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EXPLORING THE IMPACT OF NETWORK CONFIGURATION AND TRANSPORT ACCESSIBILITY ON POPULATION DYNAMICS. THE CASE OF NAXOS ISLAND, GREECE

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Abstract

Transport is one of the most important factors which influence and largely determine an urban society's spatial relations and interactions. Urban societies as socio-spatial systems are typically formed out of densely populated, well developed, productive and prosperous central areas and smaller settlements usually depended from one or more of the closest of the former. In terms of development and growth dynamics, road network lines are the basic arteries for the flow of people, economic resources and goods as well as information among places delineating to a large extent, the arrangement of transport relations and thus monocentric or polycentric organization of spatial systems. To this end, transport network quality and connectivity can generate a competitive advantage for specific locations/nodes i.e. settlements of the system. In this paper we utilize the space syntax method in order to explore the impact of transport network configuration and structure on population growth. We apply our methodology in order to describe, analyze and evaluate population dynamics of the settlements of Naxos Island, Greece for which their direct and significant correlation with accessibility is demonstrated.

Keywords: *space syntax, road network, network accessibility, population dynamics, geostatistics*

1. INTRODUCTION

Road network analysis of extensive geographical regions has been used in previous research to identify the key structural characteristics of large cities and regions (Porta, et al., 2012; Wang, et al., 2011; Serra & Hillier, 2019; Berghauser Pont, et al., 2019a; Berghauser Pont, et al., 2019b). These studies have established a strong correlation between various variables such as vehicular movement, land use distribution, centre hierarchies with various measures of spatial network analysis, such as space syntax 'Choice' (or betweenness in graph network analysis) and 'Integration' (or closeness in graph network analysis). Urban and rural space present hierarchical structures which are observed as administrative regional delimitations resulted from special geographical, political and historical processes. These spatial boundaries influence infrastructure such as the street network which is of the basic means of communication and exchange between settlements (Tsompanoglou and Photis, 2013; Arcaute et al, 2016). Usually, large villages, towns and cities function as central places for their peripheral areas. These places are the poles of accumulation and promotion of all kind of economic activities (tertiary services, manufacturing, etc) as well as the channels of ideas and information flow for a wider region.

Many Space Syntax studies have been carried out in order to provide more information concerning social function of public spaces and propose possible ways of improving their accessibility (Önder and Gigi 2010; Khan, 2014; Paraskevopoulos & Photis, 2020). Specifically, pedestrian accessibility of public spaces in cities has been extensively investigated by relevant studies based on space syntax (Talavera, 2012; Koohsari et al. 2013a; Koohsari et al. 2013b) However, far less investigated is the impact of road network configuration on the population dynamics of a regional area over time.

The objective of this paper is to explore the relation between population dynamics and network accessibility as measured by space syntax analysis especially for an island region heavily influenced by the structural configuration and complexity of its road network.

2. BACKGROUND

2.1 Regional development and road network accessibility

From a geographical point of view, the way in which human habitat is organised in space, all around the globe, forms out what we call regional hierarchy. Urban and rural systems (and more generally, human settlement systems) can be described as the hierarchical organisation of human activities which in geographical scale consist of: the elementary units (housing units, public buildings, transportation networks etc.), the settlement as a whole, the sum of the settlements that constitute a system belonging to a given territory (Pumain, 2006).

Transport is one of the most important factors that influence and form spatial relations and spatial interactions in society, thus, road network defines along with other factors the role of a region in a wider area and also predetermine monocentric or polycentric organization of spatial systems (Schmitt, 2010). Transportation network is the artery for the transit of economic resources and goods from the more prosperous places to the areas of deficiency. The efficiency of the road network represents an effective transportation system that plays significant role in the development of a region by determining the investments opportunities in economic sectors. Thus, various entities of transportation, like national highways and railways, village roads and forest roads, are taken into account to workout the regional hierarchical set up. Undoubtedly, street network configuration is an elemental part of urban form. At the same time this component is the largest spatial pattern of cities; where all the movement flows are realized through it. Therefore, its configurational characteristics are shaping street accessibility which make possible to measure the spatial segregation through space syntax (Legeby, 2010; Vaughan, 2007; Vaughan, 2005).

In terms of regional development, the quality of road network infrastructure, such as level of service, connectivity, travel time etc., determines the role of each location in the spatial system, since the accessibility that is derived by the configuration of road network ultimately generates a competitive advantage for some locations/nodes in the settlements' network. Accessibility is generally used to describe the location of an area – an administrative unit or a randomly selected area - with respect to opportunities, activities or assets existing in other areas and in the area itself. The degree of access to a location is often seen as an important determinant of its socio-economic activities (Willigers et al., 2007).

