Chapter 6

Classification of the Greek counties using the NPMLE application results

The mapping of the previous paragraph can also be done for the rest years and offenses, but it will only give a picture of one offense in a given year. In order to have a picture for a given offense during the whole time period 1987-1997, or a picture for a given year for all available offenses, or even for all available offenses for the whole time period, we need to further classify the obtained results.

In this chapter we classify the Greek counties using the results obtained from the NPMLE application. We first replace the obtained cluster membership by the mean λ of that cluster. Using the mean number of offenses instead the cluster memberships we can cluster the Greek counties using known hierarchical clustering methods. Since Centroid and Ward's methods tend to give spherical clusters (Everitt, 1993), the Complete Linkage method calculating the Euclidean distances will be used.

In order to select the number of clusters for each classification the Mojena's (1977) stopping rule with the Milligan and Cooper's (1985) correction will be used. Mojena's stopping rule suggests that one should select the number of groups corresponding to the first stage in the dendrogram satisfying the condition

$$\alpha_{j+1} > \bar{\alpha} + k s_{\alpha}$$

where $\alpha_0, \alpha_1, ..., \alpha_{n-1}$ are the fusion levels corresponding to stages with $n, n-1, ..., 1$ clusters. The terms $\bar{\alpha}$ and s_{α} are, respectively, the mean and unbiased standard deviation of the α values and k is a constant. Mojena suggests that values of k in the range 2.75 to 3.50 give the best results.

Milligan and Cooper (1985) reported a detailed investigation of indices for the number of groups and found that Mojena's stopping rule is one of the three most satisfactory criteria. However, they suggest that the value of k for Mojena's stopping rule should be 1.25. This is the value of k that we will use in our application.

The statistical package used for the classifications of Greek counties is Minitab 14.

For a further discussion on the hierarchical clustering methods and the corresponding stopping rules for selecting the number of clusters see Everitt, 1993.

6.1 Clustering of Greek counties per offense activity

6.1.1 Taking the law into one's hands

The first offense used for the clustering of the Greek counties is the cases of taking the law into one's hands. Using the obtained fusion levels of the hierarchical clustering, we calculated Mojena's stopping rule. The mean $\bar{\alpha}$ was found to be 389.5856 with standard deviation s_α=458.0369, resulting to a value of 962.1317 for the stopping rule. In the sequence we noticed that for $\alpha_5 = 991.56 > 962.1317$ the condition is for the first time satisfied. Thus, we should keep four clusters. The obtained dendrogram with the four clusters is given in figure 58.

We notice that Zakynthos and Kerkyra are left not clustered with any other county. Average number of cases of one taking the law into one's hands per year for Kerkyra is 669.12, while for Zakynthos is 486.21. Arkadia, Dodekannhsa, Ioannina, Kefallhnia, Lesbos, Messhnia and Samos are clustered together with average number of offenses 343.55. All other Greek counties are clustered together with the smallest average number of offenses equal to only 78.85 per year. The mapping of this first clustering is given in figure 59.
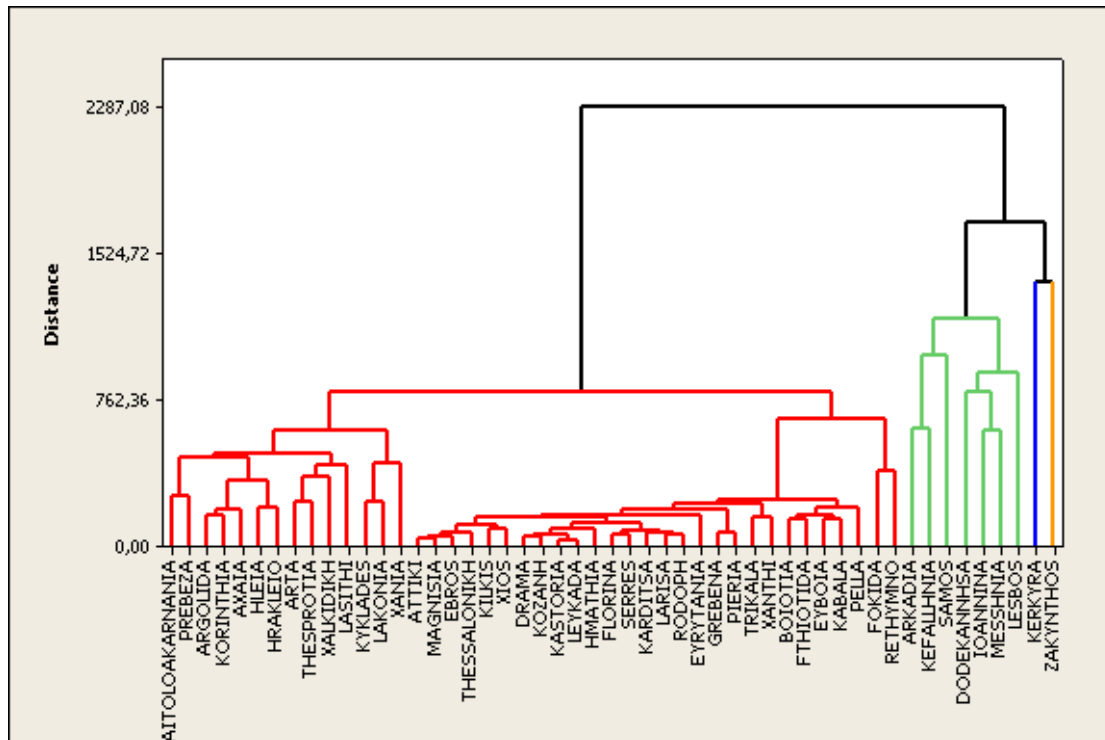
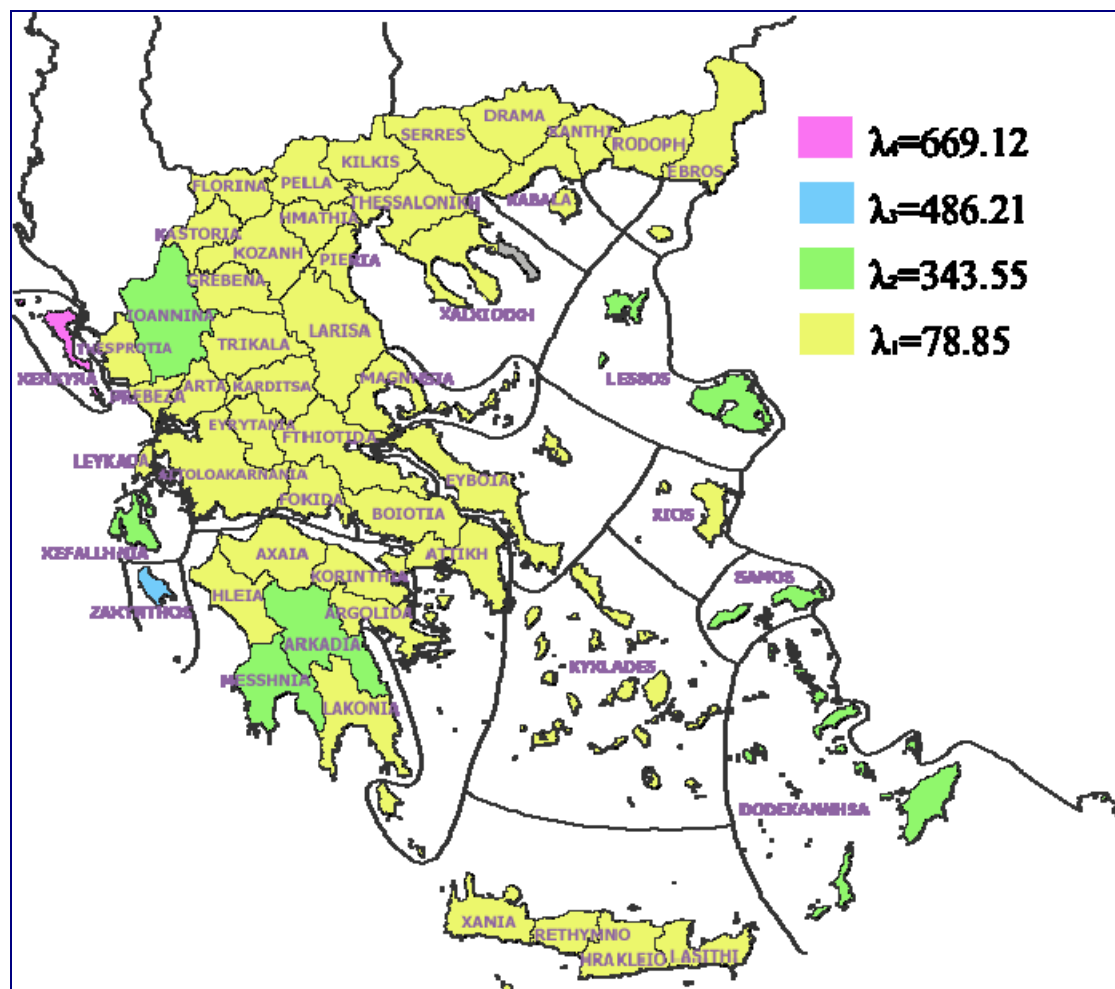**Figure 58.** Dendrogram of 'Taking the law into one's hands' using Complete Linkage.

Figure 59. Mapping of Greek counties according to 'taking the law into one's hands'.

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6.1.2 Arsons

In this paragraph we cluster Greek prefectures according to arson counts for the period 1987-1997. The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 78.36574 with standard deviation s_{α}=102.44959, resulting to a value of 206.4277 for the stopping rule. The condition $\alpha_5 = 212.105 > 206.4277$ holds for the first time at stage 5, resulting as before in four clusters. The obtained dendrogram with the four clusters is given in figure 60.
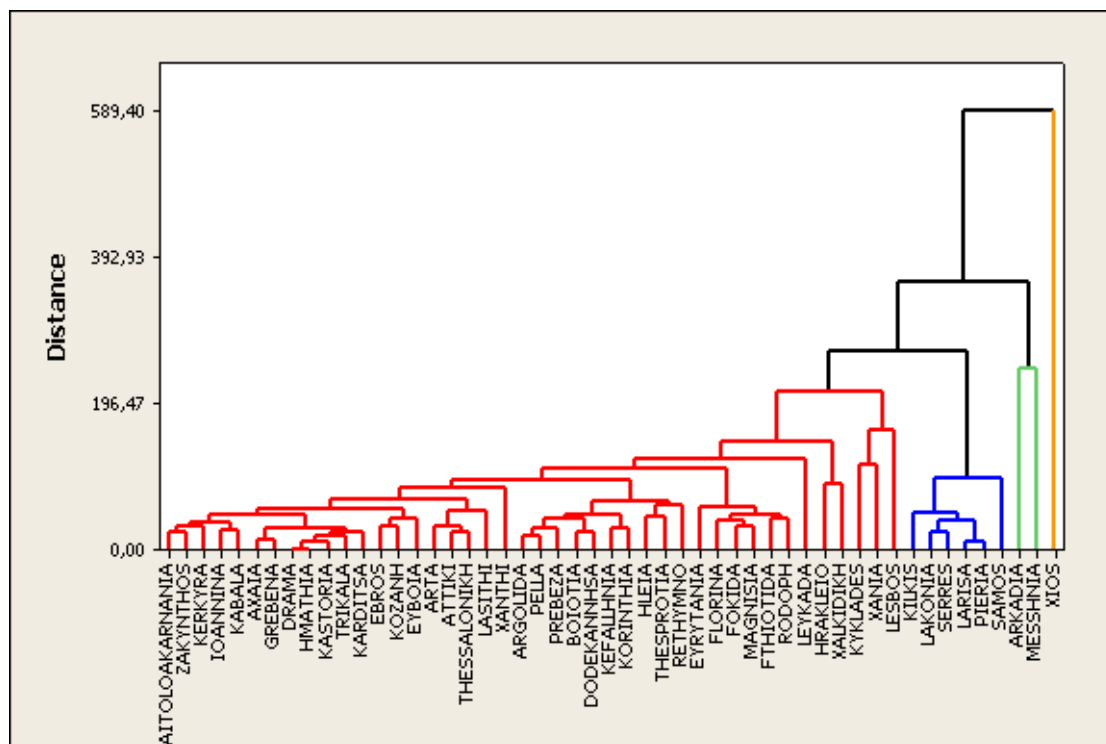
Figure 60. Dendrogram of 'Arsons' using Complete Linkage.

In this clustering, Xios is not clustered with any other prefecture, with 115.39 average arsons per year. Knowing Greek culture, this is probably because of two Xios villages habitats Easter rocketeers. Arkadia and Messhnia are the next cluster with average of 60.61 arsons. Kilkis, Lakonia, Larisa, Pieria, Samos and Serres follow as the next cluster with 33.46 average arsons. All the other counties are forming the last cluster with 16.69 average arsons.

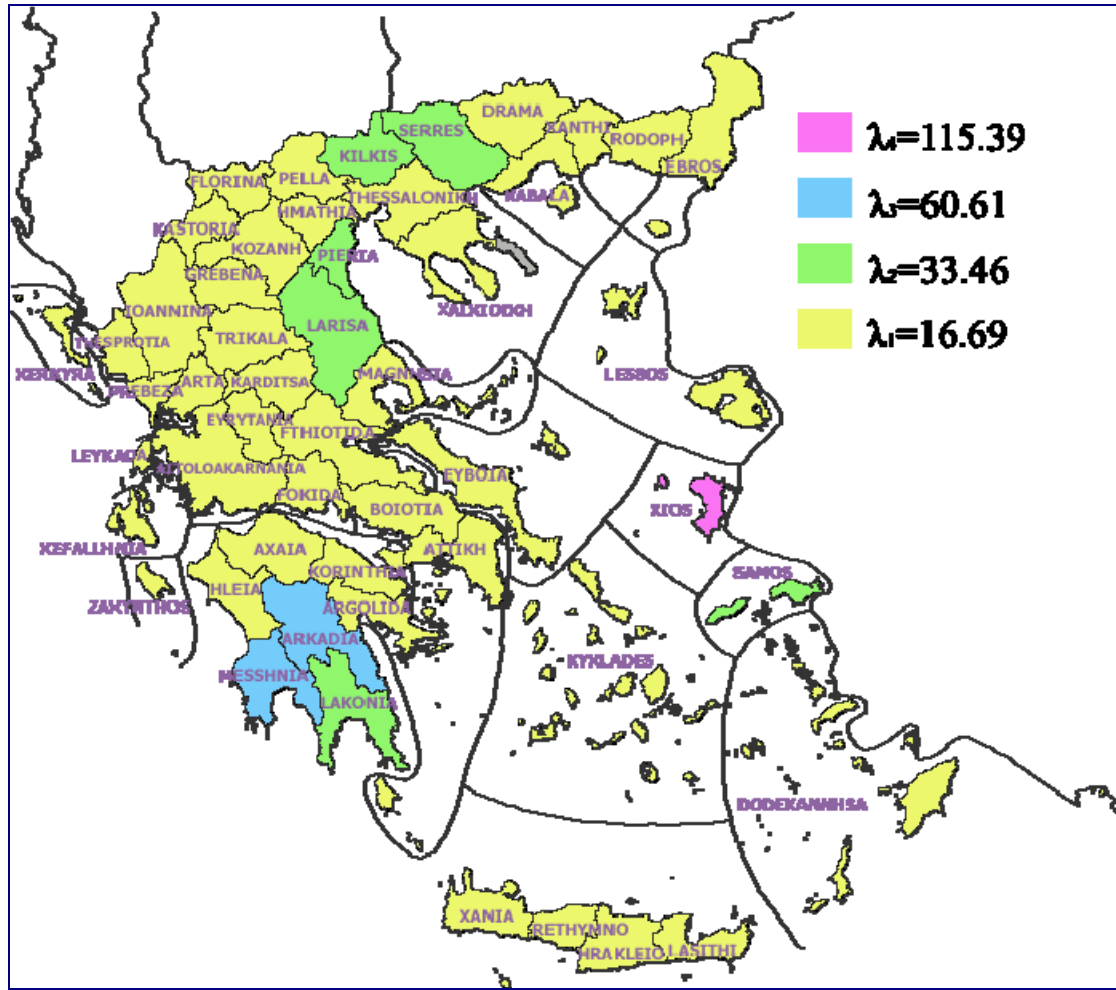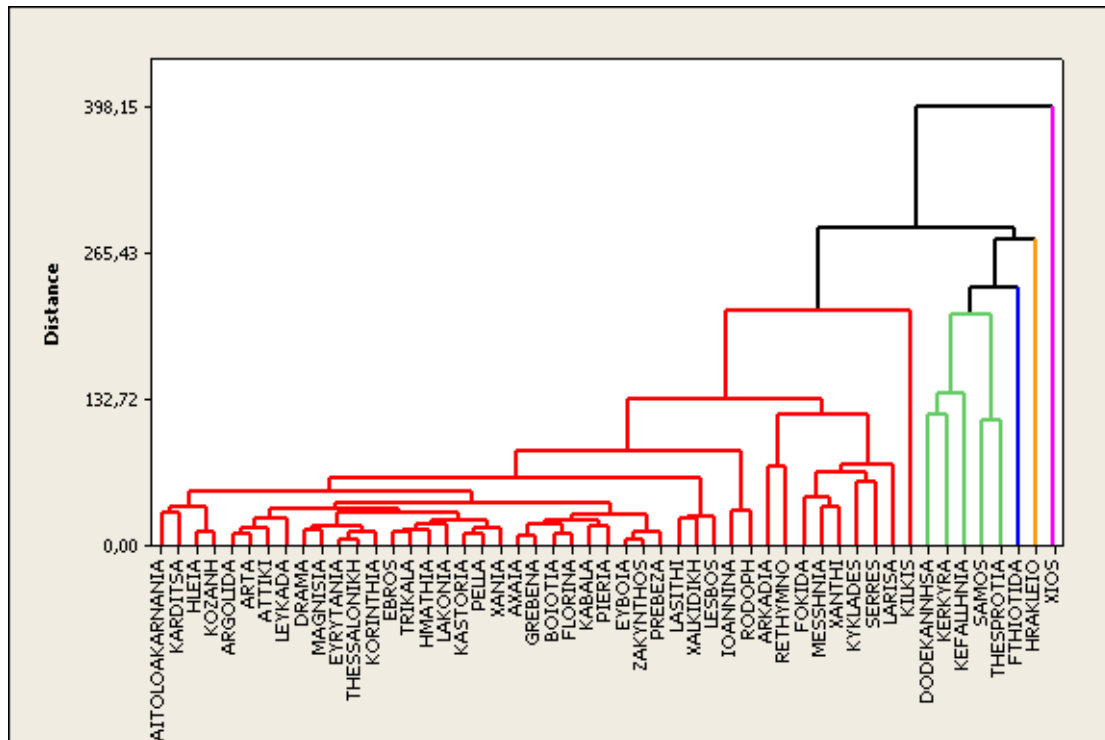The mapping of Greek counties according to arsons counts is given in figure 61.

Figure 61. Mapping of Greek counties according to 'Arsons'.

6.1.3 Offenses concerning antiquities

In the sequence we cluster Greek counties according to offenses concerning antiquities. The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 67.2978 with standard deviation s_α=86.16687, resulting to a value of 175.00641 for the stopping rule. The condition is satisfied for the first time at stage 6, giving $\alpha_6 = 209.333 > 175.00641$ and resulting in five clusters. The obtained dendrogram with the five clusters is given in figure 62.

We notice that the counties of Xios, Hrakleio and Fthiotida are not clustered with any other county, with average numbers of offenses 60.68, 62.77 and 74.66, respectively. The next cluster is forming by the counties of Thesprotia, Samos, Kefallhnia, Kerkyra and Dodekannhsa. The average

number of offenses for this cluster is 34.14. All other prefectures belong to the last cluster with average number of offenses equal to 12.31.

Figure 62. Dendrogram of 'Offenses concerning antiquities' using Complete Linkage.

Due to the history of Greek civilization that goes thousand years ago, one might expect higher counts of offenses concerning antiquities. Therefore, one could be relieved of the results. However, these are only the reported offenses, and even in that numbers are still a menace for our ancient treasures.

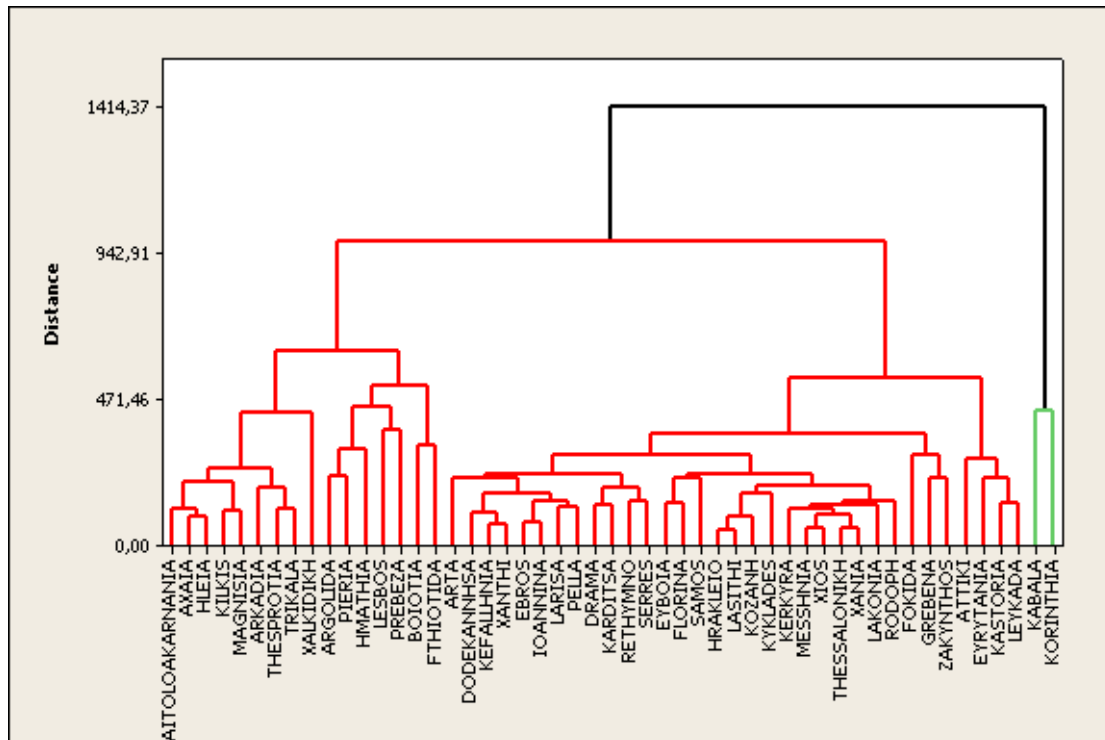Figure 63 gives the mapping of the clustering of Greek counties according to offenses concerning antiquities.
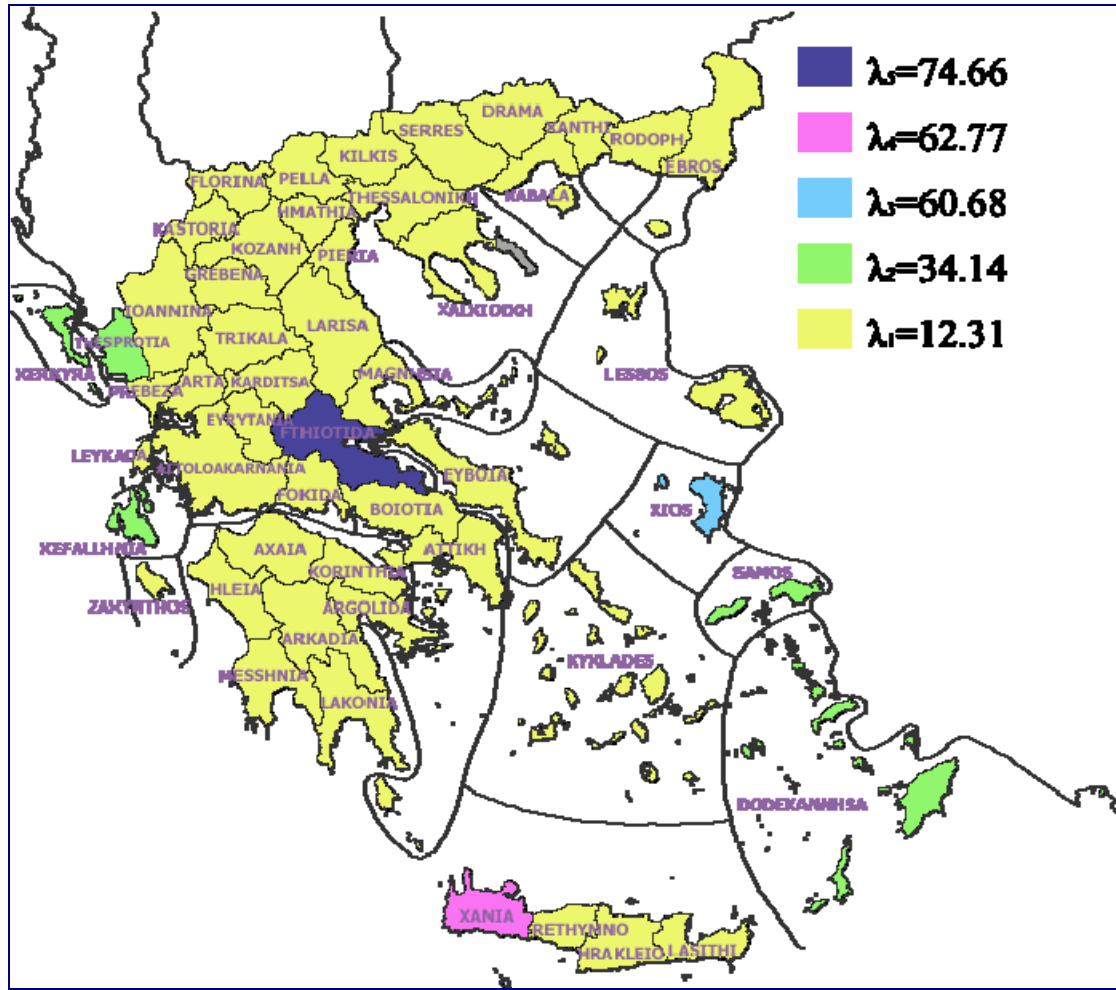
Figure 63. Mapping of Greek counties according to 'Offenses concerning antiquities'.

