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RESEARCH ARTICLE

VULNERABILITY GRADIENTS AND SPATIAL PATTERNS IN THE GREEK RURAL SPACE: DETECTING REQUIRING SMART SERVICES

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Abstract

In Greece, rural depopulation is observed over time, reflecting a particularly unbalanced population distribution. In recent years, however, the economic crisis is leading to rapidly decreasing rates of urbanization, and relative revitalization of some rural areas. Considering the above, there is therefore the question of the resilience and attractiveness of rural areas, especially marginalized ones. The fundamental objective for ensuring their sustainability is the possibility of addressing the key social and economic needs of the local population, thus contributing to a minimum level of social integration and improvement of living standards. The main purpose of the present study is to introduce a typology for the marginalized rural areas in Greece, applied to the local administrative spatial level and more specifically to detect among those, the most vulnerable requiring the implementation of smart services. Based on the acknowledgment of territorial heterogeneity, the analysis is defined by a multidimensional data warehouse. In particular, spatial, societal, environmental, and cultural marginalities define the corresponding data collected. Multicriteria Analysis (Explanatory Factor analysis, Hierarchical analysis and Discriminant analysis) and spatial tools (GIS) identified the main types (spatial patterns) of Greek marginalized local administrative units. The implementation of this methodological tool aims at the evaluation and classification of the needs of local societies. The proposed research is an innovative approach to Greek data, in terms of scientific contribution to the identification of rural areas with new criteria and the emergence of smart services as rural resilience tools.

Introduction:-

During the recent decades, the chronic problems of the Greek disadvantaged and isolated areas have created significant difficulties for their permanent residents and acted as a deterrent for the youngest with high aspirations. The aging and the demographic weakening of the population characterize the composition of the local rural society in Greece. In parallel, the rural areas of the European southern member states, including Greece, are confronted with higher poverty rates (European Commission, 2021). Addressing such fundamental problems is a prerequisite for the sustainability of disadvantaged rural areas. The aim of the present study is to produce knowledge on vulnerability

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gradients and spatial patterns of vulnerability in the Greek rural space requiring adequate (including smart) interventions, appropriate to their local specificities.

The rural territory of Greece presents a large heterogeneity in terms of relief, landscapes, land-uses, and access to basic socio-economic services. At the local scale, it is possible to observe geomorphological and infrastructural variants which mainly justify those rural areas do not automatically mean disadvantaged areas. If obviously, some rural areas combine various handicaps presenting over time a high risk of crystallization (Berthod-Wurmser et al., 2009), the vulnerability of the rural space – as a whole – is obviously relative and depends on the remoteness degree of the rural territories that are part of it.

The rural space and consequently its vulnerability has to be understood not only as a "multidimensional" concept but moreover, as a "gradient" that goes beyond the simple and traditional urban-rural dichotomy (Chomitz et al., 2005; Montalvo et al., 2019). Through such a gradient approach, it is possible to detect more efficiently not only the intensity but also the type of vulnerability faced by rural areas at a local scale.

The first list of Greek disadvantaged (less favorite) areas as defined in Directive 81/645 (Official Journal of the European Communities, 1985) based on the characteristics and criteria contained in Directive 75/268 (Official Journal of the European Communities, 1975), according to which they include: (i) mountainous areas with a significant reduction in land use potential and a significant increase in operating costs (ii) areas threatened with the abandonment of land use and in which the conservation of natural space is necessary (iii) other areas with special handicaps where agricultural activity should be continued under conditions for the preservation of natural space and the preservation of the tourist potential of the area.

Based on the above findings, the focus is on the possibilities of enhancing the resilience of the rural area and consequently the search for new approaches to local development, especially for the most socio-economically fragile areas. Local communities do not just need outdated sustainable solutions, but innovative actions and horizontal actions, which will bring about drastic changes in the culture and operation of the space.

This requires a new approach to the rural space as a non-single space and the emergence of smart and innovative methods and tools that allow for its sustainability, attractiveness, and growth of its population and businesses. The international experience seeks the answer in Smart Villages. They constitute a serious tool of modernization, which may be the key factor in rehabilitating disadvantaged areas, improving the quality of life, resilience, and attractiveness of the disadvantaged rural areas (ENRD, 2018).

In this context, the scope of the article is to conduct systematic research and analysis of the Greek rural area, in order to detect vulnerability gradients and the spatial patterns of vulnerability. These can be useful tools for exploring possibilities for creating smart ser-vices that will contribute both to the durability and attractiveness of disadvantaged rural areas and their gradual transformation into smart areas.