In theory, the transportation network defines the different levels of accessibility, in other words the locational advantage or disadvantage among the nodes-regions that further determines their potential for development (Wang et al, 2015). Many previous studies regarding spatial development have demonstrated that factors such as location and road network are of considerable importance in urban growth and sustainable development (Liu et al., 2005; Feng et al, 2014; Dalal et al, 2011). These studies show that the spatial linkage among cities and settlements can be quantitatively computed by analysing their location and connectivity of road network. Distance from core areas and spatial interaction is instrumental in characterizing the location of an area. According Wu (Wu et al., 2013) regional central cities tend to influence and promote the development of cities around them. Sohn (2012) also claims that the distance to regional core city has direct impact on the population growth of surrounding cities (Sohn, 2012). Spatial interaction intensity, measures the radiation effect of core city to other cities (Guan et al., 2014).

Therefore, nowadays, though phenomena like urban sprawl and decentralization occur along with the formation of multi-center areas (polycentricity) development in the peripheral regions often lags behind the center. As shown by numerous studies, the lowest accessibility is usually recorded in the less developed and most remote regions, which are mainly mountain regions and deserts. This fact underlines that peripheral regions are still detached and marginalized despite the expansion and improvement of road network (Vickerman, 1995). At the same time, the areas with high accessibility correspond with the areas constituted of densely populated regions and are characterized by a well-developed economy.

According to the research “Accessibility and Spatial Development in Europe” by Spiekermann and Wegener (Spiekermann et al, 2006) the results confirm that in general the more accessible regions are more prosperous. The most prosperous and productive regions, such as Munich, Frankfurt, Paris and Düsseldorf are also most central, i.e. most accessible while remote areas with poor accessibility are among the poorest regions. In addition, it should be noted that in countries with small NUTS-3 territories, such as Germany, GDP per capita does not reflect the transfer of income from the central areas to the suburbs via commuting. What is more, it has to be noticed that in countries with small NUTS-3 territories such as Germany the GDP per capita figures in these regions are not reflecting the income transfer from the centre to the suburban regions via commuting.

Spatial morphology (urban morphology and street network configuration) is fundamental in shaping the form of a city or of a whole area consisted of cities and settlements(Bartzokas-Tsiompras & Photis, 2017). Especially, streets are the dominant elements that shape the framework and the core of human settlements, by enclosing the various human activities within them. Peponis, et al (2007) assess the mutual relation between ‘street connectivity’ and density in urban environment through a spatial perspective. According to them, the degree of street connectivity could fundamentally affect the characteristics of human environment and facilitate or impede people movement, population density, and land use. Higher connectivity in street pattern attract more users by offering more accessibility, choices and opportunities for them (Long et al, 2007; Bartzokas-Tsiompras & Photis, 2019). Road network connects spatial units within a wider spatial entity into an organic whole, and space syntax model reveals the connectivity of it. Road network is playing an increasingly important role in the process of urban sprawl (Li et al., 2014; Iacono et al., 2016).

2.2 Network Centrality and Space Syntax Analysis

Space syntax is a form-function theory that studies cities and human settlements in general, by quantifying the geometry and topology of street network in order to predict the human activity in space. Since it was first introduced by Hillier, and their colleagues (Hillier & Hanson, 1984; Hillier, et al., 1987), space syntax research has produced a series of analyses, measures and tools to this end (Karimi, 2018; Jiang, Claramunt & Klarqvist, 2000). One of the most widely used measure is angular integration, due to its power in predicting human movement especially when constrained by metric radius (Turner, 2001; Hillier, et al., 2007). Angular integration (also known as angular closeness centrality in the network science literature) demonstrates the angular "shallowness" between segments (Hillier and Iida 2005; Hillier et al., 2012; Shen & Karimi 2017) and quantifies the "to-movement" potential of a place, meaning the ability of the network to facilitate movement as a destination (Charalambous & Mavridou, 2012). In other words, it measures the network-driven accessibility of a place, within a whole system or a specified radius.

Another crucial component of space syntax analysis is its ability to implement radii that correspond with different spatial and ultimately functional scales. Low metric radii correspond well with local (pedestrian) movement while high metric radii represent longer distances and therefore vehicular movement (Al_Sayed, et al., 2014) and highlights the main routes through and between settlements (Nes, et al., 2012).

Space syntax analysis has been always somewhat focused on the effect of network accessibility on human behaviour and economic development and has built on the idea that spatial configuration is at the epicentre of the mechanism that supports 'spontaneous' and 'organic' urban evolution (Hillier, 2003; Porta, et al., 2009). This mechanism is termed by Hillier (2003) as "city creating process", is based on the principles of "natural movement" (Hillier, et al., 1993) and "movement economy" (Hillier, 1996/2007) and suggests that cities can be approached as self-organising spatial systems that evolve from collections of buildings to vibrant cities through the interaction of spatial configuration, human movement and land-use distribution. Accordingly, there is extensive literature which highlight the strong correlation among space syntax analysis, human movement and economic activities (e.g. Hillier, 1999; Porta, et al., 2009; 2012; Scoppa & Peponis, 2015; Serra & Hillier, 2019). However, the vast majority of space syntax research has been focused in urban settings, since there were significant methodological and processing obstacles in performing space syntax analysis in regional scale. Having said that, recent developments in space syntax practice take advantage of road-centre-line maps which are greatly available ready-made GIS maps and allow for large-scale regional analysis (Stavroulaki, et al., 2017; Kolovou, et al., 2017) and this is the objective of our paper. Specifically, we set to perform large scale space syntax analysis in a regional insular area, in order to assess the role of road network accessibility as conceptualised by space syntax literature, on its population dynamics, a proxy for economic strength, since road network accessibility has been singled out as a crucial factor regarding regional development (Kotavaara, et al., 2011; Tschopp et al., 2005).

