS0 representing countries, NUTS2 regions and LAU2 communes (local administrative units, formerly NUTS5) (see reference at the end).

3.2. Definition of indicators for individual drivers

Indicators were built for each driver using the available datasets. Table 2 shows the drivers and the defined indicators. It also shows their effect on farmland abandonment.

Each indicator was assessed in terms of data availability and quality, and its relevance for the driver. The evaluation follows the approach adopted for the evaluation of the actual usefulness of individual IRENA agri-environmental indicators (EEA, 2005). Evaluation criteria, their description and scoring scheme are shown in Table 3.

Data were processed for all EU-27 countries at NUTS2 level which represents the basic regions for the application of EU regional policies, and which is the 'official' reporting level for agri-environmental indicators. For Germany and the United Kingdom data were processed at NUTS1 level, as in these countries NUTS2 units are much smaller than in the other countries. For Cyprus, Estonia, Lithuania, Luxemburg, Latvia, Malta and Slovenia NUTS2 are identical to NUTS0 (there is no subdivision of countries into smaller territorial units).

For mapping the indicator results, values were classified in quintiles (20% of data in each of the five classes).

3.2.1. Weak land market (D1)

As indicators of weak land market, a regional weighted average of the rental price for agricultural land and the share of rented UAA (utilized agricultural area) on the total UAA were calculated.

Table 2
Drivers of farmland abandonment, indicators and effects. Indicators are calculated at regional level (NUTS2). Negative effect: if the value of the indicator is low, the risk of farmland abandonment is high; positive: if the indicator value is high, the risk is high as well.

Driver	Indicator name	Indicator calculation	Effect
D1 Weak land market	Weighted average of the rental price	$\text{Rentalprice} = \frac{\Sigma_{farms}(\text{rentpaid}\times\text{farmweight})}{\Sigma_{farms}(\text{UAA}_{rented}\times\text{farmweight})}$	Negative
	Share of the rented UAA	$\text{ShareofrentedUAA} = \frac{\Sigma_{farms}(\text{UAA}_{rented}\times\text{farmweight})}{\Sigma_{farms}(\text{UAA}_{total}\times\text{farmweight})}$	Negative
D2 Low farm income	Average farm income	$\text{Averagefarmincome} = \left(\frac{\Sigma_{farms}(\text{farmnetvalueadded}\times\text{farmweight})}{\Sigma_{farms}(\text{farmweight})}\right)/\text{GDP}$	Negative
D3 Low farm dynamism/adaptation capacity	Average level of farm investment	$\text{Farminvestment} = \frac{\Sigma_{farms}(\text{investment}\times\text{farmweight})}{\Sigma_{farms}(\text{UAA}\times\text{farmweight})}$	Negative
D4 Ageing farmer population	Share of old farmers	$\text{Proportionofoldfarmers} = \frac{\text{numberfarmers}_{65years}}{\text{numberoffarmers}_{total}}$	Positive
D5 Low farmer qualification	Share of farmers with practical experience only	$\text{Shareoffarmerswithpracticalexperience} = \frac{\text{numberfarmers}_{practicalexperienceonly}}{\text{numberfarmers}_{totaloftrainedfarmers}}$	Negative
D6 Previous trend of farmland abandonment	Loss of agricultural land	Loss of agricultural land = $\text{UAA}_{t2} - \text{UAA}_{t1}$ where $t1$ and $t2$ are two points in time	Positive
D7 Remoteness and low population density	Share of remote agricultural area	$\text{ShareofremoteUAA} = \frac{\text{UAA}_{remoteareas}}{\text{UAA}_{total}}$ where remote are areas (LAU2) are at more than 60 min from an urban centre and with less than 50 inhabitants/km^2	Positive
D8 Small farm size	Share of small farms	$\text{Shareofsmallfarms}_{farmtype} = \frac{\Sigma\text{farms}_{UAA<50\%farmtyperegionalaverage}}{\Sigma\text{farms}_{farmtype}}$	Positive
D9 Farm enrolment in specific schemes	Share of farms under organic farming scheme	$\text{Shareoforganicfarming} = \frac{\text{UAA}_{certifiedorganicfarming}}{\text{UAA}_{total}}$	Negative

Table 3
Criteria used to evaluate indicators (evaluation schema based on EEA, 2005). Data are ambiguous in case of interpretation problems or if the parameter definition changed during the observation period.

Criteria	Description	Scoring
Availability of data	Spatial resolution is NUTS2 or better (at best micro-data)	2 = NUTS2 or more detailed level 1 = resolution lower than NUTS2 0 = absence of data
Quality of data	Mainly defined by the presence of missing and ambiguous data	2 = high quality (no missing or ambiguous data) 1 = medium quality 0 = low quality (missing and ambiguous data)
Relevance of the indicator	Pertinence of the indicator in measuring the driver	2 = appropriately measuring the driver 1 = measures but with exceptions 0 = does not measure the driver

The rationale behind this is that high rental prices are generally linked to a high demand for agricultural land and hence a low risk of abandonment.

3.2.2. Low farm income (D2)

The weighted average farm income normalized by the gross domestic product (GDP per capita) was defined as an indicator for the low farm income driver. Income was estimated from the 'farm net value added' (FNVA) variable in FADN, which measures the amounts available for remuneration of fixed factors of production (labor, land and capital), expressed per annual working unit. Thus, it represents the economic performance of the farm from which wages, rents and interests still need to be paid and own labor and capital need to be remunerated. FNVA is compared to the national GDP per capita at market prices that is a proxy for the national income. It is assumed that when differences between FNVA and national GDP are large, the agricultural activity may not be economically sustainable anymore. As a consequence, people might leave the farming sector for possible opportunities in other sectors. By choosing the national GDP rather than the European, it was assumed that farmers may quit agriculture to move preferably to a different sector in their own country rather than emigrating to another country.

3.2.3. Low farm dynamism/adaptation capacity (D3)

As an indicator for the low farm dynamism driver, the FADN variable 'total investments before deduction of subsidies' was used. It covers investments for agricultural land, building, rights, forest, machinery and circulating capital. Given the structural differences that occur between different farming systems, the amount of investment per farm was normalized by the physical size of the farm (UAA), as small farms will often have lower investments (in absolute terms) than large farms. This indicator assumes that new investments are a signal of a medium/long term strategy and can be a proxy of the willingness to continue farming activity and adjust to new available techniques.

3.2.4. Ageing farmer population (D4)

As an indicator for an ageing farmer population, the share of farm holders above 65 years old, which is the average age for retirement in Europe, was calculated assuming that farmland abandonment is more likely to occur when the farmer is old and close to retirement. It furthermore assumes that even if the farmer continues after this age, activity will probably decline. Information related to successors was not used as this information was not available in the FSS database.

