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GIS modelling and data analysis methods to identify territorial disparities: case of Taroudant-Morocco province

Sherouk Laaniba[1][a], Mustapha Souhassou[1][b], Youssef Es-Saady[2][c], Fouad Lotfi[1][d], Rachid El Gareh[1][e]

[1] Exploration and Management of Natural and Environmental Resources Laboratory, Ibno zohr university, Taroudant, Morocco
[2] IRF-SIC, Ibno zohr university, Agadir, Morocco

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Abstract

In this work, we developed a methodology for mapping the territorial disparities of the province of Taroudant-Morocco, using data analysis such as principal component analysis (PCA). The latter has been elaborated on fifteen variables (social, economic, and natural environment) for all municipalities in the province. Then a hierarchical classification (HAC) was carried out and allowed us to classify the municipalities into five homogeneous groups basing on a dendrogram. The results were represented using a geographic information system (GIS). We found that the territory can be grouped into five coherent zones: illiterate and unattractive municipalities like "Ait abdellah" and its surrounding; vulnerable and poor municipalities located in the south-east and north-east; agricultural municipalities of the plain where we find "Ighrem", "Taliouine" and "Aoulouz"; municipalities with poor access to public facilities located in high Atlas like "Toubkal' and "Iguidi'; and urban chiefs-places which are "Taroudant", "Ouled Teima", and "Ouled Berhil".

*Corresponding Author
Name: Sherouk Laaniba
Email: sherouk.laaniba@gmail.com,

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[a] https://orcid.org/0000-0001-6274-0010.
[b] https://orcid.org/0000-0002-0082-9172.
[c] https://orcid.org/0000-0002-4934-2322.
[d] https://orcid.org/0000-0002-3620-1256.
[e] https://orcid.org/0000-0001-5268-5804.

INTRODUCTION

Currently, Morocco is marked by a large territorial disparity which strikes in several fields such as education, health, the state of housing and basic infrastructure. The origin of these disparities can be, on the one hand, geographical, climatic, lack of natural resources or difficulties in their development, and on the other hand, the political marginalization that lasted a very long time.

With this marked imbalance between the urban and rural world, the centers and their peripheries, the coast and the interior of the country, we give the impression of being in the continuity of «useful» Morocco and «useless» Morocco (El Moussaoui, 2019). Indeed, in its latest report on April 29th, Oxfam considers Morocco to be one of the most unequal countries in North Africa.

The province of Taroudant is not exempt from the rule. It is one of the most disadvantaged regions. However, the municipalities of the plain are more

advantaged than the mountain municipalities. Therefore, reducing regional, provincial and communal disparities should be a major development concern. Numerous studies and projects have been carried out on disparities and territorial inequalities in several fields, such as tourism, education, politics, and health (Peng Bin, 2016; Winkler and Andreas, 2012; Bakour and abdelhamid, 2019; Ibourk and Raoui, 2021; OECD. Morocco,2018; Benjilali M,2019; Royaume du Maroc,2018; Peptenatu, Daniel et al,2009 ; Andrei Schvab, 2009 ; Vittorio Daniele, 2021 ; Luca Salvati, 2016).

Despite Morocco's adoption of the advanced regionalization strategy. Thus, several projects and studies were set up to improve the country's territorial development. such as the regional development plan, the regional territorial development plan and the prefectural development plan. There are still significant gaps in local development.

This study is part of the analysis of territorial inequality between urban and rural territories, particularly in the province of Taroudant. It is based on determining the typology of municipalities while comparing the skills and assets, as well as the constraints of the areas concerned, in socio-economic terms, including population density, unemployment, poverty, living conditions, education and public equipment. Our results will help decision-makers to propose a correct development plan aimed at reducing territorial inequalities.

MATERIALS AND METHODS

Study area

The studied area is part of a larger whole, the Saïs In this paper, we chose to work on an area suffering from a tremendous territorial imbalance. Taroudant is a Moroccan province located in the region of Souss Massa (figure 1), created in 1983. It has a population of 834,907 inhabitants with an area of 16,500 Km^2. The province is subject to an arid to semi-arid climate. The intensity of aridity increases as one move from west to east and from north to south. The average rainfall in the province of Taroudant is 275 mm, with a maximum temperature of 45° and a minimum temperature of 12°.

