

The role of geographic information systems (GIS) in decision-making for the localization of industrial areas and the evaluation of existing industrial areas (an applied study in the Nador province)

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Abstract. The study presents a comprehensive analysis of industrial localization in Nador Province, northeastern Morocco. By employing a descriptive and analytical methodology, we have thoroughly examined the province's natural and human data, diagnosing all indicators influencing the process of industrial localization. Our comprehensive approach has classified the area based on its suitability for industrial localization, ranging from ideal to unsuitable regions. The ideal areas for manufacturing, estimated to cover approximately 1,469 hectares, represent 0.5% of the province's total area. The suitable areas for establishing industrial units, estimated to cover 14,211 hectares, represent 5.4% of the province's total area. These comprehensive findings, which encompass several municipalities, such as Selouane, Al Aroui, Ouled Settout, Beni Ansar, and Zaio, provide a robust foundation for policymakers, urban planners, and industrial stakeholders. Furthermore, our correlation between the current industrial zones delineated in the direction plan, Nador Horizon 2040, and the outcomes derived from the spatial analysis of industrial localization factors using geographic information systems (GIS), adds to the validity and comprehensiveness of our research.

Keywords: Industrial localization, evaluation, direction plan, Geographic information systems, Nador Province.

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1 Introduction

Geographic Information Systems (GIS) play a pivotal role in the selection of optimal industrial sites. They are a powerful tool for making informed decisions by analyzing and managing spatial geographic data [1, 2, 3]. Their contribution to industrial site selection is significant [4, 5, 6]. The versatility of GIS is evident in its applications in various studies in Morocco, including the selection of optimal sites for dam construction [7], identification of key tourist sites [8], and locating sites for fish farming [9]. Notably, this tool has also been instrumental in selecting the best industrial sites in the Chaouia-Ouardigha region of Morocco [10].

Selecting the ideal industrial site is of paramount importance in industrial geography due to the numerous factors that influence the determination of the optimal industrial location and the challenge of prioritizing one factor over another, as well as the interplay of natural and human factors, which complicates the selection of the optimal site for industrial establishments. Therefore, the application of this tool in the Nador province is considered an essential tool in selecting the ideal locations for industries through a descriptive and accurate analysis of all-natural and human characteristics in the region, in which these characteristics serve as intervening factors in the process of industrial localization [11]. One of the primary objectives of this study is to identify optimal locations for industries and present them to potential investors. The second objective is to reduce the costly expenses of technical studies for all local administrations. Achieving these objectives requires starting with a research hypothesis stating that all geographical areas in the region are suitable for industrial establishment.

2 Methodology

2.1 Study area

The province of Nador is situated in the Oriental region of northeastern Morocco. The province experiences a Mediterranean climate [12]. It extends over an area of approximately 3111 Km², with borders adjacent to the occupied enclave of Melilla.

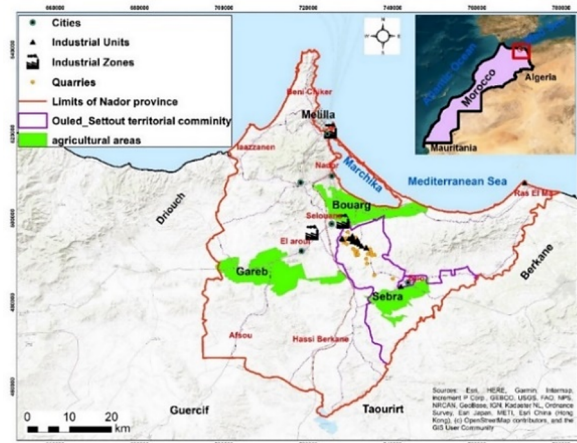


Fig. 1. Study area location

The province, strategically located between Berkane, Guercif, and Driouch, with the Mediterranean Sea to the north, has been a key factor in its consistent industrial development

since the 1970s [13]. This location has facilitated trade and transportation, contributing to the province's economic growth.

2.2 Description of the study stages and the data used:

The study was meticulously conducted, relying on a comprehensive description and analysis of the province's natural and human data within the framework of territorial diagnosis of the industrial reality. This involved frequent field visits to identify the key features of the field and ensure the alignment of the digital data used in geographic information systems with the field reality. In a subsequent phase, the study gathered crucial data for the spatial analysis, which included information regarding road locations, topography, slope, proximity to industrial zones, density of industrial units, proximity to the port, airport, and other relevant factors, all of which played a significant role in the study's findings. In the third stage, the study saw a significant transformation of the data. The raster, line, and cadastral data were all converted into raster data, marking a clear progression in the study's process. In the fourth stage, these data were reclassified using the reclassify tool. This process allowed for the retention of areas that do not directly impact industrial localization. In contrast, areas unsuitable for this study (such as beaches, mountains, and forests) have been excluded. The final stage was characterized by integrating the dependent factors and assigning a weight (in %) to each factor using the overlay tool; we used the following equation to aggregate these criteria and indicators, considering them as factors of industrial localization [14]:

$$\text{Note pixel} = \sum_{i=0}^5 P_i * N_i$$

Were P_i : Weight of the Criterion i ; and N_i is the Grade of criterion i

3 Results and Discussion

3.1 Identifying ideal areas for manufacturing.

After integrating the indicators and factors influencing industrial localization, a province map was obtained based on the degree of suitability of geographic areas for establishing industries such as manufacturing, agriculture, and services.