3. METHODS AND METHODOLOGY

The objective of this research is to quantify the impact of network configuration, specifically the accessibility of the main road network, on population dynamics in a regional, insular area. To this end, space syntax analysis was used and in particular angular integration measure with high metric radius (20-km) was employed for the estimation of this relation. The selected high metric radius is considered to be strongly correlated with vehicular movement and also represents the distance between the two most populous settlements of the study areas (Naxos City and Filoti).

In order to explore the role of network accessibility in shaping population dynamics, the correlation and cross-tabulation analysis between angular integration and population in different years are utilised. A straightforward three-step methodology is proposed to this end.

The first step is to calculate the angular integration (20-km) of the main road network as a proxy to network accessibility. The next step is to transform the line-measured network accessibility and the point-measured settlements' population into the same unit of analysis. To this end, Kernel Density Estimation (KDE) is utilised and density maps of Network Accessibility and Population are created. The final step, for preparing our data for correlation is to define the populated zones of the study area, because in such regional areas there are territories of the island that are not inhabited. Since the boundaries of the settlements were not available, a buffer zone of 5 kilometres around settlements is designated as the inhabited zones where the correlation and cross-tabulation are implemented.

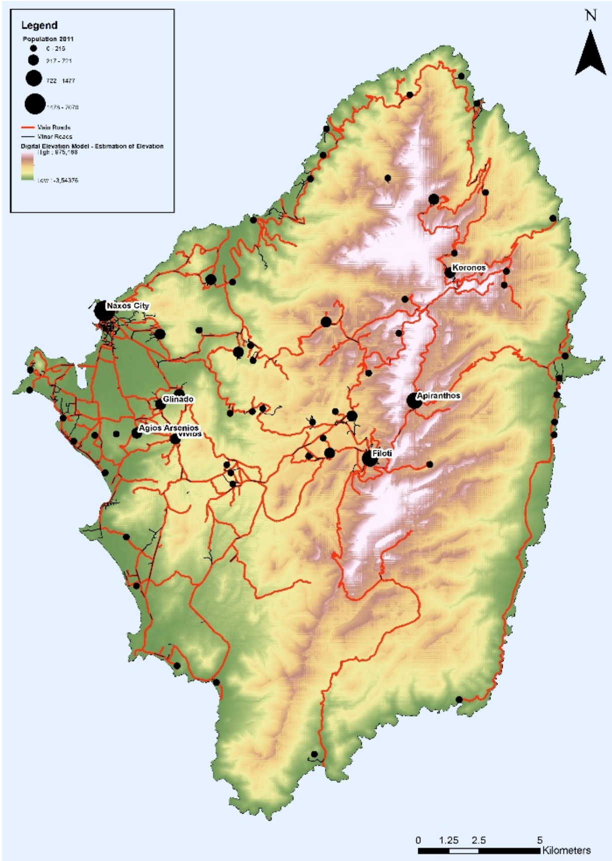
The kernel density estimation (KDE) method is used to transform both network accessibility and population density values to a common scale (i.e., a grid system) in which the relationship between them can be determined. For the data transformations of different analysis units spatial smoothing or spatial interpolation techniques are used. In this research the KDE method is chosen. The KDE estimates the density within a range (window) in order to find the representative value in the center of the window. Within the window, the KDE weighs nearby objects more than far ones based on a kernel function (e.g., Fotheringham et al., 2000, pp. 146–149; O'Sullivan & Unwin, 2003, pp. 85–87). The KDE generates a density of the events (discrete points) as a continuous field (e.g., raster). In fact, it uses the density (or average of features) of nearby objects to determine the status in the middle location, the KDE records the very essence of the location: it is not the place itself but the environment that makes it stand out and explains the setting of (Wang, et al., 2011).

4. ANALYSIS / RESULTS AND DISCUSSION

4.1 Study area – Data Sources

Naxos is a Greek island in the South Aegean and also the largest one of the Cyclades island group (Map 1). The capital of the island is Naxos city while some of the most important settlements are Filoti, Apiranthos, Vivlos, Agios Arsenios, Koronos and Glinado. Over the last decade, the population of the city of Naxos increased by about 8%. In particular, by 6533 inhabitants in 2001 it reached 7070 inhabitants in 2011, while the total population growth over the last 40 years increased by 89% reaching today about 18000 inhabitants. The largest settlements of the island are Filoti (1477 inhabitants), Apiranthos (722 inhabitants) and Agios Arsenios (717 inhabitants). The road network is denser on the western side of the island, and more specifically in the area that spreads around the city of Naxos, while increasing the altitude, in the centre and in the eastern part of Naxos, it is fairly arid and, in many parts, it appears completely detached.