6.1.4   Deaths caused by car

Deaths caused by car is the offense used to cluster Greek counties in this paragraph. In this case, $\bar{a}$=255.3894 with standard deviation s_α=239.2621, resulting to a value of 554.4670 for the Mojena's stopping rule. The condition is satisfied for the first time at stage 3, giving $\alpha_3 = 625.08 > 554.4670$ and resulting in only two clusters. The obtained dendrogram with the two clusters is given in figure 64.

The one cluster has members only the counties of Korinthia and Kabala, with 402.40 average caused deaths by car, whereas the other cluster of all the other Greek counties has an average of 161.75. One might not be surprised by this result, since the constructions on the Athens-Corinth's highway were not

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completed during that period, and the traffic there is always dense, since it is the main connecting point between both Peloponnesus and West Greece and the rest of Greek continental counties. As far as Kabala is concerned, it has the biggest port, besides the one of Thessalonica's, which is used by tracks and it connects North Greece with the most of the Aegean islands. A single car accident involving a truck can cause more than one deaths.

Figure 64. Dendrogram of 'Caused deaths by car' using Complete Linkage.

The mapping of the clustering according to caused deaths by car is given in the next figure, although there are only two clusters.
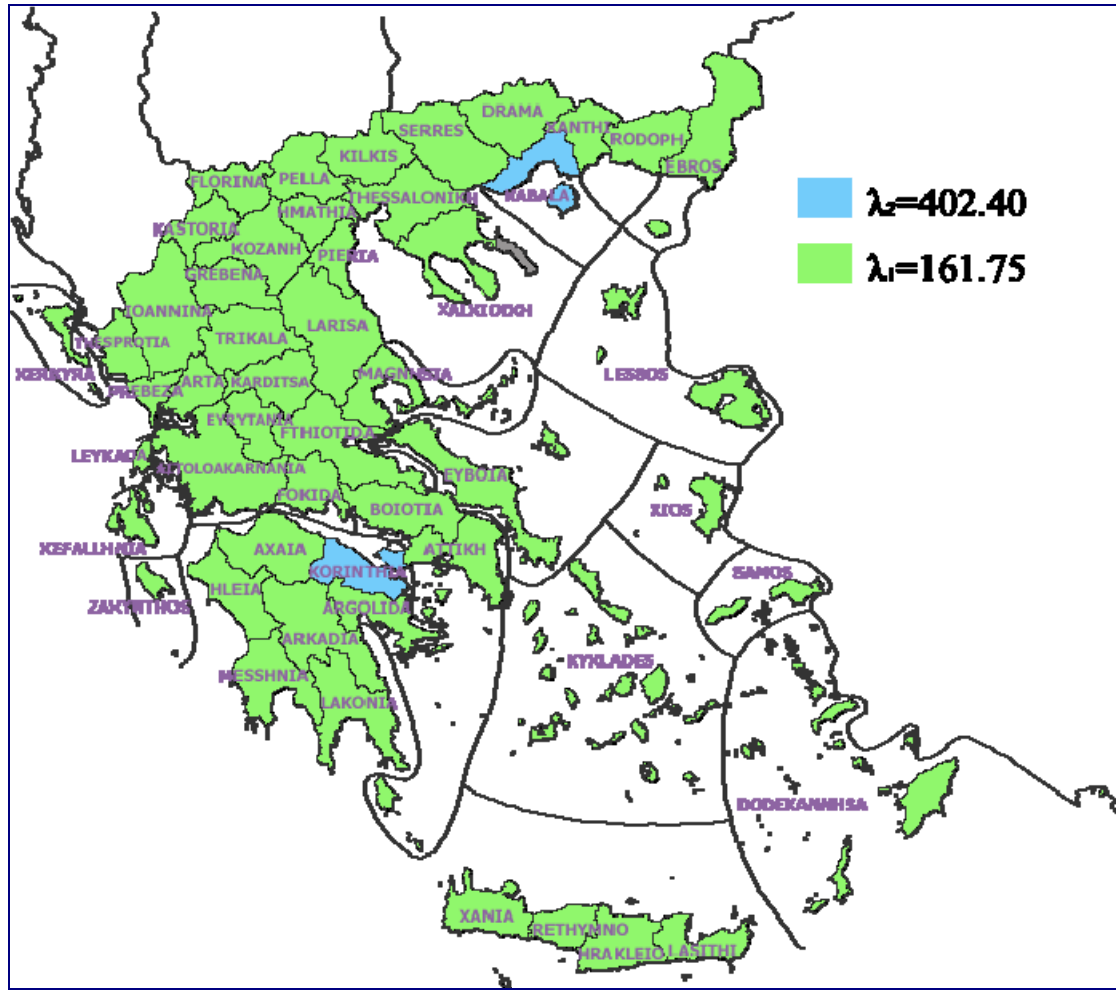
Figure 65. Mapping of Greek counties according to 'Caused deaths by car'.

6.1.5 Commonly dangerous crimes

The next clustering of Greek prefectures is according to commonly dangerous crimes. The mean $\bar{\alpha}$ of the dendrogram fusion levels was found to be 119.3224 with standard deviation $s_\alpha = 153.0163$, resulting to a value of 310.5928 for the stopping rule. We notice that for $\alpha_4 = 361.751 > 310.5928$ the condition is satisfied for the first time. Thus, we should keep three clusters. The obtained dendrogram with the three clusters is given in figure 66.

We notice that Xios is not clustered with any other county. Recalling that commonly dangerous crimes include arsons, we may assume that this is the reason why again Xios is left alone in a separate one-member cluster. The average offenses for Xios are 193.48 (whereas for the arsons was 115.39).
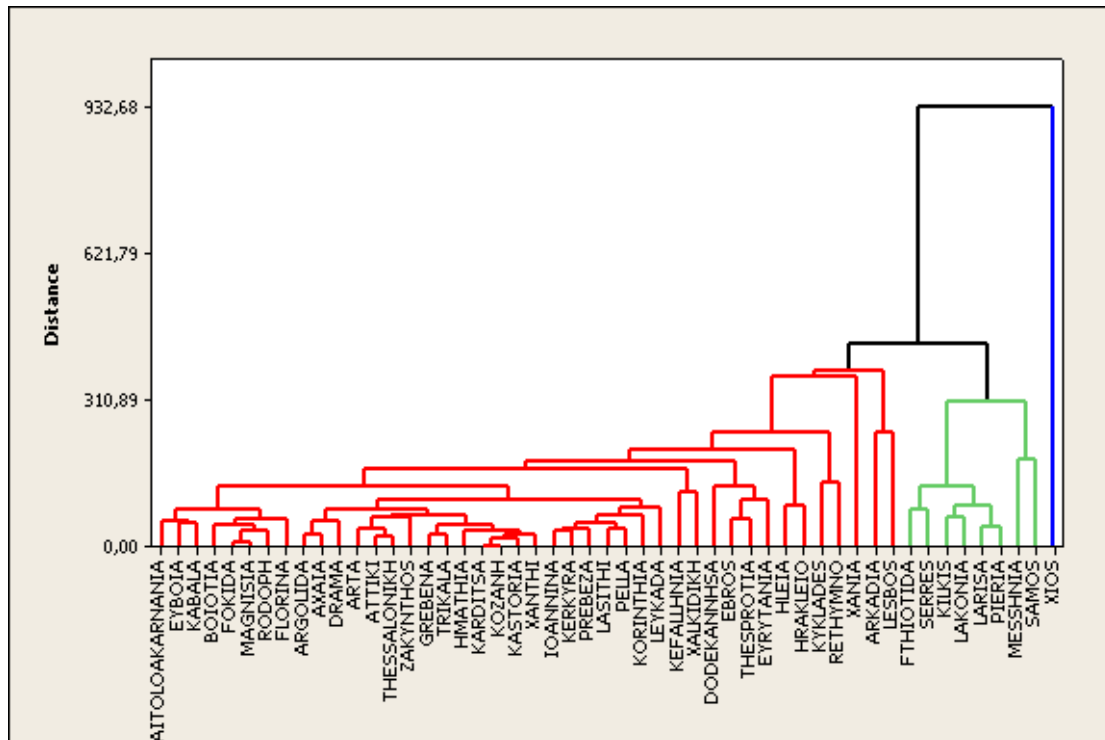
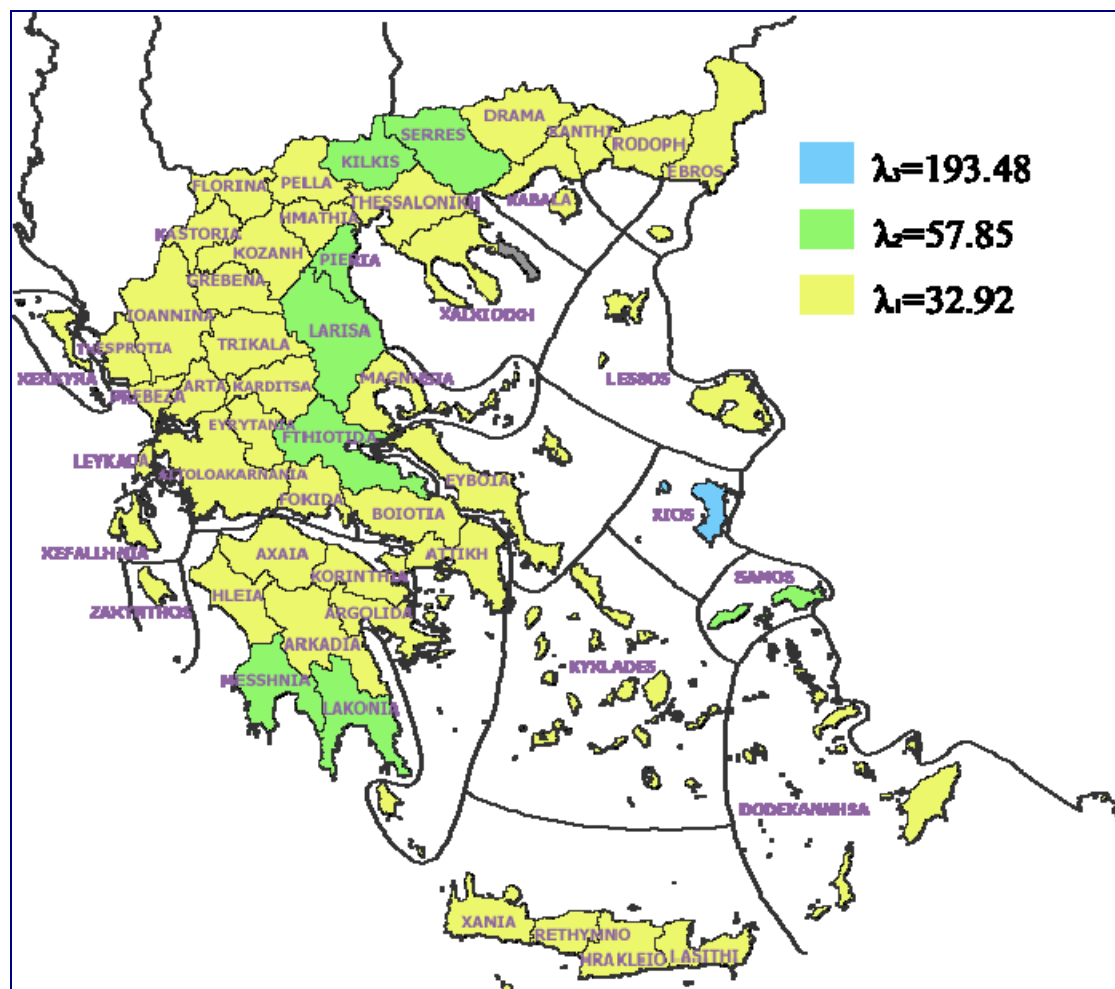**Figure 66.** Dendrogram of 'commonly Dangerous Crimes' using Complete Linkage.


Figure 67. Mapping of Greek counties according to 'Commonly dangerous crimes'.

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The second cluster includes Samos, Messhnia, Pieria, Larisa, Lakonia, Kilkis, Serres and Fthiotida with average number of offenses 57.85. The last cluster has as members all the other Greek counties with average number of offenses 32.92.

The mapping of Greek counties according to commonly dangerous crimes is given in figure 67.

6.1.6 Drug offenses

Offenses concerning drugs are the next criterion to cluster Greek counties. To select the number of clusters we will use Mojena's stopping rule as before. This time mean $\bar{\alpha}$ of the dendrogram fusion levels was found to be 233.4644 with standard deviation s_α=164.98145, resulting to a value of 439.69126 for the stopping rule. For $\alpha_4 = 483.339 > 439.69126$ the condition is satisfied for the first time. Thus, we should keep three clusters. The obtained dendrogram with the three clusters is given in figure 68.
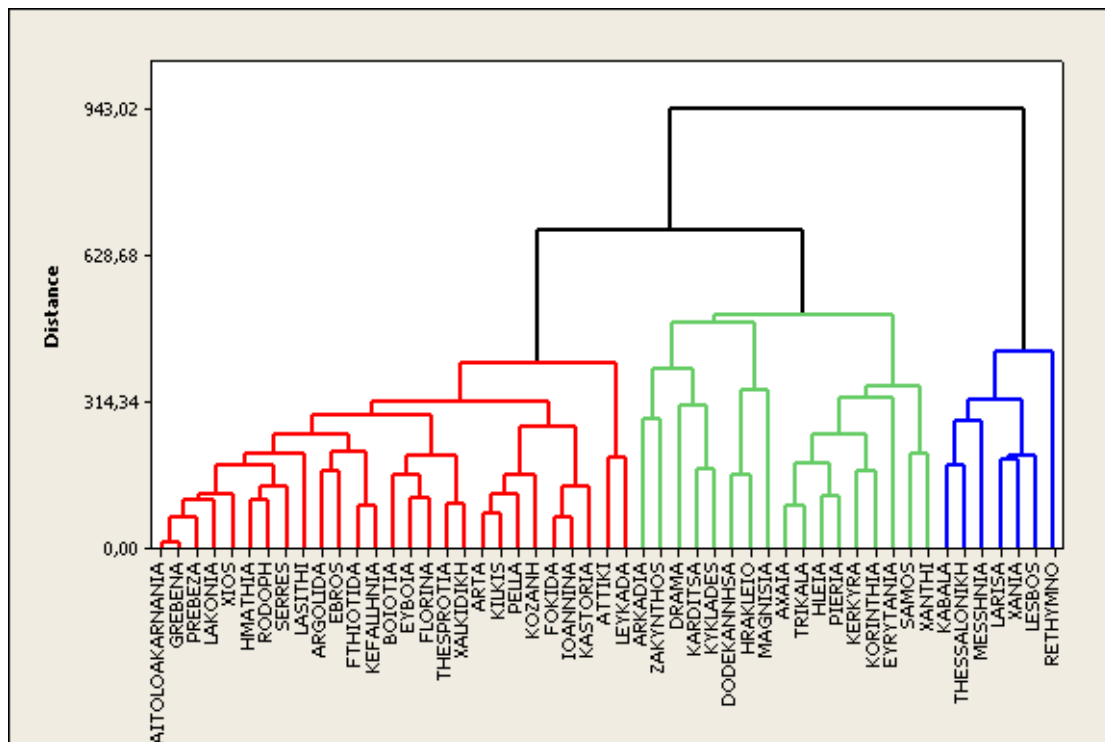
Figure 68. Dendrogram of 'Drugs offenses' using Complete Linkage.

The first cluster includes Rethymno, Lesbos, Xania, Larisa, Messhnia, Thessaloniki and Kabala with average number of offenses 259.60. The second cluster has as members the counties of Xanthi, Samos, Eyrytania, Korinthia, Kerkyra, Pieria, Hleia, Trikala, Axaia, Magnisia, Hrakleio, Dodekannhsa, Kyklades, Karditsa, Drama, Zakynthos and Arkadia with average number of offenses 171.59. The last cluster includes all other counties with 104.36 offenses in the average.

The mapping of this clustering is given in figure 69.
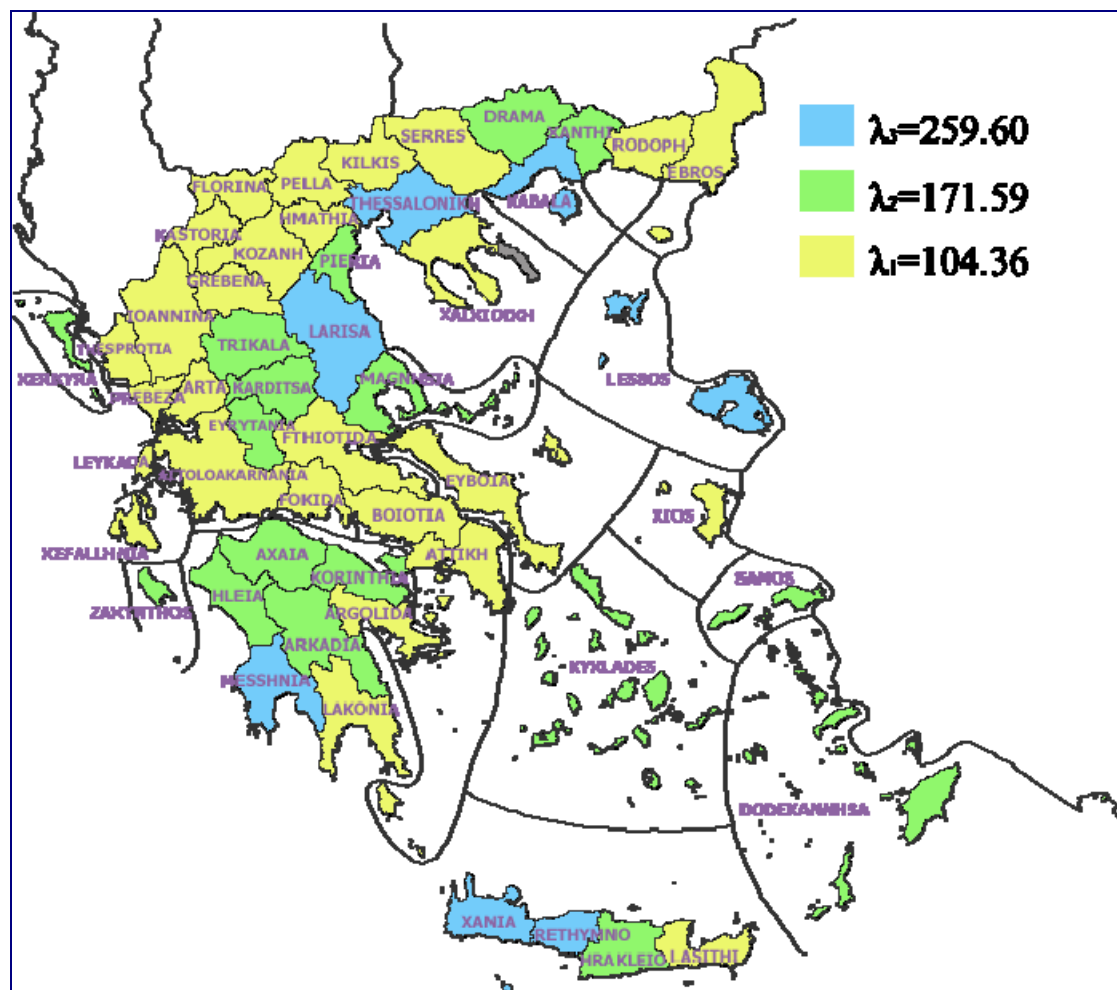
Figure 69. Mapping of Greek counties according to 'Drugs offenses'.
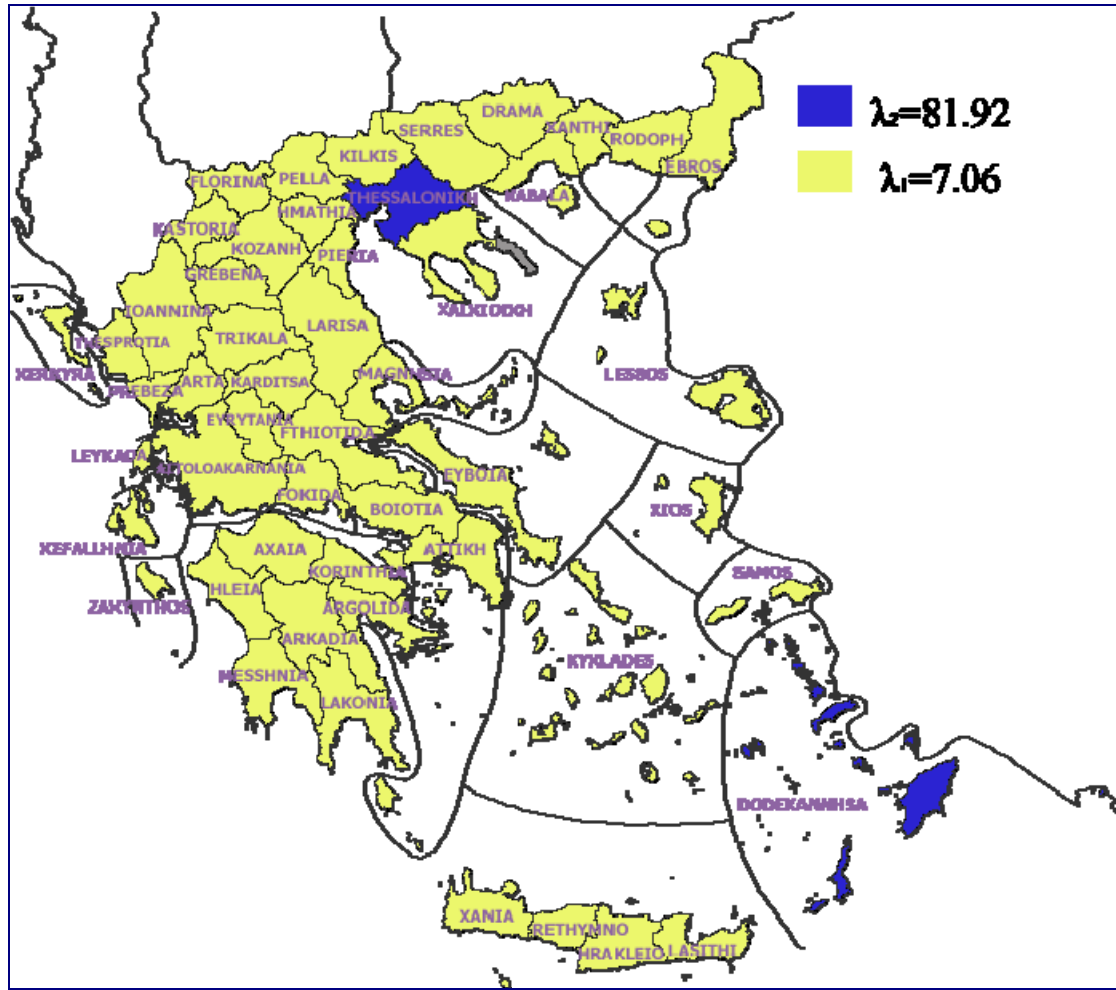
6.1.7 Beggary and vagrancy

At this point we should remind to the reader that vagrancy was abolished in 1994, thus, counts of 1995 to 1997 are only counts of beggary. In order to apply Mojena's stopping rule we calculated the mean $\bar{\alpha}$ of the dendrogram fusion levels which was found to be 61.82678 with standard deviation s_α=80.01262. As a result we got a value of 161.84256 for the stopping rule. For $\alpha_3 = 165.333 > 161.84256$ the condition is satisfied for the first time. Thus, we should keep only two clusters. The obtained dendrogram with the two clusters is given in figure 70.
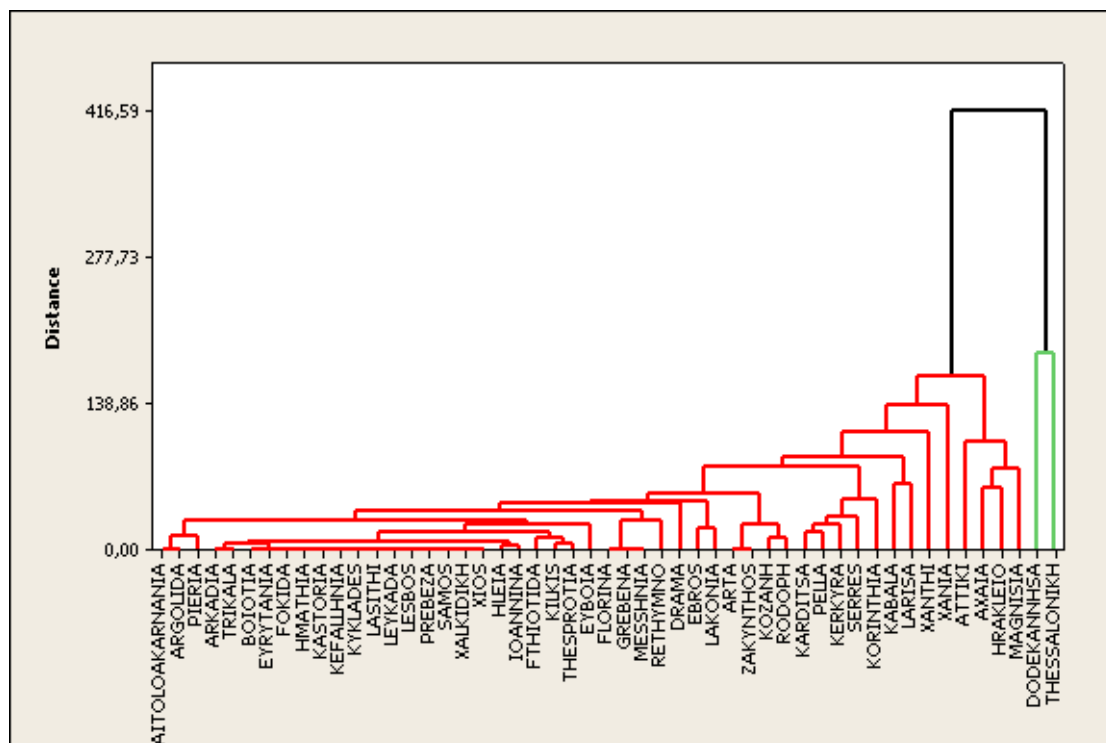
Figure 70. Dendrogram of 'Beggary and Vagrancy' using Complete Linkage.