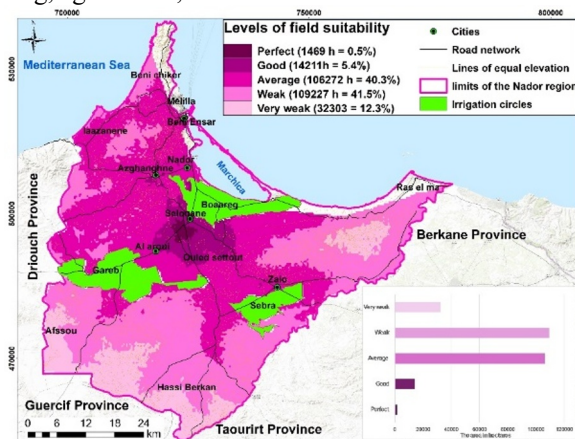


Fig. 2. Levels of spatial suitability for building industrial units in Nador of the province

From Figure 2, it is evident that the spatial suitability ranges from unsuitable areas (i.e., excluded) to the ideal areas represented by dark red, especially those dispersed within cities;

Selouane et al. of Oulad Settout, as it is rich in clay used in the brick-making industry [15]. as indicated by the table. The table illustrates the strategic distribution of suitable areas, carefully selected after excluding unsuitable ones. The results concluded that the ideal areas, Selouane, Al Aroui, and Ouiksane, have been distributed according to the manufacturing sectors. This distribution was made considering the available natural, human, infrastructural, technological, and economic resources in each territorial community, as outlined in the works of El Haddar [16] and Barodi et al [17].

Table 1. The ideal and suitable areas for establishing industries (in hectares) vary depending on the sector of industries.

	The optimal locations for manufacturing	Suitable locations for manufacturing	Industrial sector
El Aroui	149	2064	Iron and steel
Selouane	1060	2332	Diverse
Nador	0	169	Textile industries
Beni Ensar	0	146	Food, boat manufacturing, and
Ouled Settout	0	5601	Building materials and
Zaio	0	45	Food industrial
Ouiksane	260	1818	Iron and steel
Beni Bouyfrour	0	245	Iron and steel
Azghanghane	0	372	Textile industries
Other communities	0	1419	-
total	1469	12792	-
the decision	Perfect	Good	-

3.2 Evaluating the Existing Industrial Areas

For the evaluation of the existing industries, we used a reliable technique. This involved matching the current industries with the planned industrial development in the Greater Nador area by 2040. We also utilized key findings obtained through the spatial analysis of indicators representing industrial localization, ensuring the reliability of our conclusions. Based on the direction plan: Nador Horizon 2040 prepared by the Nador Urban Agency, the industrial triangle of Selouane, Al Aaroui, and Oulad Settout is the most important industrial area in the region. This triangle, which includes the industrial area in Selouane extending to Al Aaroui [18] over 44 hectares, and the 140-hectare industrial park in Selouane, equipped by the influential Chamber of Commerce, Industry, and Services of Nador, is a significant contributor to the region's industrial growth. The industrial area dedicated to brick manufacturing, located in the north of Oulad Settout, further enriches the region's industrial landscape. After conducting a spatial analysis of these factors, the results mapped below were reached.

Figure 3 illustrates the most optimal and conducive locations for industrial development. Notably, the primary areas identified align closely with the boundaries of existing industrial zones. The drawn inferences are : (i) the industrial zone in Nador-El Araoui is situated in an optimal industrial zone, (ii) the industrial zone in Selouane is suitable for industrial use, and (iii) the brick manufacturing industrial zone in North Ouled Settout is a suitable industrial zone.

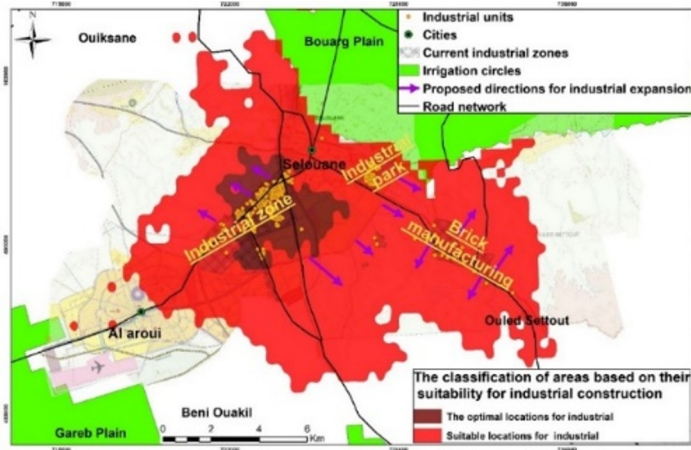


Fig. 3. Evaluation of Industrial Areas in the Direction Plan: Nador Horizon 2040

4 Conclusion

In conclusion, the study has identified several key findings regarding the proposal of ideal and suitable areas for manufacturing. The ideal manufacturing areas, estimated to cover approximately 1,469 hectares, representing 0.5% of the region's total area, are distributed across Selouane, Al Aaroui, and Oukrane territorial communities. The suitable manufacturing area, estimated at 14,211 hectares, was also included. These findings, along with the adoption of several indicators for industrial localization and their spatial analysis, have been instrumental in evaluating the existing industrial areas in the strategic plan for Greater Nador by 2040. The results showed a strong correlation between the industrial areas and the ideal and suitable manufacturing zones derived from the spatial analysis conducted using Geographic Information Systems (GIS).

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Author Contribution

All authors (B. El Monhim, A. Sbai, M. Arabi, M. Makkaoui, M. Hlal & K. Benrbia) reviewed and approved the final manuscript, with B. El Monhim, M. Arabi, M. Makkaoui, M. Hlal contributing to study design, methodology, and the draft manuscript, A. Sbai and K. Benrbia providing supervision and reviewing and interpreting the data.

Ethics approval and consent to participate

Not applicable.

Consent for publication

All the authors have agreed to publish this article.

Competing interests

The authors declare that they have no competing interests

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