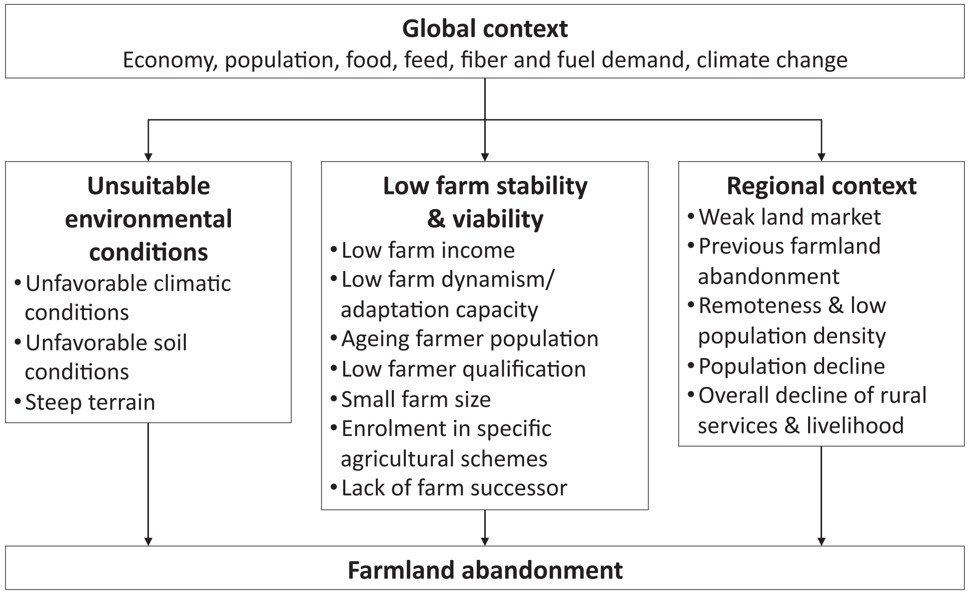

Fig. 1. Main drivers of farmland abandonment and inter-linkages.

3.2.5. *Low farmer qualification (D5)*

For the evaluation of the farmer's qualification the share of farmers with 'practical experience only' on the total number of farmers that participated in training was used. The assumption here is that training and the use of advisory services are a proxy for the professionalism of the farm, and willingness to invest in terms of human capital and knowledge with a sufficient time horizon, which will prevent farmland abandonment.

3.2.6. *Previous trend of farmland abandonment (D6)*

A way to assess the trend of farmland abandonment is to compute the loss of agricultural land (UAA) between two points in time estimated from a time series, assuming that the land was not transformed into forests or artificial areas (Pointereau et al., 2008). This non-utilized agricultural land is no longer farmed for economic, social or other reasons, and is not included in the crop rotation system. The calculation needs to be done at local level (LAU2) in order to avoid compensation effects that occur when calculations are made in larger administrative units, especially when urbanization or afforestation rates are important. Therefore the calculation of this driver requires using UAA data from FSS at LAU2 level from at least two censuses. Due to confidentiality restrictions, FSS data at LAU2 level were not accessible and thus the indicator was not calculated Fig. 1.

3.2.7. *Remoteness and low population density (D7)*

This driver was evaluated through the share of agricultural area in remote and low population density areas. The general assumption here is that the risk of farmland abandonment is higher in areas with low population density and which are remote from the closest urban centre (access to services). For the calculation, a methodology similar to the OECD regional typology methodology (OECD, 2011) was applied which involves a combination of geographic datasets. Fig. 2 depicts the workflow used to calculate this driver.

The method requires the elaboration of two data layers: (i) low population density areas and (ii) remote areas (LAU2). Those two layers are then used to quantify at NUTS2 level the agricultural area in scarcely populated and remote areas. Scarcely populated areas are identified from population statistics and were defined as areas with a population density below 50 inhabitants/km^2. This threshold is set much lower than the threshold used by the OECD (2011) for classifying rural areas to target rural communes with very low population density. The remoteness of an area was identified through the distance between the centroid of each LAU2 unit (origin) and the closest urban centre (destination). Following the method in Dijkstra and Poelman (2008) urban centres are defined by a population of more than 50,000 inhabitants. The distance was identified through the road travel time between origin and destination, and calculated through road specific speed limits. Impedance of travel speed in cities (congestion) and from relief (slope) is included in the calculation through two indices developed by Dijkstra and Poelman (2008). Finally, remote LAU2 units were identified as those where the travel time to the closest urban centre is more than 60 min.

As a last step, the share of agricultural area (from Corine land cover) in scarcely populated and remote areas was calculated at regional level (relative to the agricultural area in NUTS2).

3.2.8. *Small farm size (D8)*

The indicator for the small farm size driver calculates for each farm type the share of small farms. A farm is considered as small when its physical size (ha UAA) is below half the regional average (NUTS3). Distinction between farm types is necessary as specialization can influence structure (e.g., physical size). They range from specialist field crops, horticulture, permanent crops, specialist grazing livestock and granivore to mixed cropping, livestock and crops-livestock. The indicator is based on the positive relationship between farm size and farm viability in economic terms (competitiveness). In general, larger farms can benefit from lower production costs, are more suitable for most of the competitive agricultural practices (use of machinery or a better efficiency in the use of inputs), they are more frequently related to innovation and usually more competitive and viable in economic terms. Moreover, fragmentation has a generally negative effect on farm output and, put simply, the more fragmented a farm is, the more significant the negative impact on it's economic results.

3.2.9. *Farm enrolment in specific schemes (D9)*

We look at enrolment in specific agricultural schemes and in particular in agri-environment measures (AEM) as a proxy for this driver. AEMs are designed to encourage farmers to undertake environmental commitments. Farmers commit for at least five years to manage their land accordingly, therefore keeping the land in

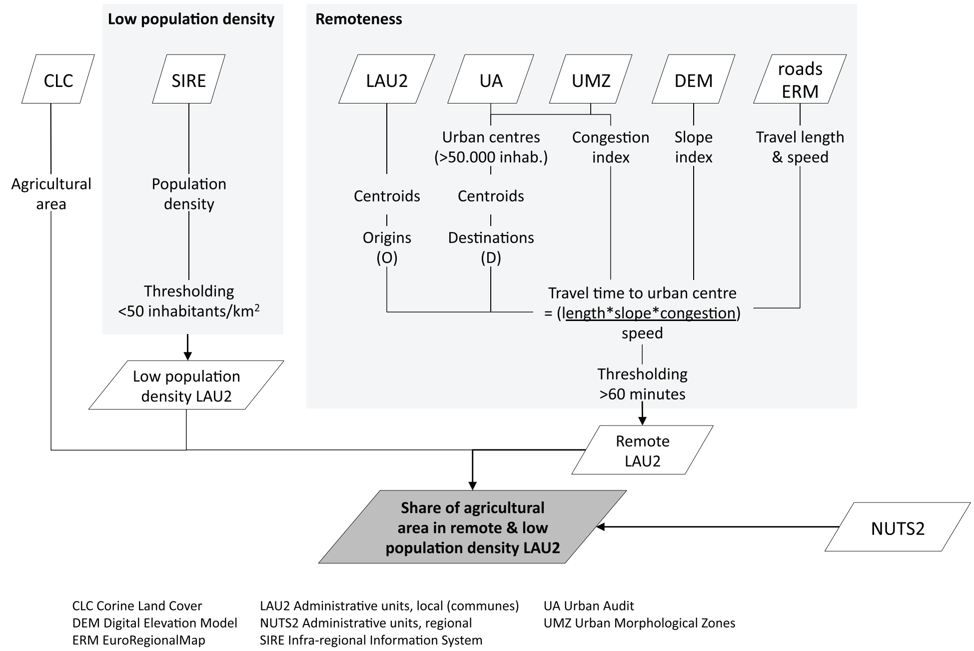

Fig. 2. Workflow for the calculation of the share of agricultural area in remote and low population density areas.

production. The enrolment in organic farming systems is the only measure for which data is systematically collected by FSS, i.e., it is the only measure for which a regional breakdown at NUTS2 level is available. The indicator for this driver computes the share of agricultural area under the organic farming scheme.