As we can see from the dendrogram, the one cluster consists of Thessaloniki and Dodekannhsa, leaving the rest of the counties to the other cluster. The average numbers of offenses for the two clusters are 81.92 and 7.06, respectively. This is a quite unexpected result. Greek authorities should further investigate it.

The mapping of this clustering is given in figure 71.

Figure 71. Mapping of Greek counties according to 'Beggary and Vagrancy'.

6.1.8 Offenses concerning explosives

The next clustering will be done using offenses concerning explosives. We first select the number of clusters using Mojena's stopping rule. The obtained mean $\bar{\alpha}$ was 81.8732 with standard deviation s_α=75.6335, giving a value of 176.4151 for the stopping rule. The Mojena's condition is satisfied for $\alpha_5 = 177.856 > 176.4151$. Thus, we select four clusters. The corresponding dendrogram with the four clusters is given in figure 72.

Kyklades are not clustered with any other county, having an average number of offenses equal to 65.09. Samos, Lesbos and Hmathia are grouped together with 36.16 offenses in average. Dodekannhsa and Arkadia form the next cluster having an average number of offenses equal to 52.74.
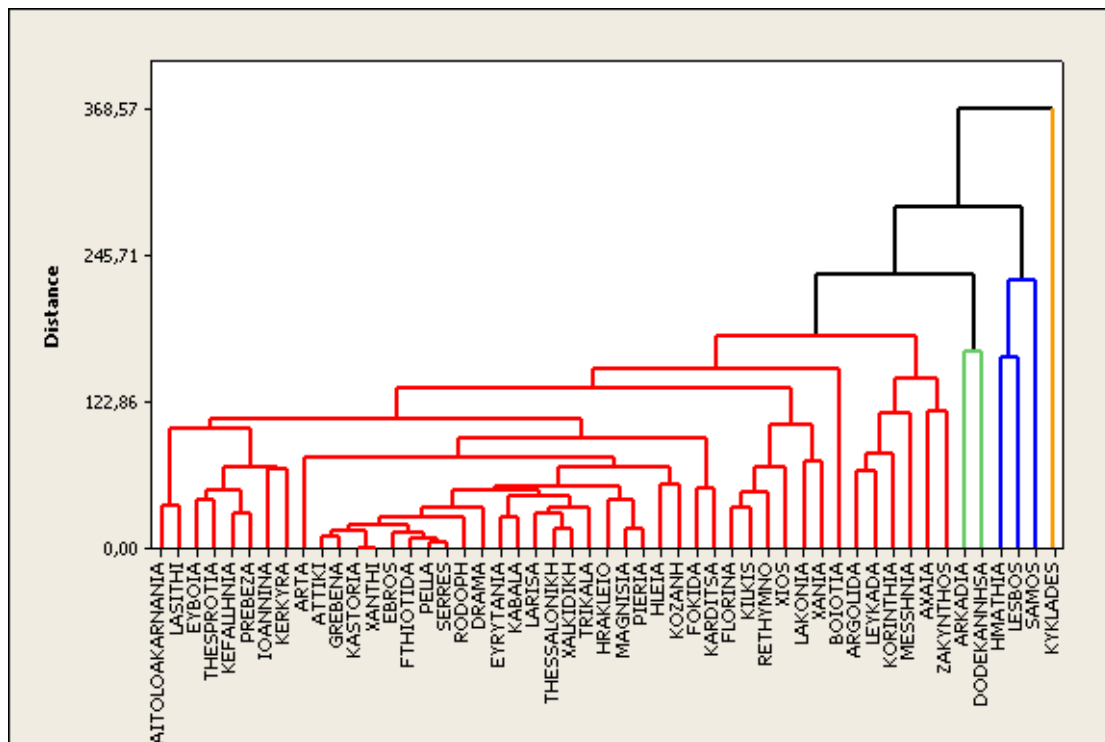
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Figure 72. Dendrogram of 'Offenses concerning explosives' using complete Linkage.
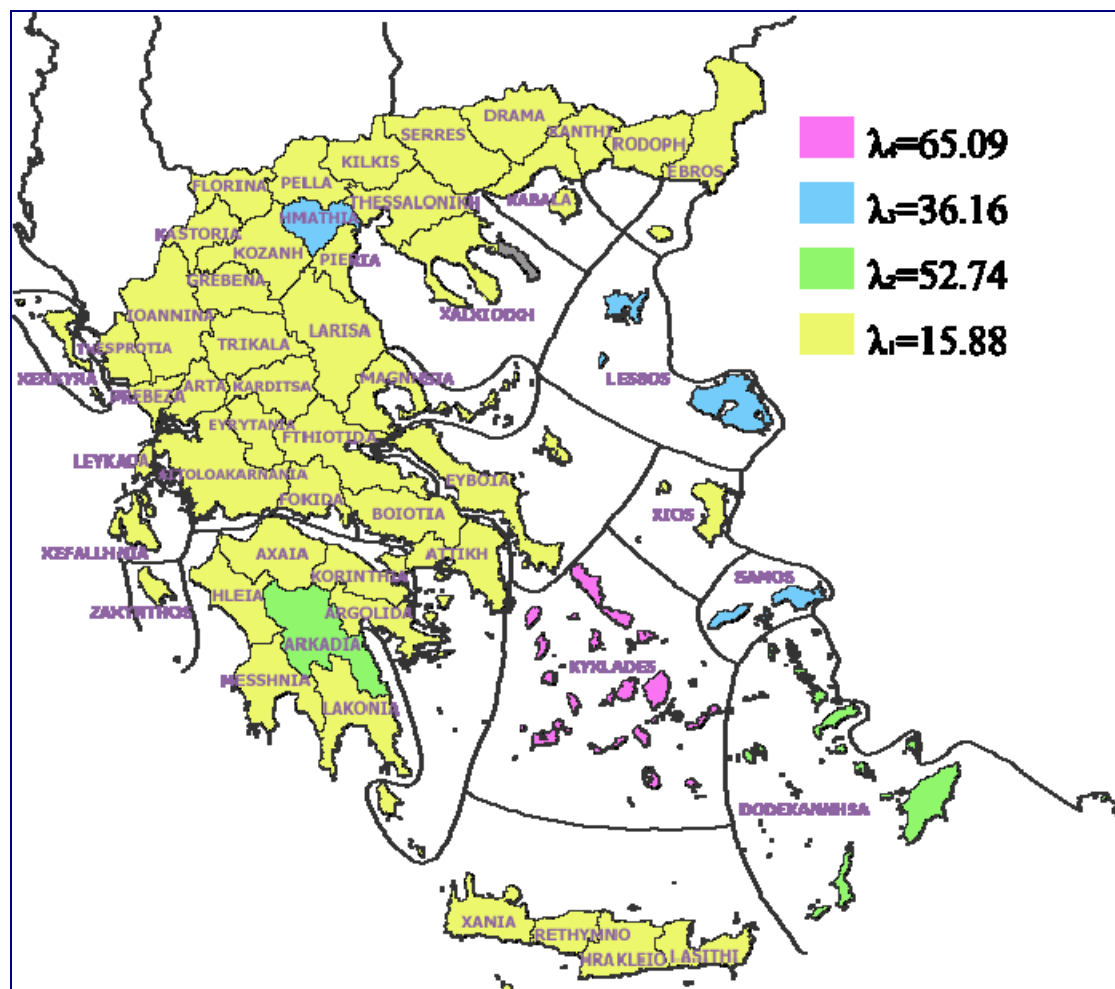

Figure 73. Mapping of Greek counties according to 'Offenses concerning explosives'.

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The last cluster of the rest counties has a low average number of offenses concerning explosives equal to 15.88.

The fact that the clusters with the highest number of offenses in this category are mainly composed by islands may be explained by the use of explosives by local fishermen.

6.1.9 Arsons in forests

The Mojena's stopping rule for this clustering, with mean $\bar{\alpha}=26.25616$ and standard deviation $s_\alpha=50.27575$, got a value of 89.10086. The Mojena's condition is satisfied only for $\alpha_3=97.26>89.10086$. Thus, we select two clusters. However, as shown in the corresponding dendrogram, given in figure 72, the only member of the second cluster is Xios.

The average number of arsons in forests for Xios was 54.43, whereas for all the other counties together was only 6.13.

Since the mapping of such a clustering is of no interest we will not show it.
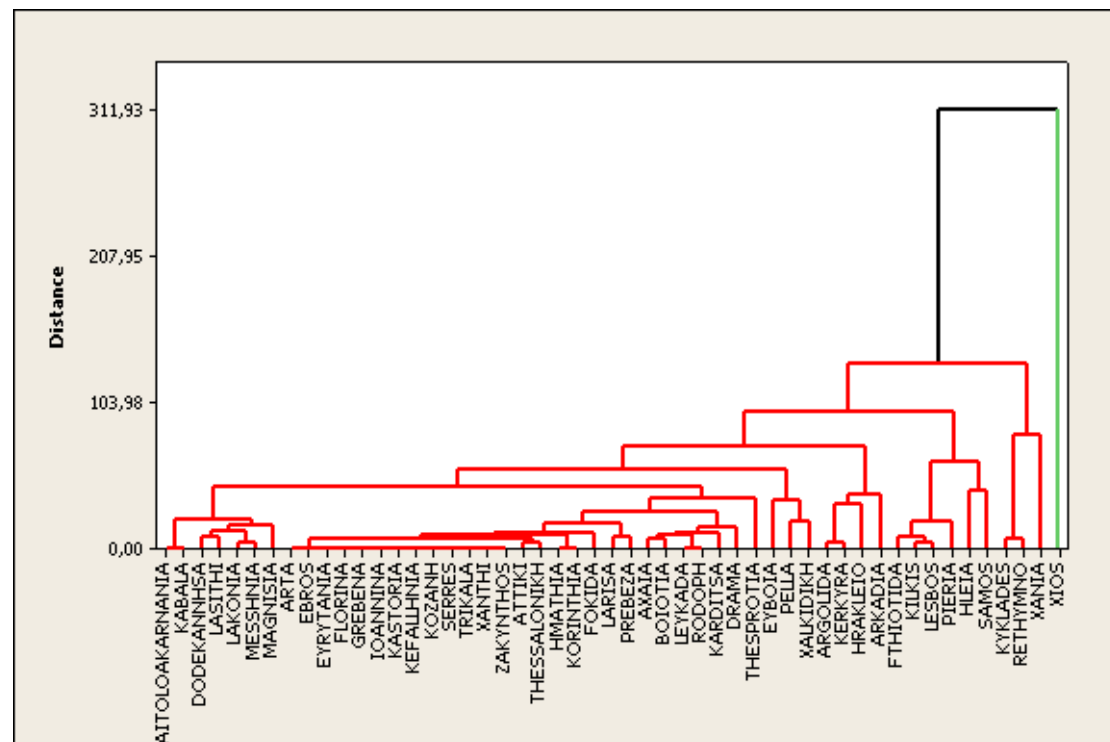
Figure 74. Dendrogram of 'Arsons in forests' using Complete Linkage.

However, in an attempt to derive a clustering in the remaining 50 counties, we will cluster them again using Complete Linkage, leaving Xios outside.

Mojena's stopping rule this time resulted in three clusters. Figure 75 presents the new dendrogram.
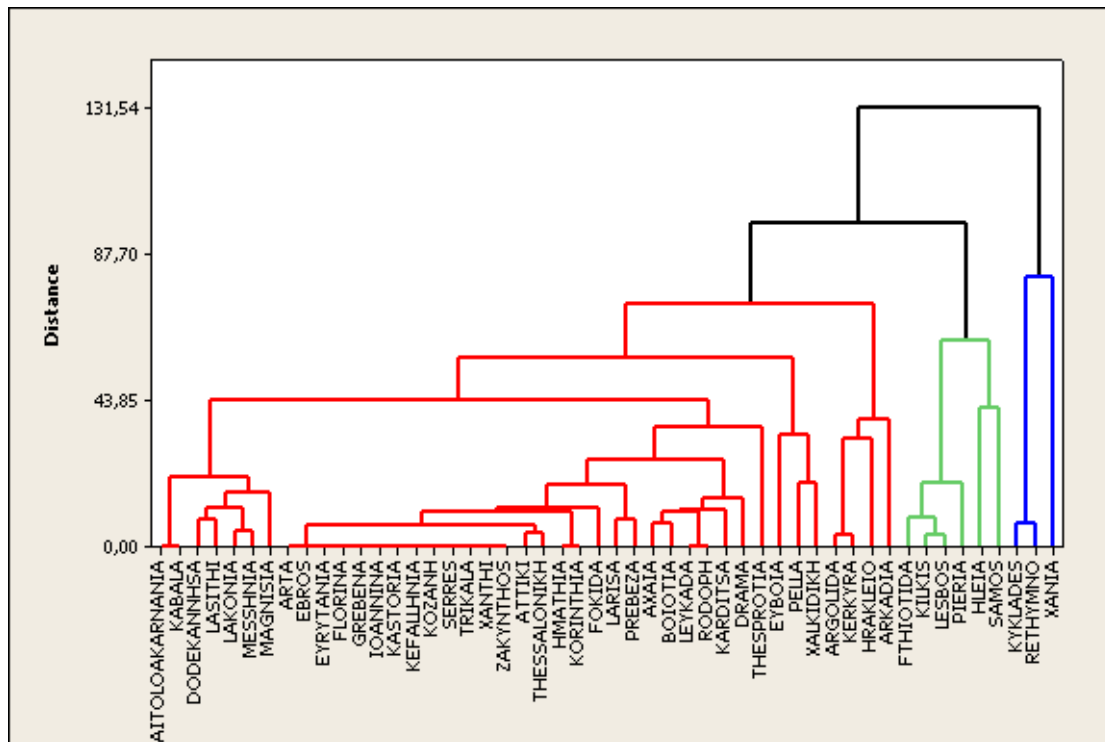
Figure 75. Dendrogram of 'Arsons in forests' using Complete Linkage, excluding Xios.

The first cluster consists of Xania, Rethymno and Kyklades, with an average of 17.02 arsons in forests. The second cluster has as members the counties of Samos, Hleia, Pieria, Lesbos, Kilkis and Fthiotida, with 13.15 arsons in forests in the average. The last cluster with the rest of the counties has an average number of arsons in forests equal to 4.30.

Combining the two results we give a mapping of the Greek counties according to arsons in forests in figure 76. By $\lambda_{1,i}$, where $i=1,2,3$ we denote the average number of offenses coming from the second clustering, where we excluded Xios.

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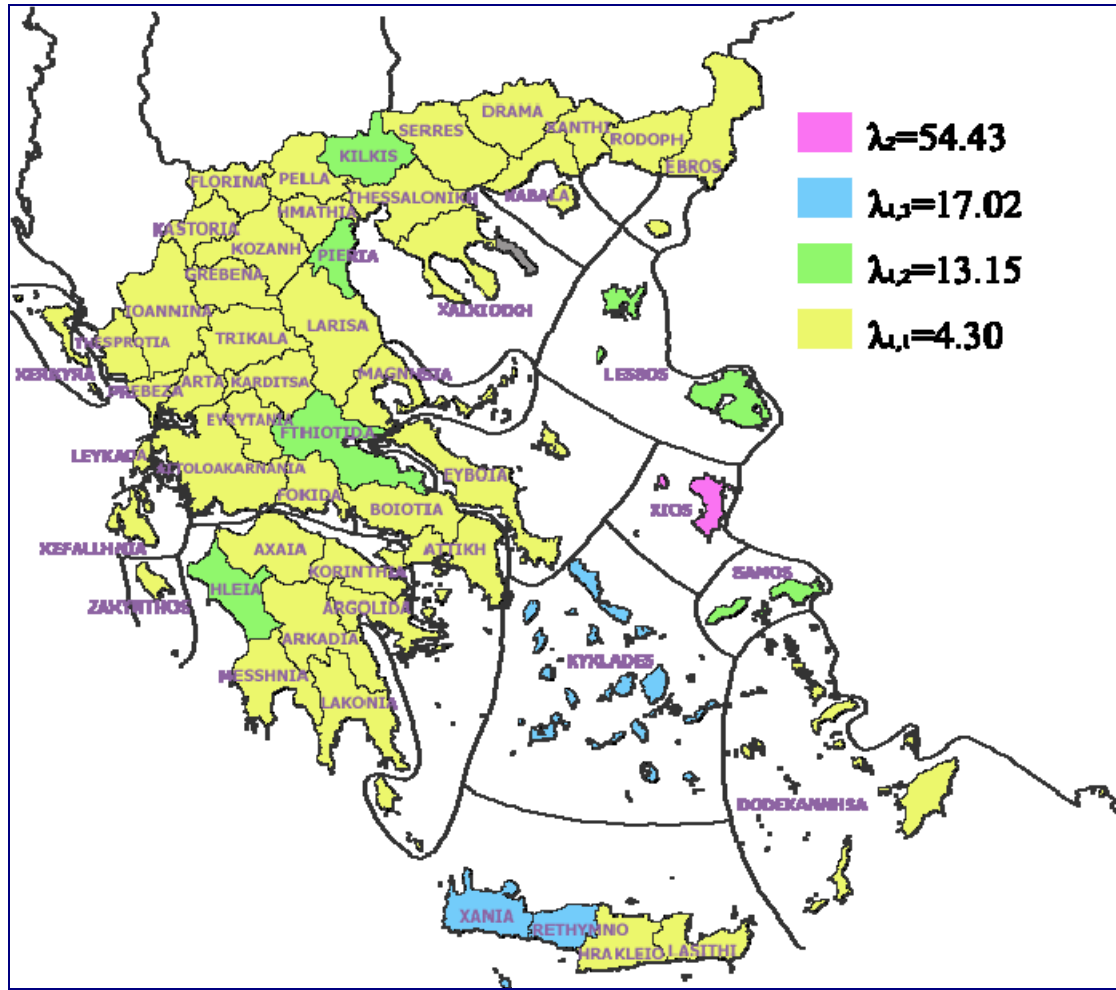
Figure 76. Mapping of Greek counties according to 'Arsons in forests'.

6.1.10 Illegal possession and usage of fire guns

Some counties, such as Xania and Rethymno in Crete, are known of their vendettas. These vendettas premise the illegal possession of fire guns in many households. The results of this clustering prove that.

The mean $\bar{\alpha}$ of the dendrogram fusion levels was found to be 205.9288 and standard deviation s_{α}=313.35942, resulting to a value of 597.6281 for the stopping rule. The Mojena's condition is satisfied at stage 4 with $\alpha_4 = 633.59 > 597.6281$. Thus, three clusters are chosen. The obtained dendrogram with the three clusters is given in figure 77.
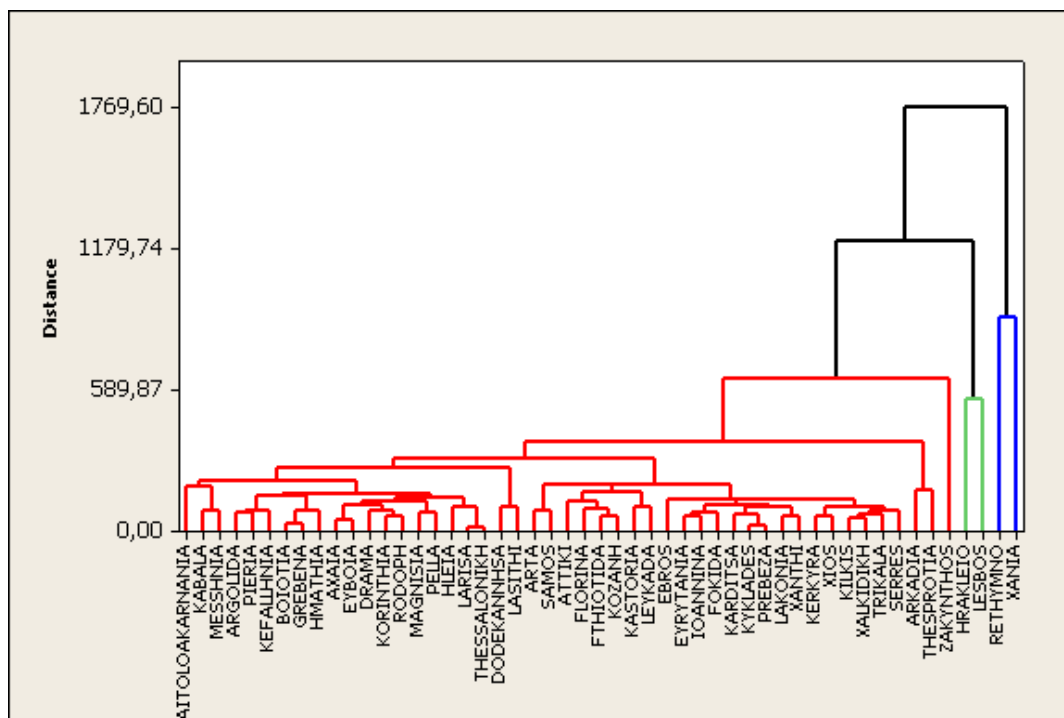
Figure 77. Dendrogram of 'Illegal possession and usage of fire guns' using Complete Linkage.
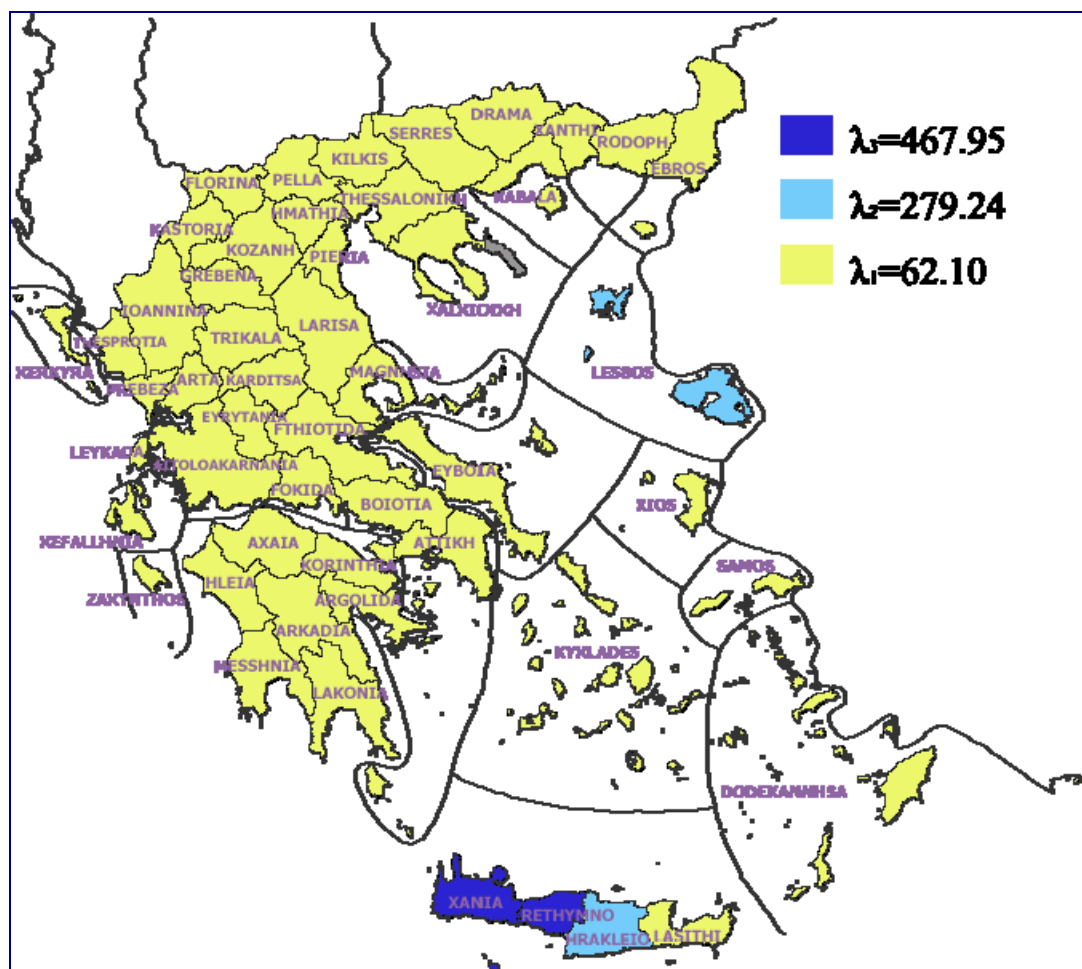
Figure 78. Mapping of Greek counties according to 'Illegal possession and usage of fire guns'.

