THE IMPACT OF DEMOGRAPHIC TRENDS ON SECURITY FORCES POLICY

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ABSTRACT

The SIM4SECURITY project aims to build a decision support model which is focused in the optimization of the distribution of the security forces and services (SFS) in Portugal and the efficiency improvement of the operational activity, by reorganizing and strengthening its presence in the territory. This study portrays the first achieved outputs of the project. We compute the changing demographic characteristics of local population up to 2040, combining state-of-the-art statistical methods to model and forecast the components (births, deaths, migration) of local population growth. The variation of the population is depicted, having as reference the 2011 Census, by the most relevant age groups: school-age, active, and senior populations. Moreover, a spatial analysis of the SFS location is shown. Distances by road network, the allocated areas, and the assigned population to each of the SFS stations are determined. It is possible to conclude that around 14% of the Portuguese population lives at a distance higher than 10 km of a SFS station, corresponding to 49% of the area of Portugal mainland. Taking this study into consideration, it will be possible to define the SFS locations that must be altered to respond to the future characteristics of the population.

Keywords: demographic projections, spatial analysis, dasymetric maps, population distribution, ageing.

1. Introduction

The Constitution of the Portuguese Republic determines that “all citizens have the right of freedom and security”. The compliance of this right implies that the presence of the security forces and services (SFS) must be effective, visible, and holder of a measurable impact in whole territory. To do so, four objectives should be pursued (Lourenço et al., 2015): the dimensioning of the Internal Security System (ISS), at medium and long-term, as a reference of the National Security, by increasing the role of the SFS; the presentation of the priorities in the ISS in order to improve its efficiency; the proposal of measures that bring together synergies to the cooperative performance of the several agents of the ISS, namely in the activity of public security, intelligence, criminal investigation, and protection and relief; and, the intensification of the capacities of the SFS.

The SIM4SECURITY project (Forecast and Spatial Analysis Model for Public Security, Ref. FCT: PTDC/ATPDEM/1538/2014) fits in the first and second above-mentioned objectives. The goal of the project is to present a scientific tool to support decision making, which is based on the development of a Geographic Information System (GIS) model and demographic scenarios to assist the improvement of the effectiveness of the SFS regarding the Portuguese population.

This goal will be achieved by undertaking the following five tasks: Analysis and diagnosis of the current national situation, regarding population and public security; Demographic forecast and scenario development, and population risk groups; Development and implementation of a GIS and design of a dynamic geoprocessing model; Implementation of Advanced Spatial Analysis Methods; and, Modeling the distribution of Security Forces (Rodrigues et al., 2016). Thus, a thorough assessment and spatial analysis of the SFS structure and the population needs is essential to fulfill the SIM4SECURITY goal.

On one hand, the right of security should be guaranteed to all, on the other hand, the economic restrictions imply the rigorous management of the distribution of the SFS throughout the Portuguese territory, which should be assisted by decision support instruments. This is an even more challenging task taking into consideration the change of the demographic scenario, provided that the increase of older populations over the next twenty years, nonetheless, has serious consequences to the phenomenon of crime (Sever and Youdin, 2006). Moreover, Lachs et al. (1996) and Minaker and Frishman (1995) believe that increases in older populations will have a number of implications for criminal justice, most notably an increase in crime victims.

The SIM4SECURITY project will provide a simulator that will help decision-makers and forces of command in the planning and rational affectation of resources that are adjusted to the local dynamics of criminality and population needs, in order to reduce the former and ensure the right of security to the latter.

This study portrays the preliminary outcomes of the first and second tasks of the SIM4SECURITY project, engaging three different parts: the computation of demographic projections, the preparation of dasymetric maps, and finally, the use of spatial analysis to understand the coverage of SFS in Continental Portugal, currently and in the future.

The first part involves the calculation of demographic projections up to 2040. In comparison with 2011 census data, it is possible to present the variation of population that will potentially occur in Continental Portugal, considering three age groups: school age[1], active[2] and senior[3] populations. This is a very important analysis since it is expected the ageing of Portuguese population, as it is currently happening in developed countries. This analysis also brings to attention the areas where, due to shift in the age characteristics of the population, SFS need to revise its structure, with the strengthening of its presence or the creation of additional programs to assist the population needs.