3.3. Composite indicator

A possible way to gather information from all relevant drivers into a final indicator of risk of farmland abandonment is to integrate the indicators into a composite indicator. This was done through an empirical framework following a methodology proposed by the OECD (2008).

Normalization was applied prior to data aggregation as the datasets used to build the indicators are in different measurement units and have different ranges of variation. A normalization process was applied to have a range of values between zero and one by subtracting from each observation the global minimum and by dividing the result by the data range of the whole dataset. The min–max normalization was performed at two geographic levels: (1) at EU-27 level and (2) at the level of individual Member States. The first level is an attempt to elaborate a risk composite indicator covering all Member States together. The second attempt builds a risk composite indicator for each country. In this latter case, the assumption is made that one cannot compare, in absolute value, economic results from Member States having heterogeneous economic and structural developments in their agricultural sector. Otherwise, many regions could be identified as being at risk in the new Member States and very few for western European regions. Depending on the correlation between the indicator and risk of farm land abandonment, each value X^N_{qc} of the q indicators for a NUTS (N) region of the country c is transformed into:

Eq. (1) $I^N_{qc} = \left[\frac{X^N_{qc} - \min\left(X^N_{qc}\right)}{\max\left(X^N_{qc}\right) - \min\left(X^N_{qc}\right)}\right]$ if the correlation is positive

or

Eq. (2) $I^N_{qc} = 1 - \left[\frac{X^N_{qc} - \min\left(X^N_{qc}\right)}{\max X^N_{qc} - \min X^N_{qc}}\right]$ if the correlation is negative-

where X^N_{qc} are (i) the minimum and maximum value of X^N_{qc} for EU-27 countries together; (ii) the minimum and maximum value of X^N_{qc} across all NUTS regions in country c, respectively.

In the third and last step, the composite indicator (CI) was established by summing the normalized indicators (linear aggregation) and assigning equal weights to all indicators:

$$\mathrm{CI}^N_C = \sum_{q=1}^{Q} W_q I^N_{qc}$$

with the sum of weights of each indicator $\Sigma_q w_q = 1$ and $0 \le w_q \le 1$, for each indicator $q = 1,\ldots,Q$. CI^N_C has a range between zero (minimum risk) and one (maximum risk) [0,1].

4. Results and discussion

In this section, the indicators of the farmland abandonment drivers are discussed, and, in particular, their spatial variation as well as the availability and quality of the data used for their calculation, as well as their relevance. Table 4 summarizes the results of the evaluation.

4.1. Individual drivers

4.1.1. Weak land market (D1)

The main result for this driver is presented in Fig. 3 (left). Eastern European countries, the Baltic States and regions in Sweden have very low rental prices. To a lower extent, reduced amounts of paid rent also occur in some regions of Spain, France, Italy, the United Kingdom, Bulgaria and in Romania. The indicator excludes farms where the rent paid or the rented UAA are equal to zero. The first case occurs when the land is available for free, e.g., a family member is owner of the land and lends it for free. Positive rents for zero rented UAA can be explained by renting buildings or milk quotas. These observations affect the quality of the data. Excluding these cases avoids biasing the indicator and ensures that only the real market of rented land is considered. In Fig. 3 (right) the share of rented UAA was mapped to show regions where this might influence the results. Particularly, in regions where rental prices are low and where the share of rented land is high, the risk of farmland

Table 4
Results of the indicator evaluation: individual scores for the three criteria and final score (sum).

Driver	Availability	Quality	Relevance	Sum of scores
D1 Weak land market	2	1	1	4
D2 Low farm income	2	2	2	6
D3 Low farm dynamism/adaptation capacity	2	0	1	3
D4 Ageing farmer population	2	1	1	4
D5 Low farmer qualification	2	1	0	3
D6 Previous trend of farmland abandonment	0	-	-	0
D7 Remoteness and low population density	2	2	2	6
D8 Small farm size	2	0	0	2
D9 Farm enrolment in specific schemes	2	2	0	4

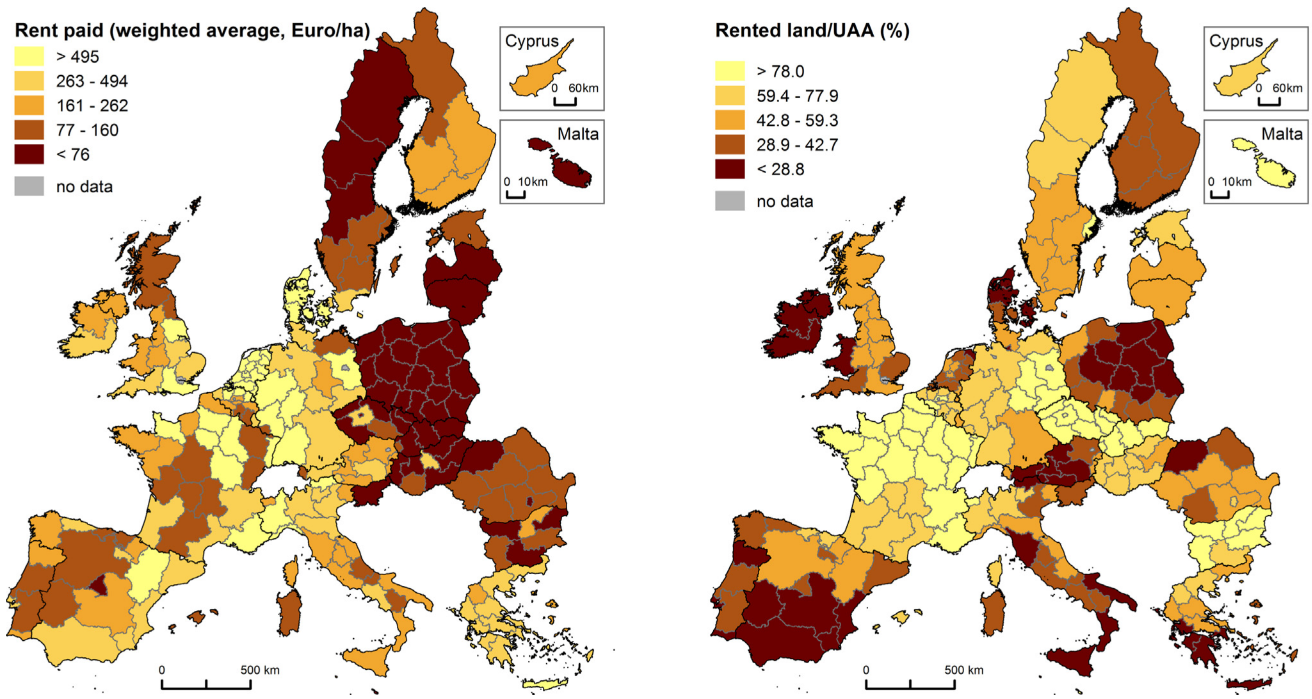

Fig. 3. Rent (euro/ha) paid by holding (left) and share of rented land on the total agricultural area (right) (both in quintiles; source: FADN data 2006–2008). No data for the region of Aland (Finland) and the cities of Vienna, Brussels, Bremen, Berlin and London.

abandonment will be high because in these regions there is either a low demand for agricultural land or regulations and/or institutions are hampering the land market (e.g., by setting a maximum rental price). The relevance of the indicator is affected by the bias in the data for regions where the land tenure model is mainly ownership (in Italy, for instance), other conditions being constant. In the case of land ownership the risk of abandonment is accordingly lower than when land is rented. Based on these observations, the good data availability (NUTS2) and their medium quality, a medium overall score was assigned to this driver.