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As we can see from the dendrogram Xania and Rethymno forms the first group with average number of offenses equal to 467.95. Lesbos and Hrakleio come next with 279.24 offenses in average. All the rest counties are grouped together having 62.10 as an average number of offenses.

Mapping of the Greek counties using illegal possession and usage of fire guns is shown in figure 78.

6.1.11 Homicides by misadventure

Since homicides by misadventure do not imply reasons why some counties should have a different behavior than others, we expect that this clustering will not give a large number of clusters. Indeed, the Mojena's rule indicates the existence of only two clusters. The mean $\bar{\alpha}$ was found to be 13.2585 and standard deviation s_α=12.81431, resulting to a value of 29.27635 for the stopping rule. The Mojena's condition is satisfied at stage 3 with $\alpha_3 = 42.1764 > 29.27635$. The obtained dendrogram with the two clusters is given in figure 79.
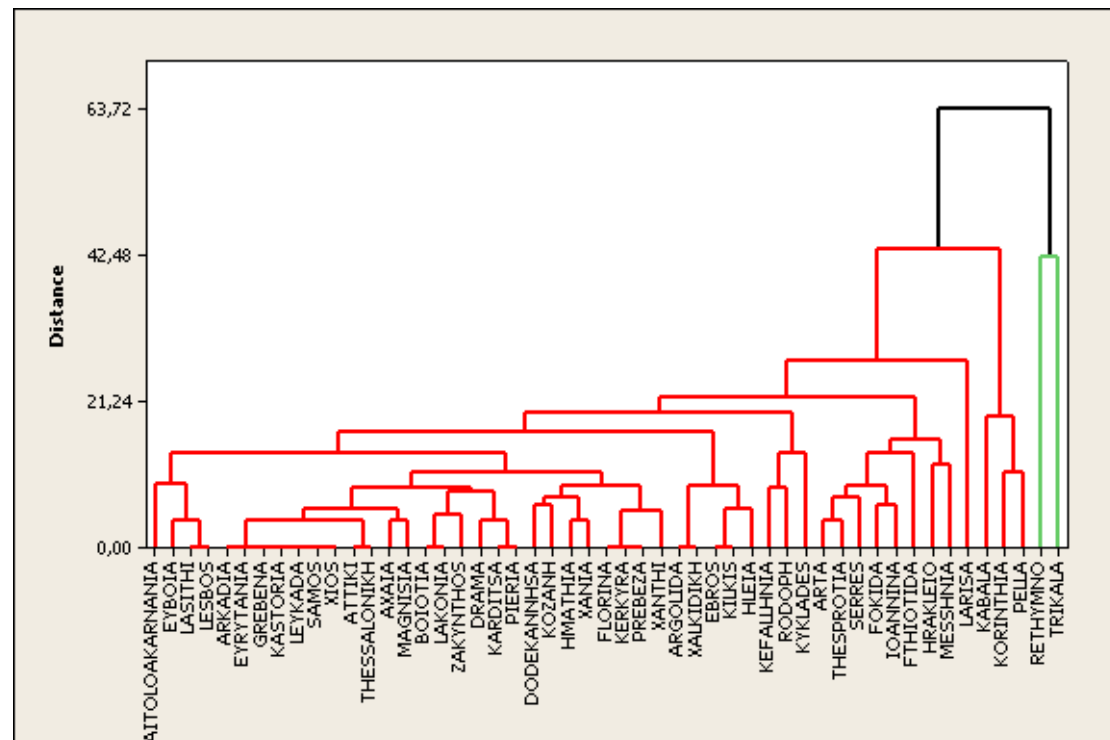

Figure 79. Dendrogram of 'Homicides by misadventure' using Complete Linkage.

All counties except from Rethymno and Trikala belong to one cluster with average number of homicides by misadventure equal to 3.27, whereas for the cluster of Rethymno and Trikala the average number equals to 9.96. Therefore, as expected, the picture of homicides by misadventure is quite uniform over Greek counties, keeping the number of offenses rather low.

The mapping of this clustering is given in figure 80.
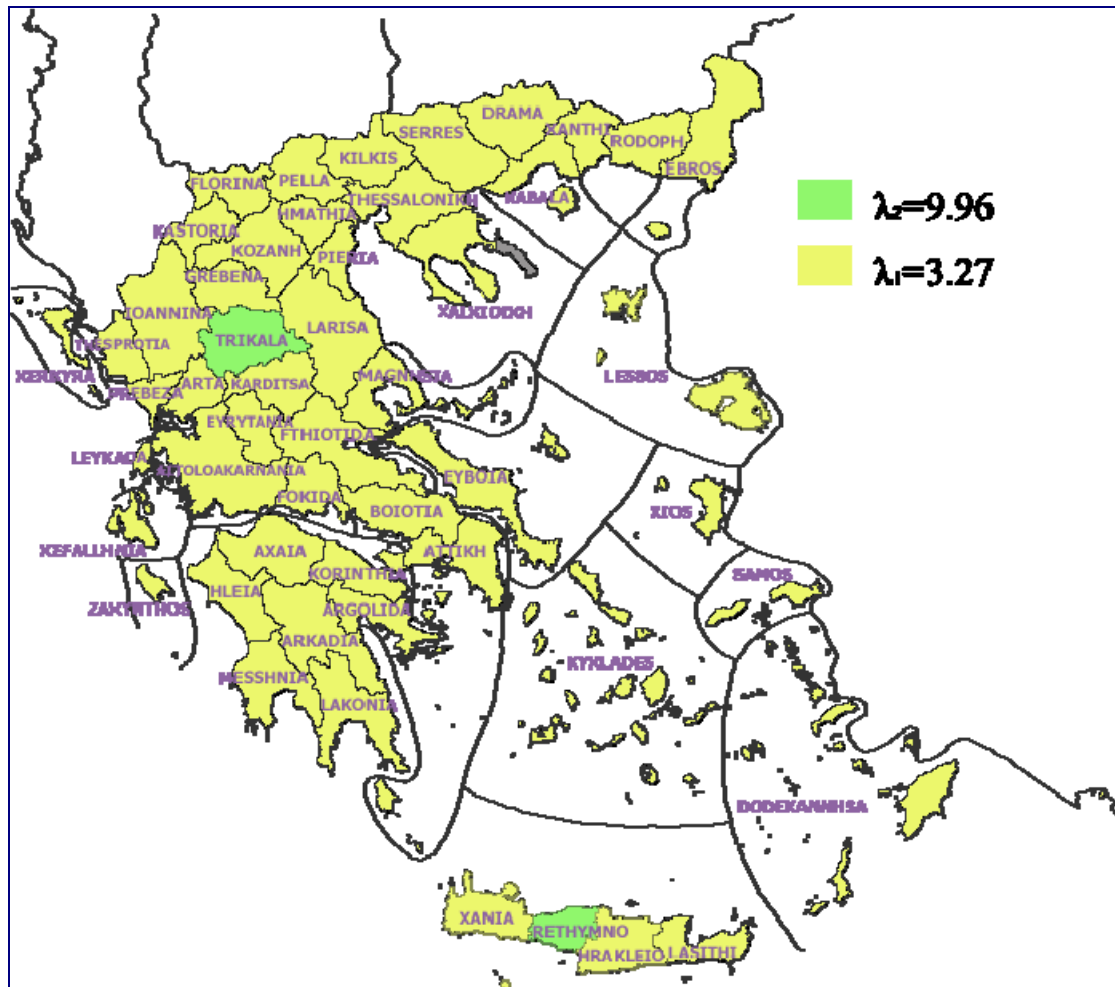
Figure 80. Mapping of Greek counties according to 'Homicides by misadventure'.

6.1.12 Smuggling

The clustering of Greek counties according to smuggling gave four clusters. We calculated $\bar{\alpha}$=62.5822 and s_α=130.9835. Mojena's stopping rule criterion was satisfied at stage 5, since $\alpha_5 = 248.612 > 226.3115$. The obtained dendrogram with the four clusters is given in figure 81.
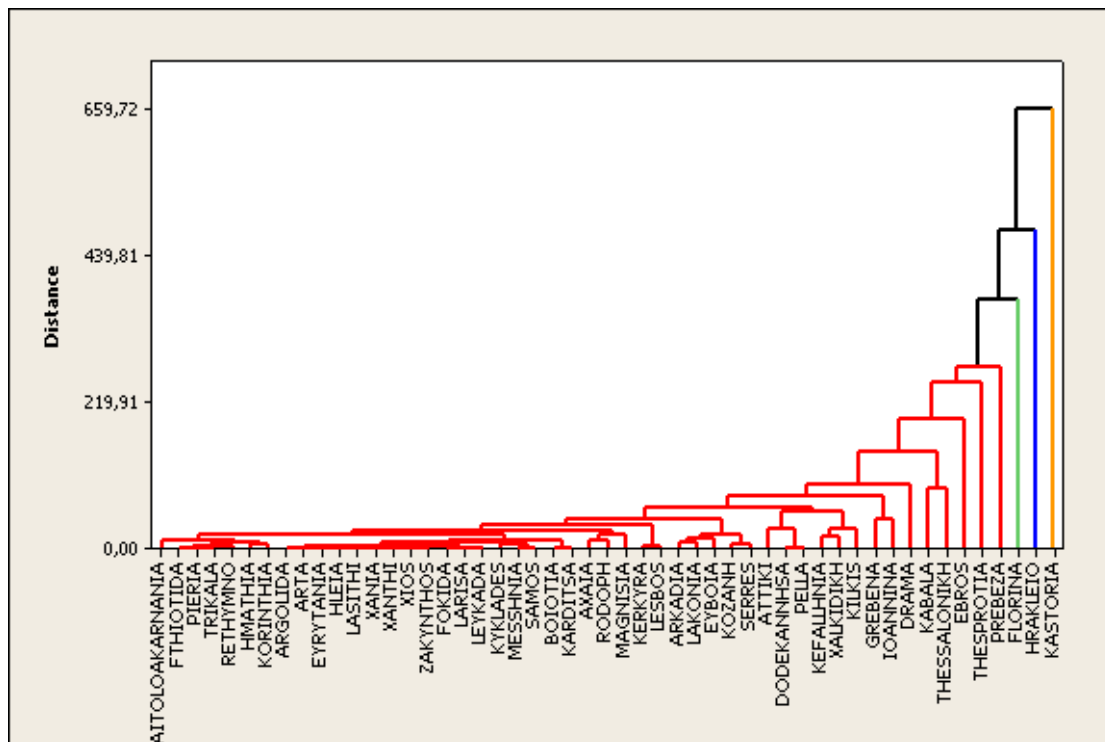
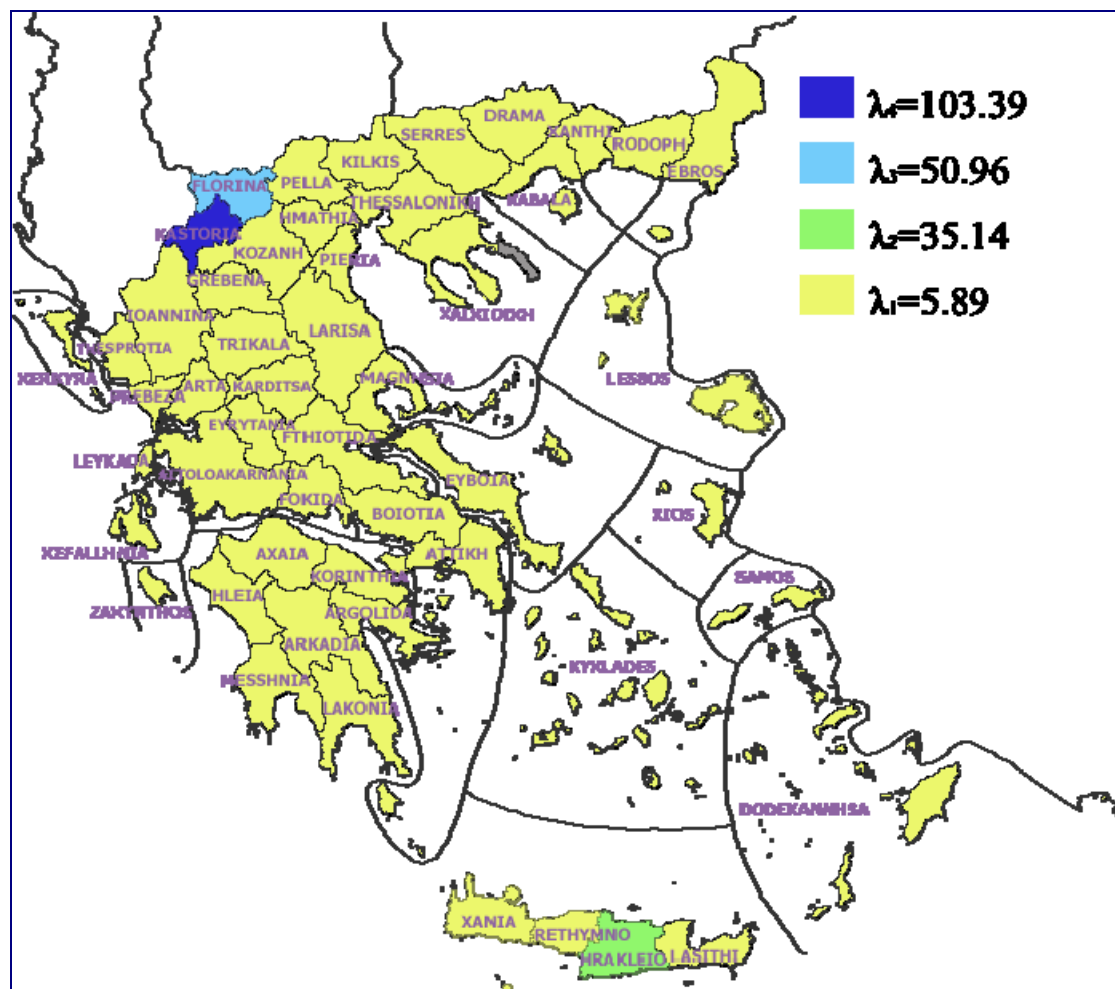**Figure 81.** Dendrogram of 'Smuggling' using Complete Linkage.

Figure 82. Mapping of the Greek counties according to 'Smuggling'.

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Kastoria, which is the county with the higher average number of offenses, is known of its furs, since castors live there. Florina lies beside Kastoria; therefore, this might be the reason of its high average number of smuggling offenses. Hrakleio, besides its archeological places, has the largest port in Crete, and because of its geographical position is a very convenient place for smugglers both for importing and exporting.

6.1.13 Offenses against life

At this point we remind to the reader that offenses against life include homicides by misadventure and murders.

The mean $\bar{\alpha}$ and the standard deviation s_α for Mojena's stopping rule were calculated to be 266.227 and 273.40218, respectively, resulting to a value of 607.9797 for the criterion. Mojena's condition was satisfied for $\alpha_4 = 722.75 > 607.9797$, indicating three clusters. The obtained dendrogram is given in figure 83.
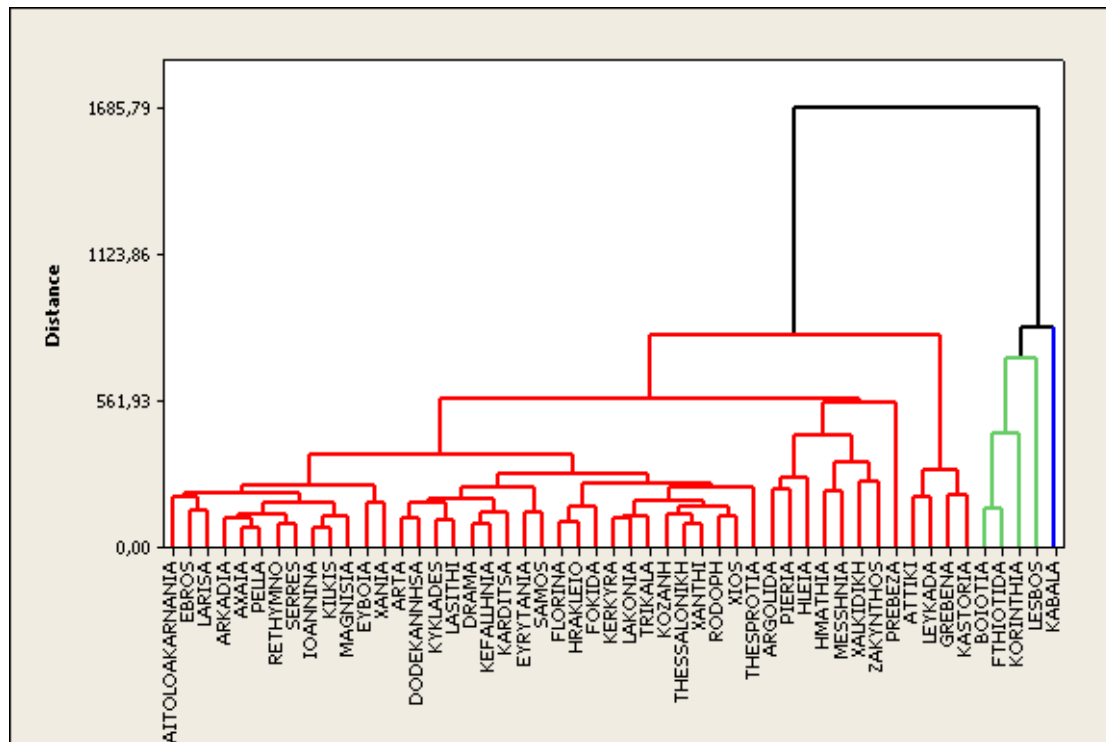
Figure 83. Dendrogram of 'Offenses against life' using Complete Linkage.

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Kabala is not clustered with any other county. The average number of offenses against life is 542.02. Lesbos, Korinthia, Fthiotida and Boiotia are clustered together having an average number of offenses equal to 393.60. All other counties are clustered in the last group with average number of 186.27 offenses.

In figure 84 we present the mapping of this clustering.

Figure 84. Mapping of Greek counties according to 'Offenses against life'.

6.1.14 Robbery

Robbery is an offense that one can expect to be more often in large urban centers, where wealth is gathered.

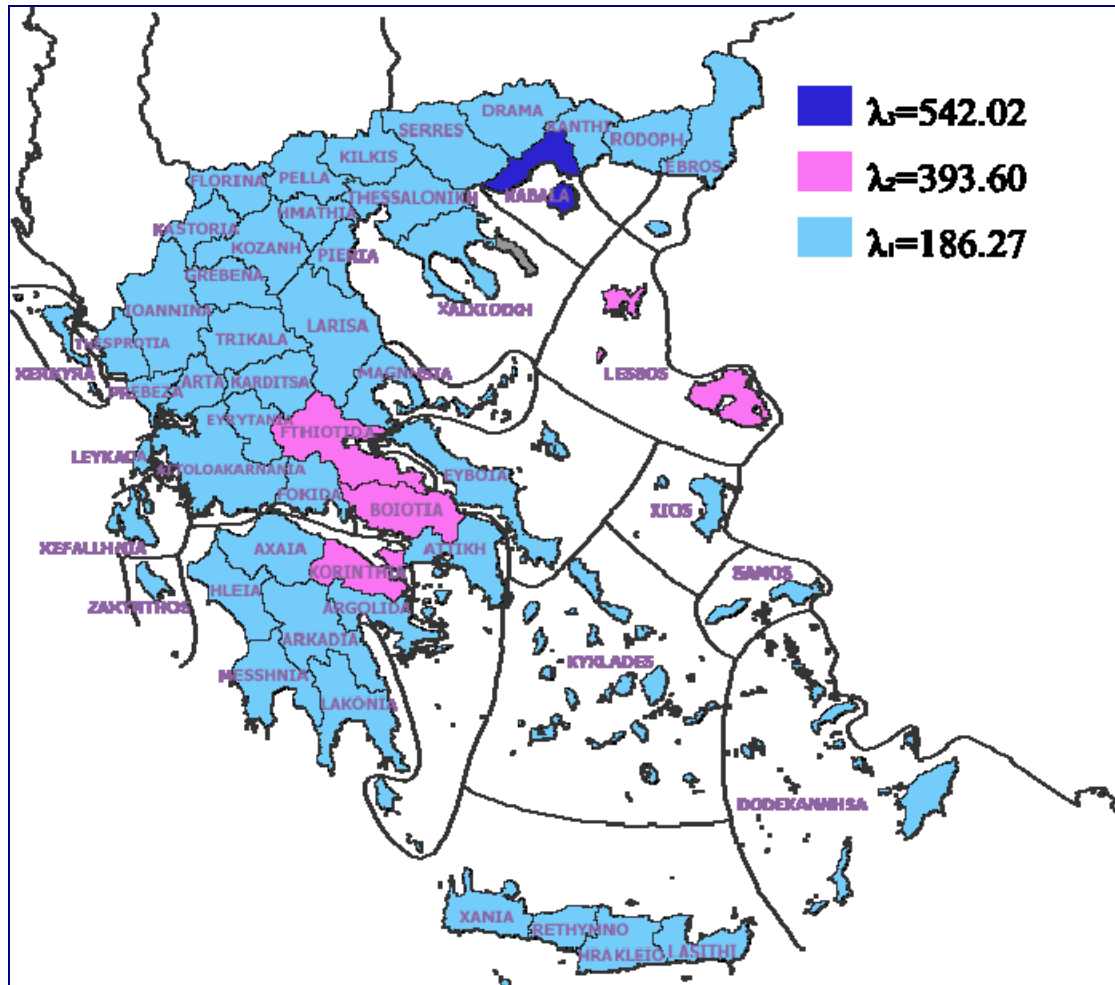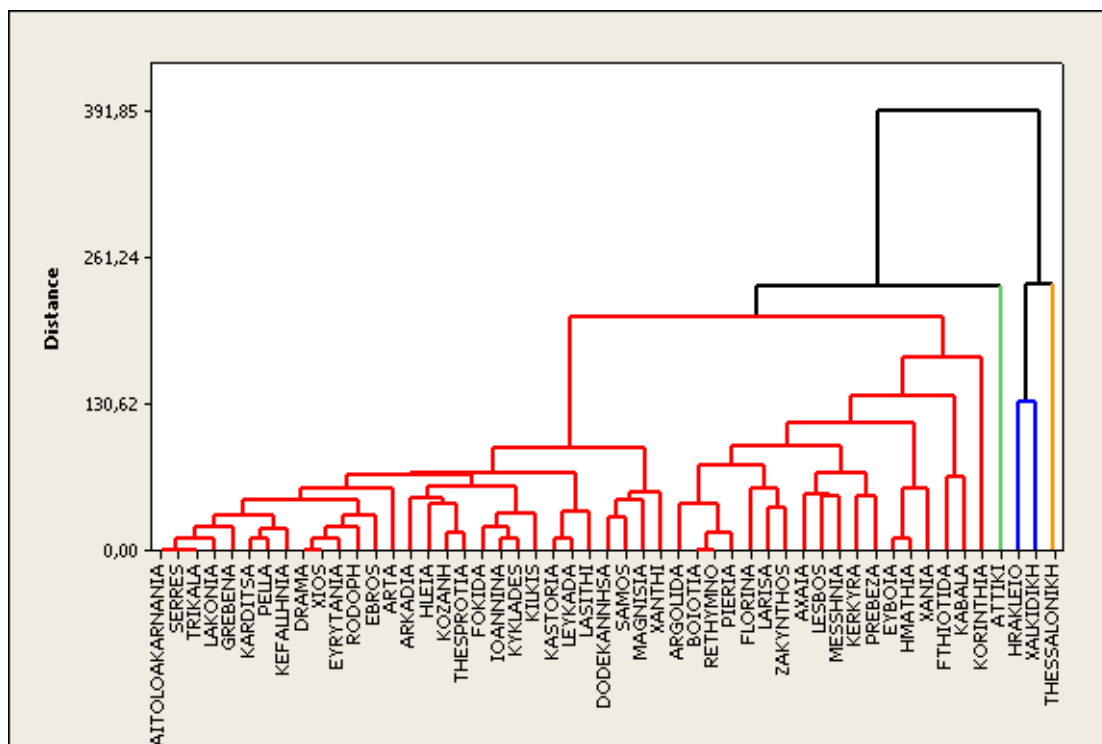Calculating mean $\bar{\alpha}$ and the standard deviation s_{α} for Mojena's stopping rule they were found to be 68.9079 and 74.8506, respectively,

resulting to a value of 162.4712 for the criterion. Mojena's condition was satisfied for $\alpha_5 = 172.933 > 162.4712$, indicating four clusters. The obtained dendrogram is given in figure 85.

Figure 85. Dendrogram of 'Robbery' using complete Linkage.

As expected, the higher number of robberies is given for the counties of Thessaloniki, which is not clustered with any other county, Xalkidiki and Hrakleio, which are clustered together, and of course Attiki, which is also not clustered with any other county. The average numbers of robberies for the three clusters are 122.35, 68.08 and 51.41, respectively. The cluster with members all the other counties has an average number of robberies equal to 26.26.

All the four above mentioned counties have a large population and the majority of Greek wealthy people have properties in them. Xalkidiki is one of the most expensive destinations for holidays. The complexes in Xalkidiki are of the most luxurious ones, and the number of robberies there might be higher if some of them were not remain closed in winter. Besides, there are many bank branches there.

