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AN ATTEMPT TO REVEAL THE PATTERNS AND CHARACTERISTICS OF ENVIRONMENTAL CONCERN IN THE MUNICIPALITIES OF CONSTANTINE PROVINCE USING FACTOR AND CLUSTER ANALYSIS FOR THE YEAR 2021

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ABSTRACT

Environmental issues have garnered a significant share of research by specialists. The results of studies have yielded a deeper understanding of the environmental phenomenon in many of its aspects. There is almost a consensus among researchers that addressing environmental problems is closely related to the success of development efforts.

This research paper attempts to reveal the patterns and characteristics of environmental concern in the municipalities of Constantine Province. To achieve the study's objectives, statistical methods were used, particularly factor analysis and cluster analysis.

We have arrived at important results that favor the development of the province and in diagnosing and preserving the environmental situation. The results of factor analysis revealed the existence of three main factors in the set of study variables, which explains the variance values of the environmental phenomenon. The results of cluster analysis led to the identification of four homogeneous patterns in terms of environmental concern across the entire provincial territory.

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Introduction.

There are numerous trends among administrative bodies and institutions concerned with development and the environment to find innovative approaches to address environmental problems, conserve and maintain natural resources, mitigate environmental damage, and provide alternatives in the process of resource utilization that are equivalent in economic value and avoid disrupting environmental balances. (Rezzik, 2007) considered economic instruments to be among the most successful means of environmental protection.

Environmental issues have attracted the interest of many researchers and experts. Their attempts have focused on understanding the characteristics, functions, and dynamics of environmental systems. (Boudraa,2018) emphasized the reliance on modern methods in environmental protection. The interest has increased when linking environmental concern to improvements in the environmental situation and the protection of natural resources. In a study by (Abdallah, Ambarek 2022), he identified many environmental challenges that pose an economic and social threat to all regions of the world.

Understanding the causes of encroachment on the environment is not enough to address the environmental problems, but rather determining the appropriate framework for intervention and knowing its prior conditions and characteristics is a systematic organization that allows us to determine when, where and how to intervene and maintain environmental balances. Providing a clean environment that encourages development and makes life pleasant is one of the most important challenges facing our communities today, and this is what (Gharabia, 2010) tried to emphasize in his study.

Algeria, like many other countries, has tried to provide alternatives for the protection and preservation of environmental balances and to make important reviews to mitigate the environmental damage that has affected our resources. In response to this, many laws have been put in place to protect our environmental surroundings and to try to assess the negative impacts and the extent of the influence of economic, social and developmental aspects on them. Algeria, with its significant area in Africa and the Arab world, has resources that are characterized by fragility and sensitivity at times, and by poor distribution of its resources at other times, affected by many economic, social and even regional conditions. Algeria has put in place a package of regulatory laws, especially Law (03-10) dated July 19, 2003 relating to the protection of the environment within the framework of sustainable development, and the law has addressed several aspects for the protection of the environment. Many decrees have also been ratified to limit environmental encroachment, especially Executive Decree No. (07-144) dated May 2007, which defines the classified and environmentally protected establishment. The programs, projects and laws put in place to protect and maintain natural resources are important interventions by the state, but the experience remains in its infancy. Environmental violations seem to be the dominant feature, as the novelty of the Algerian experience in restoring environmental balances is linked to many failures, some of which are related to the administrative management of environmental concerns, and others to the means and techniques capable of addressing environmental issues. For this reason, the study aims to search for an analytical framework by which we can reveal the environmental reality with all its elements and identify the environmental characteristics and patterns, using statistical methods such as factor analysis and cluster analysis, and relying on the SPSS program. The method of factor analysis and cluster analysis has been used by many researchers, such as the study by (Nassouh et al., 2017) on the role of factor analysis in determining the factors affecting services, the study by (Bouras and Jarroud, 2020) on psychological and educational tests, and another study by (Al-Fil, 2022) on statistical data analysis. In general, studies in this area are numerous. Our study has a classificatory objective related to the environmental topic, relying on statistical methods, which is an effective contribution to developing a new vision on how to deal with the changing environmental reality.

Research Methodology.