4.1.2. Low farm income (D2)

Fig. 4 shows regions with low income in Ireland, Portugal, southern France, central and southern Italy, Slovenia, mountain areas in western Austria, central and southern Greece, Cyprus, western Bulgaria, eastern Romania, central Slovakia, central/eastern and southern Poland, and some areas in northern Sweden and eastern Finland. For some countries the data variability is high (coefficient of variation > 2.0) such as for Bulgaria, Cyprus, Hungary, Ireland, Romania, Slovenia and the United Kingdom. The lowest values (<0.9) are measured for Austria, Belgium and Germany.

Different situations in the Member States may have different underpinning explanations. The economic and structural farming context is still very heterogeneous between Member States and applying a unique European threshold value for the income makes little sense. Agricultural income is still disparate throughout Europe where, e.g., a low value in The Netherlands could be high in Bulgaria. There is indeed a ratio of 1–15 amongst EU-27 Member States between the smaller and larger average national agricultural incomes.

The indicator is based on farm income only, while using the total household income (tourism, external income from part-time work, external income of the partner, etc.) may change the picture. For example, the situation in the western Austrian mountains with low agricultural income may be overcome by external additional income from farm tourism and as a consequence reduces the risk. However, this information is not available in the FADN database. FSS provides qualitative information on other activities but not as a measure that could be linked to the quantitative income of the FADN data. In general, the concept of total income of agricultural households is relevant but appropriate data are not available (Hill, 2008) and the EU's effort to collect this data was abandoned in 2002. Moreover, the farm income provides information on the real performance of the agricultural activities of the farm, while the household income could include revenue from other sectors (e.g., partner not working in agriculture).

Farm income was further analyzed with the distribution of farm-types (as share of affected farms) for NUTS2 with the lowest value

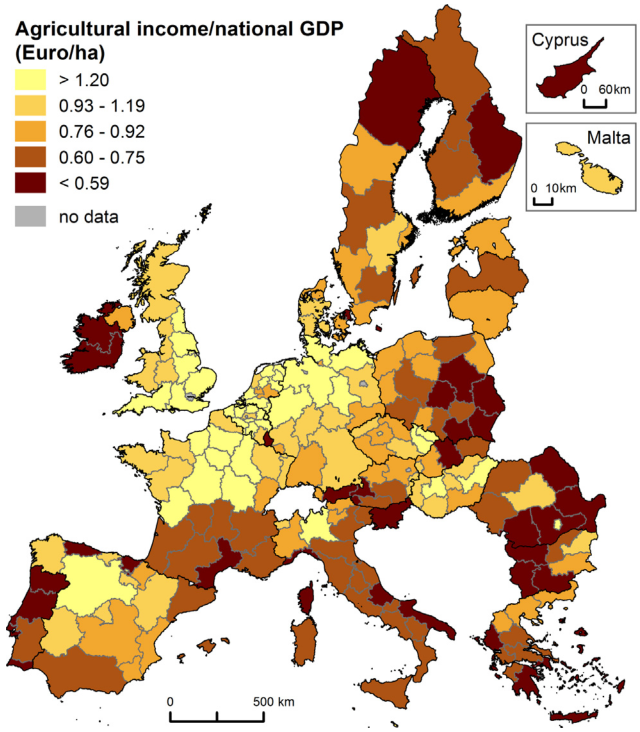

Fig. 4. Ratio agricultural income/national GDP (quintiles) (sources: FADN data and national accounts 2006–2008). No data for the region of Aland (Finland) and the cities of Vienna, Brussels, Bremen, Berlin and London.

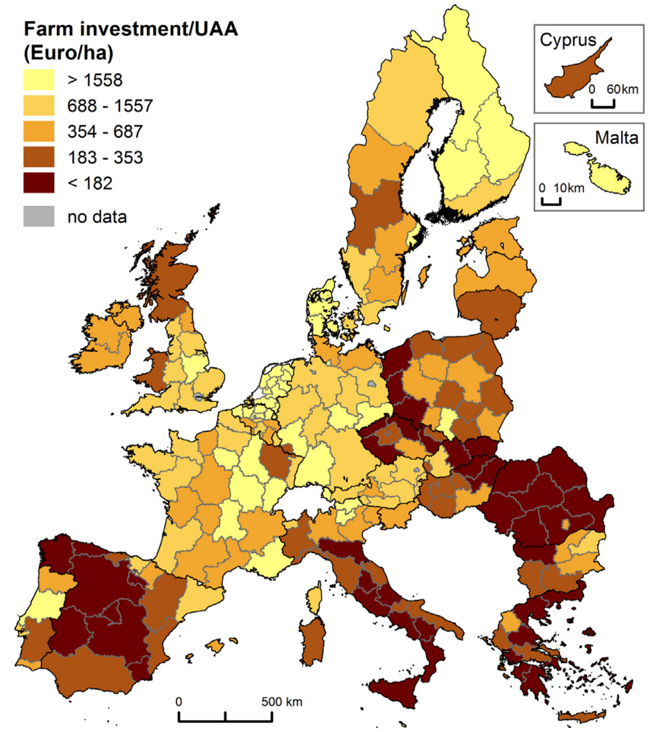

Fig. 5. Average level of investment per holding (normalized by physical size) (quintiles, source: FADN 2006–2008). No data for the region of Aland (Finland) and the cities of Vienna, Brussels, Bremen, Berlin and London.

Table 5
Presence of farm types in low income NUTS2 (NUTS2 with ratio 'income AWU/GDP per cap' <0.59).

Farm type	Nb (%)	Area (%)
Specialist field crops	12	6.00
Specialist horticulture	3	2.64
Specialist permanent crops	23	35.52
Specialist grazing livestock	20	31.68
Specialist granivore	2	2.30
Mixed cropping	14	3.41
Mixed livestock	11	3.72
Mixed crops-livestock	15	14.74

(taking only the first quintile, where the indicator <0.59). This threshold is indeed close to the EU relative poverty index which is 0.6 (i.e., people falling below 60% of median household income are said to be at-risk-of poverty). Table 5 shows that 23% of the holdings are 'specialist permanent crops' type followed by 'specialist grazing livestock' type (20%). Farms of the first type also hold the biggest share in UAA. Most of these farms are located in southern Europe (Spain, Greece, Italy, Portugal, and Cyprus), in regions where olive groves are most frequent. The other most frequent type of farm ('specialist grazing livestock') is mostly present in Ireland and in central Europe (Austria, Slovakia, and Slovenia). These results bring forward the potential risk of farmland abandonment from farm-types using large shares of land (livestock grazing system), often in an extensive manner. This is also the case for extensively managed olive groves in Mediterranean countries.

Data availability and quality, and the relevance of the indicator are high, leading to an overall high score for the driver.