The mapping of the clustering of Greek counties according to robberies is given in figure 86.
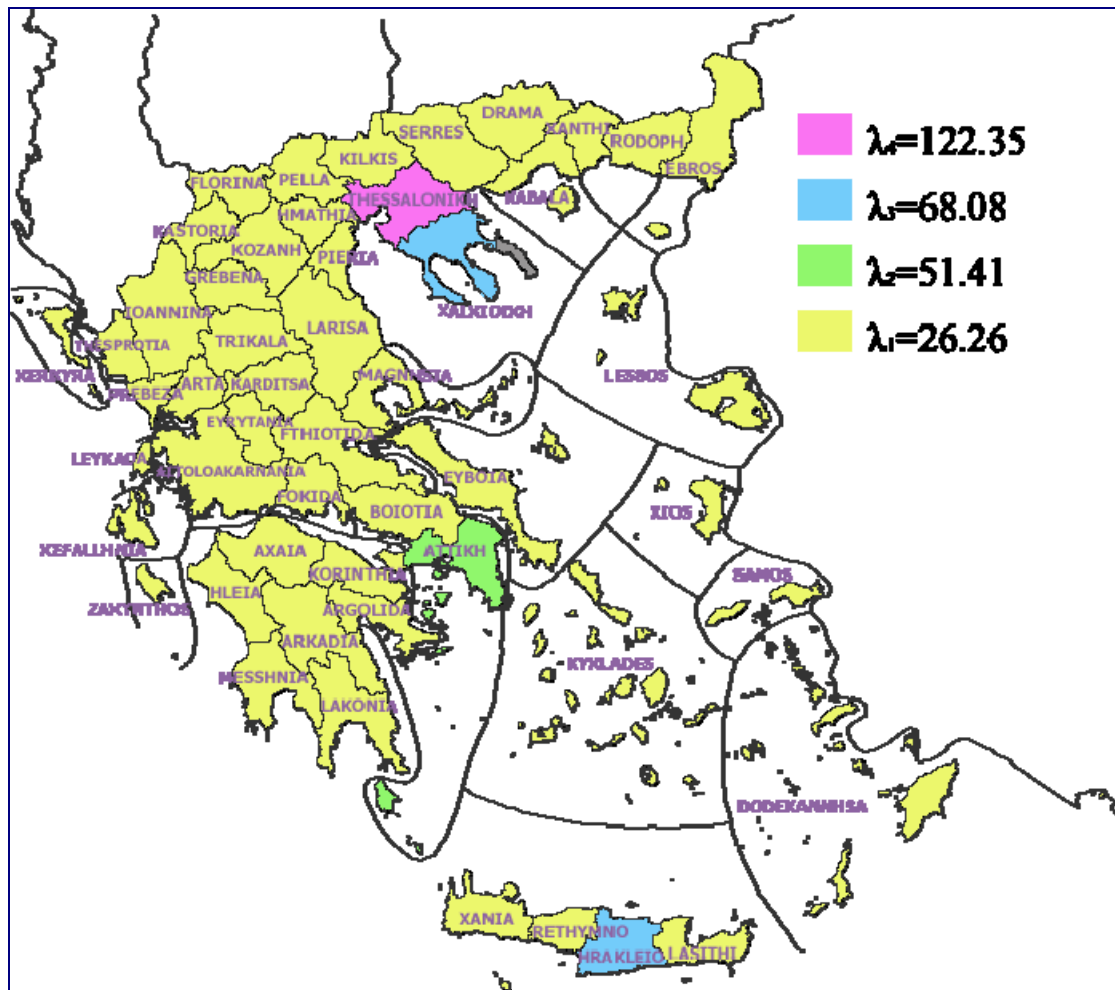
Figure 86. Mapping of Greek counties according to 'Robbery'.

6.1.15 Murder

In previous paragraphs we have clustered Greek counties according to homicides by misadventure and offenses against life. In this paragraph the offense that we will use to cluster the Greek counties is murder.

The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 55.93062 with standard deviation s_α=66.58785, resulting to a value of 139.16543 for the stopping rule. The condition is satisfied for the first time at stage 5, giving

$\alpha_5 = 157.264 > 139.16543$ and resulting in four clusters. The obtained dendrogram with the four clusters is given in figure 87.
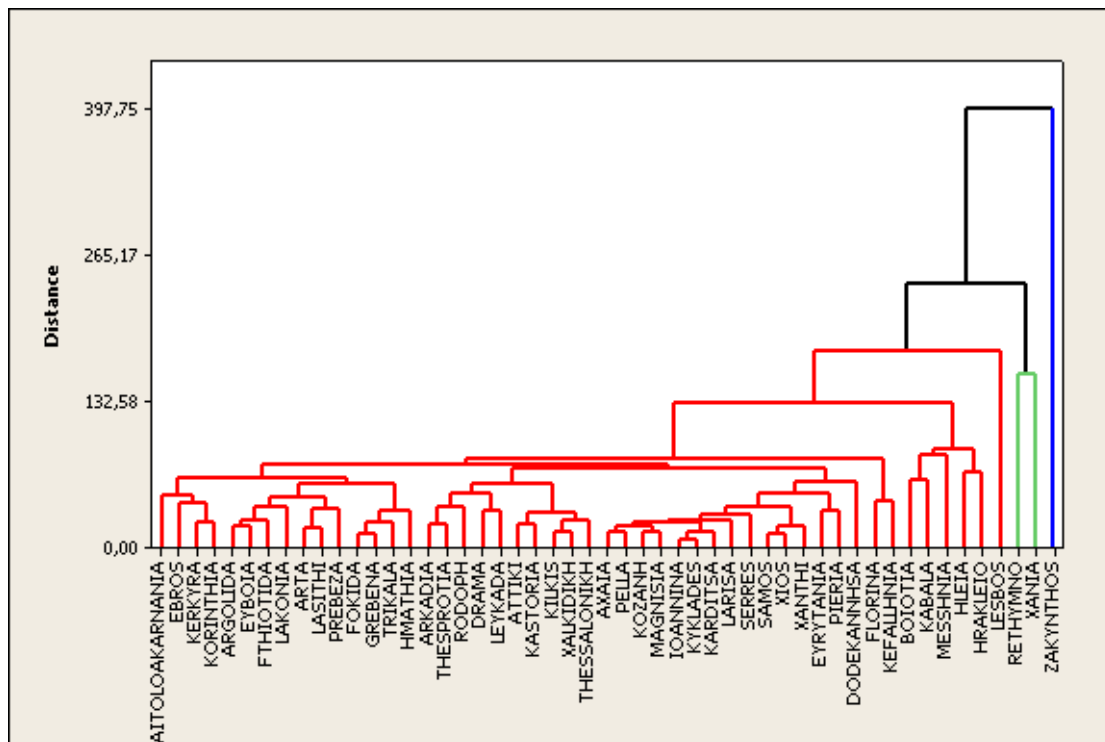
Figure 87. Dendrogram of 'Murder' using Complete Linkage.

The results are not surprising. People with origin one of the counties of Xania, Rethymno are known of their continuous vendettas, and those with origin of Zakynthos are known of their hot temper.

However, among the other counties that are grouped together, we notice that the last joined members in the cluster are those of Lesbos, Hrakleio, Hleia and Messhnia, that one might expect them to be among those with the higher numbers of murders. The fact that they are the last joined members in their cluster consolidates that expectation.

Figure 88 presents the mapping of Greek counties according to murder and gives the average numbers of murders in each cluster.
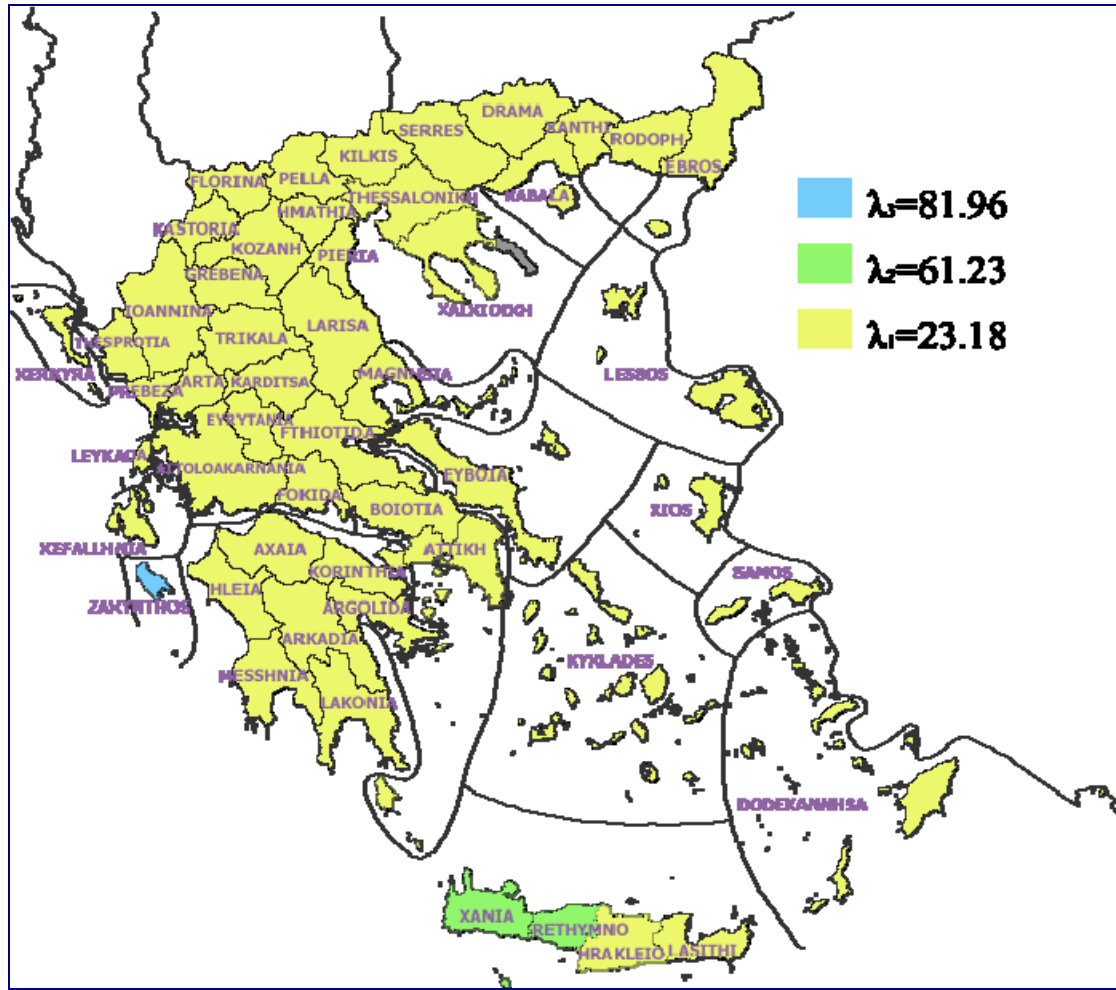
Figure 88. Mapping of Greek counties according to 'Murder'.

6.1.16 Rape

Rape, as mentioned before, is recording as a separate offense only since 1988.

Since Greece is a holiday's destination for many tourists, especially Greek islands, one can expect that rape should be more often in Greek islands, especially in the summer, when the dressing is rather stimulative.

The clustering of Greek counties according to rape indicated only two clusters, since Mojena's stopping rule's conditions is satisfied at stage 3 with $\alpha_3 = 159.981 > 127.66249$. The obtained dendrogram is given in figure 89, and the mapping of the Greek counties based on this clustering is given in figure 90.
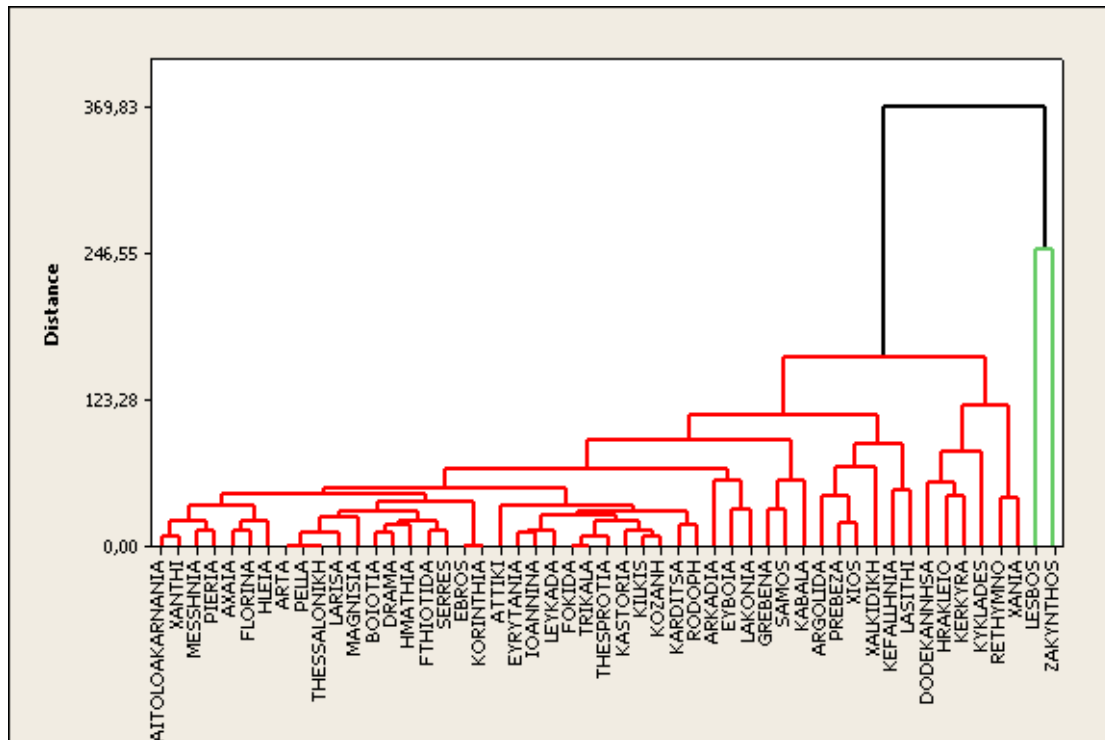
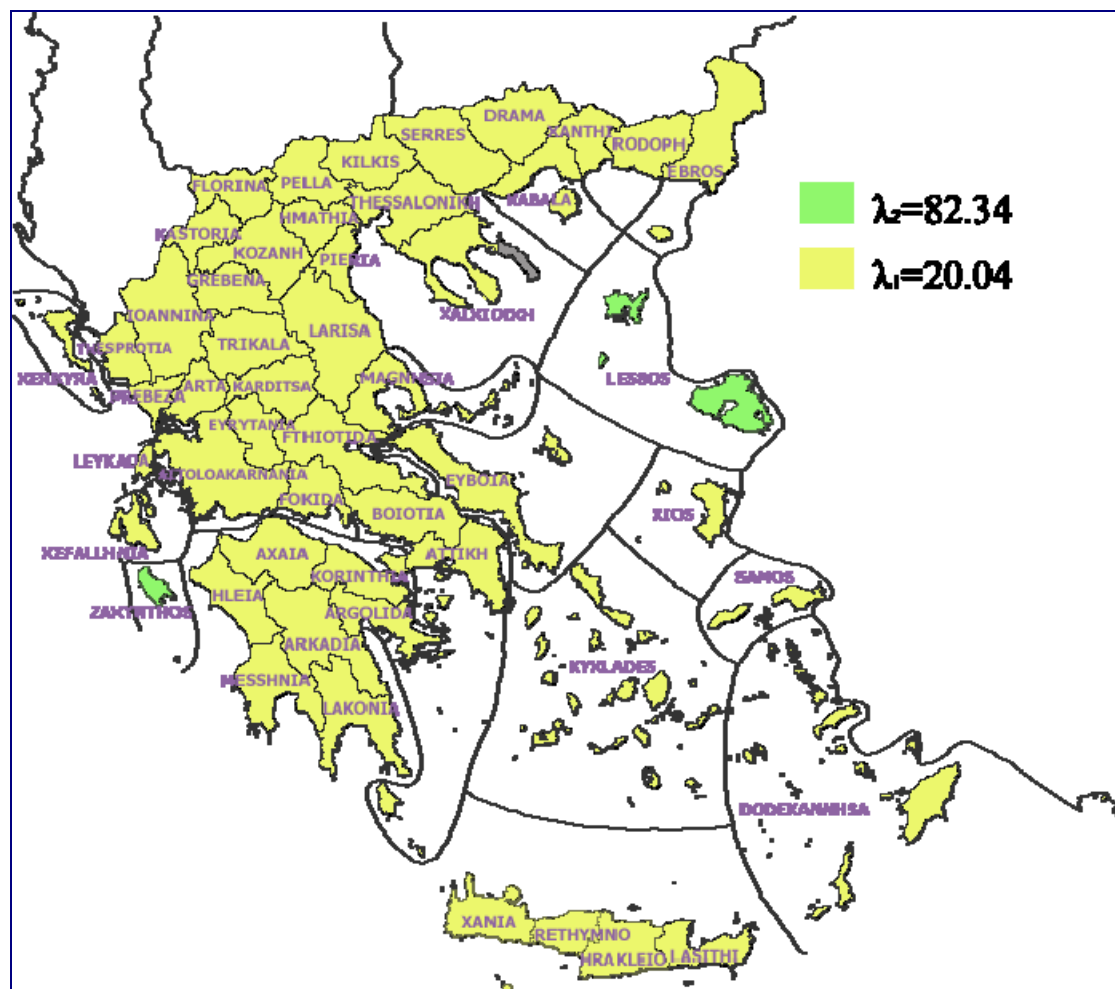**Figure 89.** Dendrogram of 'Rape' using Complete Linkage.

Figure 90. Mapping of Greek counties according to 'Rape'.

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As one might expect Zakynthos, which was often one of the subjects in the news due to the shindigs of tourists, is the one of the two members in the cluster with the higher average number of rapes (82.34). Lesbos, in the other hand, the second member of the same cluster, consists of two islands, Limnos and Lesbos, which are very close to Turkish borders and they have a high percentage of Greek soldier serving there. Some even say that in Lesbos there are many lesbians. This saying may provoke even more the sick minds of the rapers.

All other counties are grouped together, with an average of 20.04 rapes. However, it is worth mentioning that the counties which are the last ones to join this cluster are the counties of Crete – Xania, Rethymno and Hrakleio – and the islands of Kyklades, Dodekannhsa and Kerkyra. Therefore, the initial expectation of higher numbers of rapes in Greek islands is confirmed.

6.1.17 Physical injuries

Last but not least, we cluster the Greek counties according to the numbers of physical injuries.

In order to apply Mojena's stopping rule, we calculated the mean $\overline{\alpha}=74.9758$ and the standard deviation $s_{\alpha}=102.52745$. As a result we got a value of 203.13507 for the stopping rule. Mojena's condition is satisfied for the first time at stage 4, since $\alpha_4=208.825>203.13507$, indicating the existence of three clusters. The obtained dendrogram with the three clusters is given in figure 91.

Pella is not clustered with any other county with average number of physical injuries found to be 98.07. The counties of Xanthi and Messhina follow with an average number of 42.97. All other counties are gathered together with average number of physical injuries equal to 13.26.

The mapping of this clustering is given in figure 92.

Figure 91. Dendrogram of 'Physical Injuries' using Complete Linkage.

Figure 92. Mapping of Greek counties according to 'Physical Injuries'.

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6.2 Annual clustering of Greek counties by all offenses

In the following paragraphs we will cluster the Greek prefectures according to their volume of crime per year. However, since commonly dangerous crimes include arsons, arsons in forests and illegal manufacturing, supply, or possession of explosives, we will not take them into account, since adding their counts would only duplicate the counts of the included in them offenses. Moreover, offenses against life include murder and homicide by misadventure; therefore, they will be also excluded from the following analyses. Thus, the analyses will be done for each year separately, using all the offenses of the previous section, with commonly dangerous crimes and offenses against life excluded, for the period 1987-1997.

The method of clustering is, as in the previous section, the Complete Linkage using Euclidean distances, and the stopping rule for cutting the dendrogram is again Mojena's rule.

6.2.1 Crime volume of 1987

The applied stopping rule for 1987 indicated three clusters. The performed calculations gave mean $\bar{\alpha}=125.2336$ and standard deviation $s_\alpha=128.1377$. As a result the Mojena's condition is satisfied for the first time at stage 4, giving $\alpha_4 = 315.644 > 285.40576$. The obtained dendrogram is given in figure 93.

122
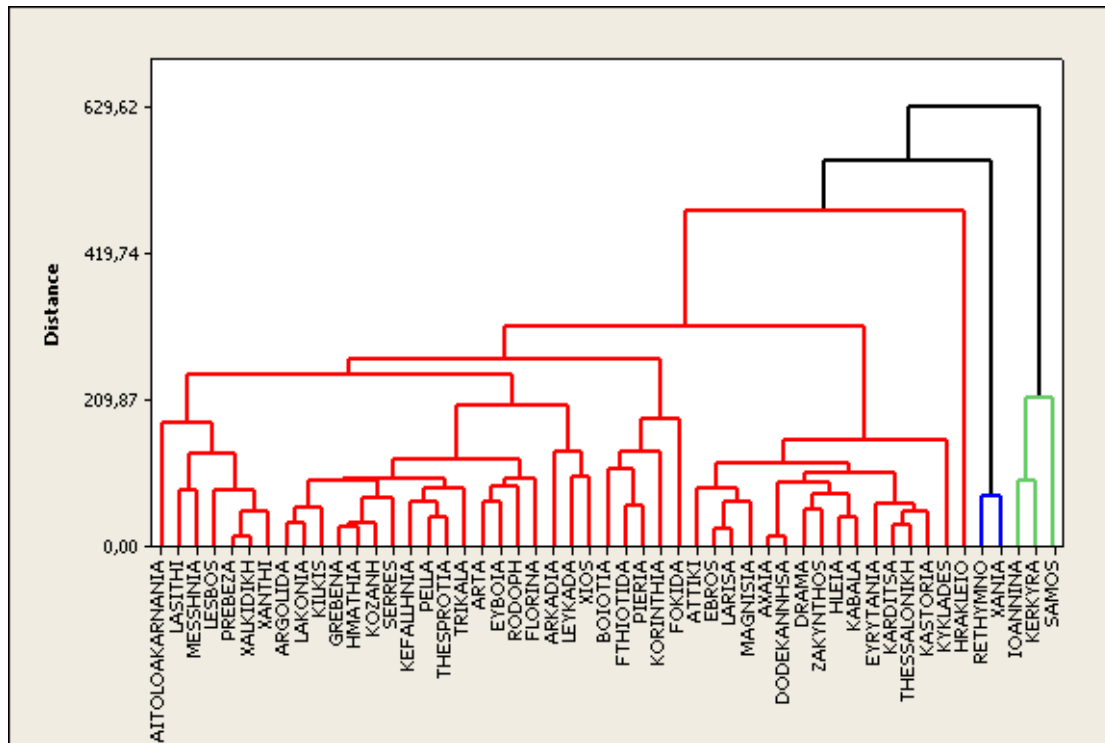
Figure 93. Dendrogram of 1987 using Complete Linkage.

Xania and Rethymno are the members of the cluster with the higher volume of reported offenses in 1987, with average number of offenses equal to 1185.19. This result is almost predictable since these two counties were often members of the clusters with the higher average numbers of offenses in the classifications of the previous section.

Samos, Kerkyra and Ioannina come next giving 676.23 as an average number of offenses to their cluster. These three counties where among those with the higher numbers of 'taking the law into one's hands', and they were often high in the hierarchy, even when they belonged to the cluster with the smallest number of offenses.

All other counties belong to the same cluster with an average number of 472.22 offenses for 1987.

The mapping of Greek counties according to the crime volume of 1987 is presented in figure 94.

123
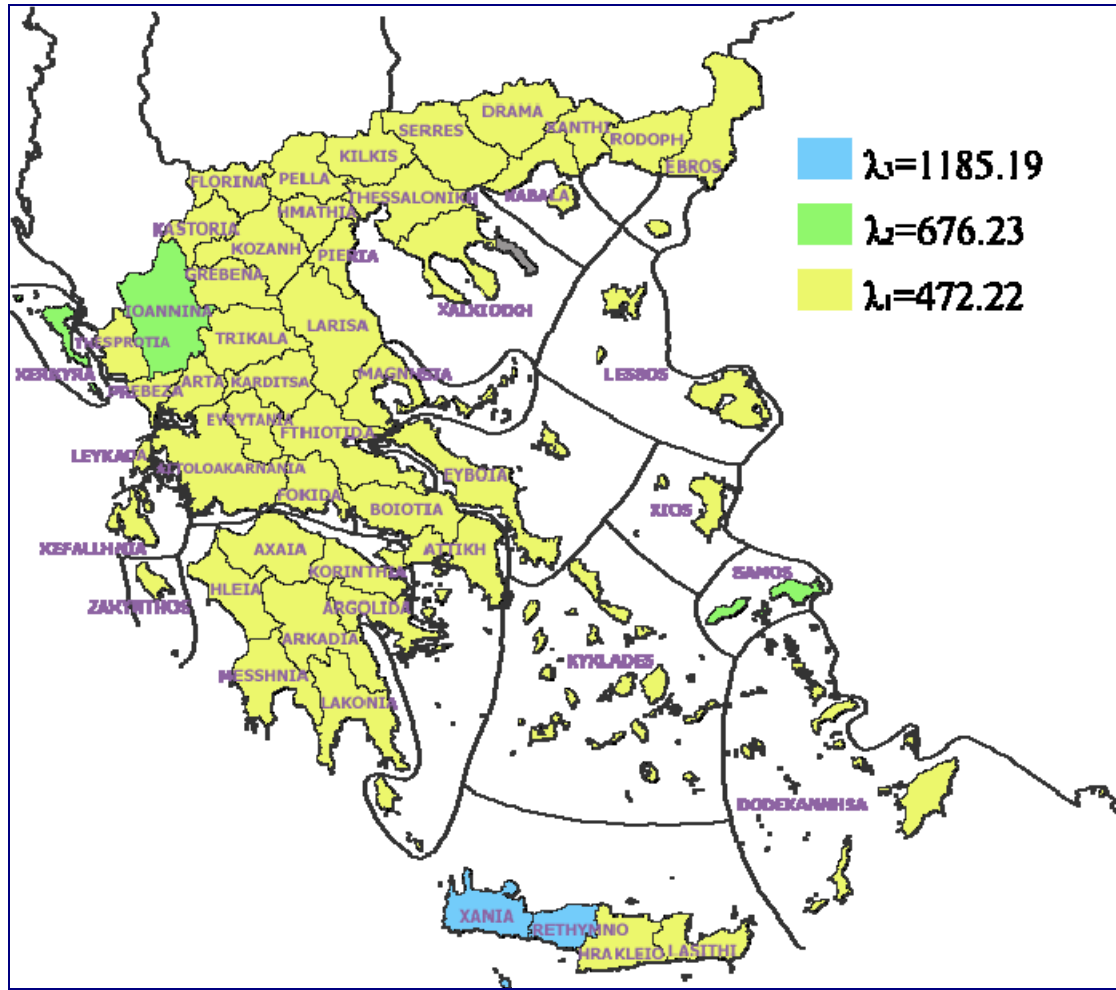
Figure 94. Mapping of Greek counties according to crime volume of 1987.

