European Journal of Geography

Volume 11, Issue 4, pp. 110 - 125

Article Info:
Accepted: 16/12/2020
Corresponding Author: *linapap27@yahoo.com
https://doi.org/10.48088/ejg.p.pap.11.4.110.125

Special Issue: *"Selected Papers from 12th International Conference of the Hellenic Geographical Society (ICHGS): Innovative Geographies II, 2019"*

Analysis of population dynamics of the regional unit of Chania using remote sensing and census data

Paschalina V. **PAPANIKOLAOU**[1*],
Terpsichori K. **MITSI**[2]

[1] *Aristotle University of Thessaloniki, Greece*
[2] *National and Technical University of Athens, Greece*

Keywords:
Population Density,
Location Quotient,
Gini Index,
Remote Sensing,
Built-up Index,
Linear Regression

Abstract

Information about the size and the evolution of a place's population has been sought from ancient times. That kind of information can be secured by periodic census enumerations. The Hellenic Statistical Authority provides data about the population and social conditions, also economical indices for each economic sector and the industrial trade. The study area, the regional unit of Chania, is in the island of Crete and the population resides mostly in the lowlands. In order to study the density, distribution and evolution of the population, many quantitative geographical methods were used, such as the Location Quotient (LQ), the Coefficient of Specialization (CS), the Coefficient of Localization (CL) and the Gini – Hirschman Index. The dataset chosen to execute the models, is derived from the Hellenic Statistical Authority's website, for the years 2001 and 2011, the most recent census available data and is free of charge. To examine the distribution and the density of the population in accordance with the urban sprawl in the area the results were correlated with remotely sensed image. To do so, the Built – up index was calculated and for each municipality in the county and the mean value was used in a linear regression model with the population. In conclusion, the analysis combines the results of the quantitative methods for the productive sectors, the population density and growth with the urban sprawl, to examine the way the population of the county evolved.

The publication of the European Journal of Geography (EJG) is based on the European Association of Geographers' goal to make European Geography a worldwide reference and standard. Thus, the scope of the EJG is to publish original and innovative papers that will substantially improve, in a theoretical, conceptual or empirical way the quality of research, learning, teaching and applying geography, as well as in promoting the significance of geography as a discipline. Submissions are encouraged to have a European dimension. The European Journal of Geography is a peer-reviewed open access journal and is published quarterly.

1. INTRODUCTION

The increase of the population throughout the years is directly linked to the expansion of urban areas (Osgouei et al, 2019). As the population grows the form of the Earth's surface is changing because of the urban spread, which causes land surface changes and environmental degradation. Especially, in Mediterranean cities, the augmented population leads to urban sprawl and an uneven distribution of population, where the phenomenon can be observed since 1970 (Gonzalez, 2017). So, it is important to examine the way and the reasons behind the moving of the population. Information about how the population is distributed can be derived from the Hellenic Statistical Authority which also provides useful information about its social and economic conditions.

To fully understand the population dynamics, is important to combine different scientific disciplines, like Population Geography and Quantitative Methods in Geography. Those methods allow the researcher to study, evaluate and comprehend all the different factors that form the population. Thus, there is a need for accurate, up-to-date, and periodic data of the population and the urban expansion to develop efficient decision-making mechanisms and effectively manage and plan cities (Osgouei et al, 2019).

Moreover, geographic systems use data to generate new insights into how the nature of places affects people and communities (González, 2017). Also, with the advances in satellite technologies and the availability of free global and historical satellite data it is possible to map and estimate constantly and effectively the urban sprawl. Remotely sensed images are usually converted into useful information such as land cover or vegetation maps. In this study, satellite data from the Landsat Collection are used to monitor and detect changes in the urban and semi – urban areas.

The study area is the regional unit of Chania, which is the second largest regional section of Crete, the largest island in Greece. The island of Crete due to its location has a high rate of tourism and the main source of income is the tertiary productive sector. The tourism "forms" the economy of the island because most of the population is employed to hotel units, travel and car rental agencies. Counter to the island, Chania is the only regional unit which is based on the primary productive sector and has highly developed agricultural activities.

Chania is divided in 7 municipalities according the plan of Kallikratis (3852/2010), those are Chania, Apokoronos, Gavdos, Kandanos – Selinos, Kissamos, Platanias and Sfakia. In Chania, it is also located the Technical University of Crete and most of Cretan businesses and according to the Hellenic Statistical Authority, in the area closer to the university (Kounoupidiana) resides the most educated part of the population. In addition, the south part of the county, like Elafonisi, Samaria's canyon, Agia's lake, Georgiopoli beach, and islands Gaudos and Gaudpoula, belongs to the Natura 2000 network of protected areas.

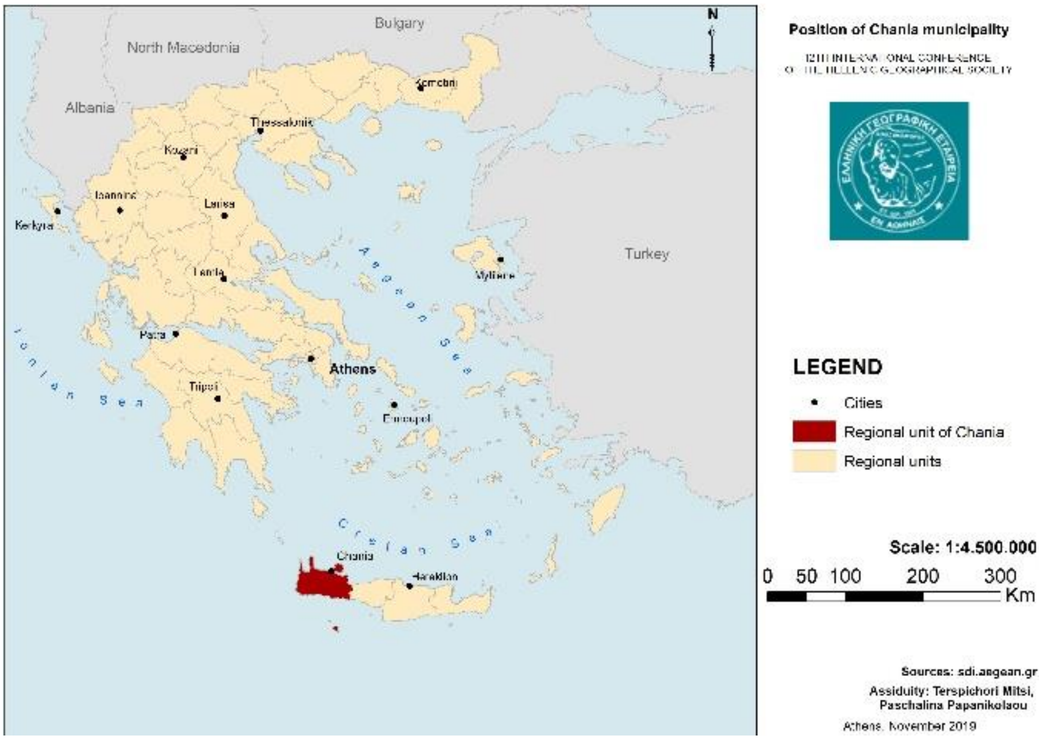

Figure 1. Study area- Chania

2. BACKGROUND & LITERATURE REVIEW

This paper aims to examine the way and the reasons behind the evolution of the population of Chania. To do so, it combines the results from the quantitative methods for the productive sectors and the results for the urban spread which were estimated through remotely sensed images. In recent years, it became more evident that studying the size and the evolution of a place's population is important and many methods for population dynamics were proposed. Such methods were the Location Quotient (LQ), Coefficient of Specialization (CS) and Coefficient of Localization (CL).