4.1.3. Low farm dynamism/adaptation capacity (D3)

The amount of investment per holding is shown in Fig. 5. Regions with lower investment ratios are found in Spain, in central and southern Italy, in most of Greece, in Romania, in several Czech regions and in western Poland. In this context, it is noticeable that there are regions in Spain, Italy, Greece, Cyprus and Romania where more than 60% of the holdings have made zero investment during 2006–2008.

The effect of normalizing the investment per holding by its economic size was tested, providing the amount of investment per euro of economic size (not shown here). For some countries such as the Baltic states, this ratio is very high for which there are two possible reasons: (i) some farms may use common land, therefore appearing smaller in physical and economic size than what they are in reality; (ii) some relatively small farms may develop contract work for other farmers, then buying more equipment than they would need for their own farm. Despite these possible reasons, data suggest that investments in the Baltic states were high during the observation period. A comparison with Eurostat data on 'gross fixed capital formation' shows that Latvia and Lithuania (no data for Estonia) have indeed made important investments in the agricultural sector in the last ten years. However, when normalized by economic size, the indicator shows a high variability at regional level (e.g., the coefficient of variation is 15 for Calabria, Italy, and 11 for Western Greece), leading to a lower confidence in the representativeness of the weighted regional average. Consequently, only the ratio of investment divided by the farm physical size was kept.

Quality issues related to ambiguous data were investigated further. Indeed, reporting difficulties in the FADN database were confirmed for the investment parameter for some (Mediterranean) countries (DG Agriculture and Rural Development personal communication). After consultation, Member States at stake explained that the financing of investment comes from family loans. Many farmers consider those as private and do not report them in their farm accounts. Consequently debts and investments are missing for these farms. Moreover, some Italian experts suggested definition issues for this FADN parameter during the observation period in their country, acknowledging possible data deficiencies. Despite good data availability the quality of the data is low, as is the rel-

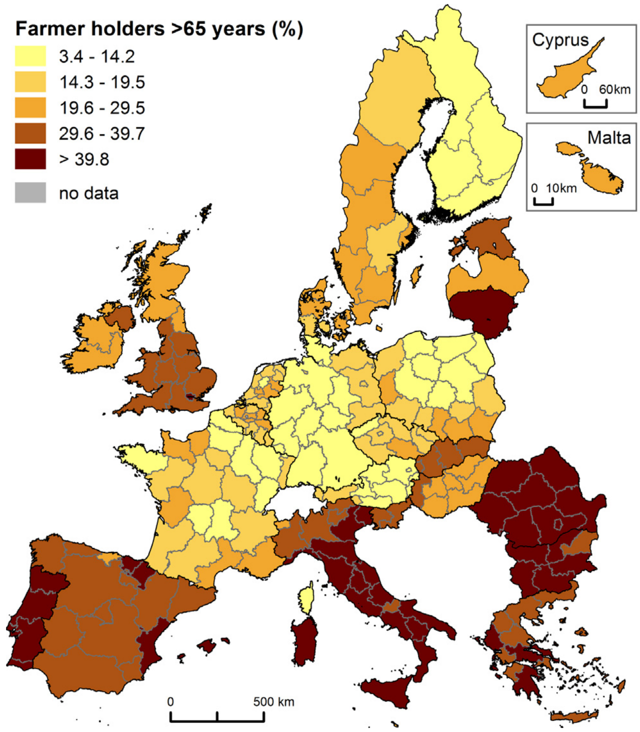

Fig. 6. Share of farm holders aged more than 65 years (quintiles, source: FSS 2007 data, no data for the city of Brussels).

evance of the indicator, resulting in a low overall score for this driver.

4.1.4. Ageing farmer population (D4)

The share of farm holders older than 65 years is very high (>39.8%) in Portugal, most of Italy, southern Greece, Bulgaria, Romania and Lithuania (Fig. 6). It is also high in England, Wales, Northern Ireland, the remaining regions of Italy and Greece, Estonia, Slovakia, Slovenia and Spain.

The calculation of this indicator raised concerns for biases due to data interpretation as, for some countries, results might be influenced by specific institutional situations such as pension scheme, tax system, farm transmission scheme, etc. rather than the real situation of actual farm holders. One example is the United Kingdom where farm owners (older) and farm managers (younger) are often not the same person. This ambiguity reduces the data quality, and despite the good data availability, only a medium score is assigned to its relevance. The overall score for this driver is medium.

4.1.5. Low farmer qualification (D5)

Mediterranean (Portugal, Spain, most of Italy, Greece, Cyprus) and southeastern European countries (Slovakia, Hungary, Romania and Bulgaria) have more than 80% of farmers with 'practical experience only', meaning that very few of them have followed agricultural education courses. To a lower extent (60–80%), the same training level also dominates in the United Kingdom, Ireland and in the Baltic and Scandinavian countries.

A high score was assigned to the data availability for this indicator (NUTS2 data). However, the rather weak definition of qualification levels in the FSS questionnaire negatively affects the data quality (farmers' response) for this driver. As a consequence of the low quality, a low score was assigned for the relevance of the driver. Overall, the score for this driver is low.

4.1.6. Remoteness and low population density (D7)

The combination of low population density and remoteness criteria (Fig. 7) identifies remote and scarcely populated areas in Spain and Portugal, southern France, Italy, Greece, mountainous regions of Romania and Austria. Additional areas are located in northern Poland, in the Baltic and Nordic States, in Wales and Scotland and in Ireland. Regions with a higher share of agricultural land in remote and scarcely populated areas occur in Portugal, Spain, south-west France and Corsica, Tuscany, Molise and Sardinia in Italy, most of Greece, the Baltic States, Scotland and Wales, and Ireland. In these regions, more than 19% of the agricultural land is in low populated areas and remote from main urban centres.

It must be underlined that there might be differences between official agricultural statistics and the CLC data that was used to estimate the agricultural areas affected by this driver. However, CLC is the only European-wide agricultural land information system accessible for the calculation of this variable at LAU2 level.

The availability and quality of data at LAU2 level for all Member States is very good, except for Bulgaria where no details for the road types were available. A high level of relevance is assigned to this indicator. As a consequence, the overall score for the driver is high.

4.1.7. Small farm size (D8)

Computing the small farm size indicator requires first a consideration of farm-types (as, e.g., horticulture farms will de-facto be smaller than grazing livestock farms), and this can highly complicate the calculation of this indicator. Consequently, the analysis of farm size targets only the two farm-types 'specialist grazing livestock' and 'specialist permanent crops' since they were already identified under the driver 'low income' as farm types with a high risk of farmland abandonment. However, two aspects raise conceptual issues in the definition of this driver, and, consequently, suggest a low relevance of this indicator. First, some areas might be identified because the farm type in question is rare (compared to other farm types present in the surroundings) in a specific area and with a size below the average regional farm type size. Indeed, the map for 'grazing livestock' identifies for example some intensive cereal growing areas in France and in the United Kingdom, only because there are few (small) grazing livestock farms in these regions. However, these areas are not at risk of land abandonment. Second, for countries such as Slovakia, Hungary and Romania, the distribution of farm size may show co-existence of few very large farms and many small farms resulting in a large share of farms below the regional average.

While the data availability is ranked high, data quality and relevance of the indicator are low. Accordingly, the overall score for this driver is low.

4.1.8. Farm enrolment in specific schemes (D9)

For most of the regions, the share of organic farming is rather low (below 10% of the UAA). Only in countries such as Italy, Austria and the Czech Republic, are there regions that have a share higher than 10%. For this reason it is difficult to raise robust conclusions on the entire agricultural area. Given this limitation the relevance of this driver is low and accordingly it was not further used.

