Optimal industrial localization by using geographic information systems in the Nador province (northeast of Morocco)

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Abstract. Geographic Information Systems (GIS) is one of the most accurate, analytical, results-based, and decision-making tools. In this context, we will try to apply this technique to the best geographical locations for the construction of industrial units in the Nador region (north-eastern Morocco); But these units vary according to the manufacturing branches. The factors in control of light industries vary compared to heavy industries. Considerations in the localization of building materials units vary compared to textile units. Thus, the criteria adopted in the localization of industrial units and their indicators differ. We decided to determine several factors that influence plant location, such as proximity to industrial units, proximity standards to cities, road density, topography nature, ports, raw materials, railways, and other factors. We find that the prime locations for establishing industrial facilities and developing industrial zones are the geographical regions neighboring the town of Selouane. The most significant areas for industrial investment cover approximately 1469 hectares, notably the flatlands to the west of Selouane. Additionally, there are well-suited areas such as Aezangan, Beni Ansar, and Zaio, totaling approximately 14,211 hectares in the outskirts of these town.

Keywords: Geographic Information Systems (GIS), Nador province, industrial units, manufacturing industries, localization.

1 Introduction

North-Eastern Morocco is classified geologically among the richest regions of natural resources [1-2-3]. This wealth positively influences the economic activity of the region. It attracts several companies that exploit the deferential substances useful to settle in this region. This part of Morocco contains several abandoned mines such as the Oued el Himer mine in the Jerada region and that of Ouiksane in the province of Nador [4]. The province of Nador is characterized by a diversified topography and geology, with extensive plains (Sabra, Garebs and Bouaarg)[5], with the construction of the railroad and the port of Melilla for the export of iron ore in the period 1912-1956, and several bentonite and clay extraction sites for the manufacture of building materials [6–7–8], and its long coastline overlooking the Mediterranean Sea and Marchica [9,10]. Hence the interest of this study, which focuses on the application of several geographic information system (GIS) techniques to capture the best geographical locations for the construction of industrial units in the province of Nador. It is based on criteria adopted in the location of industrial units and their indicators differ [11]. We decided to identify a number of criteria that contribute to the location of factories, including: proximity of industrial units, standard of proximity to cities, density of roads, nature of topography, ports, raw materials, railroads and other factors [12].

2 Methodology

The province of Nador is located in the Oriental region of northeastern Morocco. It is bordered to the north by the Mediterranean Sea, to the south by the provinces of Guercif and Taourirt, to the northwest by the province of Driouch and to the southeast by the province of Berkane. The province has a Mediterranean climate [13].
The geographical location of industrial companies is linked to the productivity and competitiveness of industries, as well as to the attractiveness of land. These aspects of habitat [14], its nature and its factors are widely studied in the geography of the economy. A series of management problems on the ground result from industrial dynamism through the form and nature of the internal relationships that structure economic conditions on the ground from the geographical area in which they are endemic. Development or recession and bankruptcy. Aggregate or dispersed industrial relocation can be explained by factors imposed by the quality of these industries and their relocation policies, i.e. location (creation of industrial zones) or endemic (free industrial choice), among these factors [15,16]: industrial zones, markets and labor, energy resources, roads, raw materials and other factors.

GIS and MCDM techniques are used to analyze spatial suitability in order to identify suitable areas for industries, balancing agricultural and industrial needs for sustainable development. [17,18]. This study focuses on the use of GIS and MCDM technologies to determine the suitability of the site for MPE industries in Jaipur, in India, while emphasizing the importance of site planning for economic and environmental efficiency [19,20]. The Geographic Information System (GIS) was used to assess the suitability of land for different types of plant in terms of environmental factors, which has led to specific classifications of suitability [21,22].