The Location Quotient was proposed by Haig in 1928 and is a way of quantifying the concentration of a particular cluster (spatial distribution), like an industry or a demographic group, in a region union as compared to the region. The Coefficient of Specialization comes from a financial theory (North, 1995) and its used to measure the diversity in a region. The Coefficient of Localization also stems from a financial theory and it measures the characteristics of specialization or diversification of an area to determine which of the economic activities employ a greater proportion of the workforce (Hoover, 1936).

Also, one more proposed index for cluster concentration is the Gini – Hirschman Index. The Gini – Hirschman Index is the most popular method and was developed to study industry concentration and market competition during the 70's and 80's (Jacquemin and Berry, 1979; Clarke and Davis 1983). The index measures inequality and is strongly affected by the number of individuals in an area. To better understand those indices, a Greek book by Lafazani (2018) was used.

In combination with those methods, remote sensing techniques were applied to detect the changes to the built-up area. Through the years, many algorithms were developed such as the NDBI (Normalized Difference Built – up Index), the BUI (Built – up Index), Shannon's entropy and landscape metrics. In this paper, a combination of the spectral indices NDVI (Normalized Difference Vegetation Index) and NDBI (Normalized Difference Built-up Index) was used, the BUI (Built-up Index). The BUI separates the built-up area from the remaining land cover e.g. vegetation (Karanam & BabuNeela, 2017). NDVI was conceived by Rouse et al (1973) is the most common vegetation index and distinguishes various vegetation covers such as thick or low vegetation and barren land. NDBI (Zha et al, 2003), like NDVI is easily calculated using spectral bands and it represents the build-up areas.

All the results were mapped because it is easier to depict them with the right symbols. To choose the respective symbol and color palette for each result, quantitative and remotely sensed, the books from Robinson H. et al (2002) and Livieratos E. (1985). Those books provide helpful information for creating a map.

3. ANALYSIS

Between 2001 and 2011, the smaller municipalities were incorporated to larger and a new system of demarcation was instituted. The former system, the Kapodistrian, was until 2001 and included 910 municipalities and 125 municipal communities. The new system as of 2011, is called Kallikratis' plan and it includes 325 municipalities, in which each municipality corresponds to the sum of its nearest Kapodistrian boundaries. The data of the census of 2011 was in the new system, so the analysis was based on that.

The quantitative indices were calculated for both years for each economic sector. The sectors are seen in the table below. All the data used for the analysis are derived from the Hellenic Statistical Authority's website (http://www.statistics.gr/).

Table 1: The productive sectors and their respective activities

Sectors	Activities
Primary sector	Agriculture, fishing, livestock
Secondary sector	Mining, quarries, salts, energy production, industry, constructions
Tertiary sector	Public and private business, trade, safety, health, financial institutions, transportation, education

Source: Hellenic Statistical Authority

3.1 Quantitative methods

Spatial factors are used to illustrate the structure of each productive sector. Each spatial factor presents the phenomenon according to the municipalities in relation to the regional unit. (Tomas Sayago Gomez et al., 2017)

The Location Quotient quantifies (LQ) the spatial distribution of a cluster. It is also useful in demographic studies because it shows what makes the region's demographics unique in comparison to its state and/or the nation.

- If **LQ > 1**, it indicates a higher rate of development in the study area (municipality) compared to the region unit.
- If **LQ = 1**, then they develop in accordance.
- and if **LQ <1**, then the study area has a lesser rate than the region unit (Lafazani, 2018).

The Coefficient of Specialization (CS) concerns the conformation of economic activities of the municipality in relation to the overall conformation.

- If **CS = 0** the conformation of economic activities in the municipality is identical to the overall conformation.
- If **CS = 1** the conformation of economic activities is completely different.

The Coefficient of Localization (CL) determines the establishment of each economic activity of the municipality in relation to the total of the economic activities. (Joseph, 1982)

- If **CL = 0** The economic activity (i) in the municipality is identical with the establishment of all the activities.
- If **CL = 1** The economic activity (i) in the municipality is established completely different from the installation of all the activities.

The Coefficient of Specialization and Coefficient of Localization range from 0 to 1.

Lastly, the Gini – Hirschman Index measures the inequality among values of a frequency distribution and is often used as a gauge of economic inequality. The coefficient ranges from 0 (or 0%) to 1 (or 100%), with 0 representing perfect equality and 1 representing perfect inequality (Lafazani, 2018). Values over 1 are theoretically possible due to negative income or wealth. In the table below, the formulas for each coefficient is listed.

Table 2: The formulas for each quantitative coefficient

Index	Location Quotient	Coefficient of Specialization	Coefficient of Localization	Gini – Hirschman Index
Formula	$QL = \frac{A_{ij}}{A_j} \Big/ \frac{A_{in}}{A_n}$	$CS = \frac{1}{2}\sum_i \left\| \frac{A_{ij}}{A_j} - \frac{A_{in}}{A_n} \right\|$	$CL = \frac{1}{2}\sum_{j=1}^{n} \left\| \frac{A_{ij}}{A_{in}} - \frac{A_j}{A_n} \right\|$	$GH = 100 \cdot \sqrt{\sum_{i=1}^{n} \left(\frac{X_i}{X_n} \right)^2}$
	Aij: the number of products in sector i in the sub-region **Aj**: the total number of products in the sub-region **Ain:** the number of products in sector i in the region **An:** the total number of products in the region			**Xi:** the variable x in region i **Xn:** the variable x in set of regions **n:** number of regions

Source: Lafazani, 2018

After calculating the coefficients, the results for the LQ, the CS and CL are noted on table 3. The LQ is over 1, in the secondary and the tertiary sectors, which signifies that their development is in higher rate than the region of Crete. The rates for the primary sector are under 1 and according to the coefficient, it's the sector that develops in a lesser rate. In 2001, LQ's values are higher than in 2011, especially in the secondary sector. The results for the CS are close to zero, so the employment in each sector corresponds with the respective Crete's employment rate. Finally, the result of CL is close to 0, this signifies that the workforce is equally distributed in each sector.