In the second part, the demographic projections are used to build dasymetric maps, in order to spatially distribute the computed projections according to the land use of a given area. This step allows the weighted distribution of population where it is more likely to be located, i.e., assuming different values of population density according to the land use (for example, higher population density in urban land, lower population density in agricultural land). It will also focus the new possible future distribution of population within the territory, providing knowledge regarding the densely-populated areas, against areas with inhabitants sparsely located.

The produced dasymetric maps for 2011 (census data), 2030, and 2040 (projections) are used in the third part of this work. A spatial analysis tool (Network Analyst) computes distances from

[1] School age refers to the population attaining the mandatory school cycle, from elementary to high school, comprising ages between 6 and 18 years old. It is considered a vulnerable group to criminal acts due to its low capability of defense.

[2] Active population refers to population between 18 and 65 years old. Mainly, it comprises the working population.

[3] Senior population is composed of people of over 65 years old. It is considered a vulnerable group to criminal acts due to its low capability of defense, and due to its potential disabilities caused by ageing and age-related diseases.

the current location of the SFS, and it creates service areas, which represent areas that can be reached up to a given distance from the nearest SFS station. The service areas are then overlapped by the dasymetric maps in order to ascertain the population that is served in each of the previously defined distances. For this work, the studied distances are: 1 km, 5 km, 10 km, 15 km, 20 km, and 25 km. The final part of the work will bring to attention the areas that are not covered by SFS in short distances. On one hand, these areas are more sensitive to the occurrence of crimes, on the other hand, people living in these areas have a different perception of security, since they know how far the SFS are to intervene in case of necessity.

Authors expect to provide some thoughts about the areas where SFS have to prioritize new programs of proximity to the populations, or other ways of intervention, since these populations are far away from the SFS stations location.

It is important to mention that, despite the fact that the SFS structure in Portugal is composed of several agencies, this study only focuses in the two SFS that are currently in the ground ensuring the day-to-day security of populations. These two SFS are Polícia de Segurança Pública (PSP) and Guarda Nacional Republicana (GNR). Each of these two SFS has specific areas of intervention in the ground, while PSP is responsible to maintain order and security in the urban and peri-urban areas, GNR is responsible for the coverage of rural areas within Continental Portugal.

This work is presented as follows. Section 2 portrays the study area and data. Section 3 explains the followed methodology. Section 4 presents and discusses the results. Finally, conclusions are provided in Section 5.

2. Study area and data

The study area is Continental Portugal. Administratively, Portugal has adopted the NUTS divisions: NUTS I[4], NUTS II[4], and NUTS III[4]. Each NUTS III has a different number of municipalities, which are also divided in parishes. Currently, there are 278 municipalities. In order to reduce the previous number of parishes (4050), a new administrative classification took place in 2013, to 2882 parishes. However, in order to simplify the calculations throughout this work and since the last counting of Portuguese population (2011 census) is prior to the above-mentioned new administrative classification, authors have opted to use the previous administrative division, considering the 4050 parishes (the upper administrative levels remain the same in both classifications).

Several data sets were employed in this study: census data, SFS locations, Portuguese Official Administrative Map (Carta Administrativa Oficial de Portugal, CAOP), the Corinne Land Cover (CLC) map, and the SFS locations.

Census data and other components' rates were used in the first part of the work, in order to compute the demographic projections. These data are provided by Instituto Nacional de Estatística (INE).

CAOP is a geographic vector data set, comprised of the administrative units (parishes, municipalities, and NUTS) of Portugal. It provides the spatial distribution of data throughout Portugal. It is available at Direção Geral do Território (DGT, accessed November 2016). The used version is from 2012.

The Corinne Land Cover (CLC) provides the information regarding the land use classification. It is available in raster and vector format at Copernicus Land Monitoring Service

[4] The Nomenclature of Territorial Units for Statistics regions comprise three levels in the Portuguese Territory: NUTS I (national level with 3 regions, Continental Portugal, and Madeira and Azores archipelagos), NUTS II (7 regions), and NUTS III (25 subregions).

(accessed November 2016). The 2000 and 2012 CLC were used in the second part of the work, for the construction of land change models for 2030 and 2040, and the dasymetric maps.

The SFS locations, PSP and GNR, in vector format were provided by the Secretaria-Geral do Sistema de Segurança Interna.

3. Methodology

This section provides the description of the processes that were undertaken in the study of population distribution in Continental Portugal, from 2011 to 2040.

