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LOCATION SELECTION FOR A TEXTILE MANUFACTURING FACILITY USING NEURAL NETWORK

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ABSTRACT

The location selection of a textile manufacturing facility is a crucial decision that could reconfiguration the economic map of any city. This selection of textile industrial zones is based on a set of criteria such as the proximity of the market, the suppliers and the logistical costs involved due to the chosen location and this in an ecosystem that must offer the most favorable conditions. Even though it is a very important decision, there are very few studies on the location selection of the textile manufacturing facility within the Moroccan context. A Neural Network Model (NNM) was developed to rank suitable areas for a textile manufacturing facility in Morocco.

The data used in this study are as follow; Surface Area, Location and general infrastructure, Internal equipment, Urban planning prescriptions, Price, Occupancy, Population, Taxation, Means of communications.

Then, according to the case study presented in this paper, which is based on the developed NNM, the area of SETTAT was determined as the most suitable area for the establishment of a textile manufacturing facility in Morocco.

This study aims to make two contributions to the literature. Firstly, to fill the research gap in one of the most attractive countries for the establishment of an industrial facility, and more specifically a textile facility. Then, a robust decision and prediction model is used to select the most appropriate location

Keywords: *Industrial Areas, Localization, Selection, Neural network*

1. INTRODUCTION

The textile sector is so important for the economy of Morocco in terms of employment and exports [1]. In 2018, the share in Morocco's total exports of textiles and clothing constituted to 13, 09% of its overall exports. Morocco's total textile and clothing exports in the same year were approximately $ 3 840 368.49 thousands of USD [2]. In 2020, textile exports rank fourth, with total exports of around 281 930 400, 00 USD [3].

As a result, it can be said that the textile sector is the backbone of the Morocco economy.

However, establishing a new textile facility is an important and strategic decision problem since the establishment will have long-term effects on the sustainability, availability, and profitability of the facility [4].

Besides this, and more globally, Africa's manufacturing value-added rate grew only 1.5 since 2018, and the foreign direct investment remains very low due to high-risk factors. Most of these factors are linked to a non-optimized location selection that can adversely affect plant performance[5].

Furthermore, the plant location selection or the facility location problem, is a widely investigated issue, affecting both costs and company performance. This problem has been faced with various approaches in the literature, mainly divided between qualitative and quantitative methods [4]–[6].

For this purpose, we aims to solve this problem of defining the accurate facility location as a key stage in industrial development; based on several criteria such as investment cost, availability of resources both human and material environmental conditions, whose will be weighed and evaluated by the investor.

By zooming in again, the classification and choice of industrial zones on the Moroccan plan is demonstrated [7] and is a field of interest to researchers. These studies are a catalyst of the Moroccan strategic plan of industrial development and at the same time customize the choice and the establishment strategy of the textile and clothing investors.

Since the improper location choices in today's competitive globe can trigger irrecoverable results for any sector [8]; the choosing decision process of the appropriate location for a clothing and textile facility with a high competitiveness, is one of the most important. Then, we discuss a strategic decision that conditions the economic profitability of any industrial facility while offering the highest customer service and quality, and which will enhance the Moroccan competitiveness.

This decision must be based on a consensus between the establishment and its environment. But very often it is made subjectively based on social or political considerations without taking into account all the success factors [9]. Then, in order to make an objective decision we need to define and classify a set of criteria choice. Furthermore, we need to define the accurate decision method in order to minimize the possibility of inaccurate location selection to a very low level, we need to conduct a methodological, analytical and planned approach to the selection of suitable establishing

Although there are many multi-criteria decision making having these attributes in the literature, the ANN approach can be used more effectively in solving this problem since there are multiple alternatives in the location selection and each alternative is are evaluated under a several criteria.

Nowadays, ANN approach have been used to solve different problems since it's a part of prediction methodologies and then its increasingly being utilized to address a range of problems [10].

The ANN training, testing and predicting the accurate textile manufacturing facility is based on many criteria, that had taken on a broader scope through a significant studies [4], [7] and has been well expanded.

This study will be conducted through 3 main steps.

- To set and aggregate the criteria choice of an Industrial Zone
- To specify, by managers, the assigned weight to each criteria while selecting the current industrial zone.
- To develop the ANN and predict the accurate Moroccan industrial zone for establishing a textile manufacturing facility.

This paper is draw up as follow: Session 2 displays all the Moroccan industrial zones and the decision criteria extracted from the literature.

Session 3 describes the two steps of the methodology: in the first step the criteria was classified by the interviewed expert and investors through the Likert scale.

In the second step, the ANN is employed as an innovative method for predicting the industrial zone based on the classified criteria. Session 4 discusses and concludes the study and draw up some future perspectives.

2. RELATED LITTERATURE

The establishment of any manufacturing facility is a very significant decision for any area and will have a significant effect on the area preferability and on the whole country.
Despite its significance, there are very few studies on the selection of textile manufacturing facility location [4].
On a global level, Weber [11] was the first to study localization problems by dealing with the case of a company that manufacture a specific product.
The objective is to minimize overall costs by integrating transport costs and the quantities of products to be transported from each of the two supplier markets to the customer market.
Furthermore, companies search to maximize profit by bringing their facilities closer to the demand market and reducing production costs in the area [12].

In other words it's the capability to develop the infrastructure that makes the area in question attractive and encourages decision-makers

to locate their companies. Then, facilities are factors that increase interest in the region and play an important role in the decision to locate in a region [13].