To achieve the main objective of the research, we need to collect a large number of variables related to the field of study, particularly those related to environmental issues. The selection of variables was based on their suitability with the research objectives and the requirements of the SPSS program. We relied on (16) variables that provide insights into environmental engagement and reflect the specific nature of the environmental phenomenon. Among the selected variables, we find, for example, the population concentrated in the center, the active population, the amount of water used, the total amount of waste, the number of uncontrolled waste disposal sites, etc.

In line with the research requirements, we collected data from official sources, notably the (Directorate of Programming and Budget Monitoring for the year 2021) for the municipalities of the Constantine province, specifically (12) municipalities, in addition to (the National Office of Statistics for the year 2021), and other data related to the environmental phenomenon.

To address the problem and extract results that are useful for our research, we adopted some methods for investigating the environmental reality (Angeres, 2004). The most important methods are as follows:

- **Descriptive-Analytical Method.** This method enabled us to diagnose the phenomenon, conduct a diagnosis, and derive results that are useful for the research.

- **Statistical Analysis Method.** For the purpose of analysis and quantifying the phenomenon under study, and in an attempt to investigate reality in all its elements and give the study more credibility and scientific rigor in formulating conclusions, we used factor analysis and statistical methods. We utilized the SPSS program to process the correlation matrix, particularly in relation to factor analysis. For cluster analysis, we employed the nearest neighbor method. The statistical methods are provided by the SPSS program.

- **Cartographic Method.** The study took into account the spatial dimension and created maps, some of which define the location of the study area, and others that represent the spatial distribution of environmental characteristics and their patterns. These maps were created using the QGIS program, which specializes in map creation.

Study Plan.

Based on the study objectives and the methodology followed, a work plan has been developed that we consider appropriate for achieving the objectives. The plan is outlined in Figure (1) as follows:

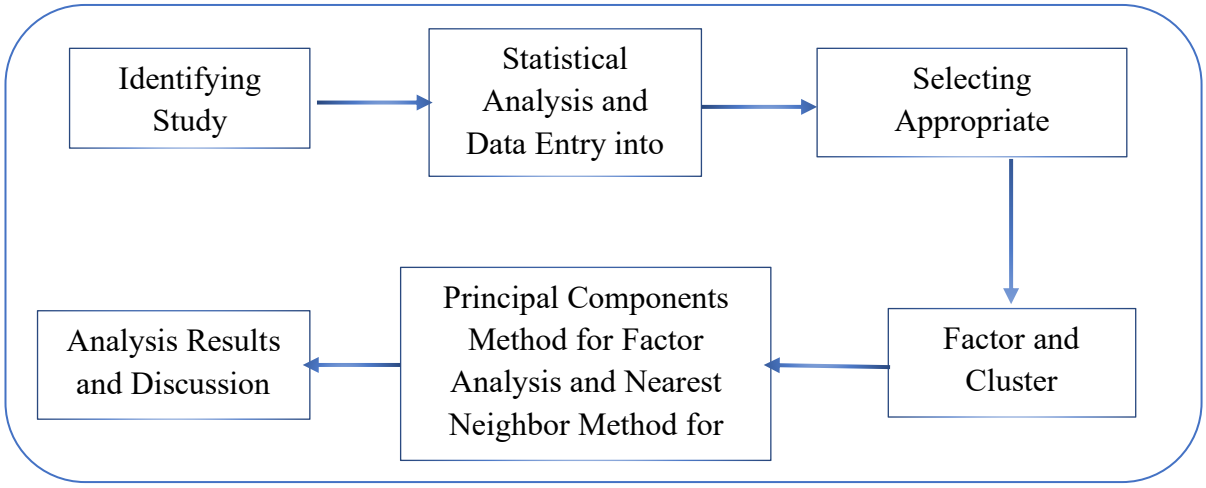

Figure 1. Study Plan.
Source: Accomplished based on data (dpbm) for the year 2021.

Study Area Localization.

The capital of Constantine province is a city steeped in history, having been ruled by numerous nations and civilizations, starting with the Roman period, through the Islamic conquests, and reaching the French colonial period. It was formerly known as the city of Cirta and was the capital of Numidia, known since 300 years before the birth of Christ. The city is known for its valley, which cuts through the city and is called "Kbir Remal" (Big Sands).