4.2. Composite indicator

The final evaluation of each driver with respect to availability, quality of data, and in particular to the relevance of the indicator was decisive for the selection of drivers to be used to build the composite indicator. As a result of this final evaluation (Table 4), the indicators were classified in three classes:

1. The indicators for D1 (weak land market), D2 (low farm income), D7 (remoteness and low population density) are considered rel-

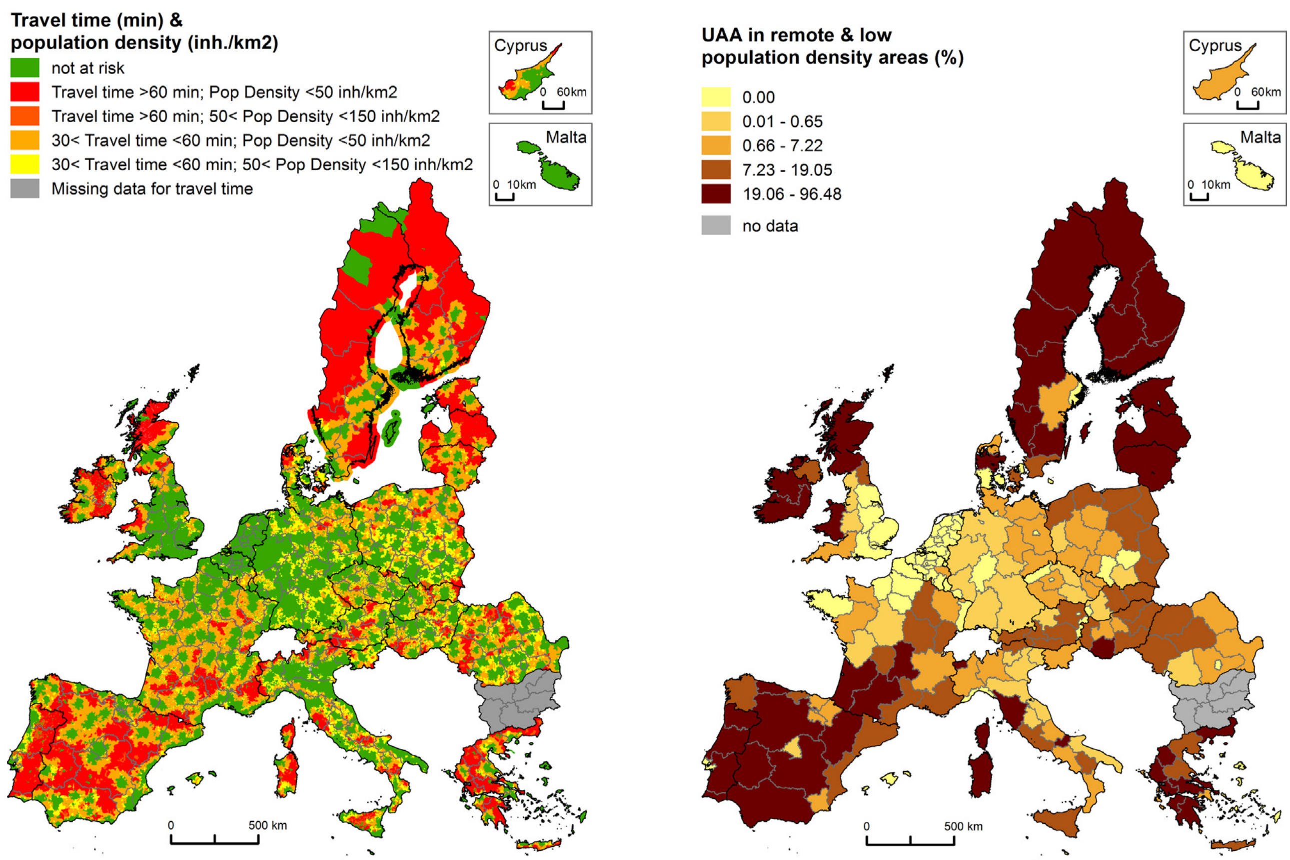

Fig. 7. Travel time to major urban centres combined with population density at LAU2 level (left) and share of agricultural area in remote and low population density LAU2 regions (right, quintiles; data sources: agricultural and urban areas from CLC 2006, UMZ, UA; population from SIRE; road network from ERM).

evant, data for their calculation are available and are of good quality.

2. The indicators for D3 (low farm dynamism/adaptation capacity), D4 (ageing farmer population) are considered as less relevant. Data for calculating these indicators are available but are of lower quality than the previous group.
3. For the definition of indicators for D5 (low farmer qualification), D6 (previous trend of farmland abandonment), D8 (small farm size), D9 (farm enrolment in specific schemes) there were no data available, or the quality was low, or the indicator was not considered relevant for the driver.

Only the indicators from the first two classes were accordingly included in the calculation of the composite indicator. They were calculated for each NUTS2 in each country for the two geographic normalization levels. The indicators were included in the composite indicator with equal weights. The possibility to assign individual weights was rejected after a principal components analysis (PCA) revealed weak correlation among the indicators (through the Kaiser–Meyer–Olkin test).

Figs. 8 and 9 display a ranking of NUTS2 regions from lower (yellow) to higher (dark brown) risk of farmland abandonment. Note that no results are provided for Bulgaria because of missing data for the indicator on agricultural area in remote and low population density areas. Regions with higher risk of farmland abandonment are found in Portugal, Spain (south, Asturias, Pais Vasco), Italy (Centre and South Italy), part of Peloponnese/Macedonia region (Greece), Slovenia, Romania, all three Baltic States, Finland, northern Sweden, and in Connacht and Donegal in Ireland.

It may be surprising to see Tuscany as a region with a higher risk of farmland abandonment in Italy. Data screening for the three economic drivers (D1, D2 and D3) shows that values for Tuscany are lower than for southern Italian regions. Additionally, the values for the indicators on the farmers' age and remoteness of UAA are relatively high, identifying consequently Tuscany as being at higher risk of farmland abandonment. The unexpected low value for the D2 indicator might be due to the presence of other sources of income outside agriculture (e.g., diversification activities such as farm tourism) which are currently not included in the farm income but which should be considered in future modifications of the data collection schemes.