The data used in the present study is the Naxos main road network as well as the population records for the last 40 years. Road network dataset was acquired by the OpenStreetMap database and the population data derived from the Hellenic Statistical Authority.



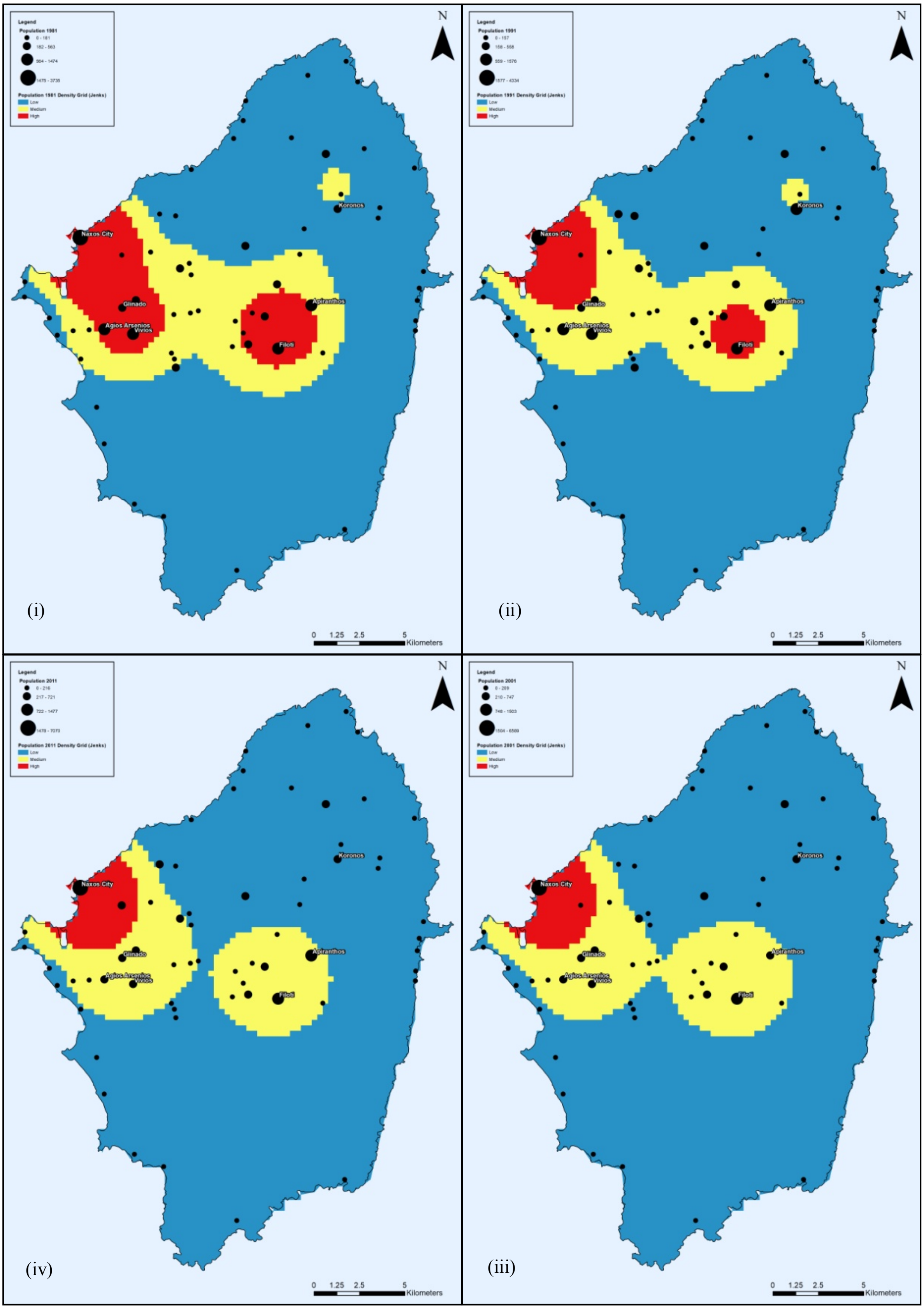
Map 1: Study area - Naxos Island

4.2. Population & Population Evolution (1981 – 2011)

As mentioned in the previous chapter, population dynamics can be used as proxies of economic development and strength of regional areas and the population density, one of the most robust metrics of population geography, is employed to this end. In our research we used Kernel Estimation Density method (KDE) with a radius of 5 km, that was considered the most appropriate for our case, to calculate the population density of Naxos for the years 1981, 1991, 2001, 2011 (population census). The results are analyzed and discussed in this chapter and accordingly presented in the following maps 2 (i-iv).