Constantine province is one of the most important provinces in Algeria, located in the northeastern part of the country. Figure (2) provides a clearer illustration of this. It is bordered to the east by the province of Guelma, to the west by the province of Mila, to the north by the province of Skikda, and to the south by the province of Oum El Bouaghi. Its area is 2187 km², and its population is estimated at 1,330,616 inhabitants. The population density is estimated at 608 inhabitants/km² for the year 2021. The administrative division of 1984 created new provincial territorial boundaries with (12) municipalities belonging to the province of Constantine.

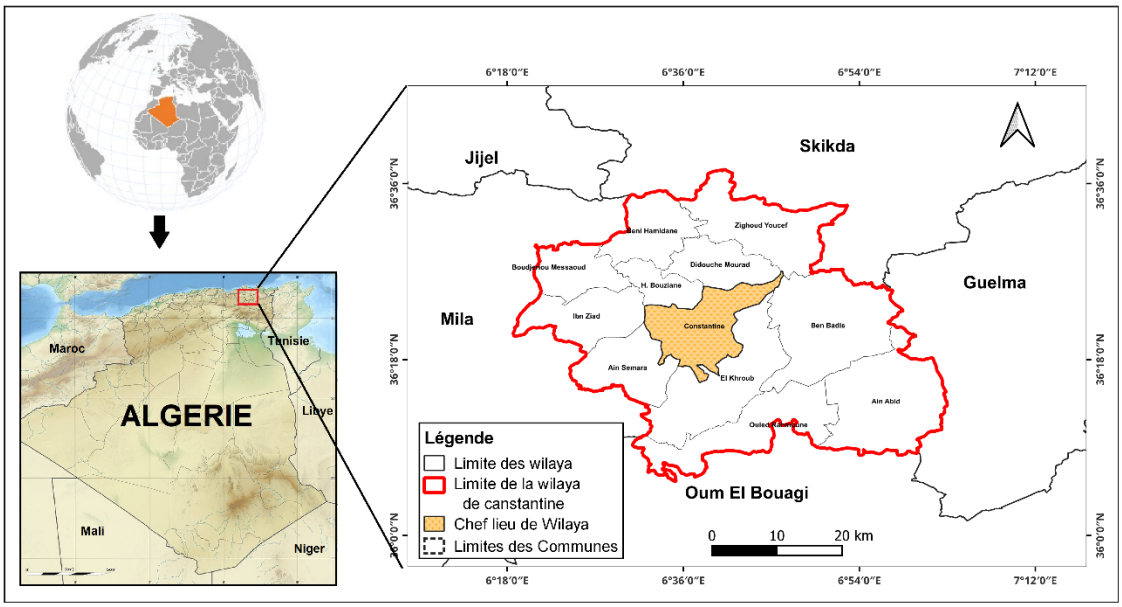

Figure 2. Localisation of study area.
Source: Accomplished based on data (dpbm) for the year 2021.

The provincial region is located in the center of the northeastern Algerian region. The region is characterized by a varied topography from north to south. The contrast and duality between north and south are evident in its climate. In general, it is characterized by a hot and dry continental climate in summer and a cold and rainy climate in winter. The region is a place where the work of humans, past and present, intermingles and crystallizes with the elements of the environment that have been shaped over millions of years.

Results and Discussion.

Factor Analysis Results.

Factor analysis methods aim to find a set of factors responsible for revealing differences in a group of (19) response variables. Factor analysis has the ability to reduce the large number of variables into a smaller number of new variables called factors. Observed variables can be expressed as a function of latent factors. By entering the variables into the program and applying the Principal Components Method, following the steps specific to the SPSS program, the following results were obtained.

The underlying roots of the correlation matrix were revealed. Through the results obtained in the SPSS program and applying the principal components method, the program provided a correlation matrix in a square formed by (16) variables, present in the number of rows and columns. The results obtained showed variation among the correlation coefficients. Examples of strong correlations include the variable "Population of the Main Cluster" with the variable "Amount of Water Used," where the correlation value was estimated at (0.980), indicating a very strong correlation close to one. Moderate correlations include the relationship between "Amount of Water Used" and the variable "Urban Population," where the correlation coefficient was estimated at (0.598). Weak correlations are identified in the relationship between the number of dwellings (residential area) and the variable "Population of the Main Cluster," with a correlation estimated at (0.391). It can be concluded that the nature of the correlations is diverse, reflecting the importance of the relationships between the variables.