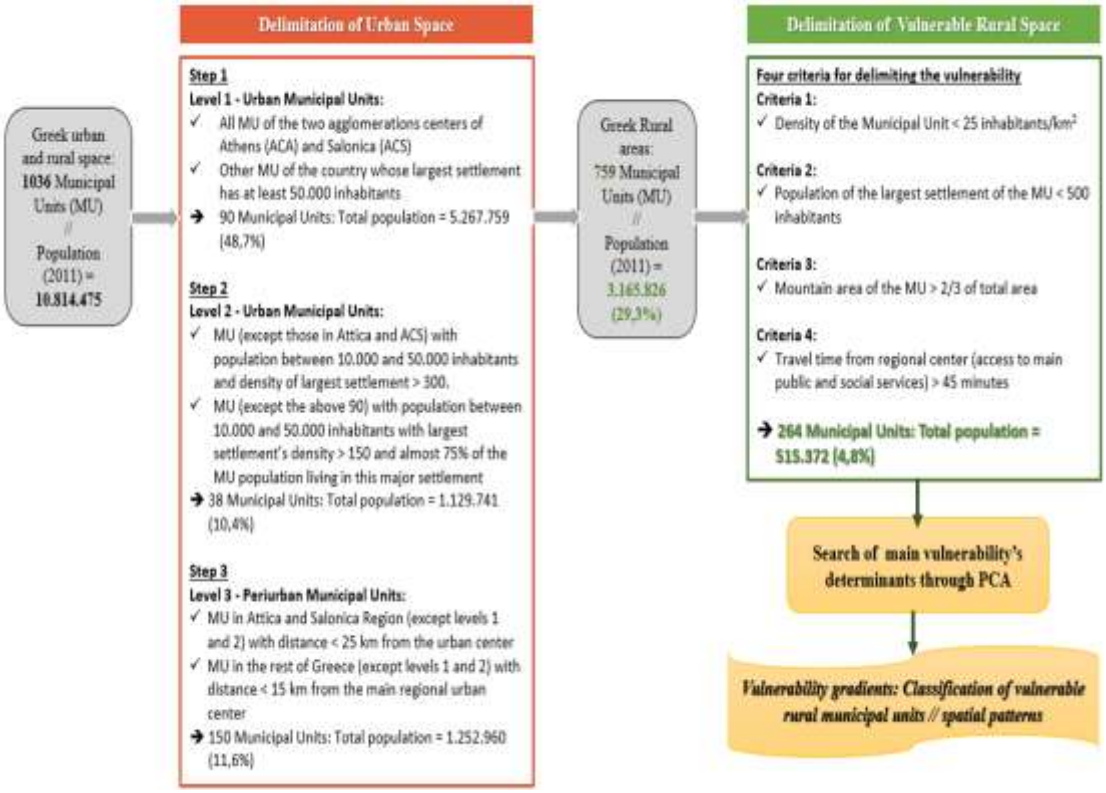
Systematic search and identification of areas facing a significant isolation problem, either physical or social, are necessary, as "smart" solutions (which are inherently innovative) must be identified according to local specificities and needs. Both the vulnerability gradients and the local spatial patterns of vulnerability identified in this article, however, can be exploited as the basis of implemented locally strategies or policies to successfully encourage resilience, and development, as well as quality of life of marginalized populations.

Data and Methodology:-

To approach the research question, two major methodological issues needed to be considered: the scale of analysis, and the delimitation of rural space. Concerning the need to detect the spatial heterogeneity the analysis is implemented at the local scale of municipal unit (level 5). The analysis at such a low scale reveals variations and a deeper under-standing of both space, and data. It is common that municipal units with large areas and small urban centers are characterized as rural due to their low density (OECD, 2011). To justify the choice of geographical scale it is necessary to refer to the major administrative reform in Greece (Law 3852/2010) according to which the new municipalities resulted from the merging process of the smallest municipalities.

To highlight the Greek rural vulnerable areas in Greece and offer a better under-standing of the complexity and the depth of the methodological context, Figure 1 was de-signed.

Figure 1:- Methodological steps.



Delimitation of vulnerable rural areas: The division process

Phase 1: Delimitation of Rural Areas

During the first phase of the analysis, the evaluation of the 1036 municipal units of Greece is performed through a criteria-based approach (Figure 2). The Greek Statistical Authority (ELSTAT) has created a typology to define urban/rural areas based on the OECD (2011) and European Union (European Union, 2019) typologies of rural and urban areas. According to those typologies, each one of the municipal and local communities (koinótites) was characterized as urban or rural and then, moving up to the hierarchy of standard geographic units, the urban/rural characterization of the 1036 municipal units (dimotikésenótites) was performed. The ELSTAT typology was not considered adequate for the present research for two reasons: (i) this typology is still based on a simple urban-rural dichotomy and moreover (ii) the threshold of 2,000 inhabitants used in this definition is subject to discussion. Contrarily to ELSTAT, Eurostat retained a minimum population of 5,000 combined to a density at least of 300 inhabitants per km2 (European Un-ion, 2019).