6.2.2 Crime volume of 1988

Crime activity has probably not the same behavior over time. However, we may see some similarities.

The hierarchy of Greek counties according to the crime volume of 1988 resulted to mean $\bar{\alpha}=189.5449$ for Mojena's stopping rule and standard deviation $s_\alpha=137.9446$, giving a value of 361.97566 for the rule. Mojena's condition is satisfied at stage 6 for the first time, since $\alpha_6 = 372.937 > 361.97566$, indicating five clusters. The obtained dendrogram is given in figure 95.

124
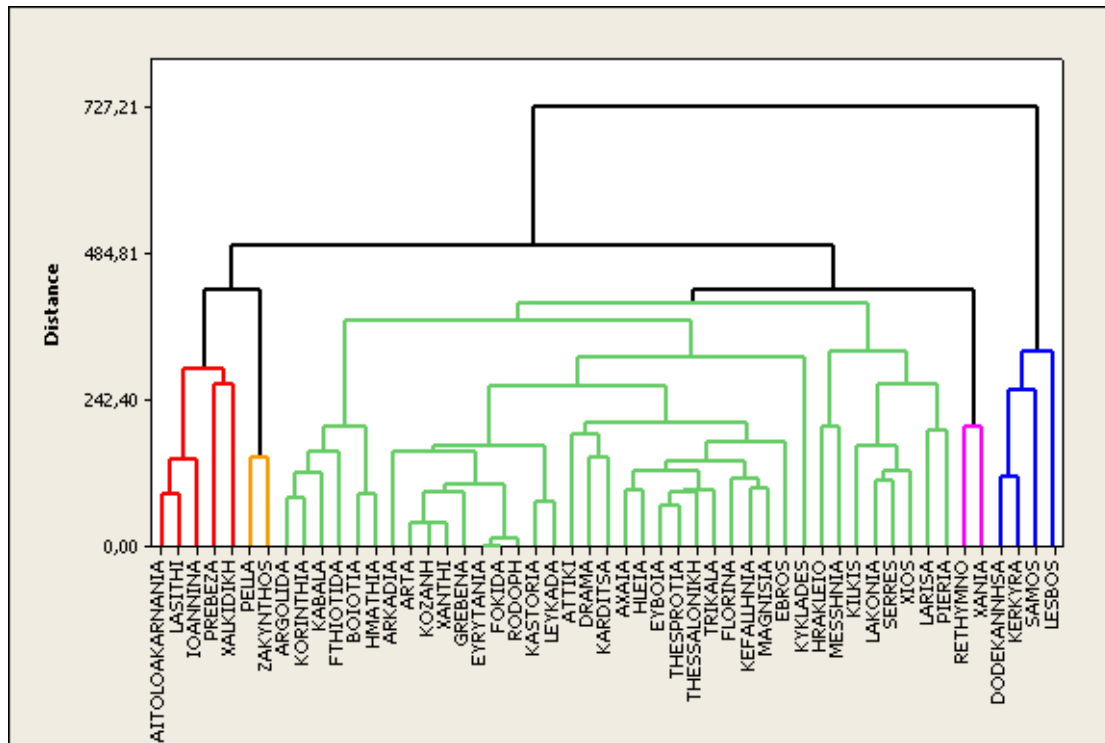
Figure 95. Dendrogram of 1988 using Complete Linkage.

Similarly to 1987, Rethymno and Xania are again forming the with the highest average number of offenses (913.52).

Samos and Kerkyra, which were also members of the second cluster with the more offenses in 1987, are clustered with Lesbos and Dodekannhsa this time, taking the second higher place with 764.39 as average number of offenses. Lesbos and Dodekannhsa were also met with relative high average numbers of offenses in the classifications per offense of the previous section.

The third group in average crime volume (680.19 offenses) for 1988 consists of Pella and Zakynthos.

The fourth group consists of Argolida, Arkadia, Arta, Attiki, Axaia, Boiotia, Drama, Ebros, Eyboia, Eyrytania, Florina, Fokida, Fthiotida, Grebena, Hleia, Hmathia, Hrakleio, Kabala, Karditsa, Kastoria, Kefallhnia, Kilkis, Korinthia, Kozanh, Kyklades, Lakonia, Larisa, Leykada, Magnisia, Messhnia, Pieria, Rodoph, Serres, Thesprotia, Thessalonikh, Trikala, Xanthi and Xios, having an average of 566.34 total offenses in 1988.

Aitoloakarnania, Ioannina, Lasithi, Prebeza and Xalkidikh form the group with the lower average number of 515.65 total offenses for 1988.

The representative mapping of these results is given in figure 96.

125

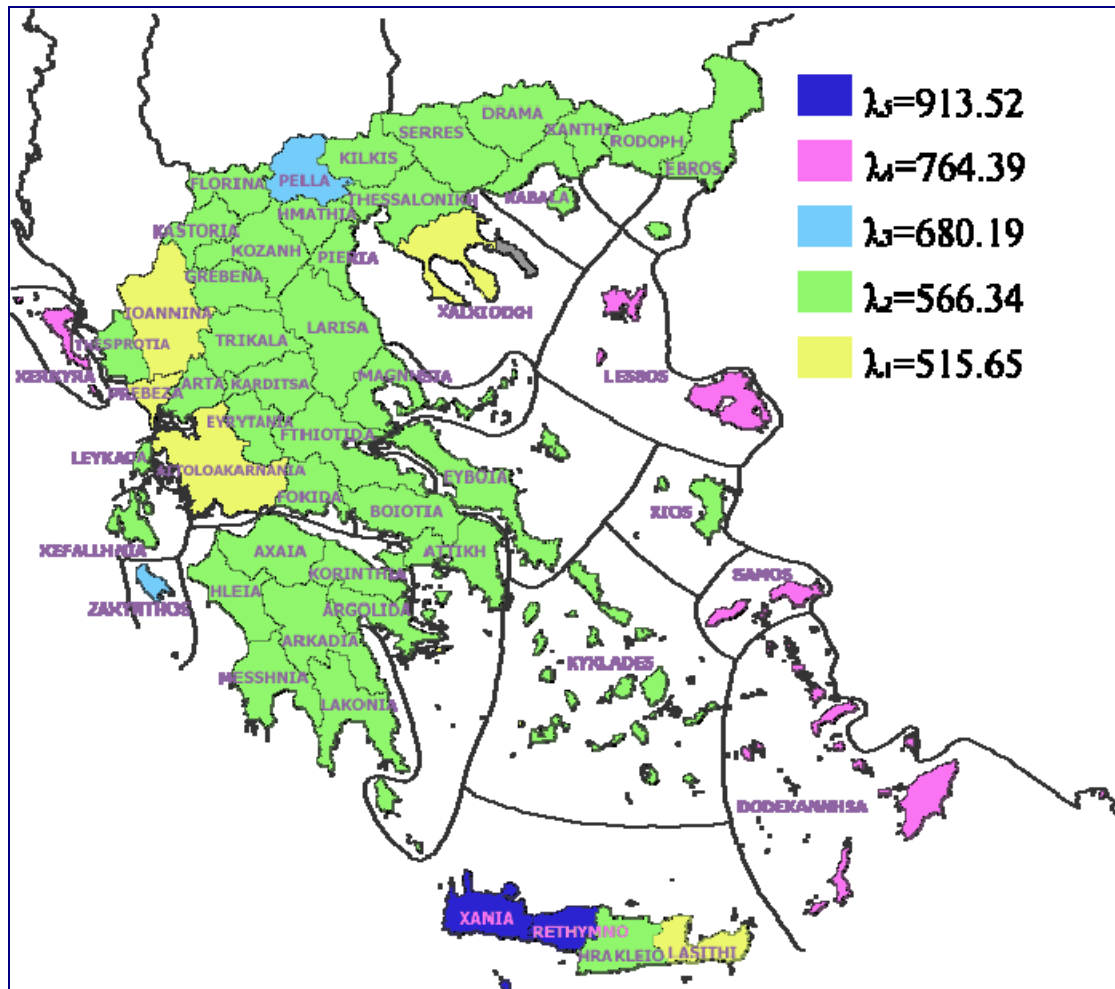**Figure 96.** Mapping of Greek counties according to crime volume of 1988.

6.2.3 Crime volume of 1989

This is just the third year under consideration, however, it has already become of quite an interest to see whether Xania and Rethymno will form the cluster with the highest crime volumes as before. The results of 1989 are some different than the two previous years, keeping, though, Xania, Rethymno, but also Samos and Dodekannhsa, among the top ones.

The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 185.833 with standard deviation s_α=206.42775, resulting to a value of 443.86769 for the stopping rule. Mojena's condition is satisfied at stage 5 for the first time, giving $\alpha_5 = 502.14 > 443.86769$, indicating four clusters. The obtained dendrogram with the four clusters is given in figure 97, and the corresponding mapping in figure 98.
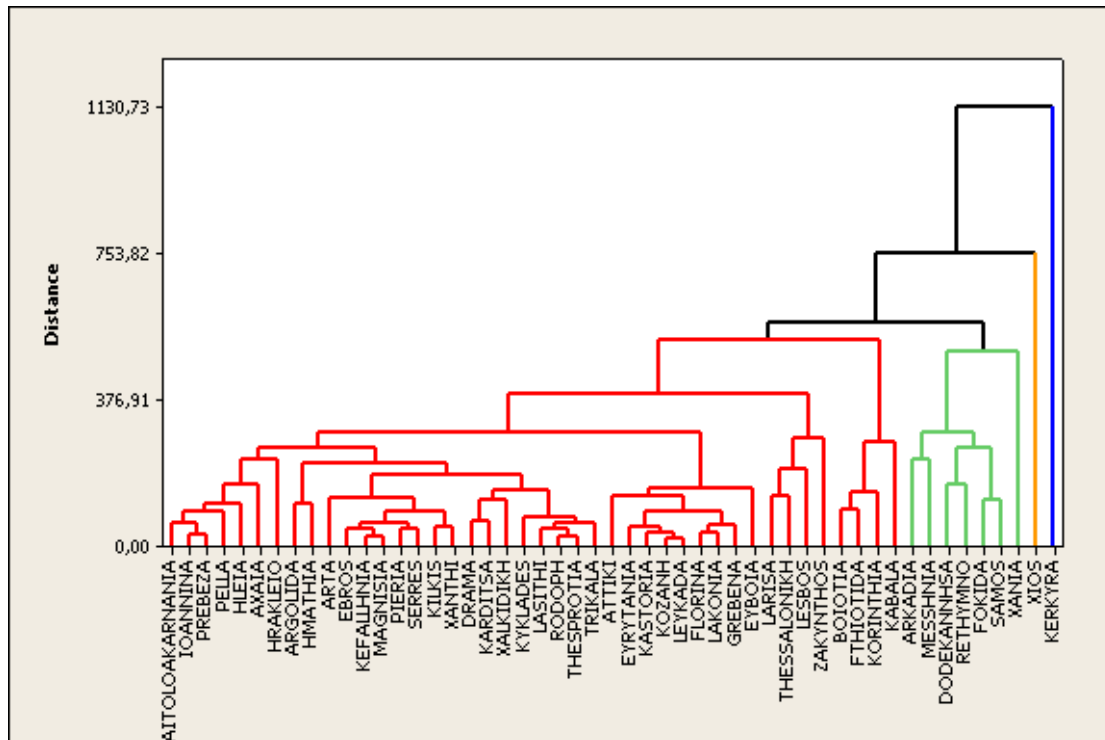
126

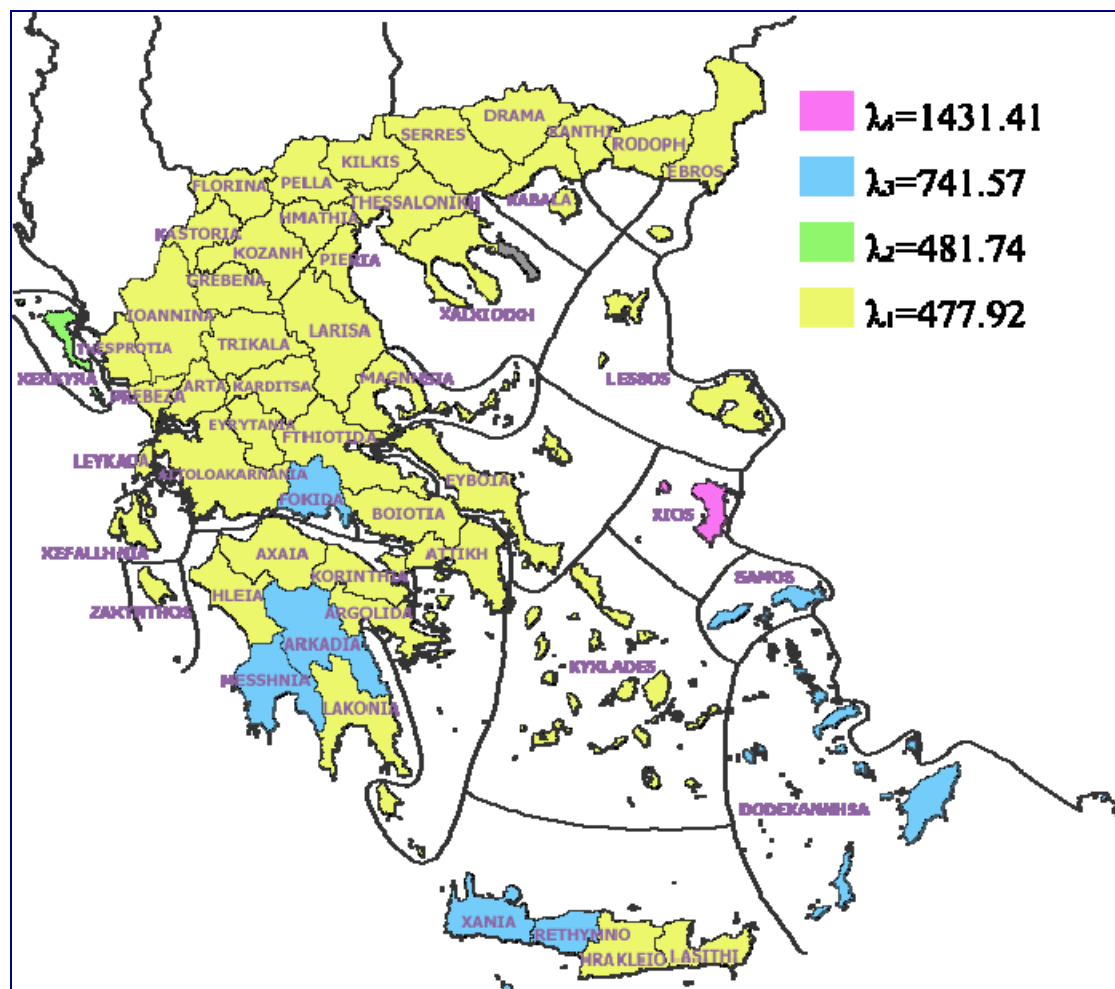**Figure 97.** Dendrogram of 1989 using Complete Linkage.

Figure 98. Mapping of Greek counties according to crime volume of 1989.

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This time Xios is alone at the top quite far from the others, mostly because of the arsons that year. Xania and Rethymno are one step from the top, accompanied again by Samos and Dodekannhsa, but having as new companions Messhnia, Arkadia and Fokida. This second cluster has an average total number of 741.57 offenses.

Kerkyra is alone at the third place, although very close to the group of all the other counties with only a difference of approximately 5 offenses in the average.

6.2.4 Crime volume of 1990

As far as 1990 is concerned, the mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 167.0401 with standard deviation s_α=157.7749, resulting to a value of 364.25865 for the stopping rule. Mojena's condition is satisfied at stage 5 for the first time, $\alpha_5 = 375.71 > 364.25865$, indicating four clusters. The obtained dendrogram is given in figure 99.
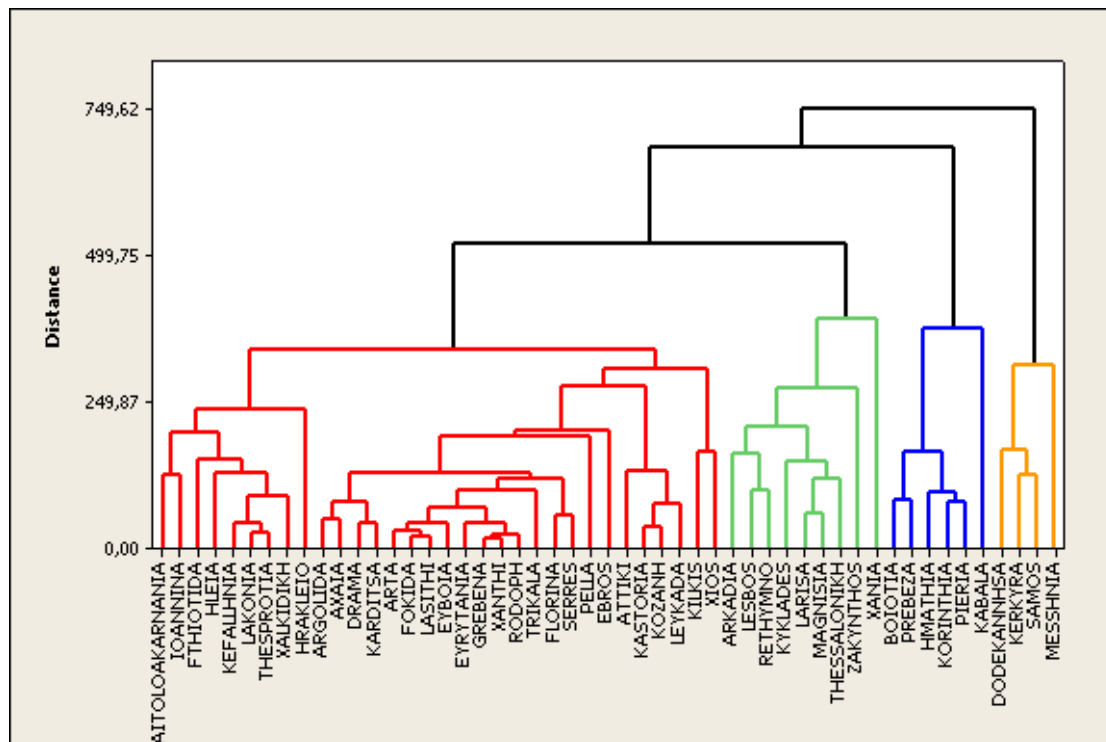
Figure 99. Dendrogram of 1990 using Complete Linkage.

This year is the first, up to now, which has more than four members in the cluster with the highest crime volume. This cluster consists of Arkadia, Kyklades, Larisa, Lesbos, Magnisia, Zakynthos, Thessalonikh, and as usual of Xania and Rethymno, and is found to have an average of 891.61 offenses per county.

The second cluster has Boiotia, Hmathia, Kabala, Korinthia, Pieria and Prebeza as members, with an average of 711.10 offenses.

The third cluster is formed by Dodekannhsa, Kerkyra, Messhnia and Samos, having an average of 661.60 offenses.

In the bottom all the other counties are found with an average of 436.96 offenses.

These results are given also graphically in the map of figure 100.

Figure 100. Mapping of Greek counties according to crime volume of 1990.

6.2.5 Crime volume of 1991

This time the mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 167.2328 with standard deviation s_α=135.46456, resulting to a value of 336.5635 for the stopping rule. The condition is satisfied at stage 6, where $\alpha_6 = 353.579 > 336.5635$, revealing five clusters. The obtained dendrogram is given in figure 101.
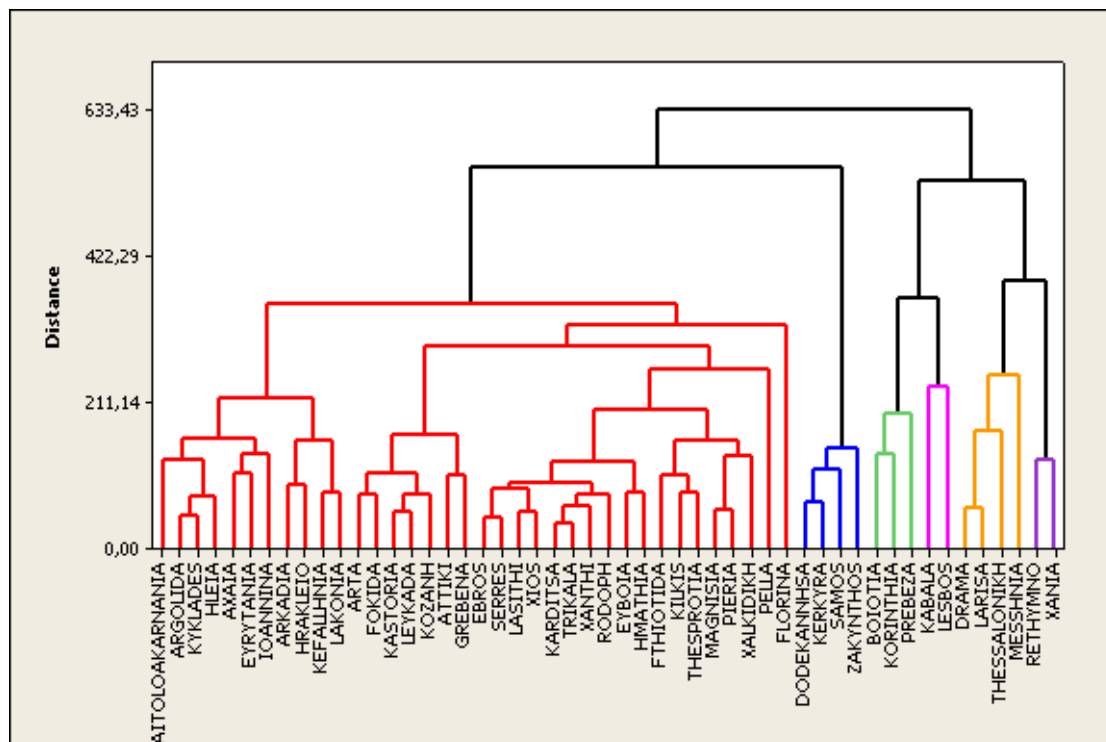
Figure 101. Dendrogram of 1991 using Complete Linkage.

Kabala and Lesbos are in the top with 1080.34 as average number of offenses for 1991. Xania and Rethymno are again close to the top in the next cluster, with an average of 1052.08 offenses.

In the third place we find Dodekannhsa, Kerkyra, Samos and Zakynthos, having an average of 947.53 offenses. One step behind them there is the cluster of Boiotia, Korinthia and Prebeza with an average of 863.76 offenses.

Drama, Larisa, Messhnia and Thessalonikh follow in one cluster with average number of offenses equal to 683.32. The cluster of all other counties holds the last place with an average of 468.42 offenses.