3.1 Demographic projections

The demographic projections refer to the resident population of Portugal. They adopt the cohort-component method, where the initial population is grouped by gender and generation (cohort), defined by the year of birth. These groups are continuously updated, according to the defined hypotheses of evolution for each of the components of population changing: fertility, mortality and migration, in addition to the natural process of ageing (Bravo, 2016).

The basis of these projections is the resident population estimated to the most recent reference moment that is available at the INE. These data are disaggregated by gender, the integer value of the actual age until the 100 and plus years old and the municipality, NUTS III, NUTS II and NUTS I of dwelling. The projection of the components of the population changing includes the analysis of the demographic tendencies in the last decades and considers specific statistical methodologies for each component.

The fertility projection involves some assumptions that regard to the expected evolution of the Synthetic Fertility Index (SFI) and to the average age of the mother at giving birth. The fertility rates are modeled by the Schmertmann's method (Schmertmann, 2003, 2005) to project specific rates per age and per chronological year.

The computation of the mortality component is based on the Poisson-Lee-Carter methods (Brouhns et al., 2002), in combination with relational models (Brass, 1971) to the municipalities and regions of low population and the method of Denuit and Goderniaux (2005) for the projection of mortality for older ages.

The migration component includes the behaviors regarding the international and internal flows. The former considers the most likely hypotheses of evolution, when refers to the recent past, namely the emigration and immigration from and to Portugal. The latter is computed through two estimation matrices of inflows and outflows in agreement with the percentage of the resident population in the corresponding NUTS II, per gender, having as reference the 2011 census data. The migration component of the more detailed administrative levels was calculated by weighting those units in the corresponding NUTS II, and assuming its possible decline in the future. The final migration balance is determined by the sum of the international immigration (positive sign), the internal immigration (positive sign), the international emigration (negative sign), and the internal emigration (negative sign).

The combination of the different evolution trajectories of each of the components of demographic changing allows the delineation of four alternative scenarios for the evolution of the resident population (Fig. 1). The four scenarios can be classified as follows:

Scenario 1 (pessimistic) – it combines the most pessimistic hypothesis of the SFI, with the hypothesis of moderate evolution of the life expectancy at birth at all ages, and the maintenance of negative migration balances;

Scenario 2 (trend) – it combines the hypothesis of optimistic evolution of the SFI with the hypothesis of moderate evolution of the life expectancy, and the hypothesis of positive migration balances;

Scenario 3 (Optimistic) – it combines the hypothesis of optimistic evolution of the SFI, with the hypothesis of optimistic evolution of the life expectancy at birth and the hypothesis of positive migration balances.

Scenario 4 – this scenario is similar to scenario 2 without the inclusion of any migration balance.

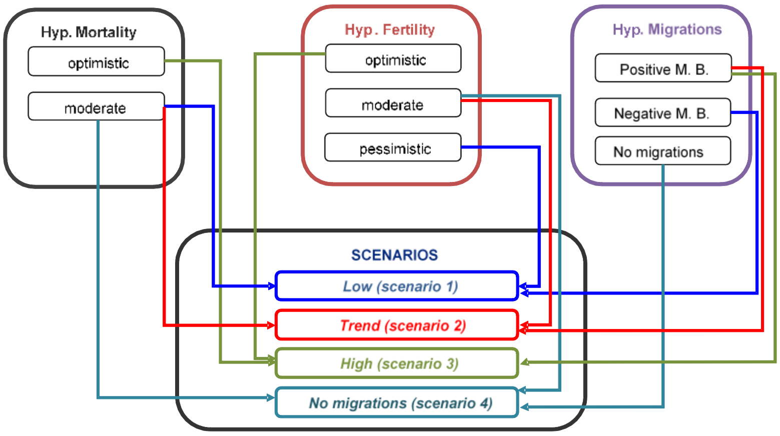

Fig.1 Projection scenarios and the corresponding combination of hypotheses of evolution of the components mortality, fertility and migrations.

3.2 Dasymetric maps

Dasymetric mapping is a technique in which attribute data is organized by a large or arbitrary area that is more accurately distributed within that unit by the overlay of other geographic themes that exclude, restrict or confine that attribute. This technique is often used in the creation of density population maps, whereas a population attribute provided by census data assigned to administrative units (for example, parishes) might be more accurately distributed by the overlay of water bodies, vacant land, and other land-use boundaries, within which it is reasonable to infer that people do not live (ESRI dictionary, 2017). Other land uses can be used as overlay themes, such as continuous urban land use, discontinuous urban land use, agriculture, and forest. In this case, it is possible to assign different densities to each of these different land uses, so to distribute more population in the areas where it is more likely to be densely populated.