In the present analysis, peri-urban areas are not considered to be part of rural space. In particular, we adopt the Eurostat definition for peri-urban areas· hybrid areas of fragmented urban and rural characteristics (Eurostat, 2016) (pp. 12), while they are also de-scribed as suburbs in high-income countries (Eurostat, 2021). Even if peri-urban areas are quite often considered as part of rural space, the final objective of the present research is to identify the vulnerable rural areas.

The first, and most common parameter featured in space taxonomies is the population size. According to that, municipal units from Attica and Thessaloniki in the corresponding urban complexes are considered urban areas. With regard to municipal units except for Attica and Thessaloniki urban complexes, the population threshold of 50,000 residents determines the urban areas (Dijkstra &Poelman, 2014).

Subsequently, the second criterion is a mix of population and density decision rules. According to that criterion, a municipal unit is characterized as urban if (i) its population is between 10,000-50,000 and the density of its major local municipal community is at least 300 inh/km2 (European Union 2019) or (ii) at least 75% of its population is urban and the density of the major local municipal community is at least 150 inh/km2 (Dijkstra &Poelman, 2014).

The last criterion for the delimitation of the urban space regards the distance. In the case of Attica and Thessaloniki, the municipal units in a distance less than 25 kilometers from the region' centers are considered urban. With regard to the municipal units except for Attica and Thessaloniki, the corresponding distance is set at 15 kilometers.

Table 1:- Procedure and criteria of urban areas' delimitation.

Criterion 1	**Population**						
Spatiallevel: municipalunit							
count:1036							
Municipal units from Attica and Thessaloniki urban complexes							
OR							
Municipal units (except Attica and Thessaloniki) with a population > 50,000							
Criterion 2	**Population and Density**						
Spatial level: municipal unit, local municipal community							
count:1036							
10,000 < Municipal units' population < 50,000 AND density of major local municipal community > 300							
OR							
Population urbanity of municipal unit = > 75% AND density of major local municipal community > 150							
Criterion 3	**Distance**						
Spatiallevel: municipalunit							
count:759							
Attica and Thessaloniki: distance from prefecture's center < 25km							
OR							
Municipal units except for Attica and Thessaloniki: distance from prefecture's center < 15km							

Phase 2: Delimitation of Vulnerable Rural Areas

According to OECD (OECD, 2018), the population living in remote areas needs to travel at least 60 minutes of distance to access services. The corresponding travel time proposed by the EU is 45 minutes' drive to the center of the major city (Dijkstra &Poelman, 2008). In the present research, based on a quantitative interpretation of the importance of trav-eling for two hours to meet the basic services, it is considered that 45 minutes is a rea-sonable daily commuting time to identify remoteness.

Table 2:- Criteria of vulnerable rural areas' delimitation.

Criteria	Description
1	Density of municipal unit < 25 inh/km^2
2	Population of bigger settlement < 500 inhabitants
3	Mountainous area > 2/3 total area of a municipal unit
4	Travel time from prefecture's center > 45 minutes

Thus, within the rural space - as previously delimited - the municipalities meeting at least two of these four criteria are considered as the most vulnerable rural areas, due not only to the small size of the municipal units (small density and/or bigger settlement < 500 inhabitants) but also to the objective lack of geographical proximity to services essen-tial to daily life (especially travel time).

Data and variables

i) Urban network in rural areas

Rural networking has been widely recognized and adopted as a key tool for support-ing and promoting sustainable rural development (Murdoch, 2000). The main added val-ue of networking is finding solutions to problems faced by rural areas, through the ex-change of knowledge and information, as well as encouraging dialogue between stake-holders (Zhou & Hou, 2021). To highlight the role of the urban network in rural areas three variables were considered: the size of the Regional Administrative center and, (iii) small-town services (Meador, 2019).