Table 3: Rates of productive sectors in 2001 and 2011

Rates	Primary Sector		Secondary Sector		Tertiary Sector	
	2001	2011	2001	2011	2001	2011
LQ	0.836	0.767	1.068	1.014	1.047	1.046
CS	0,019	0.017	0.006	0.001	0.014	0.016
CL	0.020	0.029	0.008	0.002	0.006	0.006

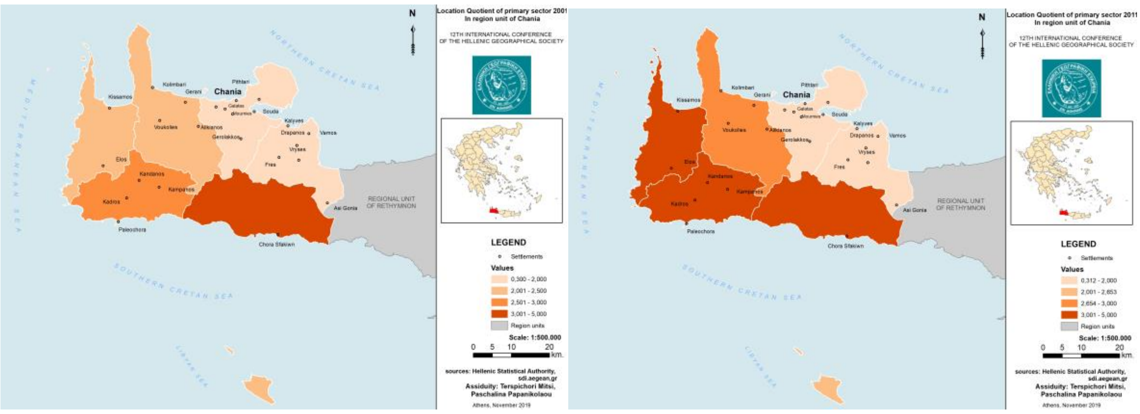

Figure 1. Map for the Location Quotient of the primary sector for 2001 (left) and 2011 (right)

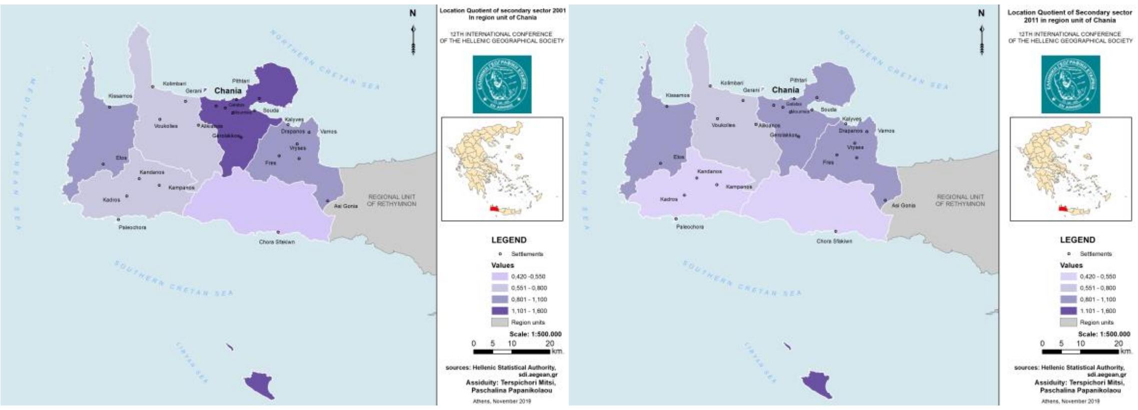

Figure 2. Map for the Location Quotient of the secondary sector for 2001 (left) and 2011 (right)

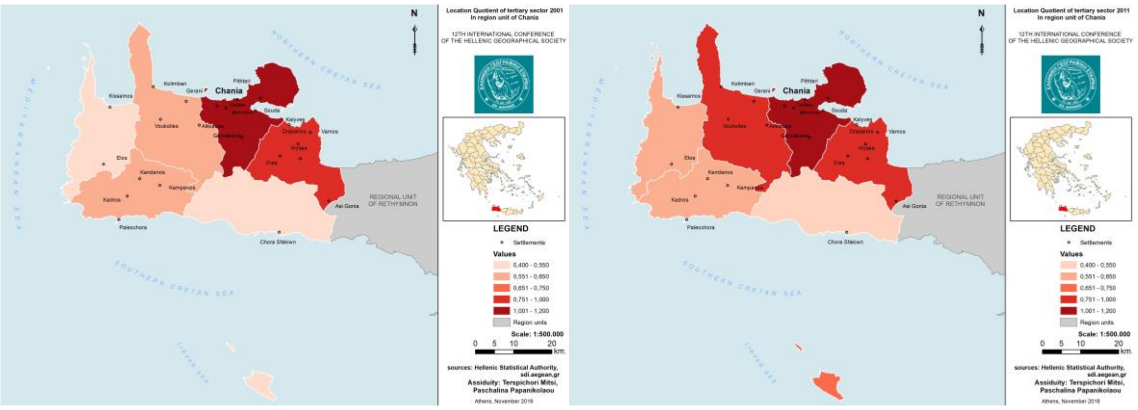

Figure 3. Map for the Location Quotient of the tertiary sector for 2001 (left) and 2011 (right)

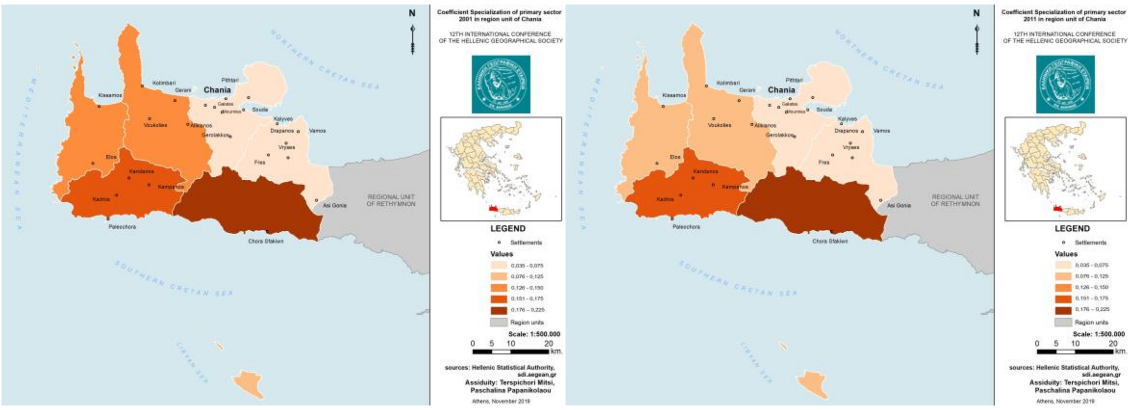

Figure 4. Map for the Coefficient of Specialization of the primary sector for 2001 (left) and 2011 (right)