Given the abundance of tables provided by the SPSS program, we selected some important tables that represent the factor analysis, particularly table number (1). This table shows the presence of (16) variables, and by selecting values greater than one, we obtained only

(3) main factors, namely (10.820, 2.228, 1.196). The percentage of variance in the first factor was determined to be (67.625%), which is the value representing the amount of variance covered by this factor. Table number (1) provides more clarity with (67.625%, 13.928%, 7.457%) representing the three factors: the first, second, and third. The first factor accounts for many strong correlations compared to the second and third factors. The table also shows the cumulative percentage, which is the ascending accumulation. The results of the table show that when the value of the first factor and the second factor are combined, they are determined to be (81.552%). However, when combining all three factors, we find a value of (89.027%), meaning that the three factors cover the entirety of the response variables. The process continues until reaching (100%). Table number (1) provides further clarification and is presented as follows:

Table 1. Principal component Analysis.

Component	Initial eigenvalues			Extraction sums of squared loading			Extraction sums of squared loading rotation		
	total	% of variance	% cumulative	total	% of variance	% cumulative	total	% of variance	% cumulative
1	10,82	67,62	67,62	10,82	67,62	67,62	9,31	58,24	58,24
2	2,22	13,92	81,55	2,22	13,92	81,55	2,86	17,91	76,15
3	1,19	7,47	89, 027	1,19	7,47	89,02	2,05	12,87	89,02
4	1,08	6,42	95,45						
5	0,50	3,16	98,61						
6	0,12	0,78	99,40						
7	0,04	0,30	99,71						
8	0,03	0,23	99,95						
9	0,005	0,03	99,98						
10	0,002	0,01	99,99						
11	0,001	0,005	100						
12			100						
13			100						
14			100						
15			100						
16			100						

Source: Accomplished based on data (dpbm) for the year 2021.

The translation of the results from the previous table with the total explained variance is presented. The values of the factors were placed on the ordinate axis, while the values of the variables were placed on the abscissa axis. It is clear that the graph confirms the dominance of the first factor and its control over all the response variables. A scree plot was drawn to graphically illustrate the table of the latent roots of the correlation matrix, and Figure (3) provides a clearer representation of this.