In this study, a dasymetric map was prepared for 2012, using the census data, per parish and the CLC 2012, with the Land Use/Land Cover (LULC) data. For 2030 and 2040, a model of land transformation was used in order to obtain the projected LULC maps. The Land Change Modeler (LCM) tool, which is part of the TerrSet software, was used for this purpose. LCM aims to analyze, predict and validate results of Land Use/Land Cover Change (LULCC) maps. LCM uses as an input two thematic LULC maps for two distinct periods, exactly with the same land cover categories. In this case, the 2000 and 2012 CLC maps were used as input, comprising eight categories: Continuous urban land use, Discontinuous urban land use, Non-urban built areas (industrial, commercial, transport units, mine, dump and construction sites), Artificial and non-agricultural vegetated areas, Agriculture, Forest and semi-natural areas, Wetlands, and Water bodies.

LCM evaluates land cover changes between two different periods, and it calculates the changes between the categories that have taken place. It creates a matrix of probability of changes between the categories, through the creation of relative transition potential maps. Then, for a given time in the future (2040, in this study), it uses an artificial neural network, namely the Multi-Layer Perceptron (MLP), to predict future Land Use maps (Megahed et al., 2015). It is possible to perform the calculation of intermediary stages between the year of the last available land use map and the given time in the future. In this study, 28 stages were calculated, so the output provides a LULC map per year, since 2013 until 2040. These stages include the LULC prediction map for 2030. Roy et al. (2014) found that LCM produces better prediction accuracy in short time scales, especially in the case of stable land covers rather than cases of rapid change. Vega et al. (2012) compared LCM with other LULCC methods, and conclude that LCM generates more accurate overall change potential maps because neural network outputs are able to express the change of various land cover types more adequately than individual probabilities obtained, for example, through the Weights of Evidence method. MLP is trained, using the matrix of probability of changes and the influence of the drivers that are indicated by the user and depend on the considered transition potential map. In this study, the defined drivers are the distance to road network and distance to existing urban areas.

Dasymetric maps were prepared by using the ArcGIS Dasymetric toolbox (Intelligent Dasymetric Mapping Toolbox, IDMT), which is composed of a set of five steps. IDMT aims at automating the process of taking population data from census enumeration units and transferring the data values to overlaying homogenous zones while maintaining volume preserving properties and using an empirical sampling and areal weighting for determining relative densities for each homogeneous zone. The output is a representation of population per pixel, in a raster map. As input, a polygon theme with population attribute (census data assigned to parishes polygons) and the LULC map are provided. A table with the preset population density values is necessary, in order to assign to each of the LULC classes the corresponding population. For this study, the following densities were assign to each of the LULC classes, based on literature review: Continuous urban land use (45%), Discontinuous urban land use (32%), Non-urban built areas (2%), Artificial and non-agricultural vegetated areas (2%), Agriculture (10%), Forest and semi-natural areas (7%), Wetlands (2%), and Water bodies (0%). The highest weights percentage was given to continuous and discontinuous urban areas. However, it was assumed that some people still live in agricultural and forest and non-agricultural vegetated areas (disperse population) that cannot be considered or classified as urban areas. Water bodies were considered as unpopulated areas, while the remaining three classes were assigned with a very low weight.

The dasymetric maps of 2030 and 2040 need the demographic projections by parish. Due to the low number of inhabitants per some of the Portuguese parishes, it is not possible to directly project population for this administrative level. Therefore, a ratio was computed between each municipality and its corresponding parishes, using the 2011 census data. Then, the same ratio was applied to the municipality projected data of 2030 and 2040, to convert it into demographic projection per parishes. The 2030 and 2040 dasymetric maps also assumed the same preset population density values table, as above-mentioned.

3.3 Spatial analysis

The third step of this study was performed by using the SFS locations and the dasymetric maps prepared in the previous step. The spatial analysis was undertaken with the Network Analyst toolbox from ArcGIS. The current road network was used in order to calculate service areas around each of the SFS location, per a given distance. Only the GNR territorial posts ('Postos Territoriais') were considered in this exercise. In the "Service Area" task, the Network Analyst application prepares a polygon that connects the points in the road network that can be reached at a given distance from an initial stop, both inputs provided by the user. In this study, the initial stops were the GNR territorial posts, and the considered distances were 1 km, 5 km, 10 km, 15 km, 20 km, and 25 km.