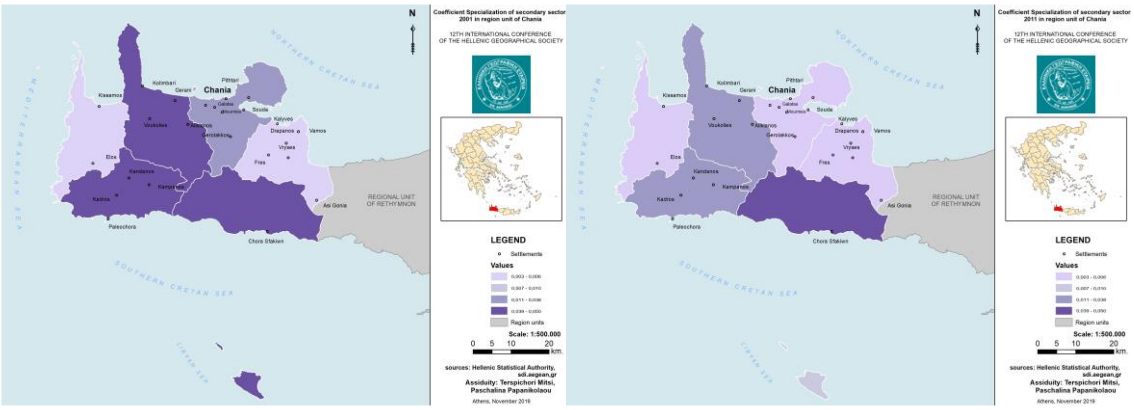

Figure 5. Map for the Coefficient of Specialization of the secondary sector for 2001 (left) and 2011 (right)

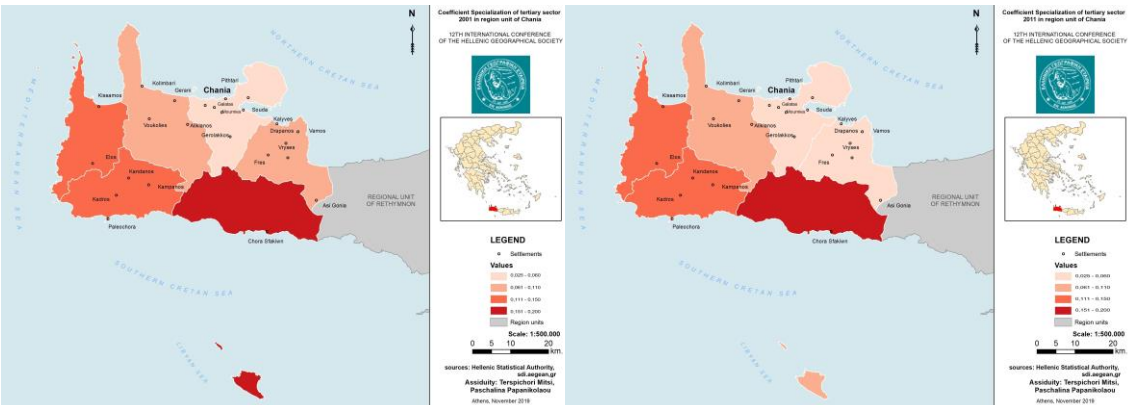

Figure 6. Map for the Coefficient of Specialization of the tertiary sector for 2001 (left) and 2011 (right)

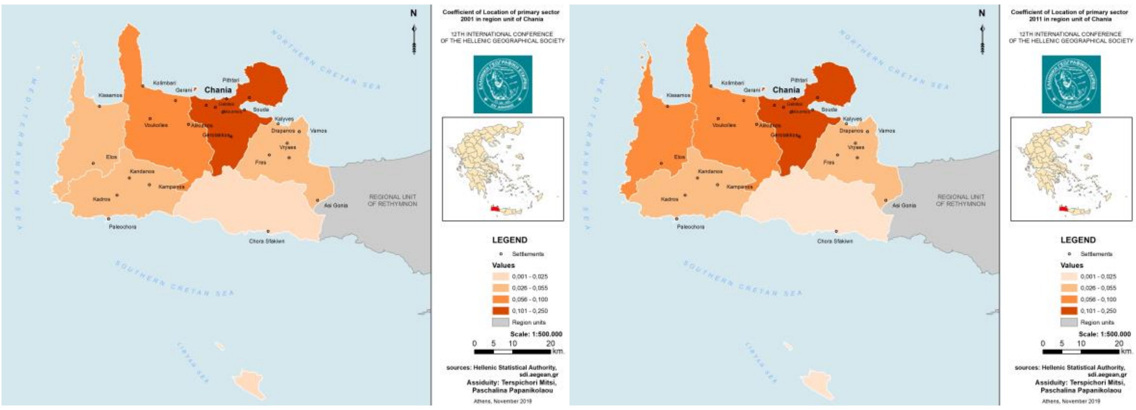

Figure 7. Map for the Coefficient of Localization of the primary sector for 2001 (left) and 2011 (right)

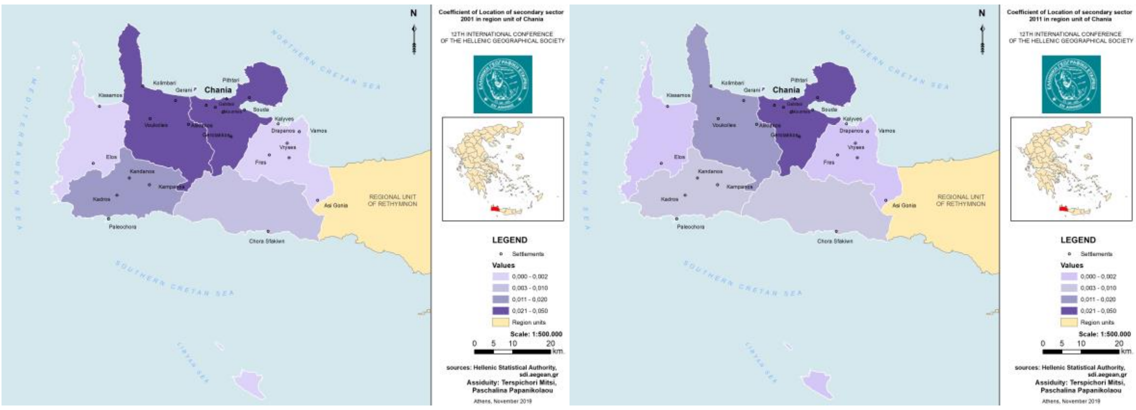

Figure 8. Map for the Coefficient of Localization of the secondary sector for 2001 (left) and 2011 (right)

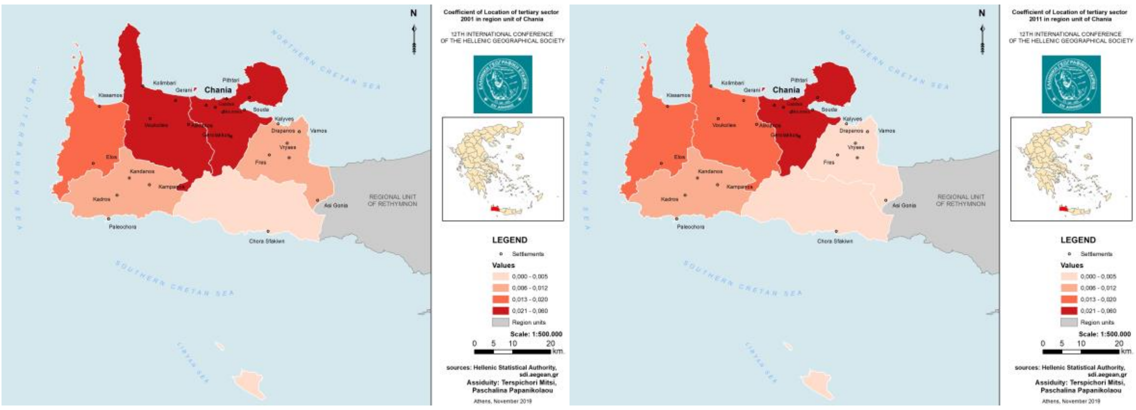

Figure 9. Map for the Coefficient of Localization of the tertiary sector for 2001 (left) and 2011 (right)

The results of the coefficients can be seen in accordance with the actual percentage of workforce per sector. The tertiary sector gathers most of the workforce in all municipalities except Sfakia. While observing table 4, the northern municipalities have largest percentages of workforce in the tertiary sector and that is because they are more populated than the others. Also, because of that they have more facilities, like schools, hospitals, and hotels.