Building the database

Creating a territorial typology is based on analyzing different indicators of socio-economic characteristics and natural environment, which are presented in four types: social variables, access to public facilities, education, and natural environment. The table 1 summarizes the different criteria necessary for the elaboration. The data are statistics retrieved from the general census of population and housing in 2014 published by High Commission for Planning (HCP).

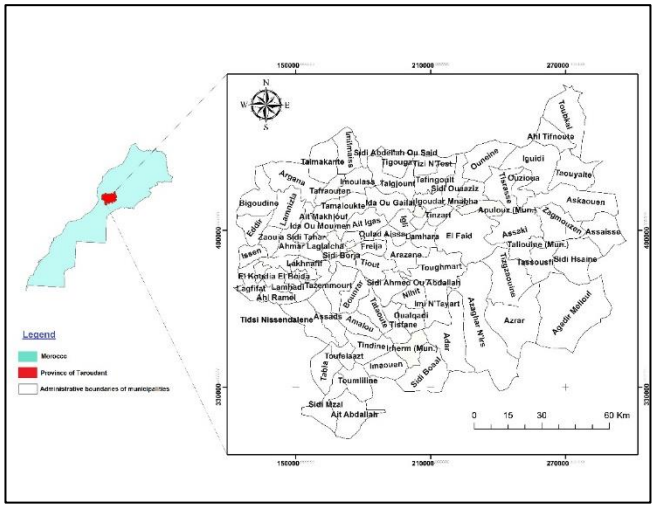

Figure 1:Location of Study area (Taroudant province)

social index	Population
	Density
	Average annual growth rate
	activity net rate
	Dependency index
	multidimensional poverty index
	Poverty
	vulnerability
public infrastructure	distance to the routed road
	water current
	Electricity
Education	illiteracy rate
Natural environment	average precipitation
	average slope
	average altitude

Table 1:Different criteria necessary for the elaboration

The methodology chosen to class the typology of

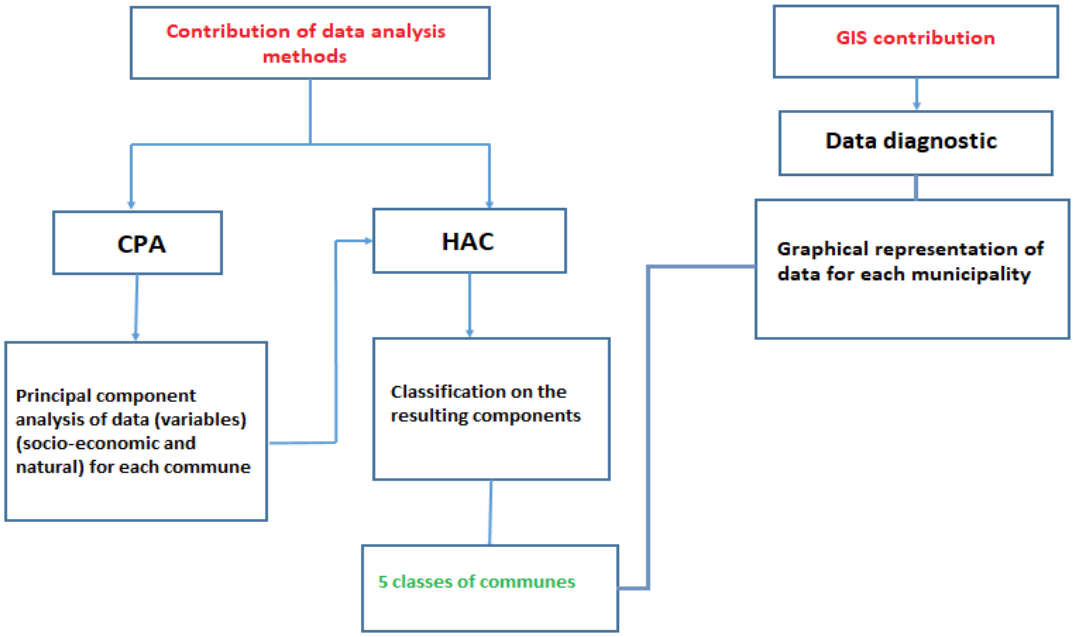

Figure 2: General architecture of the developed method.