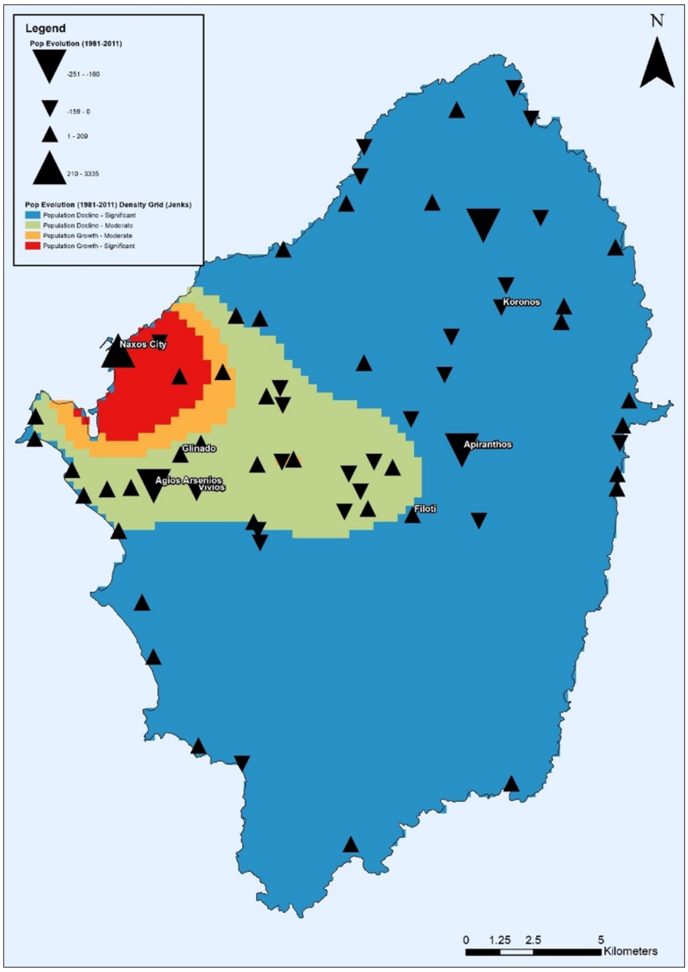
In Map 2 (i-iv) we can notice the formation of some high-density population cores as well as their change over the last 40 years in the island of Naxos. According to Map 2 (i), three high population density centres appeared in 1981. One of these areas is spreading around the city of Naxos and includes large population settlements such as the Agios Arsenios and the Vivlos settlements while a second sub-central region surrounds the mountainous communities of Filoti and Apiranthos. We can also distinguish the presence of a third population centre on the north of the island around the settlement of Koronos.

Map 2 (ii) illustrates the domination of the above central areas also in 1991, though with a decrease of density for some settlements and a shrinkage of the former central regions/cores (red color) of 1981. In the years of 2001 and 2011, we see a greater reduction in the size of these regions, as presented in Map 2 (iii, iv). In fact, the area that surrounds the city of Naxos retains high rates of population and influences many settlements of its immediate reach. At the same time, the central region of Koronos has disappeared while the former central region, outlined by Apiranthos and Filoti, has declined.



Map 2: Clockwise and from left to right - Population 1981; Population 1991; Population 2001; Population 2011

Map 3 depicts the evolution of population during this 40-years period (1981-2011). The downward triangles illustrate negative population evolution, or population decrease, while the upward triangles illustrate positive population evolution or population growth. As expected, the "*picture*" formed in Map 3 is in agreement with the population evolution depicted by Map 2 (i-iv). As is apparent, Naxos city and its immediate surroundings are the only areas exhibiting population growth (significant or moderate) during this 40-years period, while the rest areas seem to decline in population in a moderate or significant degree. It is tellingly, that the settlements displaying moderate population decline is located in somewhat proximity with Naxos City. While the settlements with significant decline, that is the vast majority of the island, are located in a substantial distance from Naxos City, mainly in the mountainous areas of the island. In this respect, a distinctive decline of Apiranthos and Koronos settlements over the last 40-year is marked.