Table 4: Percentage of workforce per sector in each municipality

Municipality	Primary Sector		Secondary Sector		Tertiary Sector	
	2001	2011	2001	2011	2001	2011
Chania	6.07%	3.53%	19.83%	15.56%	74.10%	80.91%
Apokoronos	32.66%	20.44%	18.15%	15.15%	49.19%	64.41%
Gavdos	40.43%	29.41%	27.66%	16.18%	31.91%	54.41%
Kandanos – Selino	55.08%	47.17%	9.42%	8.57%	35.50%	44.26%
Kissamos	46.04%	35.62%	18.75%	15.25%	35.21%	49.13%
Platanias	49.79%	29.99%	9.64%	10.83%	40.57%	59.18%
Sfakia	61.90%	56.94%	7.58%	6.15%	30.52%	36.91%
Total	19.97%	13.83%	17.66%	9.65%	62.37%	76.52%

Source: Hellenic Statistical Authority

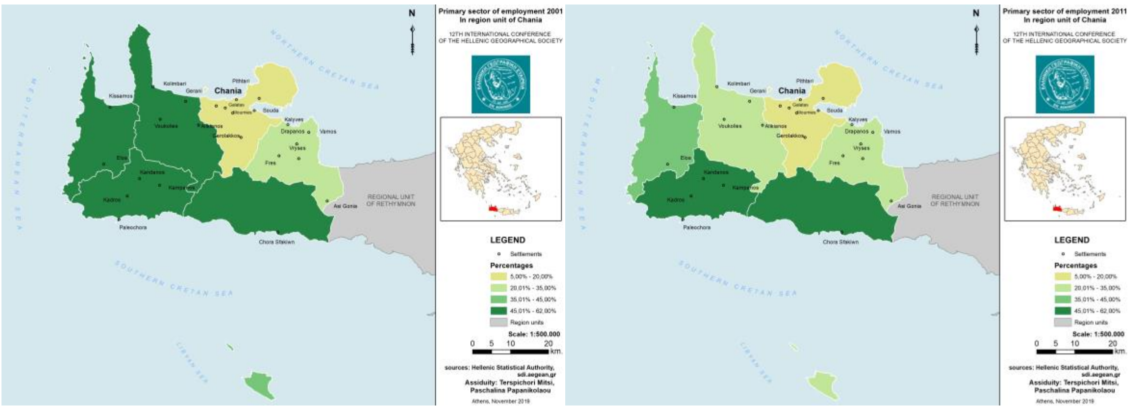

Figure 10. Map of the percentage of workforce in the primary sector for 2001 (left) and 2011 (right)

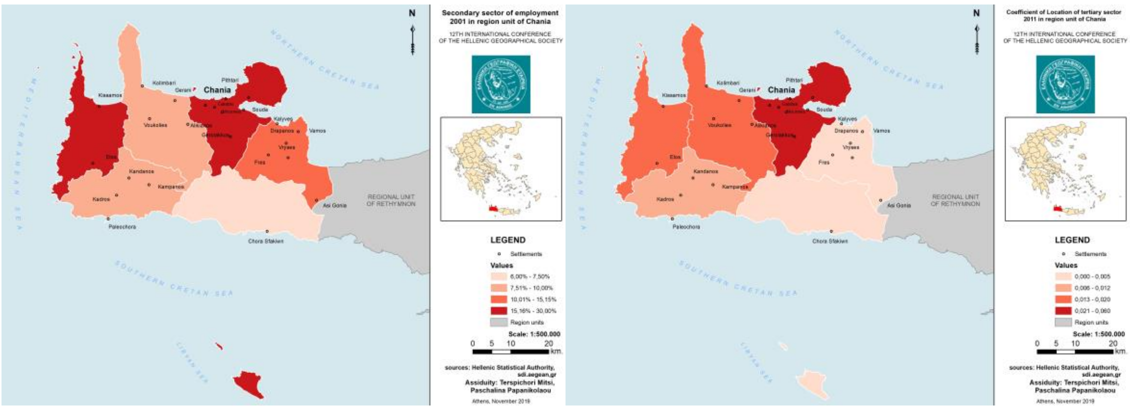

Figure 11. Map of the percentage of workforce in the secondary sector for 2001 (left) and 2011 (right)

The properties of the biophysical attributes of land and its use are the pivotal parameters in global change (Halder, 2018). In Crete as observed in the maps (figures: 11,12,13) it affects the spatial distribution of the population in the municipalities depending on the activities the land use offers. In Figure 11 can be observed the fact that the highest percentages of primary sector are in the southern part of the regional unit of Chania, in contrast to the north-eastern part. As well as in the figure 13, it can be depicted that employment in the northern part of the regional unit is occupied by the tertiary sector, resulting to the small percentages in the primary one.

The Gini – Hirschman Index measures inequality, as it is seen on the table below, the results are closer to 100. This means that there is inequality in the distribution of the workforce between the sectors. As it was mentioned before, most of the working population lives in the northern part of the region, so it's expected to have inequalities.

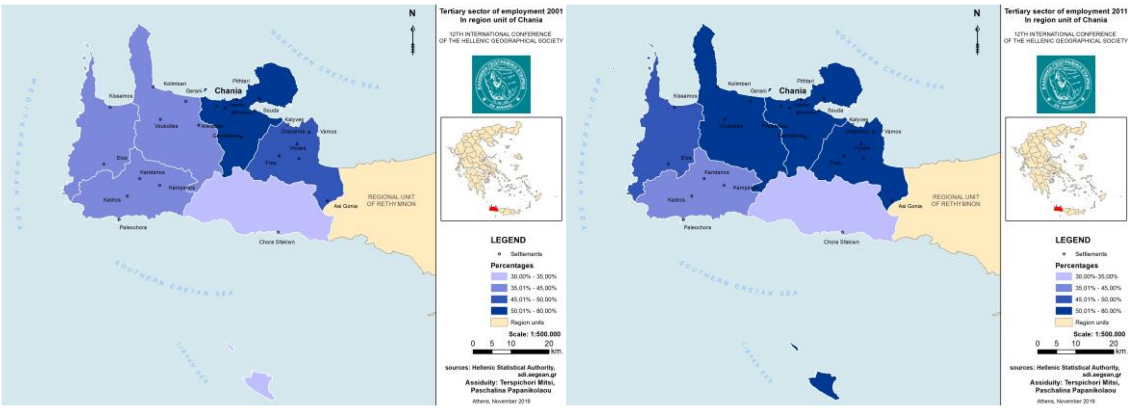

Figure 12. Map of the percentage of workforce in the tertiary sector for 2001 (left) and 2011 (right)