communes has two main interactive components (figure 2).
The first component is based on analyzing socio-economic statistical data and the natural environment. It is essentially divided into two stages:

- The first step is the principal component analysis (PCA). It helps to analyze a large number of quantitative data as (socio-economic and natural environment) in this case for each commune, which will help to eliminate correlation between variables and simplify the information to reduce all the variables to a few factorial axes (Heumann et al., 2020; Dická et al., 2019; Shlens, 2014; Jaadi, 2021).

- The second step involves the hierarchical ascending classification (CAH) (Rokach & Maimon, 2006) performed on the factor analysis. It is then a question of determining the optimal number of classes for the typology of the individuals (for the communes of the province of Taroudant). This step allows to obtain a homogeneous composition within each class and, on the other hand, the most heterogeneous classes between them (Ward, 1963; Kamalha et al., 2018).

The second component is based on a geographic information system (GIS) (Thériault & Miller, 1992; Warren, 1995). It allowed us to map information planes of the natural environment and to superimpose them with our results of the territorial typology. It is a spatial representation that will serve as an aid to decision-making to reduce territorial disparities.

Result

Factor analysis

PCA requires some necessary conditions to be checked before it is performed. The following conditions must be verified (Sène and Claude, 2016) :
1- The correlation matrix that shows if several variables are correlated (>0.5); factoring is possible.
2- The Kaiser-Meyer-Olkin (KMO) test indicates that all variables have significance if it tends to be 1, which means a normal distribution.
3- Bartlett's test; the significance (sig.) indicates that the analysis is significant if it tends towards 0.
Applying these parameters to our case study shows us that our factorization is satisfactory with a correlation matrix that contains several values more significant than (0.5), a KMO of 0.80, and a Bartlett significance test that is 0. This leads us to make sure that the factorial analysis is correct.

Hierarchical ascending classification

Based on the PCA, we adopted an ascendant hierarchical classification (AHC) (Argüelles et al., 2014). This AHC allowed us to generate classes of individuals statistically considered as homogeneous; it is based on the distance between

values of each individual (communes). These values are aggregated at the center of the closest groups in an ascending manner by successive steps.

The process for grouping communes needs two preconditions to perform. First of all, choosing a distance or an index of the distance between pairs of individuals; the distance used in the hierarchical classification algorithm is the square of the Euclidean distance, because we have different scales of measurement (Kaufman & Rousseeuw, 2005).

In the second place, we determined a criterion of aggregation of the individuals in the classes. Ward's method is the most adequate to the squared Euclidean distance (Ward, 1963); it aims to choose at each stage the grouping of class such as the increase of the intra-class inertia.
According to a dendrogram (figure 3), the communes were grouped into five classes. It shows us the best level the tree is truncated.