ii) Geographical Remoteness / accessibility

Accessibility could be defined as the degree to which a location is accessed from other locations in a geographical area and is closely related to the concepts of movement and distance. In natural and man-made environments, the

locations are not the same and have different characteristics (accessibility, density). This leads to the development of in-equalities between the geographical areas. Accessibility can be measured in units of time (hours or minutes), distance (meters or kilometers), and cost (money fuel or working hours). Based on that, distance from the nearest small-town services was used to deter-mine accessibility. The geographical distance between the municipal units and the center of the region negatively affects the operation of the municipality (Niskanen, 1975). Variable of distance from the nearest small–town services reflect the accessibility and proximity to basic services and stores in where locals can capture their basic needs. This contributes to a better assessment of geomorphological disadvantages of the region (Duquenne&. Kaklamani, 2010).

iii) Permanent natural handicaps

Rural areas suffering from permanent natural handicaps and have overall found it very difficult to keep their populations. The absence of a critical mass generally leads to qualitative or quantitative public service shortcomings in these areas. The additional costs of basic services, such as transport, have affected the economic development of these regions. To understand better the role of the permanent natural handicaps in the develop-ment of rural areas four variables were taken into account: (i) insularity, (ii) percentage of the mountain area, (iii) and (iv) weighted altitude.

Insularity is a distinct variable ("yes/no") and indicates the existence of physical lim-its to mobility, as well as a different difficulty of access by sea depending on the season. Insularity, in relation to the coastline and the size of the island, lays possible the estima-tion of both probability and ratio of any mobility, within the island (Duquenne&Kaklamani, 2010; Duquenne&Kaklamani, 2014; Karampela& al, 2014; Kolodny, 1974; Spilanis& al, 2006; Taglioni, 2006). The mountainous area is not defined solely on the basis of geomorphological criteria. The "mountainousness" of an area gives it a number of other characteristics (eg environmental, social, anthropological, economic) that should be taken into account in the analysis of productive structures and spatial inequalities. The mountainous area is also defined as the area in which the mountainous soil completely prevails, ie the soil that due to its irregular configuration is on the one hand reduced fertility and generally unsuitable to accept extensive agricultural crops and, on the other hand, extremely sensitive to human and erosion, resulting in both its qualitative deterioration and its total disuse, as well as causing damage and destruction to more distant lowland crops, facilities, and technical works. They show significant problems of accessibility and spatial discontinuity from the rest of the country and from its development process. The mountainous areas are characterized by a peculiar geomorphological environment that significantly affects the conditions of their economic and social development. These areas, once active hotspots, have faced problems of demographic desolation and economic de-cline in recent decades. Inaccessible mountains are now exposed, to a greater or lesser ex-tent, to the mechanisms of marginalization, and the solution to the problem lies in sup-porting sustainable development by introducing and maintaining economic activities that align with society's expectations. This index reflects the percentage of the surface of the municipality, which is located in mountain areas. Specifically, the index highlights the dispersion of the population and the possible existence of mobility within the municipality. Today, the development of means of transport and the upgrade of infrastructure, have contributed positively to the enhancement of mobility in the area. According to this respect, the calculation of the two types of surfaces leads to the record of mobility (Duquenne&Kaklamani, 2010).

As for the variable altitude, as a geomorphological feature is a natural obstacle to any form of mobility. The weighting of the altitude by the size of the population living in the municipality reflects not only the initial difficulty but also the human action to address this obstacle. The altitude of the surface lay feasible the investigation of the difficulty of mobility regarding its "spatial dimension". This indicator expresses in a way the difficulty of access in some municipalities, and/or that of movement within the territorial unit itself (Duquenne&Kaklamani, 2010).

iv) Natural and cultural amenities

Littoral municipal unit is a discrete "yes/no" variable allowing to stipulate the mu-nicipality's access to the sea, which possibly facilitates mobility. In the case of Greece, by studying the coastal character type, we refer to the development of tourism activities, which ultimately causes inflows into the local labor market. Also, tourism upgrades the quality of the road network. Consequently, both accessibility and mobility are facilitated (Doumenge, 1965; Duquenne&Kaklamani, 2010).

v) Basic infrastructures

By exploring the basic infrastructures at the municipal unit level, it is possible to capture the local service response in the basic needs, as they contribute to the wellbeing of the local population (Poirot &Gérardin, 2010).

The "Primary school" and "Secondary school" variables show remarkable evidence for a critical inquiry into equal opportunities or inequalities in Greek education. Finally, the presence of the Citizens' Service Center (CSC) is the last variable to be included in the basic infrastructures. CSCs are administrative units that conclude contracts with services such as the Agricultural Insurance Organization, the Hellenic Post, the Public Electricity Company, and the Hellenic Telecommunications Organization to serve the citizens in all their transactions with the state, especially in remote areas. Through the CSCs, people can be informed about all Public Administration issues and forward to cases that are related to public bodies. This serves to avoid time-consuming bureaucratic procedures and mainly reduces the movement of citizens-traders to a single location ("one-stop shop").