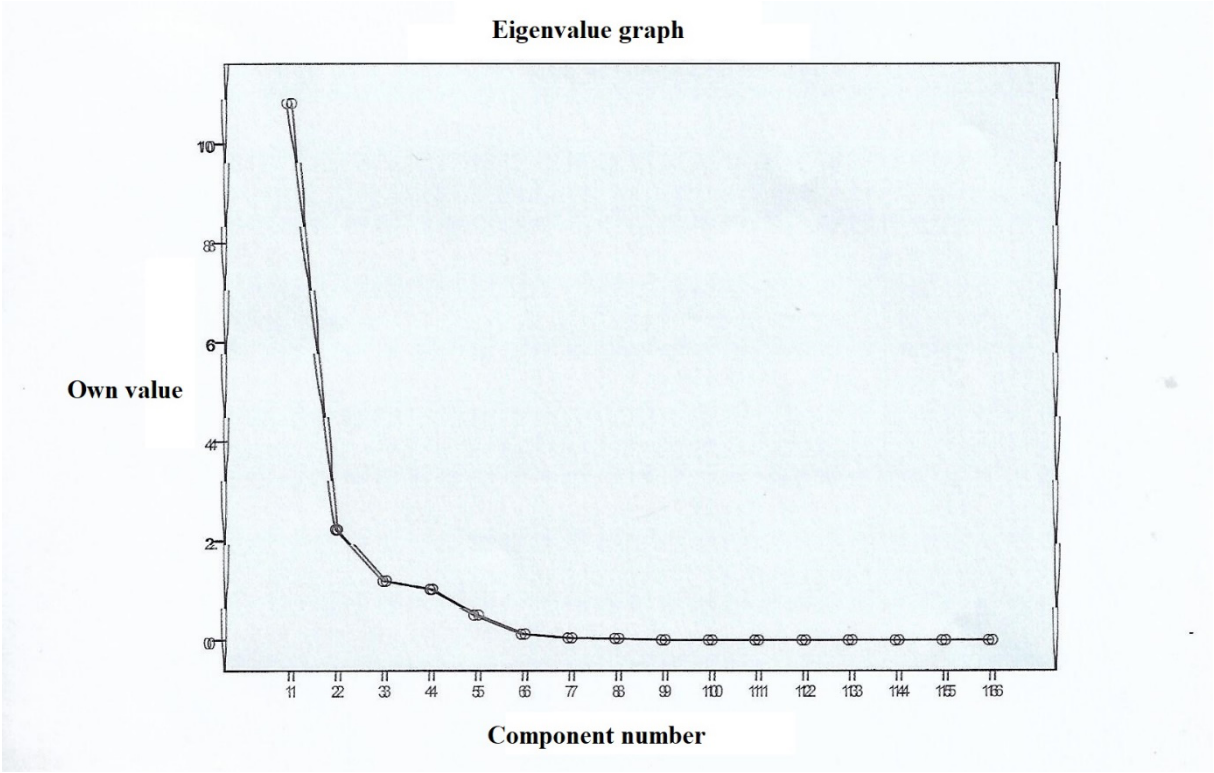

Figure 2. Graph of the corrélation matrix.
Source: Accomplished based on data (dpbm) for the year 2021.

The SPSS program, to enhance the analysis and scrutiny of knowledge, provided the following table related to the factor matrix after rotation. This table clarifies the confirmation of the dependency of any of the variables on the factors. Table number (2) determines the value of the relationship that links the (16) variables with the three factors. Numerous examples demonstrate the validity of any variable for the three factors. The variable "Population of the Main Cluster" follows the first factor with a correlation coefficient estimated at (0.968), and with a very weak correlation with the second factor, estimated at (-0.099). The same variable has a weak correlation with the third factor, estimated at (0.193). Another example is the variable "Amount of Waste Disposed," which follows the first factor with a correlation coefficient estimated at (0.870), and with a weak correlation with the third factor, estimated at (-0.164). The variable "Uncontrolled Waste" has a good correlation coefficient with the third factor at (-0.777) but a weak correlation with the second factor, estimated at (0.335.-). Table number ( ) provides a clearer representation of the degree of the relationship between the variables and the three factors. We can name the first factor "Integrated Environmental Development", the second factor "Urban and Urbanistic Environmental Development", and the third factor "Natural and Agricultural Environmental Development".

Table 2. Component Matrix (3 component extracted).

	Factor		
	1	2	3
1	2	3	4
popacl	0,968	-0,099	0,193
popocc	0,884	0,334	0,314
prolop	0,970	0,064	0,218
quusrej	0,966	0,125	0,209

Table 2. Continuation.

1	2	3	4
qudeto	0,870	0,425	0,164
qudeme	0,878	0,450	0,045
decncon	-0,270	-0,335	-0,777
popur	0,496	0,838	0,088
parlog	0,489	0,843	0,087
palopre	0,903	0,296	0,252
nomesp	0,942	0,252	0,203
noopme	0,967	0,036	0,095
nompib	0,246	-0,732	0,532
surver	0,164	0,031	0,717
suzoactind	0,956	0,248	0,096
tegersauss	-0,035	0,257	-0,515

Source: Accomplished based on data (dpbm) for the year 2021.

The results of the factor analysis for the set of response variables, regarding the set of latent factors, identified three factors, as follows:

Factor 1. Integrated Environmental Development.

The nature of the variables and their relationship with the first factor show that they are integrated. Variables related to population, as well as the amount of water used, in addition to the amount of waste disposed, showed very strong correlations in the provincial region. The main characteristic of this factor is the strength of the correlation coefficients with the variables, many of which exceed (0.9). The content of table number of the factor matrix after rotation is a true translation of the strength of the correlations.

Factor 2. Urban and Urbanistic Environmental Development.

Compared to the first factor, the second factor has less coverage and dependency of variables. The estimated values of the correlations were weak to moderate, with more variables having a good correlation with uncontrolled waste, as mentioned earlier, and a moderate correlation with the variable "Number of Libraries" at (0.335). Table number provides more clarity, particularly the factor matrix after rotation. What distinguishes this factor is the lack of strong correlations.

Factor 3. Natural and Agricultural Environmental Development.