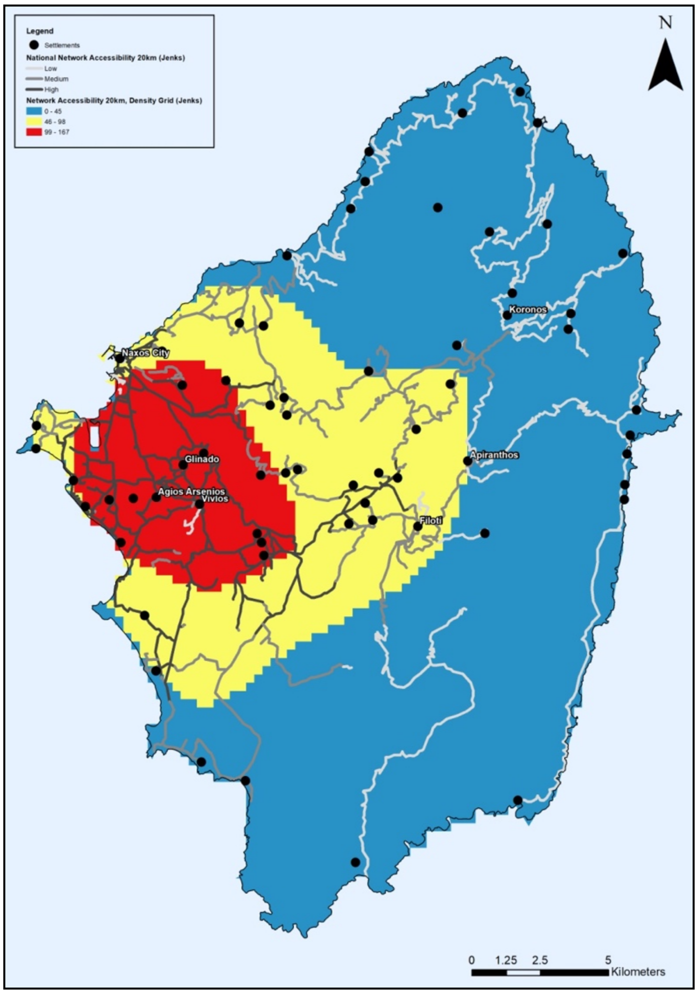
Map 3: Population Evolution 1981 – 2011

The above maps (Map 2 and Map 3), depict the different snapshots of population and pop evolution pop evolution from 1981-2011, respectively

4.3. Road network Accessibility

Network accessibility is one of the most crucial elements affecting the way settlements are evolving through time. As mentioned in the previous chapters the measure of Angular Integration with a 20-km metric radius is used, a measure suitable not only for the scope of our analysis, since it correlates highly with car-related movement, but also for our study area, since the distance between the two most populous settlements of the study area (Naxos City and Filoti) is approximately 20 kilometres.

The result of the space syntax analysis can be seen in Map 4 where main network accessibility and main network accessibility density grid are being presented.



Map 4: Main Road Network Accessibility (Integration 20km)

As it is evident from Map 4 the most integrated part of the study area is located in the west side of the island and is mainly formed out of Glinadon, Agios Arsenios and Vivlos settlements with Naxos city included. The spatial pattern of network accessibility indicates that as we move away from this area, network accessibility decreases, meaning that the density and angular integration of the network are subpar. The eastern side of the island is significantly segregated concerning the road network connectivity. Especially the coastal eastern side of the study area is essentially isolated due to lack limited presence of network as well as its low connectivity.

4.4. Correlation of network accessibility – population

The primary objective of this paper is to investigate the relationship between population distribution and network accessibility and also to determine the role of network configuration in the resiliency of regional agglomerations.

Network configuration as quantified by space syntax has proven to be directly linked to the human presence and can explain the spatiofunctional evolution that occurs in a region. Moreover, space syntax analysis offers a reliable measure of network accessibility in angular integration and could be a useful tool for measuring population dynamics.

This paper explores its ability to predict the population distribution of Naxos Island for four different snapshots (1981, 1991, 2001, and 2011) and its population evolution during this 40-years period. To this end correlation analysis is conducted to determine the direction and degree of association between network accessibility (Angular Integration 20 km) and population dynamics. Spearman's rank correlation coefficient (Spearman's ρ) is selected due to the fact that our data are not normally distributed. Table 1 and Figure 1 depict the Spearman's ρ coefficients between network accessibility density grid (Angular Integration 20 km) and population density grids for the four different snapshots and the corresponding population evolution.

Table 1: Spearman correlation between density grids of Population Dynamics and Main Road Network Accessibility (Integration 20km)

	Main Road Network Accessibility (Integration 20km)
Population 1981	0.702
Population 1991	0.679
Population 2001	0.716
Population 2011	0.734
Population Evolution (1981 – 2011)	0.734