In Greece, there is no national record for the basic infrastructures, especially at the local level. A systematic search for data at the Regional Directorates of Primary and Sec-ondary Education, Regional Health Authorities, and Ministry of Digital Governance was required.

vi) Land use

Land use is defined as the use of existing resources (such as agriculture, mining, and logging) by humans(Meyer, 1995). Agriculture is a major source of livelihood and food to a large extent, especially in remote areas. Investing in land creates local jobs and strength-ens communities creating prospects for sustainability. "Percentage of cultivated land" is the variable that reflects the distribution of agricultural areas in each municipal unit as a percentage of the total area of the municipal unit. The spatial distribution of the rate is an indication of the magnitude of the dynamism of the primary sector in the Greek municipal units.

Table 3:- Variables included in the analysis.

Variables	Calculation
Percentage of coastalarea	$\text{Coastal area}_i / \text{Total Area}_i$
Percentage of mountainarea	$\text{Mountain area}_i / \text{Total Area}_i$
Weightedaltitude	$\text{Area}_i * \sum_i \text{altitude} / \text{Total Area}_i$
Littoralmunicipalunit	Discretevariable (1 = Yes, 2 = No)
Insularity	Discretevariable (1 = Yes, 2 = No)
Forestarea	$\text{Forest area}_i / \text{Total Area}_i$
Residentpopulation 2011	Count
Secondaryschool	Discretevariable (1 = Yes, 2 = No)
Presence of Health Center	Discretevariable (1 = Yes, 2 = No)
Primaryschool	Discretevariable (1 = Yes, 2 = No)
Presence of Citizens' Service Center (CSC)	Discretevariable (1 = Yes, 2 = No)
Size of the Regional administrative center	
Percentage of cultivatedland	$\text{Cultivated land}_i / \text{Total Area}_i$
Distance (km) from the nearest small-town services	The minimum distance between the municipal unit center and the regional small towns

$*(i)$ = municipal unit

2.3. Statistical and Spatial Methods

To detect the vulnerability gradients, exploratory factor analysis was conducted in order to reduce the volume of the initial variables (Table 3) to a limited number of composite and more comprehensive indexes. Factor extraction was done implementing the principal components analysis method (PCA) and the rotation method applied was Varimax with Kaiser normalization. PCA does not presuppose the existence of a well-known correlation model between the initial variables (Brown, 2009). The initial con-ditions for performing factor analysis are verified: the number of

observations greater than 250 is considered as "satisfactory" (Cattell, 1978; Comrey and Lee, 1992) while the ratio of initial variables to the total observations is obviously greater than 10, so very adequate (264 observations, 14 initial variables) (Everitt, 1975; Nunnally, 1978).

Having defined the vulnerability gradients, the methodology utilized agglomerative hierarchical analysis to detect spatial patterns of vulnerability in the Greek rural space. The hierarchical cluster analysis method chosen is Ward's method that reduces the sort of variance in clusters, and the metric distance used is the squared Euclidean distance. Finally, through exploratory analysis, the vulnerable municipal units' profiles were created.

To visualize both the process of vulnerable areas' delimitation and the spatial patterns that emerged, geographical information systems (GIS) and thematic cartography were used.

Results:-

The procedure of urban areas delimitation, as above described, conduced to characterize 278 municipal units from a total of 1038 as urban, covering around 70% of the national population. As regards the rural space of Greece, it covers most of the total surface (80%) but represents just 30% of the population. This well-known unequal distribution of the population is the result of a vast and continuous rural exodus during several decades until the beginning of 1990. If the rural exodus has sharply slowed down during the last two decades, some rural areas even present a clear attractiveness, others however continue to be depopulated.