Further analysis was carried out to identify farm types within NUTS2 regions flagged with a higher risk (risk index >0.72). The most frequent farm-types are 'specialist grazing livestock' with around 30%, followed by 'specialist field crops' (23%) and 'specialist permanent crops' (20%). These results show that the risk of farmland abandonment is potentially higher for farm-types using large shares of land (livestock grazing system), often in an extensive manner. This is also the case for extensively managed olive groves in Mediterranean countries. The likely impacts of farmland abandonment from farms with permanent grazing livestock and permanent crops may be negative for maintaining the landscape and for biodiversity that depend on extensively managed agricultural land (typically occurring in semi-natural grassland and/or high nature value farmland) (Plieninger and Bieling, 2013). In fact, land abandonment affects extensively managed farmland much more than intensively managed farmland (Cocca et al., 2012). Abandoning this land may be negative for maintaining the actual biodiversity because vegetation succession leads to species-poor and more homogeneous vegetation types. Other environmental effects of abandonment include the loss of small scale mosaics of land use and their characteristic species (Sirami et al., 2008). Furthermore, it may

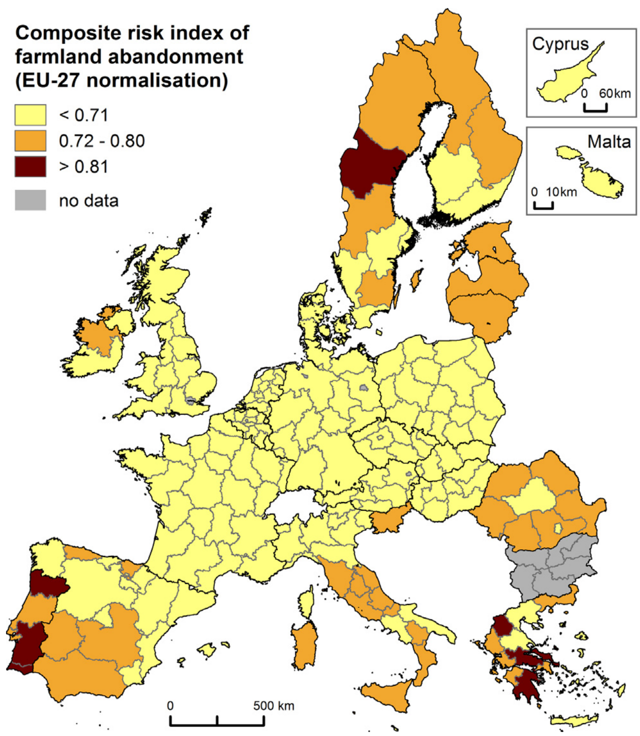

Fig. 8. Composite indicator of the risk of farmland abandonment for EU-27 (normalization at EU-27 level) calculated from drivers D1 weak land market, D2 low farm income, D7 remoteness and low population density, D3 low farm dynamism/adaptation capacity and D4 ageing farmer population. Regions are classified in quintiles with the first four quintiles summarised in the first class (<0.71, 80% of the observations) and the last quintile subdivided in two classes (80–90% risk index between 0.72 and 0.80, and 90–100% index >0.81). No data for the region of Aland (Finland), all regions in Bulgaria and the cities of Vienna, Brussels, Bremen, Berlin and London.

reduce genetic diversity of both wild species and of local breeds of livestock or varieties of crops (which are often well adapted to the semi-natural habitats), and increase fire risk in areas where grazing areas act as firebreaks (Peco et al., 2012).

Fig. 9 shows examples of the normalization at Member States level for Spain, France and Poland. NUTS2 regions were classified using five classes, starting from a composite indicator value of 0.5 (medium) up to a value of 1 (very high risk). The results for these three countries show indeed that when only the national economic conditions are considered in the risk indicator calculation, the difference between the regions is more pronounced. While in the EU-27 calculation no region in France was identified as being at high risk, the calculation at national level shows a south–north gradient with all southern regions at higher risk. In Spain the center-west with Extremadura, Castilla-La Mancha and Madrid, Asturias in the north as well as the Balearic Islands are at higher risk (>0.7). In Poland, contrary to the EU-27 calculations two regions in the north (Warmia–Marusia) and south (Podkarpackie) are at high risk.

4.3. Data issues

4.3.1. Validation of the observed risk

Given the rather theoretical process of building the composite index, it is critical to verify the results and to confront them with other independent estimates. The lack of European datasets measuring actual farmland abandonment prevents validating the results and benchmarking the proposed methodology. Such measurements, if available, could also be used to establish the weighting system for the drivers included in the composite indicator.

Nevertheless, several alternatives for cross-checking the results can be mentioned. First, the use of agricultural economic models which may provide information at regional level (NUTS2) on agricultural activity not performing well (in economic terms), bearing in mind, though, that some of the assumptions used in these models (e.g., the land supply function) are themselves not easily validated. However, the economy is not the only driver that needs

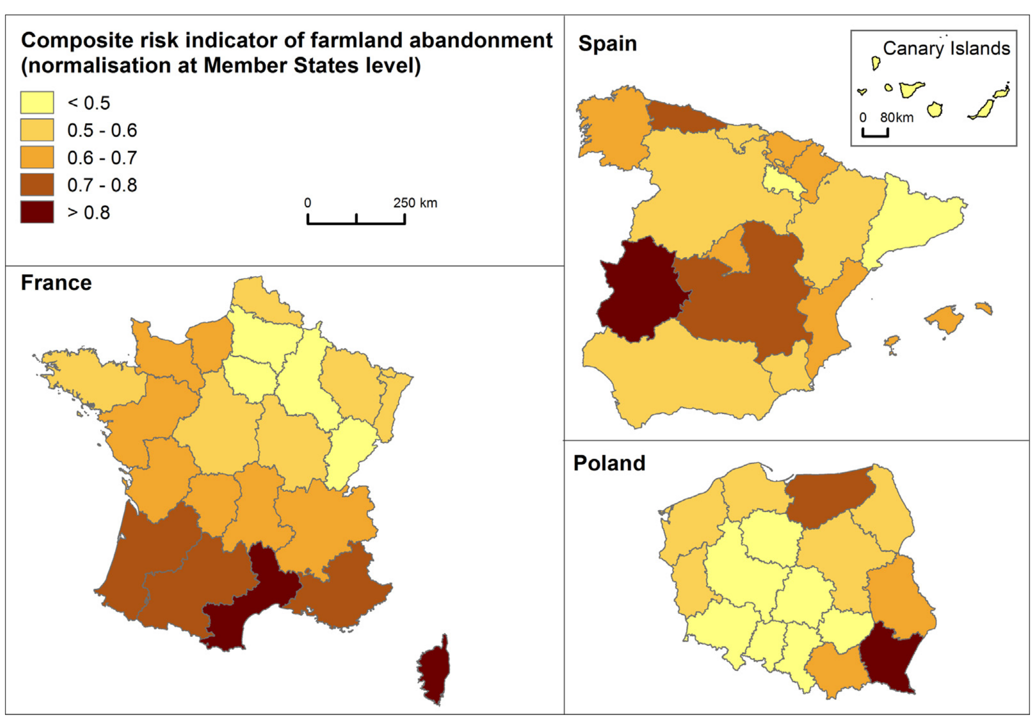

Fig. 9. Composite indicator of the risk of farmland abandonment for Spain, France and Poland calculated from drivers D1 weak land market, D2 low farm income, D7 remoteness and low population density, D3 low farm dynamism/adaptation capacity and D4 ageing farmer population (normalization at Member States level).

to be taken into account in the case of farmland abandonment. A literature review has also identified bio-physical, sociological and behavioural reasons which are not yet integrated in the available agricultural-economic models in Europe. Second, data on trends of UAA at LAU2 level for two successive censuses could be used (2000 and 2010, for example). This would require (i) access to these datasets at LAU2 level, and (ii) auxiliary data on the rate of urbanization and afforestation at the same local levels.