Source: OpenStreetMap; Hellenic Statistical Authority; processed by the authors

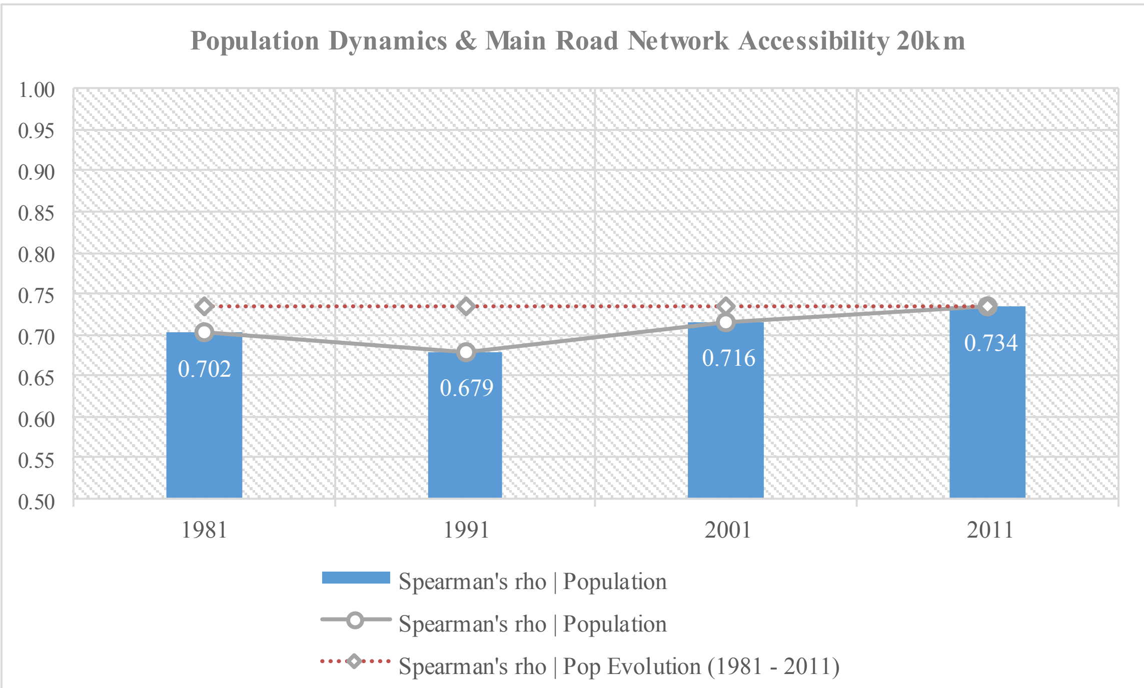


Figure 1: Spearman correlation between density grids of Population Dynamics and Main Road Network Accessibility (Integration 20km)

The results of the correlation analysis underline the strong relationship between network configuration and population since the correlation exceeds 0.7 each year. This means that the spatial distribution of population follows to a great extent the spatial distribution of main network accessibility. The very high correlation between population evolution and accessibility of the main network (p = 0.890) is still pointed out, which is identical, and slightly exceeds, the correlation between the population of 2011 and the accessibility of the main road network. As is also evident from the relevant maps (Map 3 vs. Map 4 and Map 2 (iv) vs. Map 4) the most densely populated and resilient settlements of Naxos are located in locations with high and very high network accessibility.The population centre of Naxos City and the network of settlements formed by Agios Arsenios, Vivlos, Glinadon and Galanadon, belong to this category of highly accessible locations. It is also worth mentioning that the population sub-centre that is being formed around Filoti has substantial accessibility (medium), especially if the network accessibility (integration) of roads is considered, apart from their density, since the roads connecting these settlements are highly integrated. Settlements with small population are typically located in low accessibility areas. Major settlements in the mountainous parts of the Isle, such as Apiranthos, Koronos and Koronis, are found to be in low and very low network accessibility areas due to the low connectivity and low density of the main road network.

One of the most interesting findings of the correlation analysis is how the pattern of population evolution follows the pattern of network accessibility. This means that population dynamics tend to submit to the network accessibility and proves the significance of network configuration in shaping population dynamics.

The following cross-tabs illustrate the behaviour of the population depending on the degree of its main road network accessibility for the four different time periods. In other words, the percentage of areas with low, medium and high population density that are located in low, medium and high network accessibility density areas, respectively. In Table 2 the results for the year 1981 are presented.

Table 2: Cross-Tabulation between density grids of Population 1981 and Main Road Network Accessibility (Integration 20km)

Network Accessibility Density Grid (Quantile)	**Population 1981 Density Grid (Quantile)**		
	Low	***Medium***	***High***
Low	**82.80%**	16.17%	1.04%
Medium	36.45%	**39.77%**	23.79%
High	6.56%	23.59%	**69.84%**

Source: OpenStreetMap; Hellenic Statistical Authority; processed by the authors

Regarding 1981, the agglomerations that are located in the area of influence of low network accessibility in their vast majority (82.80%) are of low population density and almost none of them (1.04%) has high population density. The road network with medium accessibility density has the most random behaviour in the sense that it services settlements with medium (39.77% of the population in areas of medium network accessibility) but also low population density (36.45% of the population in areas of medium network accessibility). Finally, the large proportion of the areas with high population density, practically 70% of them, are found in areas with dense and highly accessible road network. Table 3 shows the results for the year 1991.

Table 3: Cross-Tabulation between density grids of Population 1991 and Main Road Network Accessibility (Integration 20km)

Main Network Accessibility Density Grid (Quantile)	Population 1991 Density Grid (Quantile)		
	Low	*Medium*	*High*
Low	**81.86%**	16.86%	1.29%
Medium	35.68%	**39.95%**	24.38%
High	8.64%	22.59%	**68.78%**

Source: OpenStreetMap; Hellenic Statistical Authority; processed by the authors

In comparison to the corresponding results of 1981, a similar pattern can be observed by the cross tab of 1991. The vast majority of areas with low and high population density (81.86% and 68.78% respectively) are located in low and high network accessibility areas respectively. Whereas, the areas with medium network accessibility density are exhibiting a more irregular behaviour since they consist mainly of areas with medium population density (39.95%) and secondarily of areas with low population density (35.68%). In Table 4 and Source: *OpenStreetMap; Hellenic Statistical Authority; processed by the authors*

Table 5 the results for the years 2001 and 2011 are presented.