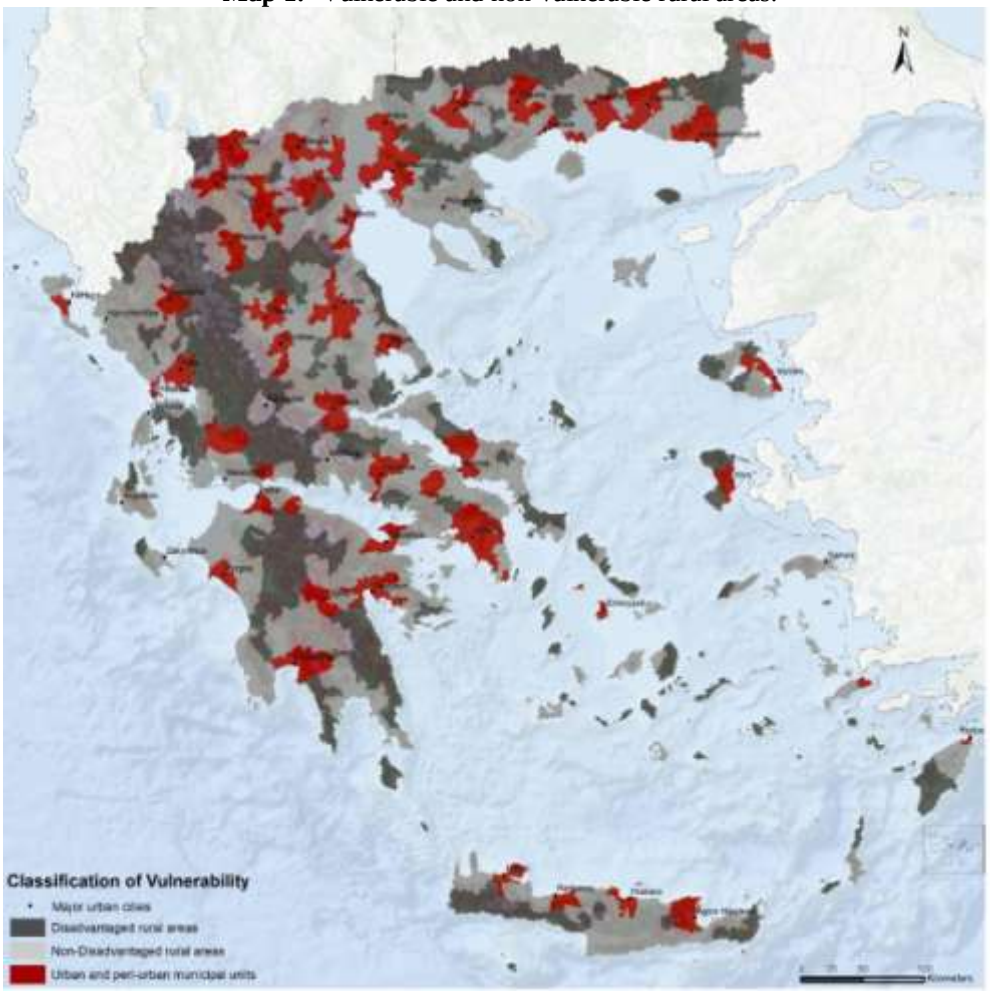
3.1. Classification of Vulnerability

Among the 759 rural municipal units, a third of them (264) can be considered as vulnerable in terms of risk as regards the continuation of the depopulation process: be-tween 2001 and 2011, the population loss exceeded 10% against just 3.5% for the non-vulnerable units. In 2011, these 264 vulnerable units account for 16% of the rural population and 5% of the total population (Table 4). While most of them are in mountain areas, especially the Pindos Mountain chain, some others concern border areas in the north of the country as well as very small islands in the Aegean Sea (Map 1).

Table 4:- Vulnerable and non-vulnerable rural areas statistics.

Typology	Population		%	Area	%	Density
	2001	2011				
Greece	10,937,646	10,816,286	100%	132,029	100%	81.9
Urban	7,620,014	7,650,460	71%	22,379	17%	341.9
Rural	**3,317,632**	**3,165,826**	**29%**	**109,650**	**83%**	**28.9**
Non vulnerableareas	2,744,912	2,650,454	25%	67,364	51%	39.3
Vulnerableareas	**572,720**	**515,372**	**5%**	**42,286**	**32%**	**12.2**

Map 1:- Vulnerable and non-vulnerable rural areas.



3.2. Vulnerability gradients

The implementation of PCA analysis indicated five principal components address-ing vulnerability gradients. The KMO criterion justified the suitability of data as they in-dicate high consistency (KMO = .785) while each one of the 14 initial variables showed significant communalities (>0.4), justifying its contribution to the final model. The volume of the initial variables was reduced at 71% (14 initial variables shaped four principal components), interpreting 69% of the total variability. In terms of decreasing importance, physical geography, social services and infrastructure, agricultural land use, and remote-ness are the main components shaping vulnerability gradients (Table 5).

Table 5:- Vulnerability gradients.