A third alternative arises from studies on the determinants of farmland abandonment available at regional or local level (e.g., Lange et al., 2013; Müller et al., 2009). However, using these studies for validating the risk identified herein is not straight forward because of differences in the data sources and spatial resolutions. In most studies land use change is used to quantify farmland abandonment (that may differ to the definition adopted here which refers to a cessation of management with negative consequences for ecosystem services and biodiversity). To some extent these studies cover the determinants analyzed in this study (e.g., population density, farm fragmentation, distance to roads, farm diversification) but in regression models drivers from the environmental (biophysical) context (elevation and soils) dominate over socio-economic drivers. As determinants of farmland abandonment are identified for one single region (NUTS2 or NUTS3), the resulting model and its predictors are tuned to this region and in the European context the power of predictors might be different (Corbelle-Rico and Crecente-Maseda, 2014).

4.3.2. Data limitations

The scientific literature widely agrees that farmland abandonment is a local-specific phenomenon, requiring availability of local data to estimate its risk. Corbelle-Rico et al. (2012) suggested working at least at municipality level (LAU2). In recently published work they analysed the relationship between the drivers defined here and changes in agricultural area for one Spanish region (Galicia) with data at LAU2 level. Their results confirm that the risk indicator defined here is meaningful, but they also revealed differences in the importance of the drivers that they partially attribute to the differences in the scale of application (one region vs. EU-27).

For an assessment at European level, the lack of accessibility to local data is clearly an issue, especially when the underlying variability of the aggregated micro-data (FSS) is not known. Moreover, for both FADN and FSS datasets, the resolution of input data available in European databases varies between Member States, ranging from NUTS3 in the best case to NUTS0 in the worst. This heterogeneity of input data is a source of difficulty and inaccuracy in the calculation and aggregation processes aiming to build comparable and homogeneous pan-European drivers of farmland abandonment at NUTS2 level.

NUTS2 regions often hold diverse agro-economic conditions, which need not influence farmland abandonment uniformly in the whole area. Analyzing data at coarse level (NUTS2) may overlook the actual risk of land abandonment occurring in smaller sub-regions. This might happen when the variability of individual drivers is high with an average value masking very different situations. Consequently, one possible improvement of the results would require the availability of statistical and socio-economic data at much finer spatial resolution (i.e., LAU2).

In future work, the following aspects should be considered:

- For the driver on weak land market, the FADN parameter on the paid rent does not refer only to land but includes all rents (buildings, quotas, etc). It therefore goes beyond the rental price for solely the land. However, it was the only available variable for the observation period. In the future it would be preferable to use information in which only the land is considered. This variable is collected from 2009 onwards. A second possible improvement of this driver would be the use of land price in selling transactions as this would give a relevant base to assess the land market. In regions with low rental prices but high sales prices and a low share of rented land, the risk of farm land abandonment might also be low. Data on the land market at European level were not available and Eurostat has just started to collect data for this item. Therefore, only rent paid is considered and is assumed to be a good proxy for the risk of land abandonment if the share of rented land is high.
- For the low farm income driver it would be more appropriate to compare a farm income per annual working unit to the national GDP per active person rather than to the national income per capita. Furthermore, information on the total agricultural household income would be more relevant but is unfortunately not available.
- It would be beneficial to include the availability of a successor in the driver on ageing farmer population because, rather than the ageing (overageing) itself, it may be the lack of a successor that more often leads to farmland abandonment (Schnicke, 2010). However, information on the successor is not available in the datasets used in this study.
- Concerning the small farm size driver, it has to be highlighted that the threshold on the minimum size of farms that are sampled in FADN data may lead to a certain under-representation of the smallest farms, which in the case of farmland abandonment may be an important issue. In addition, FADN data are statistically representative only at NUTS 0, 1 and 2 levels and thus are rather coarse. However, there are no other datasets available with such relevant variables at the EU level.

5. Conclusions

The causes of farmland abandonment in Europe are manifold, depending on the area and the period under consideration. It is a complex process which can have a wide range of drivers, varying between Member States and sometimes within a single country. Indeed, the agricultural situation differs from region to region, as a consequence of natural conditions, historic developments and the economic, social and demographic context.

This study aimed to identify the principal drivers of farmland abandonment in Europe and to test the suitability of European-wide data sources for the definition of indicators for measuring the risk of occurrence. The focus was on drivers of farm stability and viability, as well as on drivers from the regional context. Nine drivers were identified, of which six are associated to farm stability and viability, and three with regional context. Drivers for farm stability and viability are low farm income, low farm dynamism/adaptation capacity, ageing farmer population, low farmer qualification, small farm size and enrolment in specific agricultural schemes. Drivers from the regional context are weak land market, previous farmland abandonment, and remoteness and low population density. Indicators were built for each driver using European agricultural statistics from FADN and FSS. Each indicator was mapped at regional level (NUTS2) for all European Union Member States and then assessed in terms of data availability and quality, and relevance to the driver. The assessment uses some of the criteria and the scoring scheme developed during the IRENA operation (EEA, 2005). For some indicators it was not possible to obtain appropriate datasets. For others the quality of the available data was not sufficient or the available data were not representative enough for the indicator. This was the case for low farmer qualification, small farm size, enrolment in specific schemes, and previous farmland abandonment. The other five drivers were used to build a composite indicator 'risk of farmland abandonment'. Accordingly, the composite indicator was defined from low farm income, low farm dynamism/adaptation capacity, ageing farmer population, weak land market, and remoteness and low population density. It was built following OECD recommendations using the normalized values of the individual indicators, either at EU-27 level in an attempt to elaborate a composite risk indicator covering EU-27 in a homogeneous manner, or at individual Member State level. At EU-27 level regions with a higher risk of farmland abandonment were identified in Portugal, Spain, Italy, Greece, Romania, Slovenia, the three Baltic states, Finland, Sweden and Ireland. The composite indicator at Member State level illustrates that there are large variations in the risk of farmland abandonment among regions within a country. The most frequent farm types at risk identified in these regions are 'specialist permanent grazing livestock', 'specialist field crops' and 'specialist permanent crops'. All three use large shares of land, mostly in an extensive manner. Lack of management in such areas may lead to negative consequences for landscape and biodiversity maintenance.

The success of building comparable and homogeneous pan-European indicators for drivers of farmland abandonment at NUTS2 level was clearly influenced by the availability and quality of the data. Despite their good quality and high value, the two European datasets used in this study limit the analysis of a local-specific phenomenon such as farmland abandonment. The lack of accessibility to local data and the heterogeneity of input data (in terms of resolution and information collected) are the main reasons. These should be considered in future modifications to the data collection schemes and in the distribution of data.

The study contributes to assessing the risk of farmland abandonment in Europe, but validation through measurements of its occurrence is still needed. This requires European or national datasets measuring actual farmland abandonment which are currently not available. Given the high priority of avoidance of farmland abandonment in the European agricultural policy, an improved knowledge of the phenomenon including its quantification at the European level is necessary. Once data on actual farmland abandonment are available, drivers from the different contexts and interlinkages between drivers can be analysed. This would provide the basis on which to evaluate policy measures aimed at reducing farmland abandonment in Europe.

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FSS: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Farm_structure_survey_%28FSS%29
LAU local administrative units: http://ec.europa.eu/eurostat/web/nuts/local-administrative-units
National accounts: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/National_accounts_%E2%80%93_GDP
NUTS nomenclature of territorial units for statistics: http://ec.europa.eu/eurostat/web/nuts/overview
SIRE no public access
UA: http://www.eea.europa.eu/data-and-maps/data/external/urban-audit-database
UMZ: http://www.eea.europa.eu/data-and-maps/data/urban-morphological-zones-2000-umz2000-f1v0-1.