The outputs of the SPSS program showed the presence of generally moderate correlations, with the strongest correlations being the variable "Number of Green Spaces" at (0.717) and the variable "Number of Green Spaces" at (-0.515). The third factor gave importance to the natural and agricultural aspects.

To determine the dependency of the municipalities on the factors, the program provides this service, identifying the characteristics of each municipality according to its priorities in environmental activity and development. Table number (2) and figure number (4) show that the municipality of Constantine, for example, has a connection with the first and second factors. According to the table, the municipality of El Khroub has a strong relationship with the second factor. The municipality of Ibn Ziad has a connection with the third and second factors. The municipality of Ibn Badis specializes in the third factor, while the municipality of Ouled Rahmoune specializes in the first and second factors. The table provides a clearer representation of the tourist characteristics of all (12) municipalities in the province.

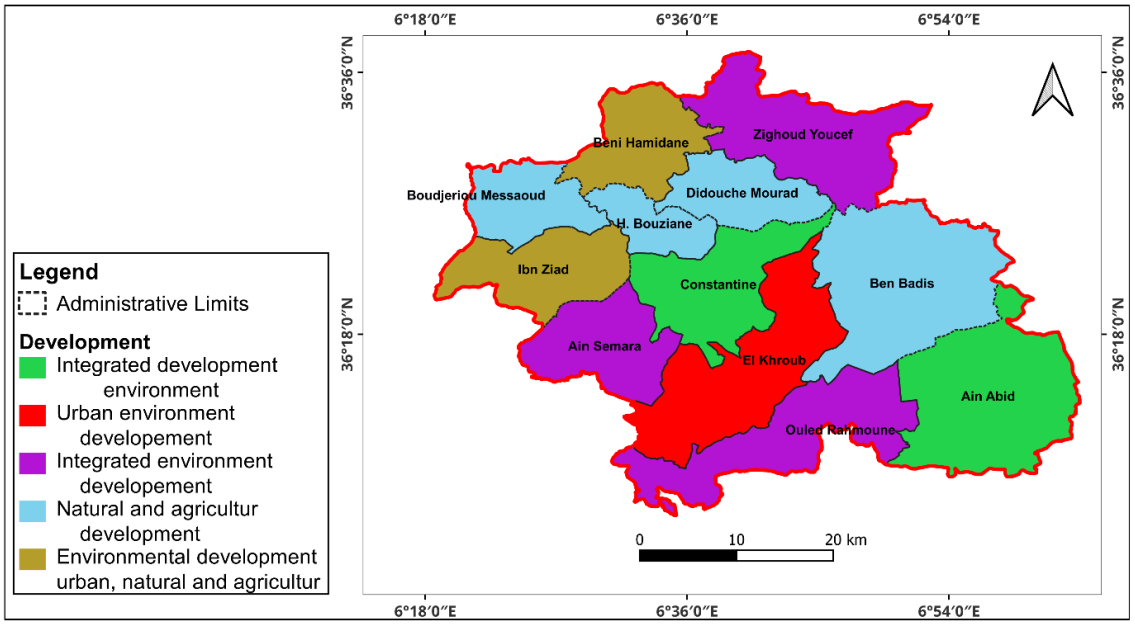

Figure 4. Environmental characteristics of the municipalities of Constantine Governorate for the year 2021.
Source: Accomplished based on data (dpbm) for the year 2021.

Results of Cluster Analysis.

In accordance with the research objectives and our attempt to give spatial dimension variable importance, the SPSS program gives value and purpose to the classification process within its research. The nearest neighbor method, which was chosen as the classification method, aligns with the research requirements. The results of applying this method are shown in table number (3). The units were grouped into two clusters with standardized coefficients. The second stage begins with the appearance of the initial results, which are also divided into two clusters. Table number (3) determines the affiliation of each spatial unit (municipality) to a specific spatial category. The results identified four groups:

Group 1. Municipality of Constantine.
Group 2. Municipality of El Khroub.
Group 3. Municipalities of Ain Smara, Ain El Abeyed, Hamama Bouzian, and Didouche Mourad.
Group 4. Municipalities of Ouled Rahmoune, Ibn Badis, Beni Hamidan, Zighoud Youcef, Ibn Ziad, and Messaoud Boudjriou.

Table 3. Extract classes (merger chain).