These service areas were then combined with the dasymetric maps in order to ascertain the resident population living in each of the areas. Results are shown in the next section.

4. Results

4.1Demographic Projections

Table 1 shows the results of the demographic projection of 2030 and 2040. In the four different scenarios, population tends to decrease. The decrease rates vary between 5% and 11% in 2030, and between 7% and 18% in 2040, when compared to 2011. By comparing scenarios 2 and 4, the influence of migration seems irrelevant in 2030, while it is more significant in 2040.

Table 1 Results from demographic projection 2030 and 2040, by scenario, and comparison with 2011.

Scenario	2030	2030-2011	2040	2040-2011
1	8 931 846	-1 115 775 (-11%)	8 173 856	-1 873 765 (-18%)
2	9 454 770	-592 851 (-6%)	9 210 083	-837 538 (-8%)
3	9 533 041	-514 580 (-5%)	9 387 787	-659 834 (-7%)
4	9 428 233	-619 388 (-6%)	8 960 065	-1 087 556 (-11%)

Fig. 2 depicts the total variation of population, while Figs. 3, 4, and 5 show the variation in separate age groups: school age, active and senior population, respectively, between 2011 and 2030. The scenario 2 (Table 1) was considered in the calculation of this difference. It is possible to observe the decrease of population in the interior of the country, whereas the coast has a moderate decrease. The exception of this tendency occurs in the municipalities around greater Lisbon, and in some municipalities in the territory. Alcoutim is the municipality that will lose the highest rate of inhabitants, 45%. It is also noteworthy the decrease of population in the two main cities: Lisbon will have a decrease of 33% of population, while Porto will have less 32% of residents in 2030. This decline is even more visible in the 6-18 years old variation map (Fig. 3), since it happens in almost the entire territory, with very few exceptions around the capital (Montijo, Odivelas, Mafra, and Alcochete municipalities). Castanheira de Pêra (-57%), Porto (-54%), and Alcoutim (-54%) are the three municipalities with the highest decrease rates of school age population. The variation in the active age population group is smoother (Fig. 4). The trend of decrease is kept; however, the municipalities around greater Lisbon have an increase of population (Montijo, Mafra, Alcochete, Arruda dos Vinhos, and Benavente).

Fig. 5 illustrates a complete inversion of the trend, where the variation of senior population is observed. There is a very strong increase of this age group throughout the territory, with the few exceptions of some municipalities located in the interior. Four municipalities will more than double its senior population in 2030: Paços de Ferreira (112%), Vizela (109%), Paredes (103%), and Lousada (102%), all located in the area of greater Porto.

Other fact is also noteworthy: the percentage of the senior population out of the total population. In 2011, 18.1% (1,820,185 inhabitants) of the total population were over 65 years old. It is predicted that this age group would achieve 25.7% of the total population (2,431,430 inhabitants) in 2030. It is a considerable increment of this group of population, and this fact will require more attention from SFS. Consequently, the other two groups have a decrease in its ratio. Active population decreases from 64.4% in 2011 to 60.0% in 2030, and population under 18 years old drops from 17.9% to 14.3%.

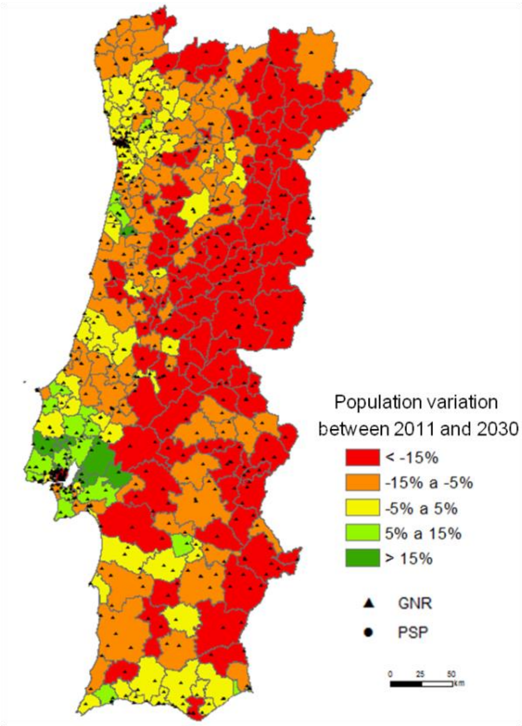

Fig.2 Population variation between 2011 and 2030.