Table 5: Results for the Gini – Hirschman Index

Gini – Hirschman Index	Primary Sector	Secondary Sector	Tertiary Sector
2001	44.66	74.80	78.65
2011	43.87	77.78	80.21

3.2 Remotely Sensed Techniques

The dataset consists of 6 images from the Landsat Collection, which were mosaicked together to have the full scene. The date of the images corresponds to the most recent census data, 2001 and 2001, and the current year, 2019. All the acquired images are downloaded from the USGS website (https://earthexplorer.usgs.gov/) and are free of charge. The images are generated at a 30 - meter spatial resolution and they are in Level – 2 format. That kind of format provides an estimate of the surface reflectance as it would be measured in the absence of atmospheric effects like absorption at ground level (USGS,2019). As mentioned above the spectral indices NDVI (Normalized Difference Vegetation Index), NDBI (Normalized Difference Built-up Index) and the BUI (Built-up Index) were calculated.

Table 6: Formulas for each index

Index	Formula
NDVI	$\frac{NIR - RED}{NIR + RED}$
NDBI	$\frac{SWIR - RED}{SWIR + RED}$
BUI	$NDBI - NDVI$

Before calculating the indices, the images were stacked using only the desired bands, RED, NIR and SWIR (3-4-5 for Landsat 5 and 7 and 4-5-6 for Landsat 8). Also, as it was mentioned above, the 6 images were mosaicked, to 3 for the purpose to have the full scenery. Then, the images were clipped by a vector mask layer to the extent of the study area to minimize the size of the data and make them more manageable. After completing those steps, the indices were calculated and the outputs are 3 binary images for each year, with value range -1 to 1. In NDVI 0 means the absence of vegetation, the negative values represent the water features and the positive the thickness of the vegetation. In NDBI the urban areas have positive values and the unbuilt area like woodland and farmland pixels and waterbodies have negative values (Zha et al, 2003). After calculating the indices, the results were visually interpreted to maps with the most suitable colors for each case.

From NIR to SWIR band, the values which represent built up areas experience a major increment compared to vegetation, whose DNs are not appreciable (Zha et al 2003; Karanam & BabuNeela, 2017). This increment can be seen between the bands and it allows the separation of the built-up pixels from the other land cover. That is the reason NDBI has positive values for urban regions. Therefore, the subtraction of NDBI and NDVI equals the BUI who allows the built-up area to be mapped automatically (Karanam & BabuNeela, 2017).

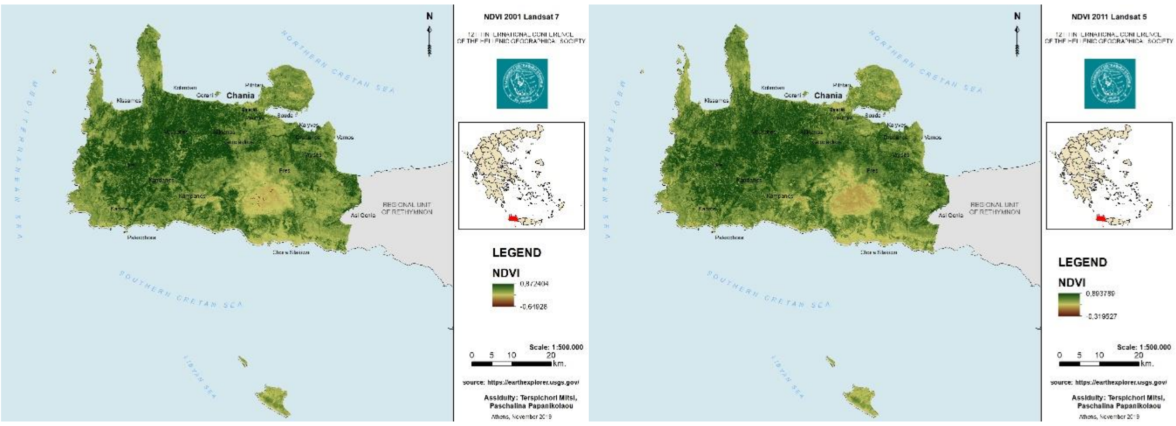

Figure 13. NDVI for 2001 (left) and 2011 (right)

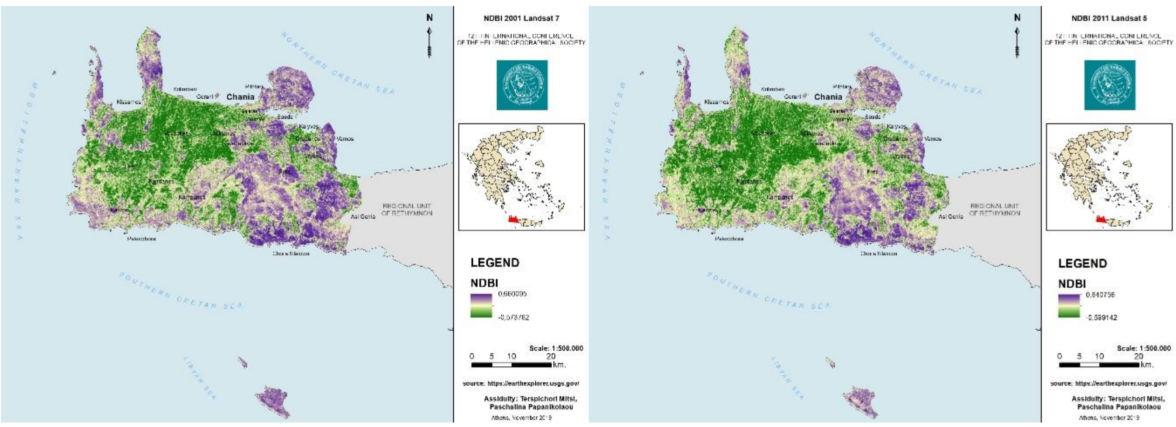

Figure 14. NDBI for 2001 (left) and 2011 (right)

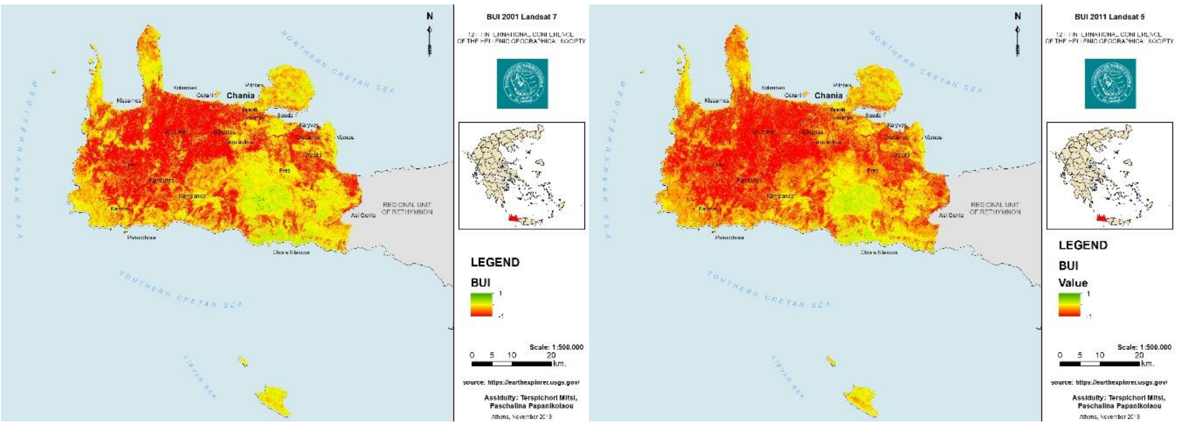

Figure 15. BUI for 2001 (left) and 2011 (right)

While observing the maps, the NDBI values for 2001 and 2011 are similar, even if the population in 2011 was larger than in 2001 (2001:148.450 and 2011: 156.585). So, it's safe to imply that the number of buildings or the percentage of built up area is not affected by the population. The built-up index has almost the same result as the NDBI.