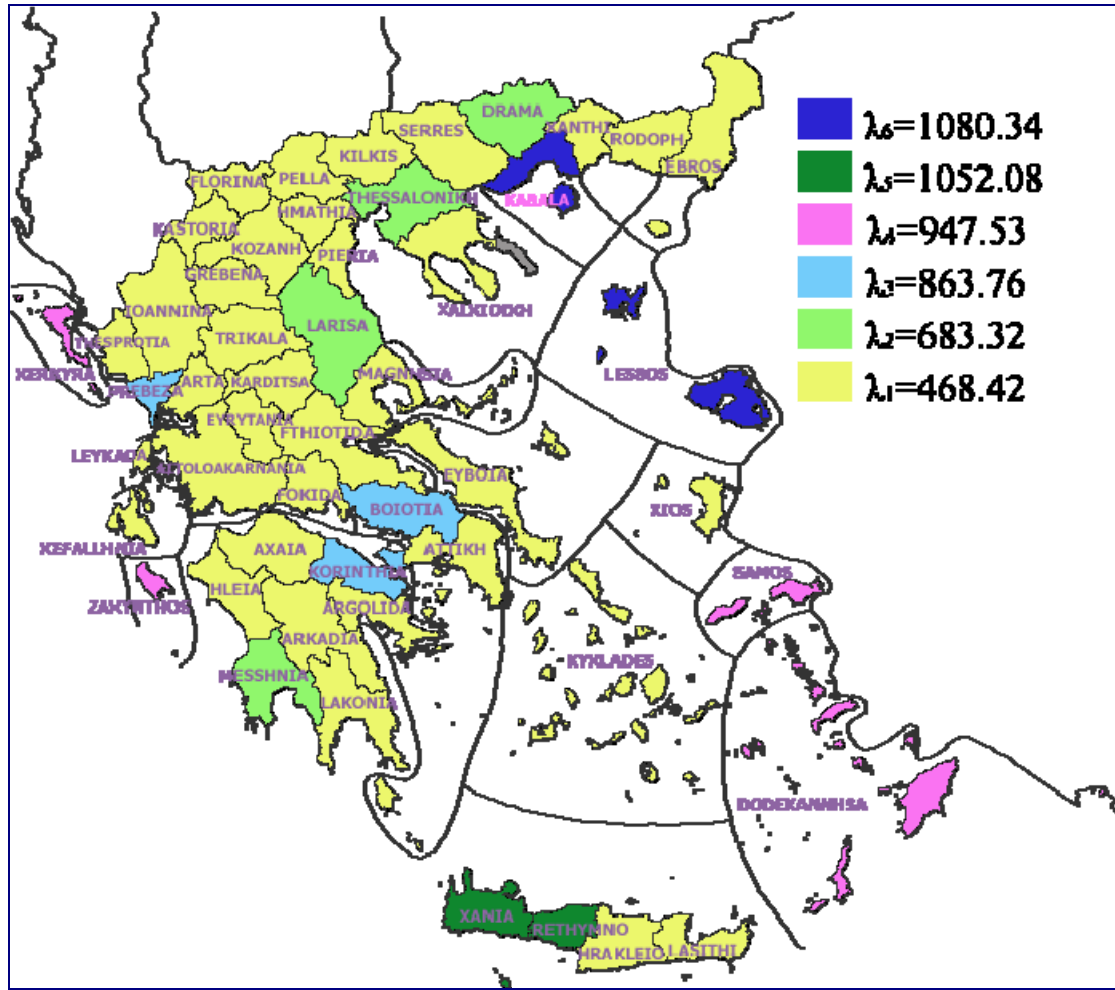The mapping of 1990's clustering is given in figure 102.

Figure 102. Mapping of Greek counties according to crime volume of 1991.

6.2.6 Crime volume of 1992

As far as 1992 is concerned, the mean $\bar{\alpha}$ of the fusion levels of the dendrogram was found to be 242.3356 and the standard deviation s_α=232.0343, resulting to a value of 532.3785 for Mojena's stopping rule. The rule's condition is satisfied at stage 5, giving $\alpha_5 = 560.96 > 532.3785$ and indicating four clusters. The corresponding dendrogram is given in figure 103, and the mapping according to the crime volume of 1992 is shown in figure 104.
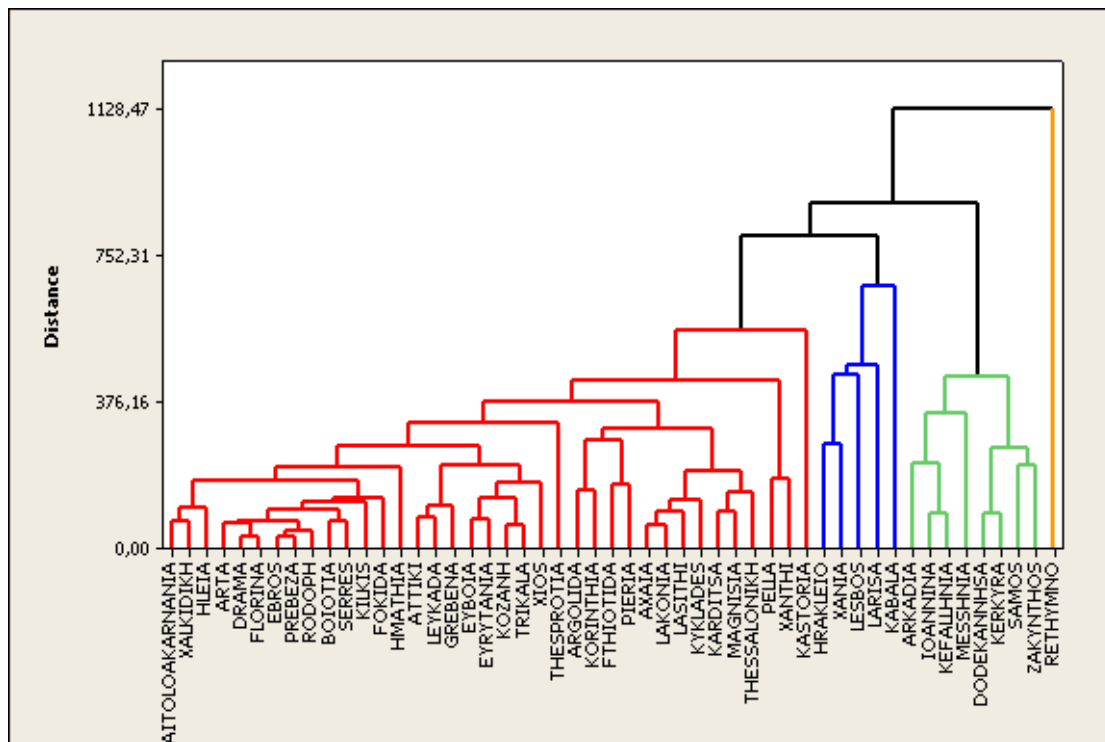
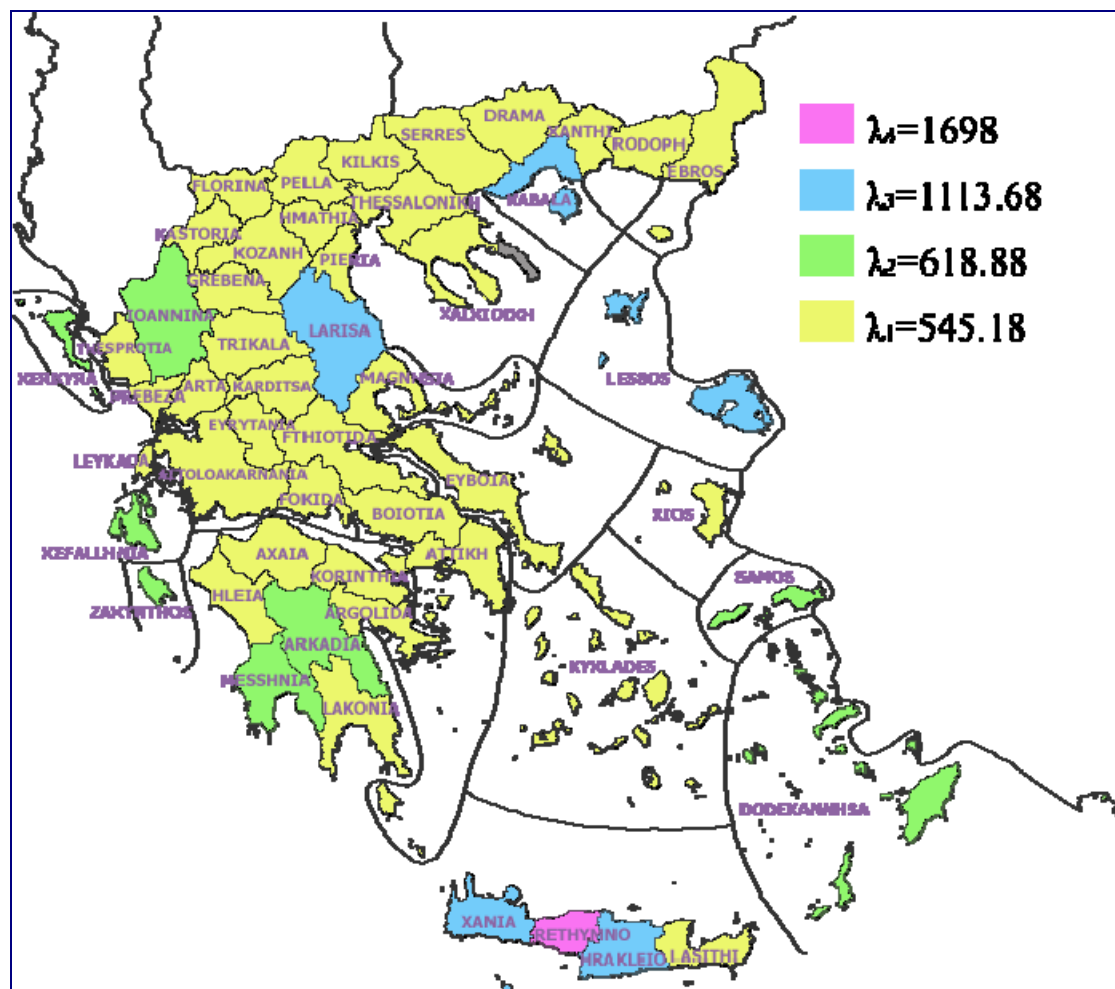**Figure 103.** Dendrogram of 1992 using Complete Linkage.

Figure 104. Mapping of Greek counties according to crime volume of 1992.

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This time Rethymno is alone at the top with 1698 total offenses. Xania is behind it in a cluster along with Hrakleio, Kabala, Larisa and Lesbos. This cluster has an average of 1113.68 offenses.

Arkadia, Dodekannhsa, Ioannina, Kefallhnia, Kerkyra, Messhnia, Samos and Zakynthos are grouped in another cluster with average number of 618.88 offenses.

In the last cluster all other counties are found with average number of total offenses for 1992 equal to 545.18.

6.2.7 Crime volume of 1993

Mojena's mean $\bar{\alpha}$ was found to be 203.3609 and the standard deviation s_α=177.3085, resulting to a value of 424.9966 for the stopping rule. The rule's condition is satisfied at stage 4, for $\alpha_4 = 462.39 > 424.9966$ revealing three clusters. The relative dendrogram is given in figure 105.
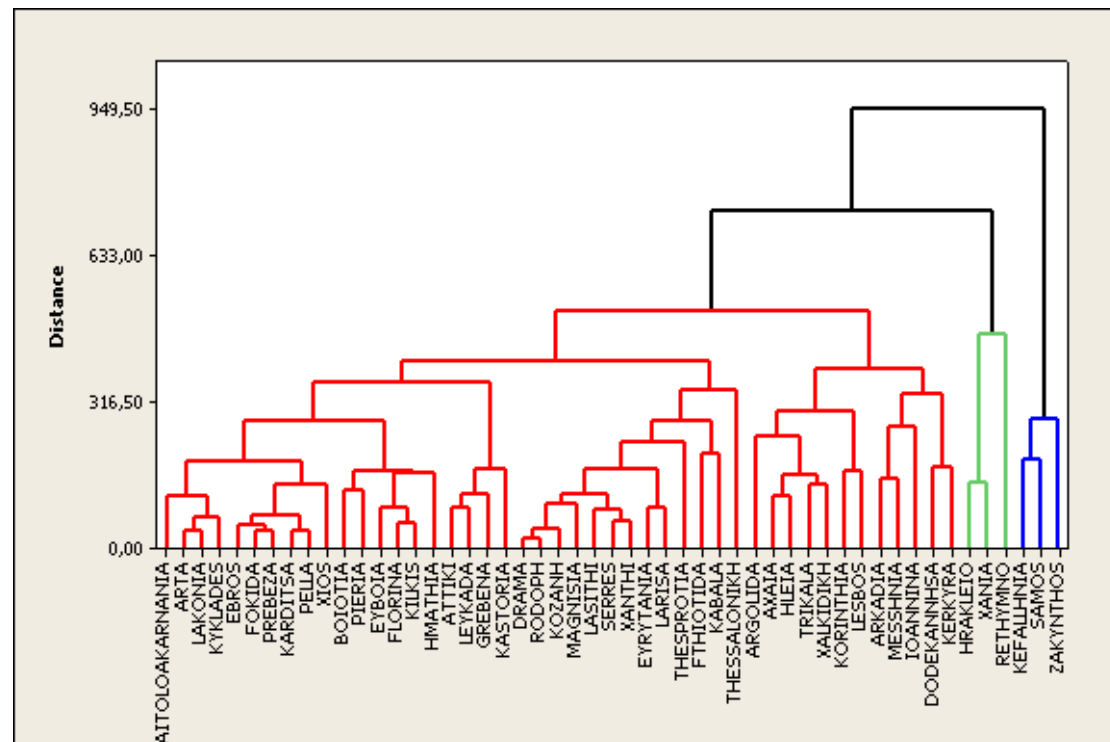

Figure 105. Dendrogram of 1993 using Complete Linkage.

Xania and Rethymno are once more at the top accompanied by Hrakleio with average number of offenses for 1993 equal to 1088.

Samos, Kefallhnia and Zakynthos are grouped together with an average number of 728.71 offenses.

The last cluster containing all other counties has an average number of 515 offenses.

The corresponding mapping to these results is presented in figure 106.
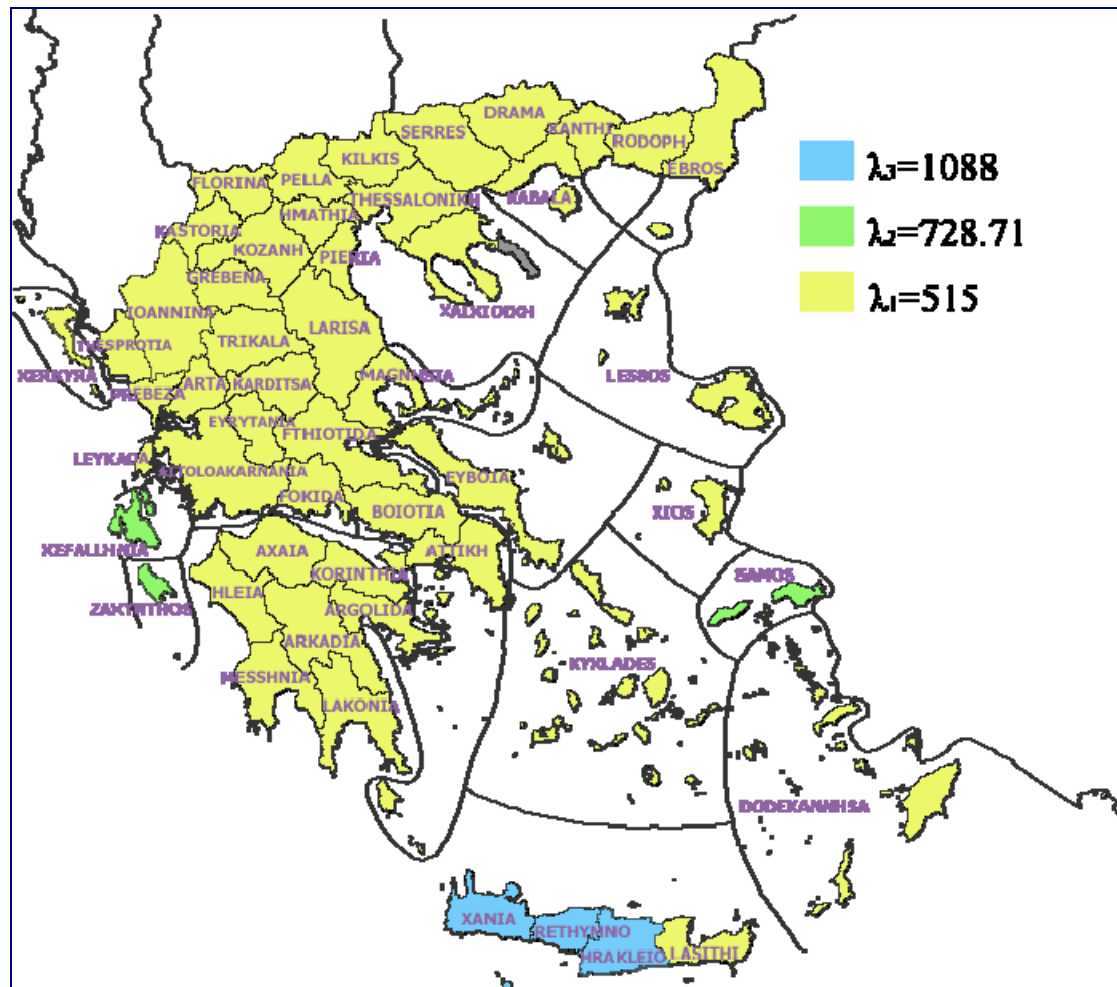

Figure 106. Mapping of Greek counties according to crime volume of 1993.

6.2.8 Crime volume of 1994

The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 202.8874 and the corresponding to the dendrogram of 1994 standard deviation s_α=223.3970. Thus, the stopping rule's value becomes 482.1336. Mojena's

condition is satisfied at stage 5, where $\alpha_5 = 492.7 > 482.1336$, indicating four clusters. The obtained dendrogram is given in figure 107.
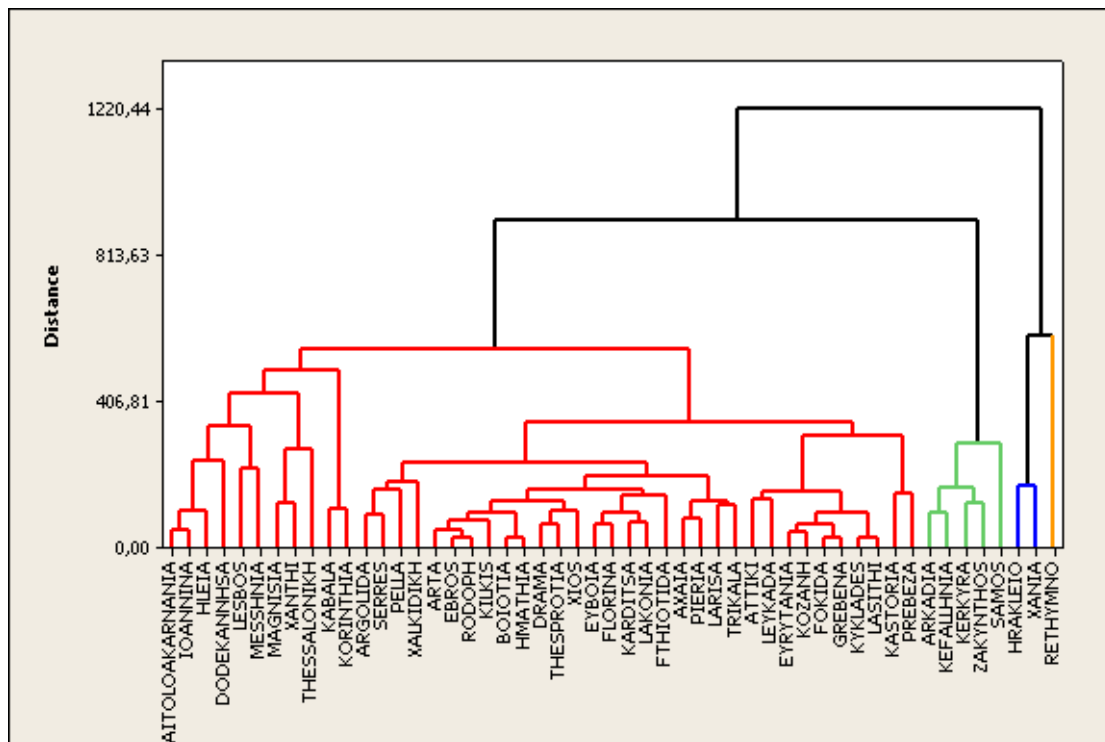
Figure 107. Dendrogram of 1994 using Complete Linkage.

Rethymno is once more at the top, alone, with total number of offenses found to be 1807.

Hrakleio and Xania are still behind Rethymno in a cluster with an average number of 1380 offenses.

Samos, Zakynthos, Kerkyra, Kefallhnia and Arkadia form the next cluster with average number of 594 offenses.

All other counties are grouped together with average number of offenses equal to 574.86.

We notice that from 1987 until now there are always certain counties, such as Rethymno, Xania, Hrakleio, Samos and Kerkyra, belonging to the clusters with the higher number of offenses.

Mapping of Greek counties according to crime reports of 1994 is given in figure 108.
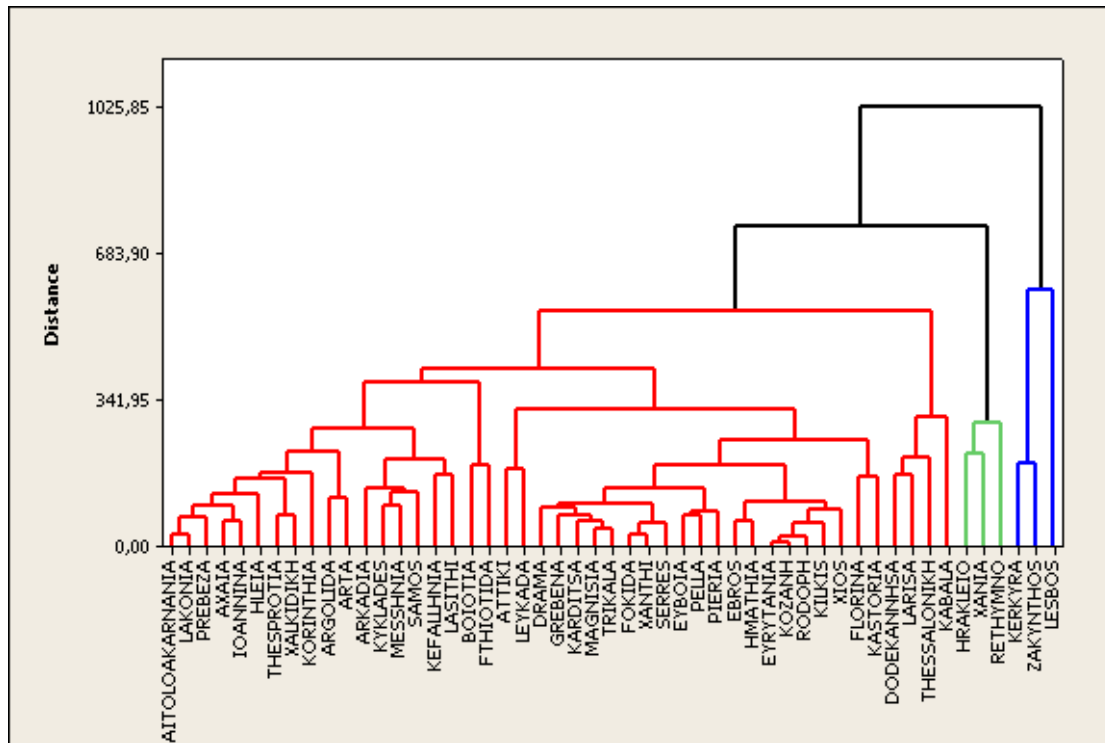
Figure 108. Mapping of Greek counties according to crime volume of 1994.

6.2.9 Crime volume of 1995

The next year under consideration is 1995. The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 191.2012 and standard deviation s_{α}=192.8404, resulting to a value of 432.2517 for the stopping rule. The condition is satisfied for the first time at stage 4, giving $\alpha_4 = 550.37 > 432.2517$ and resulting in three clusters. The obtained dendrogram with the three clusters is given in figure 109.

Once more the cluster with the higher offense counts consists of Rethymno and Xania along with Hrakleio, with average number of 1405.53 offenses.

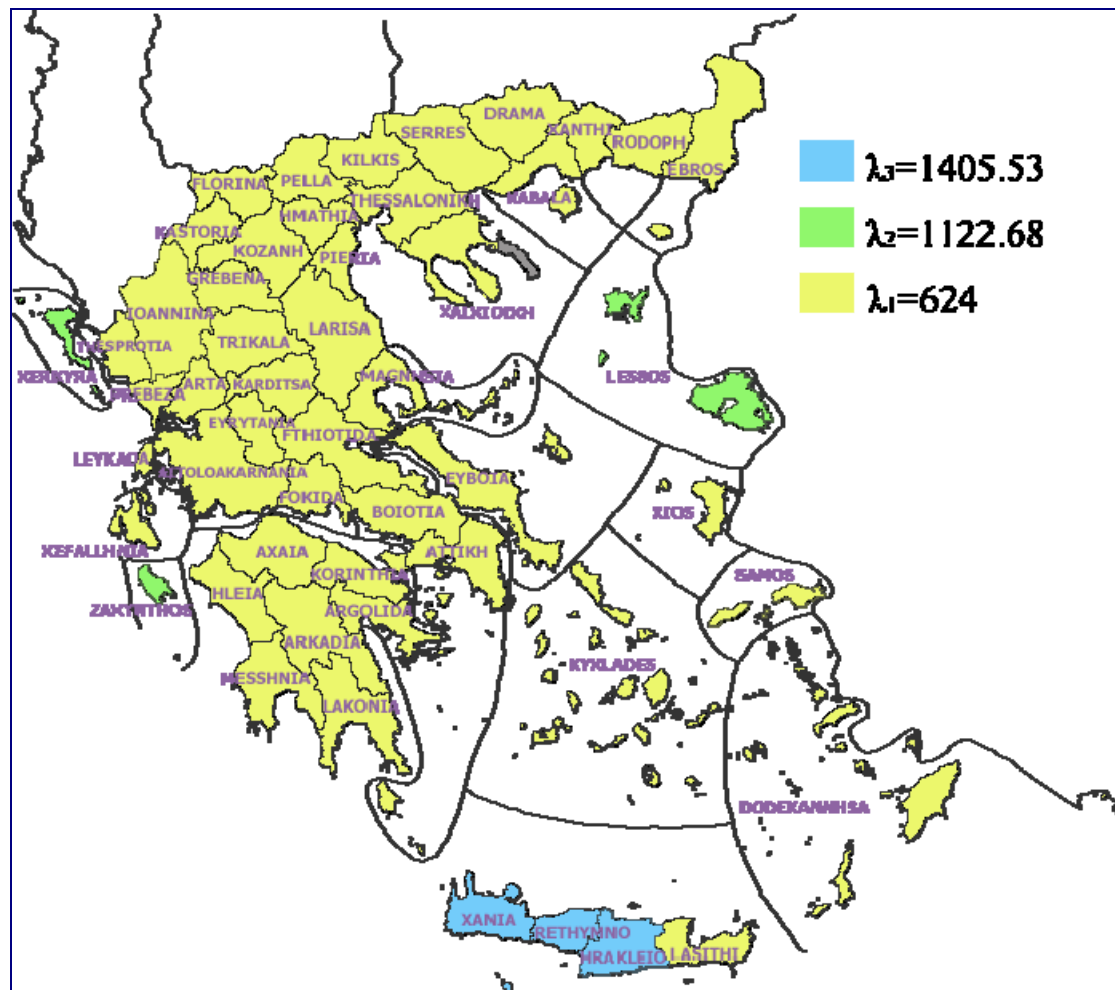**Figure 109.**Dendrogram of 1995 using Complete Linkage.