	H^2 (a)	Physicalgeography	Social services and infrastructure	Agricultural Land Use	Remoteness
Percentage of coastalarea	0.865	0.890			
Percentage of mountainarea	0.811	-0.868			
Weightedaltitude	0.857	-0.868			
Littoralmunicipalunit	0.835	0.867			
insularity	0.73	0.710			

	1				
Forestarea	0.507	-0.615			
Residentpopulation 2011	0.692		0.706		
Secondaryschool	0.624		0.695		
Presence of Health Center	0.502		0.674		
Primaryschool	0.562		0.661		
Presence of Citizens' Service Center (CSC)	0.452		0.654		
Size of the Regional administrative center	0.681			0.787	
Percentage of cultivatedland	0.730			0.632	-0.497
Distance (km) from the nearest small-town services	0.811				0.882
Totalvarianceexplained (%)	69.0	34.7	18.4	8.7	7.2
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a] a. Rotation converged in 7 iterations.					

The first principal component (PC1) elucidated 34.7% of the total variance encom-pass a significant level of negative loading of the effects of physical geographic handicaps regarding mountainous areas (- .902), and altitude (- .885); and moderate negative loading of forests and another wooded land (- .648). The littoral (.793) and/or insular (.724) char-acter of the municipal units ultimately affect positively this composite index.

The 2nd component (18.4% of the total variance) reflects the presence of social ser-vices and infrastructure and consequently, the "capacity" for the municipal units to cover vital services for the local population, especially health, education, and alsoadministra-tive local services.

The 3rd component (8.7% of the total variance) highlights to which extent agricul-tural activities are maintained thanks to relative proximity to the regional urban center and therefore to opportunities to sell agricultural products.

Finally, the last component (7.2%) indicates the degree of remoteness of the munici-pal units combined with the abandonment of agricultural activities, a traditional pillar of the local economic system.

3.3. Spatial patterns of Vulnerability

Based on the above four composite indexes, the hierarchical classification allows us to distinguish five (5) patterns of vulnerability. It is also important to mention that the im-plementation of discriminant analysis confirms the goodness-of-fit of this classification: the percent of well classified municipalities is very pertinent (95%).

Table 6:- Spatial patterns of vulnerability.

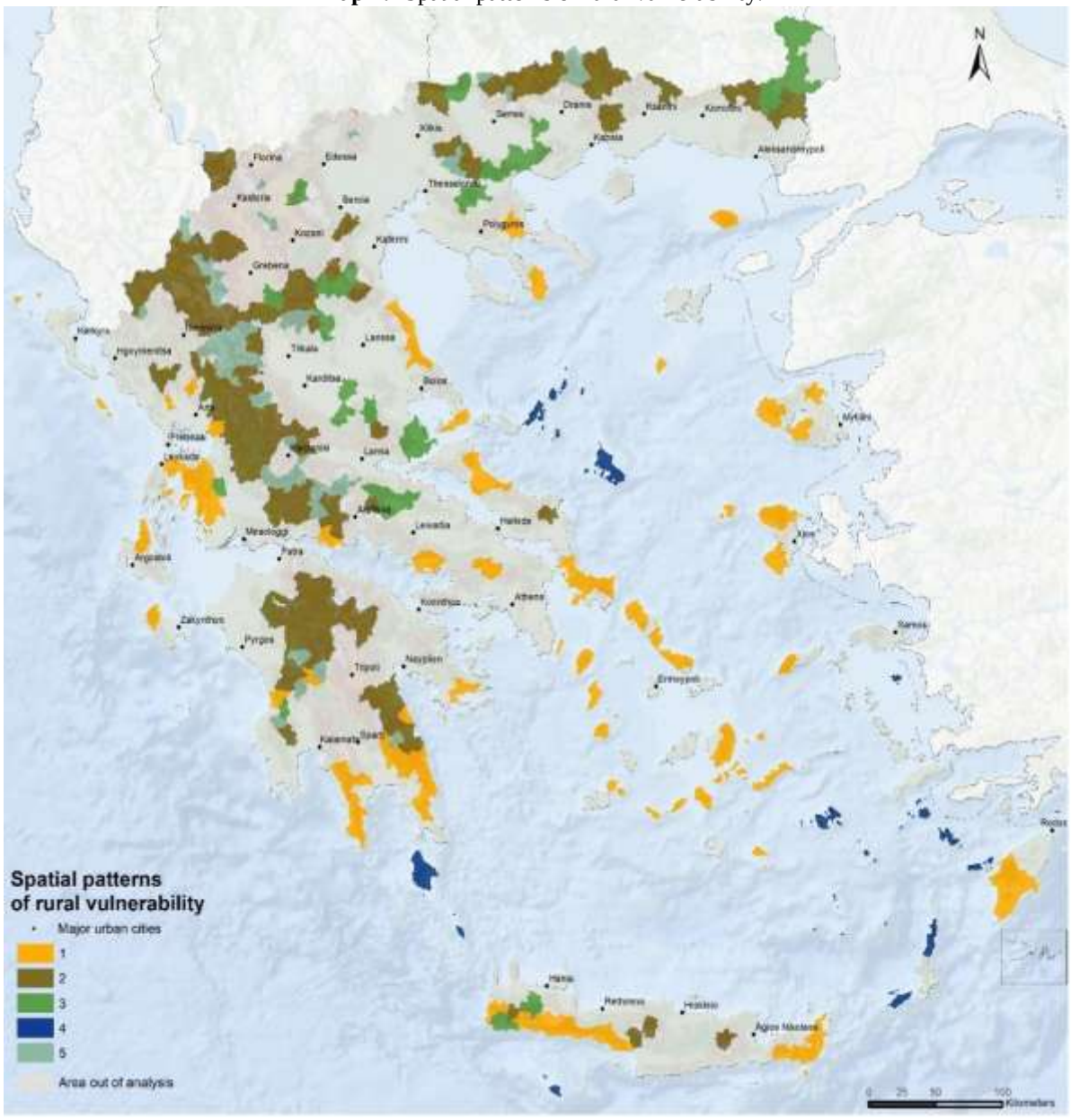
Patterns	Number	Physicalgeography	Social services and infrastructure	Agricultural areas	Remotness	Coastal	Island
1	82	1,044	0,046	-0,593	-0,267	91%	50%
2	98	-0,823	0,560	-0,005	0,280	2%	0%
3	30	0,436	0,108	1,744	-1,077	17%	0%