As far it concerns 2019, there are not available population data to compare the indices. So, a population estimate model was used. The model takes into account the population for the two past censuses and was proposed by Rives and Serow (1984) and can be used to estimate the population size of a subset of the population, or the total size of a population between census periods.

Table 7: Population estimate for 2019 and formula

Municipality	2001	2011	2019 estimate	Formula
Chania	98,202	108,642	116,994	Pest = $P_1 + n/N*(P_2 – P_1)$
Apokoronos	12,112	12,807	13,363	P_1: Population of the second to last census P_2: Population of the last census n: number of months from P_1 census to the date of the estimate N: number of months between P_1 and P_2
Gavdos	81	152	209	
Kandanos – Selino	6,302	5,431	4,734	
Kissamos	11,470	10,790	10,246	
Platanias	17,864	16,874	16,082	
Sfakia	2,419	1,889	1,465	
Total	**148,450**	**156,585**	**163,093**	

Source: Hellenic Statistical Authority; Rives & Serow, 1984

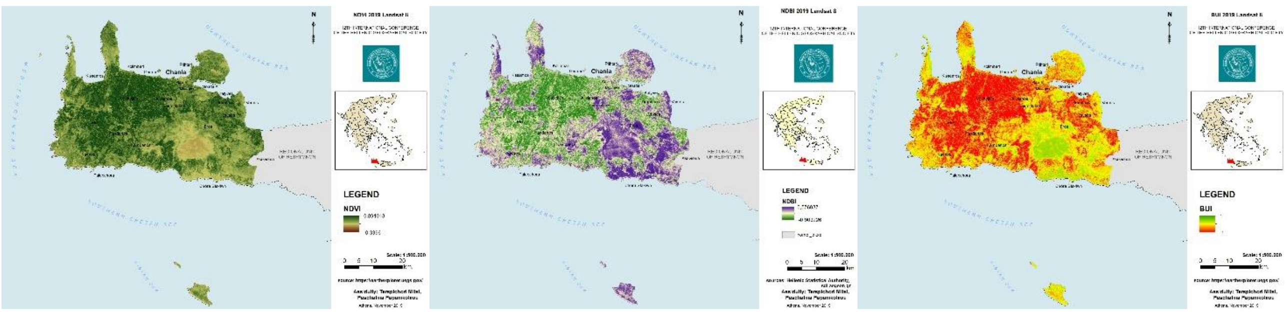

Figure 16. NDVI (left), NDBI (center) and BUI (left) for 2019

The value of NDBI for 2019 is lower than in 2001 and 2011. This is might be because many buildings might be demolished. However, the BUI value is close to 1, this could be justified because the predicted population is larger than the one in the last census. Nevertheless, the results for 2019, are estimates and they do not realistically represent the present situation.

3.3 Linear Regression

After, comparing the results of the indices with the population models, the values of NDBI and BUI were correlated with the actual population data of each year. To do so, a simple linear model was executed which had as input the population of the different municipalities in the county and the mean built up value for each corresponding to a municipality polygon. Linear regression is used for finding the relationship between target and one or more predictors. Its equation is of the form Y = a + bX, where X is the explanatory variable and Y is the dependent variable. In this case the population was set as a dependent variable and the indices as explanatory variables.

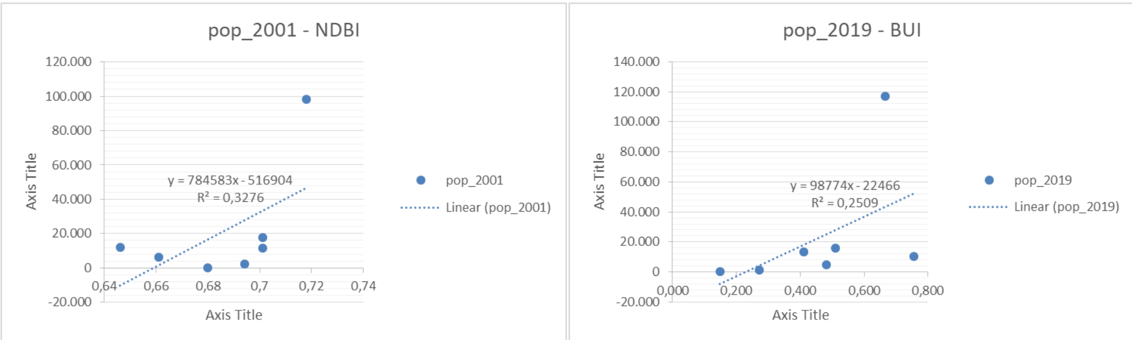

Figure 17. Scatter plots for pop2001 – ndbi (left) and pop2019-bui (right)

While observing the statistical relations between the variables, the ones with the strongest relations are the correlation between the population for 2001 and the NDBI and the correlation between the population for 2019 and the BUI. The other correlations had low significance therefore they are not considered statistically important. The strongest relation is between the population for 2001 and the NDBI with R^2 = 0.327. The result is of low statistical importance but it confirms the fact that the focalization of the population in a place can't be confirmed by the percentage of a buildup index, but a quantitative method based on the rate of employment is more accurate. The estimated population of 2019 was correlated with the BUI and the result was also of low statistical importance (R^2 = 0.25).

Table 8. The result for each index by year

Municipality	Population			NDBI			BUI		
	2001	2011	2019	2001	2011	2011	2019	2019	2019
Chania	98,202	108,642	116,994	0.718	0.596	0.292	0.296	0.683	0.666
Apokoronos	12,112	12,807	13,363	0.646	0.612	0.276	0.293	0.980	0.411
Gavdos	81	152	209	0.68	0.307	0.576	0.269	0.127	0.148
Kandanos - Selino	6,302	5,431	4,734	0.661	0.641	0.288	0.271	0.529	0.481
Kissamos	11,470	10,790	10,246	0.701	0.498	0.357	0.260	0.864	0.756

Platanias	17,864	16,874	16,082	0.701	0.634	0.299	0.649	0.508	0.511
Sfakia	2,419	1,889	1,465	0.694	0.661	0.334	0.286	0.580	0.270

4. CONCLUSIONS

Before 1970 the economy of Chania was based on the primary sector, because most of the habitants were occupied with agriculture and specifically with olive, vineyards and the production of wine. In general, the share of irrigated land in Crete is lower than the national average, causing minimal vegetation (OECD, 2005). Nowadays, the population is occupied with the primary sector but less than before. (P.Papadimitriou, N. Boussia, 2019)

Most of the population is employed in the tertiary sector because of the high tourism demand. The northern side of Chania has been shaped for tourist accommodation, with hotel units and restaurants, also travel and car rental agencies. As a result, the habitants left behind the agricultural production, while the land is the most asset that offers goods and resources by its utilization from the inhabitants (Halder, 2018).