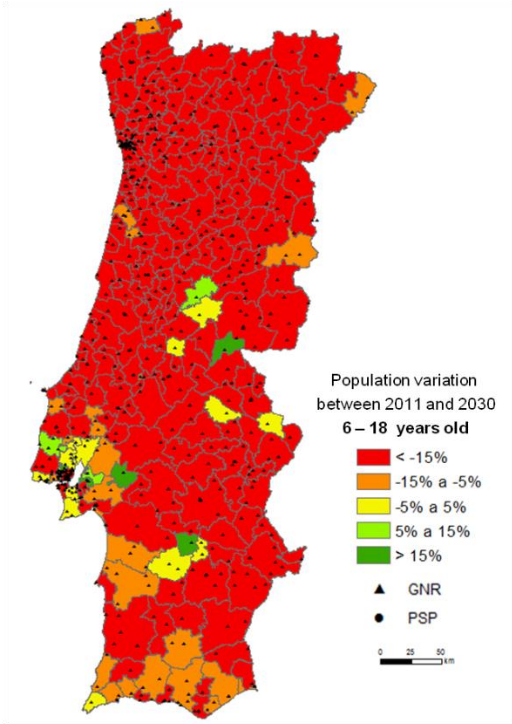

Fig.3 Population variation (6-18 years old) between 2011 and 2030.

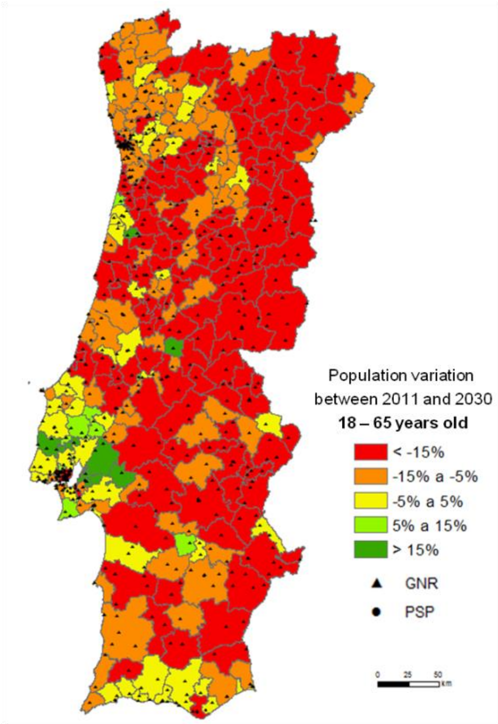

Fig.4 Population variation (18-65 years old) between 2011 and 2030

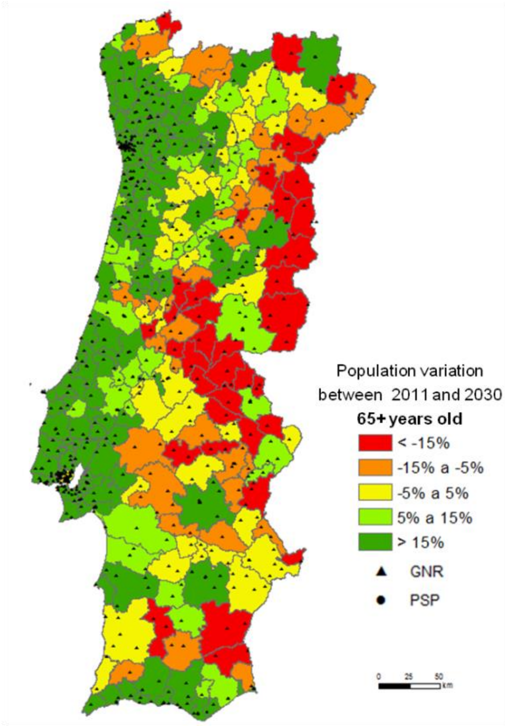

Fig.5 Population variation (65+ years old) between 2011 and 2030.