4	12	1,460	0,045	0,891	2,872	100%	100%
5	42	-0,847	-1,486	-0,332	-0,184	0%	0%

Table 7:- Main characteristics associated with the patterns of vulnerability.

1	Littoral municipalities, with limited remoteness degree but intense depopulation tendency
2	Municipalities in mountain areas (weighted altitude > 750m) with basic services and depopulation tendency
3	Relative proximity to the local service center with retention of agricultural activities even if the municipalities are confronted with population loss. These municipalities are located in the Greek Regions with important urban agglomeration (as Thessaloniki, Larisa, Volos).
4	Island municipalities with an extremely high level of remoteness without depopulation trend due to positive migration flows.
5	Municipalities in mountain areas (weighted altitude > 750) without depopulation trend due to important migration flows that compensate the very negative natural balance due to very low fertility level.

Map 2:- Spatial patterns of rural vulnerability.



Discussion and Conclusions:-

The present research focused on evaluating the vulnerability of each type of rural municipal unit to detect the most problematic ones, through a mixture of criteria and analyses. The main purpose was to formulate a contemporary, attractive and realistic framework of vulnerability gradients and then depict spatial patterns of vulnerability for the integrated development of isolated areas. This plan of action aims to improve the prospects of local communities, inspire and guide local development plans, with the aim of achieving a vital priority: developing specific policies for the integrated development of disadvantaged rural areas.

Vulnerable areas do not just refer to interior areas of rural space but vary substantially regarding remoteness, isolation, community challenges, lack of human capital, eco-nomic opportunities, and access to basic life needs and amenities. The results show significant differences in terms of geomorphology, availability of medical and social services, physical distance, and land uses. From the classification of rural vulnerable areas emerged five spatial patterns of vulnerability that reflect the regions' identity and incorporate a combination of variables concluding in the differentiation of the vulnerability. Vulnerability changes shape and form based on the identity of the municipal units.

The contribution of this article is the knowledge derived on the profiles of the vulnerable rural areas in Greece and provides insight for future analysis and consideration from interested parties by shaping a fruitful background for the emerging need of smart services integration.

Vulnerable areas are potential hubs of innovation (Manika, 2020a), (Manika, 2020b). Addressing remote areas' challenges bears opportunities for well-being and inclusion. Local stakeholders' engagement and the proximity of local actors in approaching local problems is the key to supporting population inclusion and addressing human geography challenges (Anastasiou et al., 2021).

The present typology presented the spatial patterns of the vulnerable rural areas in Greece featuring a holistic approach concerning the basic pillars of the needs of local populations. Opposed to other countries' rural typologies (European Commission, 2021) the present research did not address demographic indicators. The data limitations force the analysis to use the last population's census data (2011) implying de facto demographic changes in the interval. The next major update will be based on the 2021 Census results. The strength of the current analysis and proposed typology depends on the data quality and availability.

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