Table 4: Cross-Tabulation between density grids of Population 2001 and Main Road Network Accessibility (Integration 20km)

Main Network Accessibility Density Grid (Quantile)	Population 2001 Density Grid (Quantile)		
	Low	*Medium*	*High*
Low	**84.49%**	14.60%	0.91%
Medium	33.43%	**42.13%**	24.43%
High	6.88%	24.32%	**68.80%**

Source: OpenStreetMap; Hellenic Statistical Authority; processed by the authors

Table 5: Cross-Tabulation between density grids of Population 2011 and Main Road Network Accessibility (Integration 20km)

Main Network Accessibility Density Grid (Quantile)	Population 2011 Density Grid (Quantile)		
	Low	*Medium*	*High*
Low	**85.05%**	14.29%	0.66%
Medium	32.68%	**43.91%**	23.41%
High	6.77%	23.54%	**69.69%**

Source: OpenStreetMap; Hellenic Statistical Authority; processed by the authors

A slightly different pattern emerges when we study the results of 2001 and 2011. The proportion of low population density areas that are located in low network accessibility areas is slightly higher (approx. 85%) than the corresponding results of 1981 and 1991. However, the most interesting result is the percentage of areas with medium network accessibility density that are comprised by areas of medium population density; which in 1981 and 1991 were lower than 40% and in 2001 and 2011 were increased in 42.13% and 43.91 respectively. Finally, Table 6 depicts the results for the evolution of population between 1981 and 2011.

Table 6: Cross-Tabulation between density grids of Population Evolution (1981-2011) and Main Road Network Accessibility (Integration 20km)

Main Network Accessibility Density Grid (Quantile)	**Population Evolution 1981 - 2011 Density Grid (Quantile)**		
	Decreasing	***Stable***	***Increasing***
Low	**66.37%**	33.63%	0.00%
Medium	36.88%	**48.53%**	14.60%
High	5.73%	15.85%	**78.42%**

Source: OpenStreetMap; Hellenic Statistical Authority; processed by the authors

Regarding the cross-tabulation analysis between population evolution and main network accessibility, as shown in Table 6, a similar but stronger pattern emerges. Since, the spatial behavior of population evolution (decrease, constant, increase) is highly related to the corresponding network accessibility (low, medium, high).

In summary, the results of the cross-tabulation analysis of the population density and network accessibility density are pretty straightforward. In the main diagonal of the tables the largest proportions are concentrated, which means that the spatial behavior of the population and the network accessibility are similar. In particular, the highest correlation rates are observed in the cases between low and high network accessibility and low and high population density respectively. From this, we can deduce that while the medium network accessibility fairly influences population density, dense network with low and high network accessibility, categorically defines population density. Another interesting finding is that as time passes network accessibility increasingly defines population density as it is evident by the correlation and cross-tabulation analysis between population evolution and main network accessibility. This can be also presumed by the increasingly stronger correlations between network accessibility and population but also by the significantly higher percentage of medium-sized and stable settlements, in terms of population and population evolution respectively, that can be found in areas with medium network accessibility; the category with the higher increase in its diagonal.

5. CONCLUSIONS

In this paper a detailed quantitative comparative analysis of population dynamics and road network accessibility is presented. The findings of this study show that the population dynamics are immediately affected by the potential network accessibility and also demonstrate the significance of network configuration in the formation of high population density poles. The isolation from the mainland, the special morphology and the problematic road network (insufficient network quality, insufficient connection) make Naxos an interesting research area. One of the most important finding of this study is the degree of the positive correlation between population dynamics and accessibility of the main road network (angular integration 20 km). What is more, the Cross-Tabulation of population and network accessibility demonstrates that the robustness of positive correlation in every type of population and network accessibility. It is worth noting that in the eastern coastal part of the island where the road is detached the number of the settlements is significantly small and the population density in this area is particularly low. Space syntax is a particularly suitable tool in specifying the high integrated areas and the segregated ones.

The study findings make a clear difference between the spatial differentiation between the main population density centers and the rest scattered settlements. Of course, there are many other factors- the overall economic development of the island and the labor supply prospects that affect the local income as well as the intention of local people to stay in the island- that play an important role in population change rates over time. For that reason, the investigation of road network morphology in relation with the population distribution along Naxos is expected to be preliminary but considerable step in the approach of population patterns explanation. Finally, in this research it should be noted that the lack of time data for the road network (1981 - 2011) resulted in a relative weakness. So the time population data were analyzed in relation to the most recent state of the road network and thus the result of the correlation has probably been affected to some extent by this fact. Application of this study methodology to layout planning of relief facilities in the future will not only offer their compatibility in terms of efficiency but also will be used as an effective tool to make decisions on flow plan.

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