4.2 Dasymetric maps

Fig. 6 illustrates the LULC maps from 2012, 2030, and 2040. The 2012 LULC map is provided by CLC, while the 2030 and 2040 maps are the result of the LCM tool. Even though the population is decreasing, it is possible to observe some continuous and discontinuous urban growth in the surrounding of existing urban areas. Fig. 7 presents the population density of Continental Portugal in 2012, 2030, and 2040. The areas located in greater Lisbon and greater Porto are the most densely populated, and it is predicted that other towns around these two cities will gain some urban growth. This fact is in line with the demographic projections, whereas some population growth is only foreseen in the coast areas.

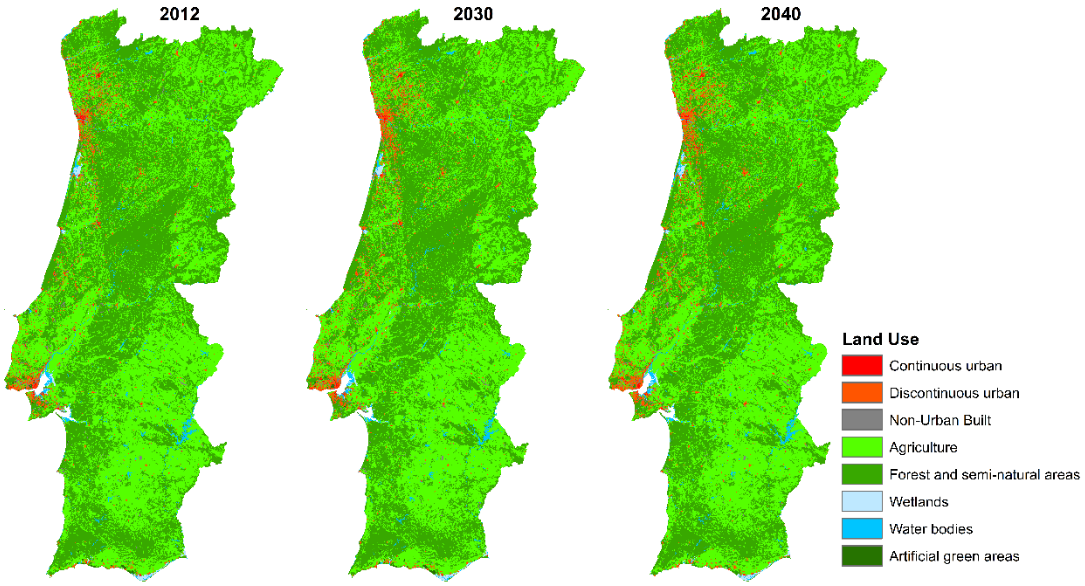

Fig.6 LULC maps for 2012 (CLC), 2030 (by LCM), 2040 (by LCM).

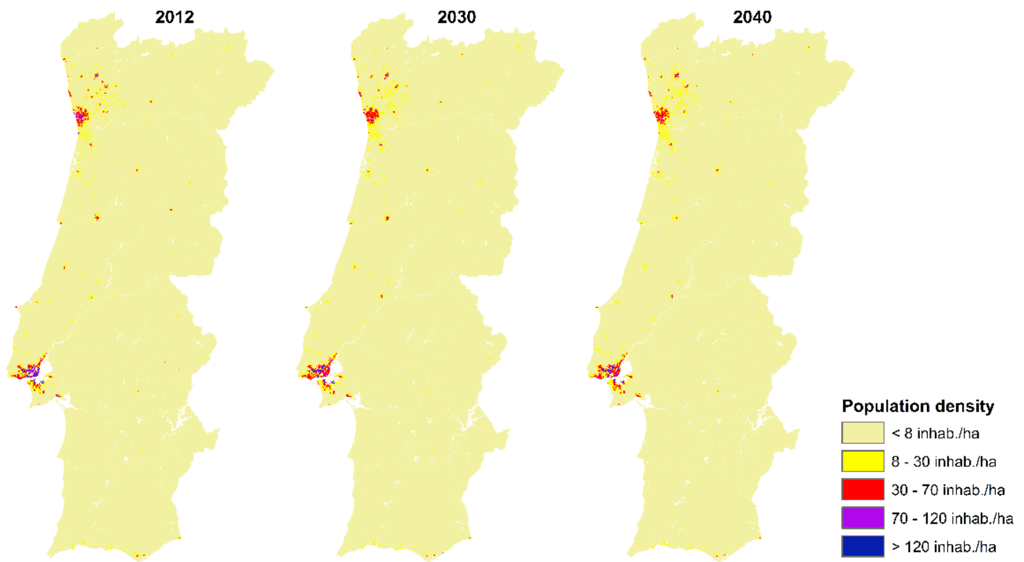

Fig.7 Dasymetric maps of 2012, 2030, 2040.