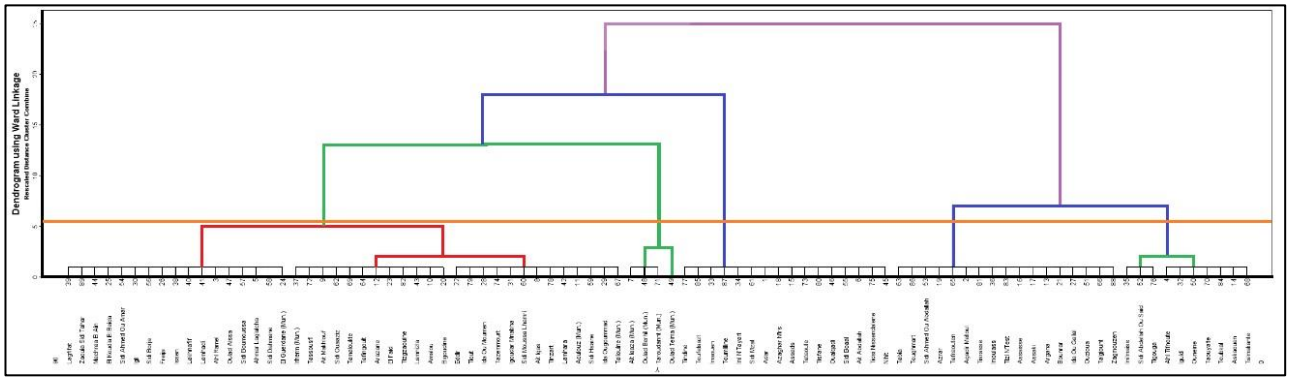

Figure 3: General architecture of the developed method.

DISCUSSIONS

Once the different strata or territories were identified, we carried out a detailed descriptive analysis of each of them. This approach made it possible to identify behavior patterns, based on the natural environment characteristics (agriculture, water resources, mineral resources), and propose a name that would highlight the most significant elements and also map each class of communes (figure 3).

Class 1: It includes the mountainous communes belonging to the Anti-Atlas, especially the surrounding "Ighrem". It has a low population density (15 inhabitants per km2) with a low activity rate of 22%. On the point of schooling and illiteracy, the municipalities record the highest illiteracy rates (57%), and this is due to the non-existence of secondary schools. At the socio-economic level, those communes are moderately poor and vulnerable, and this trend is strongly impacted by the unavailability of essential equipment (access to drinking water and electrification) and infrastructure (paved roads). These indicators are at the root of the low average annual growth rate registered by this group of communes. They can be identified as illiterate and unattractive communes.

Class 2: This class includes 17 communes in different directions (south-east, north-east) and medium populations. They are the most vulnerable and poorest of the five groups, and they have a poverty rate of up to 18% and a vulnerability of 29%. It is marked by a lack of access to public facilities and infrastructure. The main reason for this lack is the slope and, therefore, the challenging terrain due to reliefs, that make it very difficult to install equipment and minimal mobilization of job offers and public investments. In terms of education, the communes have a low illiteracy rate due to the limited availability of high schools in the area. They are classified as vulnerable and poor communes.

Class 3: In this class, in addition to "Ighrem, Taliouine, Aoulouz," we find communes of low altitudes located in Souss plain. These communes have the basic facilities and infrastructure necessary for human development. These municipalities have a high population density (111 inhabitants per km^2) compared to the provincial average. The availability of water resources characterizes the area's natural environment through dams, boreholes, and the free "Souss" aquifer, which can be the source of a prosperous economy based mainly on irrigated agricultural

activity. These communes are experiencing an improvement in the population's living conditions in terms of poverty and vulnerability (10% and 21%). This group is referred as agricultural communes of the plain.

Class 4: This class includes the mountainous communes located in the High Atlas characterized by high altitudes and steep slopes located in the north of the province; it includes the communes of "Toubkal" and "Iguidi" and the adjacent communes. They are neglected in public facilities and basic infrastructure (paved road too far). This lack of equipment may be related to the terrain, difficulty of access, and climatic conditions (rainfall, snowmelt, long winter period), which make investment in infrastructure very expensive, and the realization of equipment works very difficult to implement. These communes are grouped in a class called communes with poor access to public facilities.

Class 5: Groups together urban communes such as "Taroudant, Ouled Teima, Ouled Berhil, Ait iazza." These are the chief towns of the province; they focus on the majority of the elements of wealth (water resources, agriculture, economy, crafts…). In the first place, they are the most attractive communes with an average annual growth rate of 3.19, which means they have a very high number of inhabitants with an excellent standard of living. These communes show very favorable socio-economic indicators, with a good social level, a meager illiteracy rate of 26%, and negligible poverty and vulnerability rate compared to the other groups. They are qualified in terms of essential equipment (drinking water and electrification) and have sufficient infrastructure to facilitate economic dynamism in terms of investments mobilization of job offers in trade and industry, Named chief urban communes.