Stage	Class grouping		Coefficients	Class appearance step		Next step
	Class 1	Class 2		Class 1	Class 2	
1	8	12	17941294,94	0	0	4
2	4	11	65193193,90	0	0	4
3	3	9	153213561,5	0	0	6
4	4	8	190905751,7	2	1	7
5	6	7	406242166,5	0	0	7
6	3	10	431910772,7	3	0	8
7	4	6	631709263,4	4	5	9
8	3	5	1460268542	6	0	9
9	3	4	1876601303	8	7	10
10	2	3	75753829630	0	9	11
11	1	2		0	10	0

Source: Accomplished based on data (dpbm) for the year 2021.

The outputs of the cluster analysis program, using the nearest neighbor method, resulted in the findings shown in table number (4), which identified four spatial patterns or groups, as follows:

Table 4. The belonging of spatial units to categories.

Observation	4 Classes
1	1
2	2
3	3
4	4
5	3
6	4
7	4
8	4
9	3
10	3
11	4
12	4

Source: Accomplished based on data (dpbm) for the year 2021.

Group 1. This group consists of only one municipality, Constantine, completely separated from the other groups. The variables related to environmental engagement highlight the prominence of the municipality as the provincial capital, showcasing integrated environmental engagement in terms of population, aggregation, density, and concentration. This is also evident in the variables related to environmental engagement.

Group 2. This group comprises only one municipality, El Khroub, which stands out due to its uniqueness and distinction. The population importance (population weight and density) of the municipality has led to its environmental concerns being categorized as a unique spatial pattern

compared to other municipalities in the province. Figure number (5) reflects the distribution of municipalities based on environmental concerns.

Group 3. This group comprises five municipalities: Ain Smara, Ain El Abeyed, Hamama Bouzian, and Didouche Mourad. These municipalities share certain characteristics, including acceptable development levels and a moderate population compared to Constantine and El Khroub. However, they exhibit a distinct environmental engagement, with environmental concerns still in their early stages.

Group 4. This group includes five municipalities: Ouled Rahmoune, Ibn Badis, Zighoud Youcef, Beni Hamidan, Ibn Ziad, and Messaoud Boudjriou. The distinguishing feature of this group is its acquisition of urban characteristics in all aspects of development, population, and even economics. The figures related to the municipalities in this group reflect this trend. The environmental specificity of this group reflects the natural aspect and environmental degradation influenced by agricultural activities.

The results of the cluster analysis, after diagnosing the situation and considering the analysis results, allowed us to create a map of environmental engagement patterns in the Constantine province, as shown in Figure number (5), as follows:

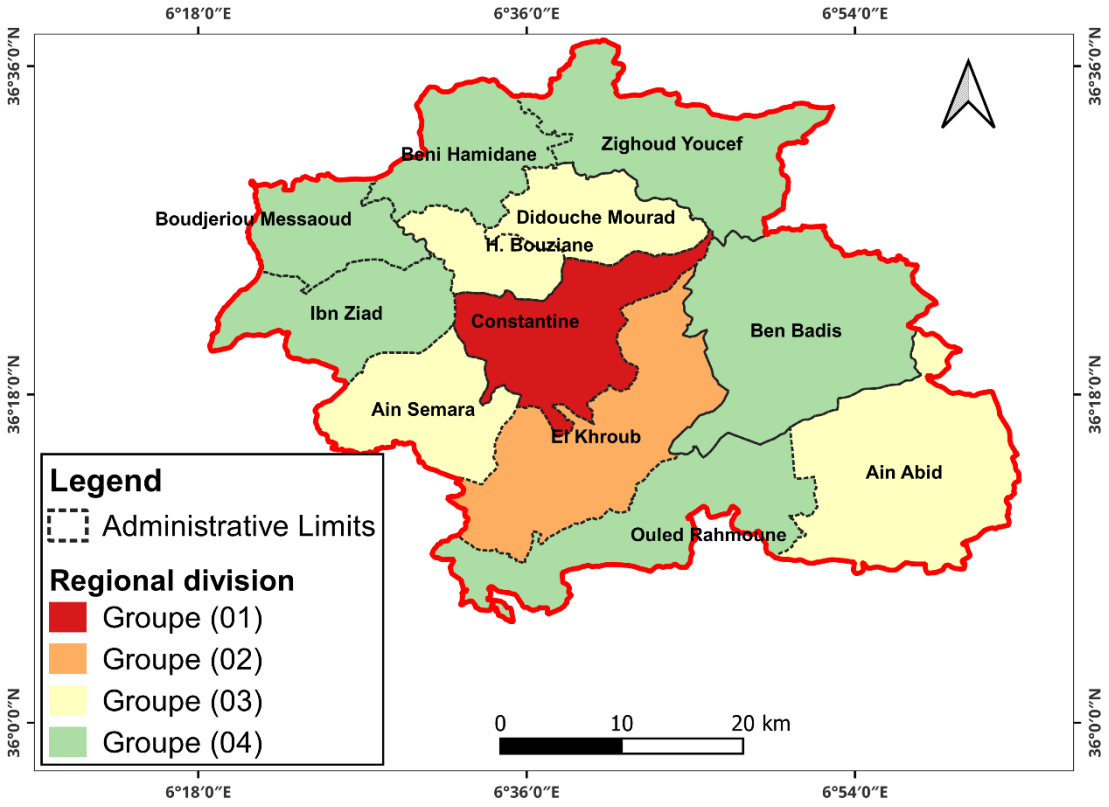

Figure 5. Environmental spatial patterns of the municipalities of Constantine Governorate for the year 2021.
Source: Accomplished based on data (dpbm) for the year 2021.

Conclusion.

This research paper has yielded significant findings concerning the reality and patterns of environmental engagement in the municipalities of Constantine province for the year 2021. Several important characteristics have been extracted, deserving attention from the authorities and those concerned with the province's environmental aspect to avoid future failures and leverage existing potential. The study considered the spatial dimension of environmental degradation. The main findings are as follows:

1. **Three development factors**. The study revealed the existence of three development factors derived from the response variables. The first factor, **integrated environmental**

development, is associated with diverse variables with high correlation values and achieves the highest percentage of variance, estimated at 67.625%. The second factor, **urban and urban environmental development**, with a variance percentage of 13.928%, is linked to specific variables and fewer in number compared to the first factor, with moderately strong correlation values based on the analysis results. The third factor, with a variance percentage of 7.475%, is linked to variables with low correlation values. This factor, **natural and agricultural development**, is characterized by strong correlations, particularly in the variable related to nature and agriculture.

2. **Four distinct groups**. The results of the cluster analysis reveal four significant groups of municipalities in Constantine province. Constantine and El Khroub stand out as individual groups, highlighting the gap between these two and the remaining groups. The cluster analysis results allow for intervention in the provincial territory and address all environmental challenges.

3. **Uneven development**. Environmental development and engagement are linked to potential, which favors the two municipalities of Constantine and El Khroub. This leads to a concentration phenomenon, becoming a real attraction and the emergence of environmental degradation with all its elements in an uneven manner across the province's municipalities. This creates a gap between these two municipalities and the rest, making it difficult to address the duality of the province's municipalities over time and develop a genuine planning scheme that reflects homogeneous characteristics for intervention in the provincial territory.

4. **Limited environmental development**. Environmental development and efforts to mitigate its effects in Constantine's municipalities are limited, particularly as evidenced by the province's figures, despite the significant potential it possesses.

5. **Data limitations**. The research conducted is linked to the size and nature of the available information. Obtaining better and more appropriate information would have yielded better results.

6. **Interactive process**. We emphasize that environmental development is an interactive process, meaning that interaction reflects different levels of development and is influenced by numerous social and economic factors.

7. **Urban centers influence**. The municipalities of Constantine province and their environmental engagement are influenced by the size of urban and population centers, not giving urban centers with lower populations the opportunity to be effective in eliminating environmental degradation.

8. **Recommendations**. We recommend expanding and refining the selection of variables in studies dedicated to environmental engagement in municipalities.

9. **Data base creation**. Establishing a quantitative and qualitative database dedicated to environmental engagement for the entire provincial territory.

10. **Environmental observatory**. Creating a dedicated environmental observatory to monitor all violations, document them within their temporal and spatial dimensions.

11. **Sustainable development**. Adopting the approach of sustainable development, as emphasized by (Zamoush, 2022), and linking it to the organization of intervention levels in terms of managing the environmental process, taking into account the study's outputs regarding intervention in the regional field.

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