Figure 110. Mapping of Greek counties according to crime volume of 1995.

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Kerkyra, Lesbos and Zakynthos follow with an average number of 1122.68 offenses. We notice that these are three counties that were among those in the second place before.

The rest of Greek counties form one large cluster with average number of 624 offenses.

The graphical representation of the clustering of 1995 crime volumes in a map is given in figure 110.

6.2.10 Crime volume of 1996

In the sequence the analysis is repeated for 1996. The mean $\bar{\alpha}$ for Mojena's stopping rule was found to be 158.5953 and the standard deviation s_{α}=175.8433, resulting to a value of 378.3994 for the stopping rule. Mojena's condition is satisfied at stage 4, since $\alpha_4 = 447.314 > 378.3994$ for the first time revealing three clusters. The obtained dendrogram with the three clusters in color is given in figure 111.
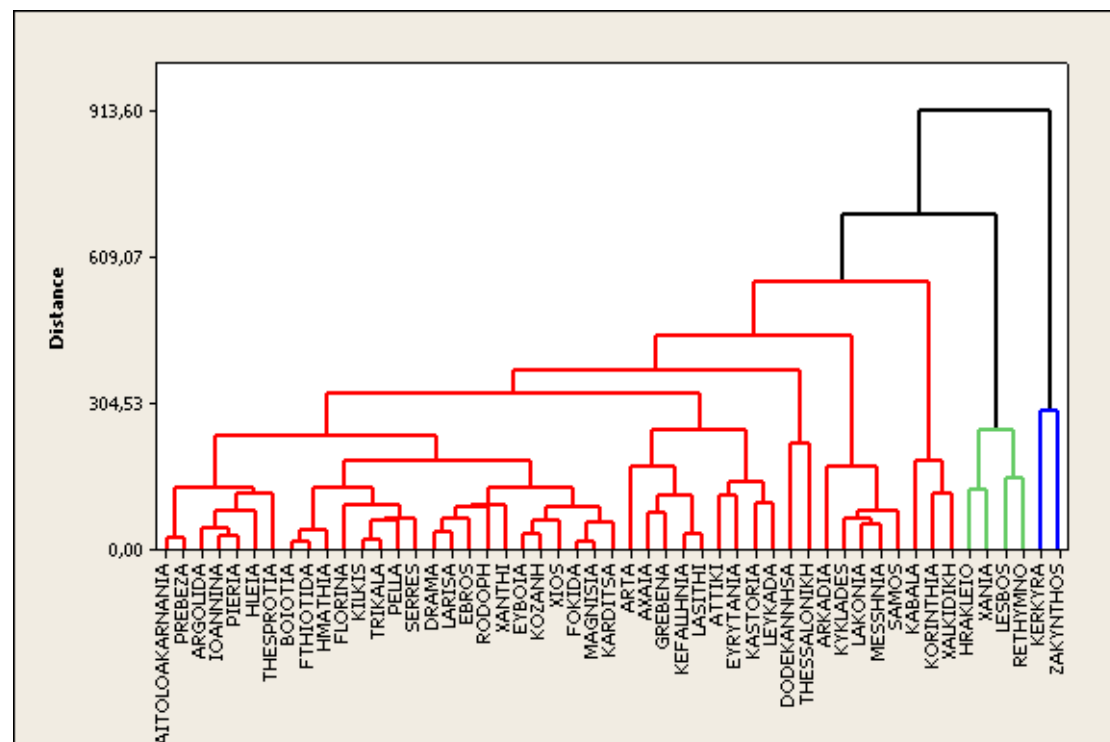

Figure 111. Dendrogram of 1996 using Complete Linkage.

Kerkyra and Zakynthos form this time the cluster with the higher crime volume, with average number of 1254.65 offenses.

Rethymno and Xania could not be very far, keeping in mind their whole crime during the previous years. They form the second cluster along with, which else, Lesbos and Hrakleio. This cluster has an average number of 1228.52 offenses.

The rest of all the other countries form, as before, a large cluster with average number of offenses found to be 490.32.

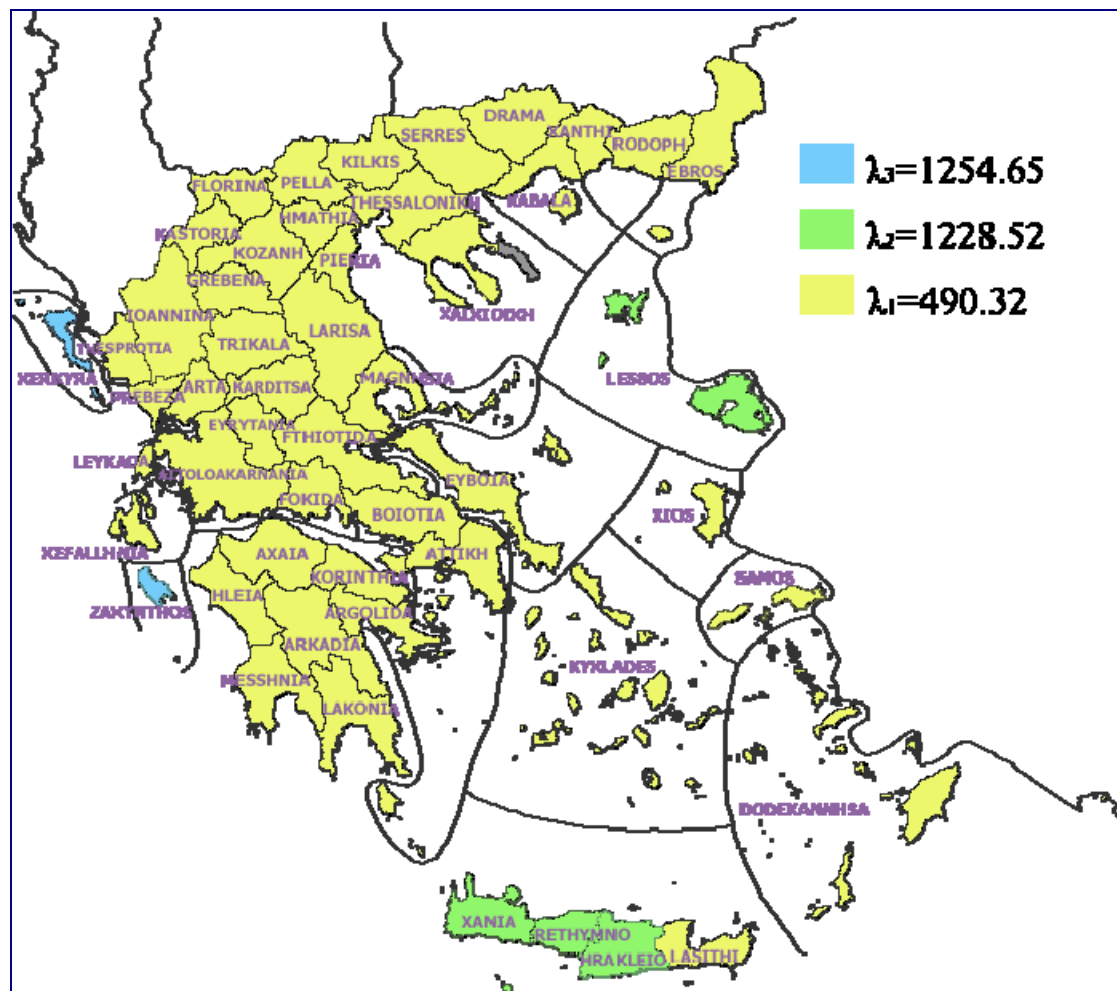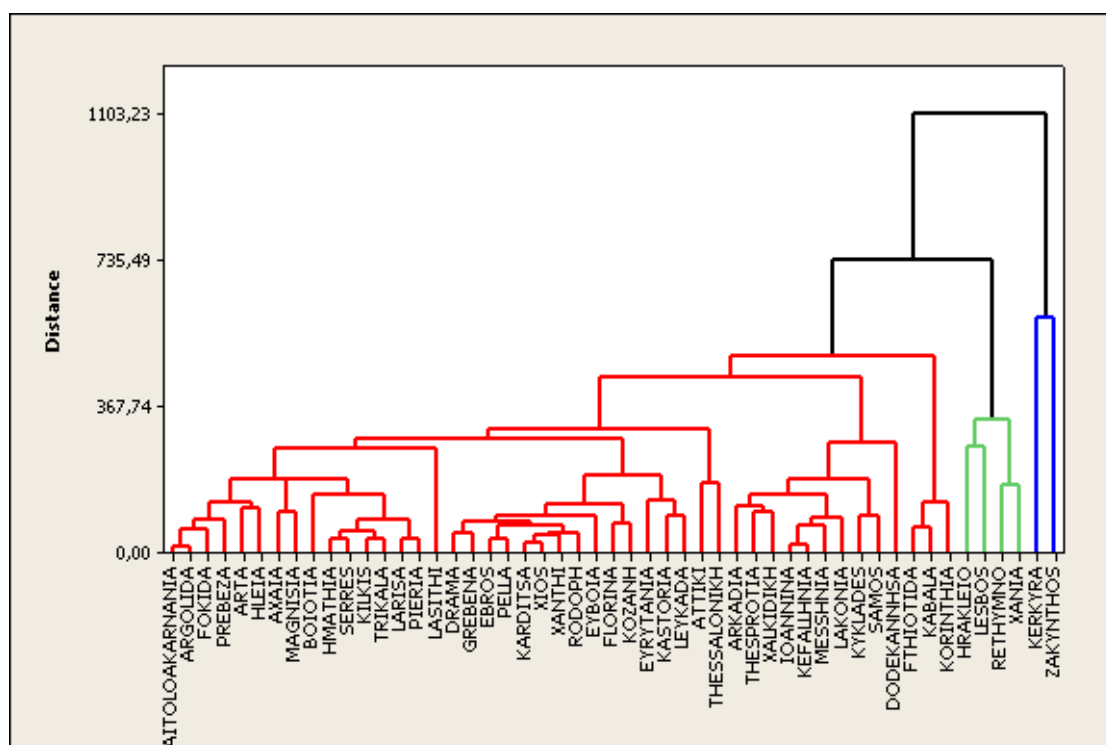The mapping of Greek counties according to 1996's crime volume is presented in figure 112.

Figure 112. Mapping of Greek counties according to crime volume of 1996.

6.2.11 Crime volume of 1997

The last year under consideration is 1997. The mean $\bar{\alpha}$ for Mojena's stopping rule was calculated to be 174.991 and the standard deviation s_α=200.4615, resulting to a value of 425.5679 for the stopping rule. The condition is satisfied for the first time at stage 4, with a fusion level of $\alpha_4 = 494.11 > 425.5679$, indicating three clusters. The corresponding dendrogram is given in figure 113.

Figure 113. Dendrogram of 1997 using Complete Linkage.

The result is almost identical to that of 1996, with only increased crime volumes. Kerkyra and Zakynthos form again the cluster with the higher crime volume, with average number of 1651.53 offenses.

Rethymno and Xania along with Lesbos and Hrakleio form, as in 1996, the second cluster with an average number of 1261.98 offenses.

The rest of all the other countries are grouped, as before, in a large cluster with average number of offenses found to be 504.59.

The mapping of Greek counties according to 1997's crime volume is presented in figure 114.
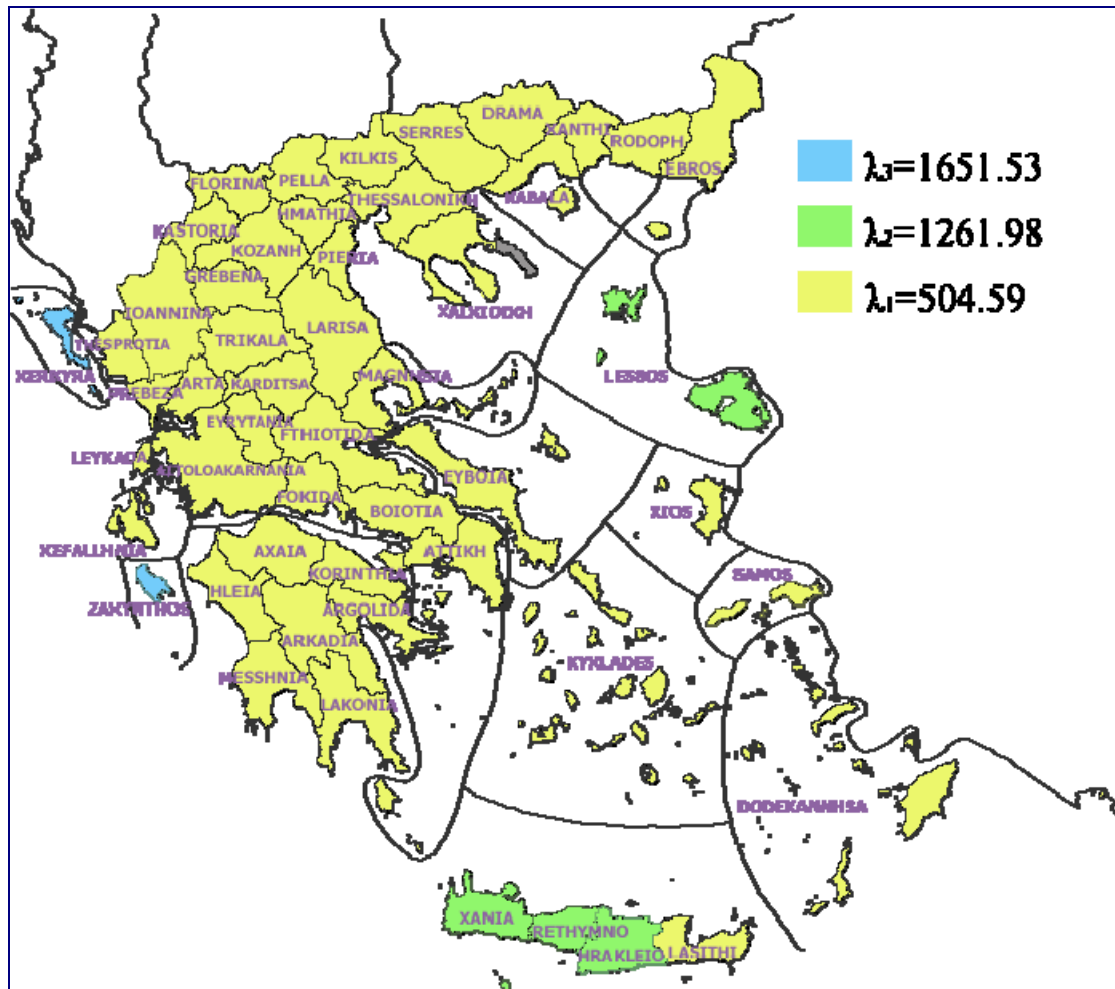
Figure 114. Mapping of Greek counties according to crime volume of 1997.

6.3 Final clustering of Greek counties based on the total volume of offenses for the whole time period 1987-1997

In section 6.1 we clustered the Greek counts according to average numbers of each offense during the whole period 1987-1997, while in section 6.2 the clustering was done based on the total average crime volumes for each year separately. In this paragraph we will perform a clustering of Greek counties according to all offenses for the whole time period under consideration. The results of the two previous sections will help us interpret this final clustering.

As in the two previous sections, the method used is Complete Linkage calculating the Euclidean distances. The criterion of cutting the obtained dendrogram is again Mojena's stopping rule.

The mean $\bar{\alpha}$ for Mojena's stopping rule was calculated to be 853.8794 and the standard deviation s_α=491.1812, resulting to a value of 1467.8559 for the stopping rule. The condition is satisfied for the first time at stage 6, with a fusion level of $\alpha_6 = 1651.94 > 1467.8559$, indicating five clusters for this final clustering of Greek counties. The corresponding dendrogram is given in figure 115.
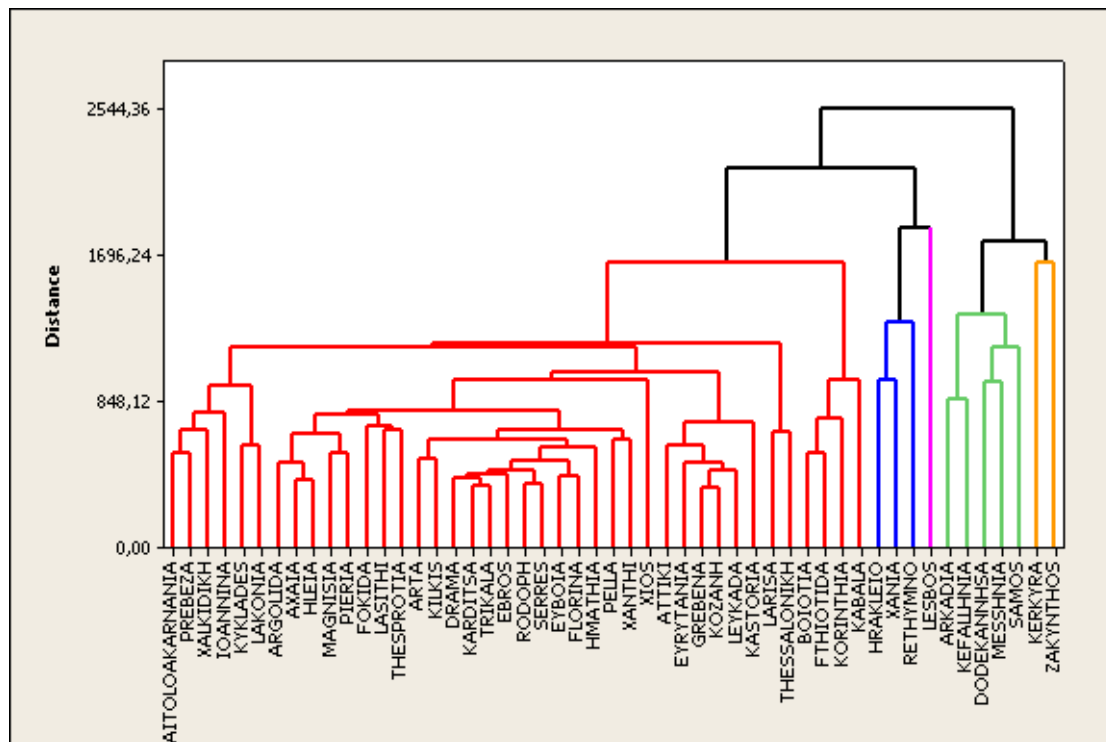
Figure 115. Dendrogram of the total volume of offenses using Complete Linkage.

Finally, the place with the highest crime activity during the period 1987-1997 is Lesbos, which is not clustered with any other county, with an estimated crime volume of 14622 offenses.

Rethymno, Xania and Hrakleio are one step behind, grouping in a cluster with average number of 13986.77 offenses.

These two results were also predictable judging on the results of section 6.2, where these four counties were always among those at the top.

Keeping in mind which the other counties among the 'top' ones were, the forming of the third cluster by Kerkyra and Zakynthos was also expected. Their cluster has an average number of 12945.42 offenses.

The fourth cluster behind them consists of Arkadia, Dodekannhsa, Kefallhnia, Messhnia and Samos, having an average number of 10747 offenses.

The rest of the counties are grouped together in the fifth cluster having an average of 6201.70 offenses.

The final mapping is given in figure 116.
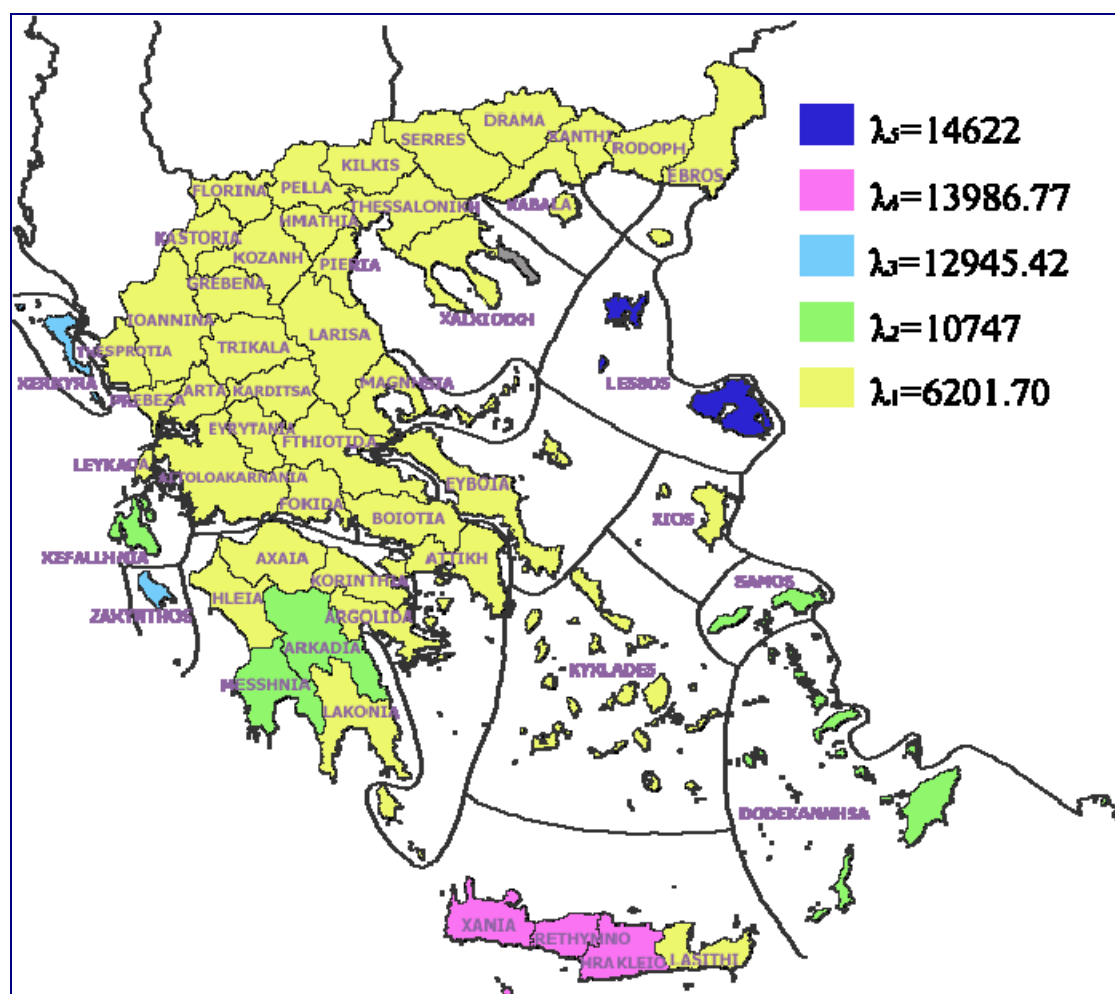
Figure 116. Mapping of Greek counties according to crime volume of the period 1987-1997.

In order to reveal which of the offenses brought Lesbos to the first place, we recall from section 6.1 that Lesbos had the highest number of rapes and was also high enough when the offenses under consideration were taking

the law into one's hands cases, offenses concerning explosives and illegal possession and usage of fire guns.

Xania, Rethymno and Hrakleio were among the clusters with the higher numbers of drug offenses and illegal possession and usage of fire guns. Xania and Rethymno had also higher numbers of murders and arsons in forests than the other counties. Rethymno was among the top ones as far as homicides by misadventure were concerned, while Xania was among those concerning antiquities' offenses. Hrakleio, on the other hand, was at the top concerning robbery and smuggling offenses.

Zakynthos and Kerkyra were members of clusters with higher numbers of taking the law into one's hands cases and drug offenses. Moreover Kerkyra had the highest average number of taking the law into one's hands cases. Zakynthos was among the counties with the highest numbers of murders and rapes.

Samos was member of clusters taking the second or the third higher place in average numbers of taking the law into one's hands cases, arsons, offenses concerning antiquities or explosives and drug offenses.

Dodekannhsa got the first place in beggaries and had high numbers of taking the law into one's hands cases, offenses concerning antiquities, drug offenses and offenses concerning explosives.

Arkadia had relative high numbers of taking the law into one's hands cases, drug offenses and offenses concerning explosives.

Messhnia had relative high numbers of taking the law into one's hands cases and physical injuries.

Kefallhnia had relative high numbers of offenses concerning antiquities.