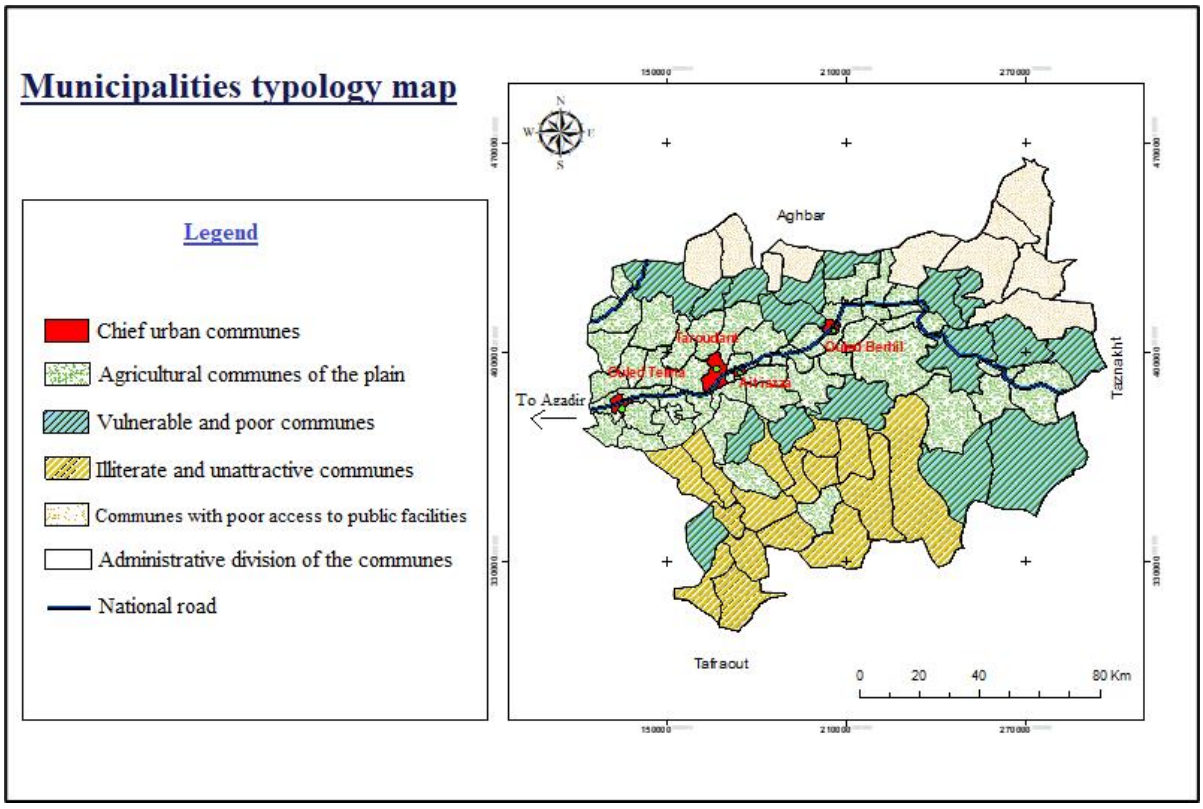

Figure 4: Communes typology map.

CONCLUSION

The present work is part of land use planning as a strategy that needs several changes to achieve more coherent territorial policies. Indeed, our work in the identification and analysis reveals quite contrasting disparities between the various municipalities of the province of Taroudant.

Beyond the factorial analysis and the hierarchical classification, which consists in reducing, centering the information necessary to the treatment, and classifying after that the various elements characterizing each group of communes, this work is based on the GIS, which allowed us to analyze the social-economic and natural indicators by mapping the socio-spatial imbalances of the territories.

The results show groups of municipalities with the same characteristics, whether strengths or weaknesses for territorial development. This work comes in this sense to complete the policy of territorial development in the interest of highlighting spatial inequalities, and in the long run, to provide elements of knowledge allowing to bring the necessary answers to the difficulties faced. And also, to answer in a reasonable way to the requirements of an effective development since the decision is based on reliable information and a multi-criteria analysis, including in an almost exhaustive way, the preponderant socio-economic factors or concerning the natural resources.

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