However, the tertiary sector is not exclusively related to tourism but also about education. In Chania, is accommodated the Technical University of Crete and most schools.

The large participation it the northern part of the regional unit of Chania is proved by the value of the Location Quotient of the tertiary sector that exceeds, especially in 2011 (figure 4). Furthermore, the least demand of the primary production sector is observed by Coefficient of Localization. In the northern part of Chania, the values tend more to one. As a result, the activity in the sector is established differently in relation to the total productive activities (figure 8). Also, while observing the values of the Coefficient of Specialization of the tertiary sector, the equal development of the activity is obvious (figure 7). Moreover, from the maps about productive sectors (figures: 11,12,13) and table 4 are inferred that the economy of Chania depends on the primary and tertiary sectors. The southern part of the regional unit is mainly occupied in the primary sector and the northern part, in the tertiary sector.

Chania is one of the most developed regions in Crete. Especially the northern part is the most flourished. The northern part includes some of the most visited places in the island, like Chania, Elafonisi, Paleochora, Balos, Chora Sfakion and Agia Roumeli. So, most of the population is clustered in the northern part, consequently the largest part of workforce, because of the augmented tourism. Throughout 2001 – 2011, the tertiary sector is the one with the most employees, comparatively with the primary and secondary, which has the lesser number of workforces. The results of the analysis are summarized to the table below.

Table 9: Percentage Change of workforce in the production sectors between 2001 and 2011

Percentage (%)	Primary Sector	Secondary Sector	Tertiary Sector
Chania	- 44.42%	- 18.12%	16.48%

Source: Hellenic Statistical Authority

According to the analysis and the table, the tertiary sector is the most developed and the one with the most employees. Notably, it was the only sector who had an augmentative rate compared to the other two sectors. The last years, because of the high tourism most of the Cretan workforce is employed to it. That is why the primary sector has the most reduced rate.

As it was mentioned before, the most developed part of the region is the northern. Also, it is the more habituated and that could be observed at the NDBI and BUI maps (Higher value of indices at the northern part). However, the urban spread is not directly linked to the population as it was confirmed by the regression. The population growth depends more to the employment vacancies, so the people move by that. In conclusion, it is perceived that the population growth in the study area depends to the also augmented tourism.

REFERENCES

Clarke R., and Davis S. W. (1983), Aggregate concentration, Market concentration and diversification, *The Economic Journal*, 93, p. 182-192.

Gomez T. - J., Stair, C., Gomez, S., & Tomas, J. (2017). Regional Research Institute Technical Documents Regional Research Institute, 10.

González M.- J. (2017). PLANNING, URBAN SPRAWL AND SPATIAL THINKING., *European Journal of Geography*, 8

Haig R.-M. (1928), New York: Regional Plan of New York and its environs, VOL I: Population, land values and government, New York, Committee on a regional plan of New York

Halder J. C. (2018). Population change and land use dynamics: A case study of Paschim Medinipur District, West Bengal, India. European Journal of Geography, 9, 3, p. 23–44

Hoover E. M. (1936), The Measurement of Industrial Localization, *Review of Economics and Statistics*, 18, p. 162-171.

Hoover E. M. and Giarratani F. (1971), An introduction to regional economics, Knopf, New York

Jacquemin A. and Berry C. (1979), Entropy measure of diversification and corporate growth, *The Journal of Industrial Economics*, 27, p. 359-369.

Joseph, A. E. (1982). ON THE INTERPRETATION OF THE COEFFICIENT OF LOCALIZATION. In the Professional Geographer, 34, 4. John Wiley & Sons, Ltd.

Karanam H.-K. & BabuNeela V. (2017), Study of normalized difference built-up (NDBI) index in automatically mapping urban areas from Landsat TM imagery, *International Journal of Engineering, Science and Mathematics*, VOL: 6, 8, p. 239 – 248

North D. C. (1955), Location theory and regional economic growth, *The Journal of Political Economy*, p. 243–258

OECD (2005). PLACE-BASED POLICIES FOR RURAL DEVELOPMENT CRETE, GREECE (CASE STUDY), p. 17-22. Paris

Osgouei P.E., Kaya S., Sertel E. and Alganci U. (2019), Separating Built-Up Areas from Bare Land in Mediterranean Cities Using Sentinel-2A Imagery, *Remote Sens*., 11, 345

Rana S. & Hossein F. (2013), An Overview on Coefficient of Localization &Localization Curve and Their Application Opportunities in the Context of Bangladesh, *IOSR Journal of Humanities and Social Science*, 12, 3, p. 72-77

Rives N - W. and Serow W. – J. (1984), Quantitative applications in the social sciences: Paper 39, Introduction to Applied Demography: Data Sources and Estimation Techniques, Newbury Park: Sage Publications

Robinson H., Morrison J.-L., Muehrcke P. – C., Kimerling A.-J. and Guptill S. (2002), Στοιχεία χαρτογραφίας, Πανεπιστημιακές εκδόσεις Ε.Μ.Π., Αθήνα

Rouse, J. W., R. H. Haas, J. A. Schell & D. W. Deering (1973). Monitoring vegetation systems in the Great Plains with ERTS, *Third ERTS Symposium*, NASA SP-351 I, 309-31

Zha H., Gao J. & Ni S. (2003), Use of normalized difference built-up index in automatically mapping urban areas from TM imagery, International Journal of Remote Sensing, VOL:24, 3, p. 583-594

USGS (2019), USGS EROS Archive - Landsat Archives - Landsat 8 OLI/TIRS Level- 2 Data Products - Surface Reflectance, Surface Reflectance Level-2 Data Products at a 30-meter spatial resolution can be ordered for Landsat 8 OLI/TIRS Collection 1 scenes. (2013-present), (https://www.usgs.gov/centers/eros/science/usgs-eros-archive-landsat-archives-landsat-8-olitirs-level-2-data-products?qt-science_center_objects=0#qt-science_center_objects), Date of Access 4/10/2019

P.Papadimitriou, N. Boussia, (2019). In Focus: Chania City, Greece. HVS. (https://www.hvs.com/), Date of Access 7/10/2020

Λαφαζάνη Π. (2018), Μέθοδοι και Τεχνικές στην Ανάλυση του Γεωγραφικού Χώρου, Θεσσαλονίκη

Λιβιεράτος Ε. (1985), Γενική χαρτογραφία και εισαγωγή στη θεματική χαρτογραφία, Εκδόσεις Ζήτη, Θεσσαλονίκη