4.3 Spatial analysis

Fig. 8 depicts the service areas computed by Network Analyst toolbox. It is possible to observe that the service area of 5 km only corresponds to 15.7% of the territory (around 1,386,700 ha), meaning that population living in the other 84.3% of Continental Portugal area lives at a considerable distance of a SFS station. Around 50% of the population is located in these areas (Table 2). For this group, the current location of the SFS stations seems to be appropriate. However, the other 50% of the population live in areas that are located at a distance higher than 5 km. For this population, the SFS presence in their day-to-day activities is less effective and visible. There is still 4% of the population living in areas further than 15 km of the closest SFS. In this case, the high distance from the SFS stations brings a negative effect on the security perception of this group and some focus should be given to ensure that these people feel safe. The area of Continental Portugal that is further from SFS at a distance of 20 km is almost 12% of the territory.

Table 2 Population allocated by service areas (2011).

Service Areas (Distance)	Population	Percentage
1 km	414 006	4%
5 km	5 084 953	51%
10 km	8 646 149	86%
15 km	9 644 620	96%
20 km	9 894 095	98%
25 km	9 977 907	99%

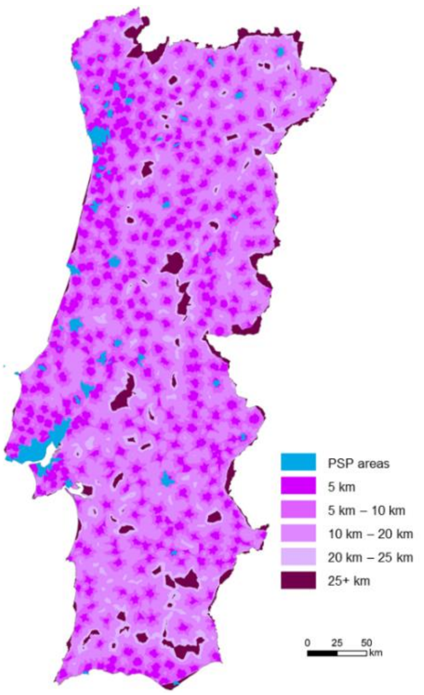

Fig.8 Service areas to GNR, at 5 km, 10 km, 20 km, 25km, and more than 25 km, by road network.

Tables 3 and 4 indicate the population covered by the SFS, within certain distances from its stations, predicted for 2030 and 2040. Distributions are similar, when compared to Table 2. This might be due to the fact that the predicted urban growth will happen in the surrounding of the existing urban land use and to the population decreasing tendency. Still, there will be 50% of the population living at considerable distances from the SFS stations. Considering that this population will have a higher number of senior population (see section 4.1), it is essential to provide measures in order to mitigate this distance, by including more SFS stations, or by changing the current model of policing.

Table 3 Population allocated by service areas (2030).

Service Areas (Distance)	Population	Percentage
1 km	391 383	4%
5 km	4 778 103	50%
10 km	8 160 769	86%
15 km	9 097 939	96%
20 km	9 318 770	98%
25 km	9 393 455	99%

Table 4 Population allocated by service areas (2040).

Service Areas (Distance)	Population	Percentage
1 km	383 128	4%
5 km	4 659 687	51%
10 km	7 958 933	86%
15 km	8 867 659	96%
20 km	9 079 428	98%
25 km	9 151 154	99%

5. Conclusion

This study provided an insight about the distribution of SFS in the current time, the results of the demographic projections and predicted LULC maps of 2030 and 2040. It is predicted the ageing of population, being visible in the increase of 42 % in this age group, between 2011 and 2030. Additionally, 50% of the Portuguese population lives in areas further than 5 km of SFS, by road network. The same percentage is predicted to be in similar situation in 2030 and 2040. Likewise, 14% of population will live further away than 10 km of a SFS station. Accordingly, a higher number of older population will live far from the SFS stations. A review of the distribution of the SFS is recommended, in order to deal with the new characteristics of the Portuguese population. While some authors refer that the police interaction with older populations should involve more training, education and focus (Sever and Youdin, 2009), it is recommended that new programs of close policing to remote areas should be planned in order to help the senior populations to improve their perception of security.

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