3 Results and discussion

This study shows the existence of several options for industrial expansion, the first and most important of which lies to the north of the Selouane industrial zone, in a flat plain characterized by an unoccupied geographical area close to the first, second and third parts of the industrial zone equipped in 1984 and 1994 [23], and the second proposed option lies to the southeast of the town of Selouane, or in the transitional border zone between the two local communities. This zone offers a semi-brutal geographical area with a few olive groves in the belly of Oued Al-Qaid, and a few industrial units have already begun to set up in the area, in particular the Moroccan cement plant, and all areas south of the Dardoura traffic circle to the water distribution station are ideal for industrial use; and are offset to the north by the Selouane industrial park. These industrial parks aim to efficient localization and clustering of manufacturing industries, infrastructure development and economic sustainability, and promote collaboration and smooth production [24].

Fig. 2. Levels of spatial suitability for building industrial units in Nador Region
The third proposed zone pertains to the clay basin located northwest of the Oulad Stout community, west of the brickworks and building materials industrial zone. While it's not a typical industrial zone in terms of centralized transformation facilities, it comprises scattered industrial units. However, in the Greater Nador 2019 master plan, it has been designated as an industrial zone for brick and building material manufacturing. It's important to note that this area is abundant in clay, leading to the establishment of such industrial units between the towns of Selouane in the northwest and Zaio in the southeast. The zone's distinctive feature lies in the absence of agricultural and residential uses, along with extensive clay quarries. Furthermore, its proximity to energy sources like water and solid fuels, including petroleum coke, enhances its industrial appeal. These available components motivate future intervention to equip these areas and use them industrially, provided that real estate prices are suitable for industrial investment, which is clearly high compared to other Moroccan regions, and therefore land settlement/liquidation systems need to be reviewed, as well as processing fees with companies benefiting from these transactions, which all contribute to the high price of industrial real estate.

![Image of geographical areas for industrial units in Nador Region]

**Fig. 3.** Suitable geographical areas for the establishment of industrial units in Nador Region

The fourth proposal is located to the north-east of the brickworks, despite some of the high peaks that characterize this geographical area, the zone is eligible for intervention and equipment, especially on the road leading to Arkmane and near the solid waste landfill.

To discuss these findings, modern technological techniques and software have become effective decision-making aids. In the same context of the findings, the localization of industrial units using geographic information systems (GIS) is an effective tool, evaluating factors such as proximity to roads, rivers, urban areas and land use types to determine their suitability [26], and Geographic proximity is very important in industrial organization [27]. Multi-criteria spatial analysis, which utilizes GIS and the Analytical Hierarchy Process (AHP), helps in selecting optimal locations for industrial parks [28]. The decision-making process for industrial localization takes into account space constraints and economic and policy differences between production and consumption areas, using GIS, AHP, and mathematical programming models to select the optimal location[29]. In parallel, understanding the spatial localization of production systems is critical for regional development [30]. Industrial development enables the realization of strategic objectives in harmony with sectoral priorities and regional characteristics of the field [31]. In the same vein, Geographic Information Systems (GIS) can effectively localize industrial units by linking different information with geolocation and assisting companies and industries.
in spatial decision-making processes [32]. The GIS tool can identify suitable industrial zones by industry class and type by selecting the determining factors in their localization [33]. In general, the Industrial Development Department aims to improve the conditions for fair competition, sustainable growth and economic development [34], of the area, province, and country as a whole.

Conclusion

This study focuses on the application of multiple Geographic Information System (GIS) techniques to identify the best locations for constructing industrial units in the province of Nador. It is based on criteria defined by the location of factories, with various indicators. Several criteria have been considered, such as the proximity of industrial units, the level of proximity to cities, road density, topography, access to ports, availability of raw materials, railway accessibility, and other significant factors.

This work examines proposals for the orientation of industrial expansion based on the cartographic model for the Nador province. It provides a subdivision of the region according to levels of spatial suitability for the establishment of industrial units, by building a cartographic network model based on several indicators. These spatial levels range from excellent areas for the construction of industrial units to unsuitable or weak areas in terms of spatial suitability for industrialization.

In this context, the flat area between Selouane to the northeast and Al-Aroui to the southwest is the best zone for the construction and establishment of industrial units, while coastal and mountainous areas remain the least favorable geographical zones for industrial investment.

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