The case of industrial localization in a region of Morocco using a multi-criteria decision support tool based on a set of criteria such as environmental, social and economic criteria of the industrial location. The selection of these criteria is based on the study of several models of sustainable development indicators [14].

Also, the choice of location depends on multiple and exogenous actors, [15]–[24] but, to list all the new social, economic, technical and technological elements entering in the selection and the localization of industrial zone.

In order to not overlook any element as mentioned above (social, economic, technical and technological) [7], we set an exhaustive list of Criteria Categories:

- Surface Area
- Location and general infrastructure
- Internal equipment
- Urban planning prescriptions
- Price
- Occupancy
- Population
- Taxation
- Means of communications

On the other side, when the network is predefined, the set of possible locations is finite [25] . In this purpose, all Moroccan industrial areas was listed (Table1).

Table 1: List Of Candidate Areas For The Project

Zone	Designation
Z_1	Al Hoceima-Ait Youssef ou Ali
Z_2	Mohammedia
Z_3	Casa-Nouaceur (aero)
Z_4	El Jadida (Jorf Lasfar)
Z_5	Meknes
Z_6	Settat
Z_7	Tanger automotive city
Z_8	Tanger-Zone Franche
Z_9	Oujda zone franche
Z_{10}	Tetouan
Z_{11}	Kenitra

In the last decade alone, the kingdom has attracted several players in the automotive and aeronautics industries. To this end, a major effort has been made by Morocco through the national plan for the development of industrial zones (PNAZI) implemented since 1980 which has made it possible to cover the whole territory [26].

As a matter of fact, Morocco had more than 80 spaces dedicated to industrial activity, spread throughout the country. These spaces total more than 4,600 hectares developed for a total of more than 11,600 lots. All this areas include: integrated industrial parks, economic activity zones and free zones [7], [27].

3. METHOD

The selection of the most suitable method to use is not easy and it is strictly linked to different factors, like the objective of the decision-maker, the available data, and the specific structure of the problem[28]. Here, we aim to create a neuronal model based on set of criteria to solve the plant location selection problem.

The application of the proposed approach includes six steps:

- **Step 1:** Identifying the existing decision-making criteria set based on the relevant literatures. A set of 35 main criteria were determined (Table2).

- **Step2:** Site visits, face-to-face interviews and discussions with Textile Research Team (REMTEX) team, and investors who had textile company experience were involved to approve the identified criteria.

- **Step3:** Then, a questionnaire was designed for identifying criteria preference or weight that affected each investor's current industrial zone choice. The questionnaire used a 1 to 5 Likert scale, representing "Equal importance (1)", "Moderate importance (2)", "High importance (3)", "Very high importance(4)" and "Extreme or absolute importance (5)". (Table3)

- **Step 4:** Applying the collected criteri'a's weight as input data of the neural network model.

- **Step 5:** Checking the consistency of the results according to the accuracy and low function level and tuning the neural network parameters.

- **Step 6:** Afterward, the accurate ANN model was employed to predict among the

alternative areas (Table1) based on criteria ranking performed by a new investor.

3.1. Data Collection

This step undertook a measurement of the affected weights to the criteria within Moroccan companies and managers that have dealt with defining the suitable Moroccan area. All data used in the study were validated with a team combined of managers, expert and academicians of the textile sector.

As a first step, the Moroccan companies managers itemizes and validated the criteria list and agreed on key criteria that corresponded to their preferences and the availability of information on the industrial areas. Then, an aggregated list of criteria was drawn up (Table2).

Table 2: Aggregated List Of Criteria

Criteria	Designation
C_1	Total surface area,
C_2	Occupied area,
C_3	Reserved for infrastructures,
C_4	Not usable,
C_5	Available and expandable.
C_6	Nearest urban center,
C_7	Nearest highway,
C_8	Nearest road and its importance,
C_9	Connected or not to the railway,
C_{10}	Proximity or not to the waterway,
C_{11}	Nearest airport;
C_{12}	Availability of public transportation
C_{13}	Aisles (width and surface),
C_{14}	Street lighting,
C_{15}	Water (quality, available volume and price),
C_{16}	Connection to sewerage networks (sewers.)
C_{17}	Electricity,
C_{18}	Natural gas,
C_{19}	Type of buildings (Levels),
C_{20}	Coefficient of right-of-way on the ground (Built area total area of the lot)
C_{21}	Amenities (Restaurants, supermarket, banks...)
C_{22}	Price per m²
C_{23}	Cost of the MO
C_{24}	Number of establishments already installed,
C_{25}	Nature of investments,
C_{26}	Type of activities,
C_{27}	Nationality of the companies
C_{28}	Number of employees,
C_{29}	Average age,
C_{30}	Level of qualification (workers, masters, managers)
C_{31}	workforce,
C_{32}	unemployed population
C_{33}	Tax incentives and exemptions
C_{34}	Telephone network,
C_{35}	Internet connection

As second step, weight of each criterion in their decisions was collected: Data was collected via an online survey, by the five-point Likert scale (Table3).

Table3: Likert scale classification

Weight	Signification
1	Equal importance
2	Moderate importance
3	High importance
4	Very high importance
5	Extreme or absolute importance

3.2. ANN Modelling

3.2.1. Identification of sub subsections

Artificial Neural Networks (ANNs) are networks inspired by the human brain in its organization of neurons and its decision-making process (called biologically inspired network). ANNs are used in application areas such as pattern recognition, classification, etc. (ANN) form sets of interconnected and distributed neurons in a parallel sequence [29].

These networks learn from an external source (dataset) and modify their structures to predict linear or nonlinear trends present in that dataset (figure1).

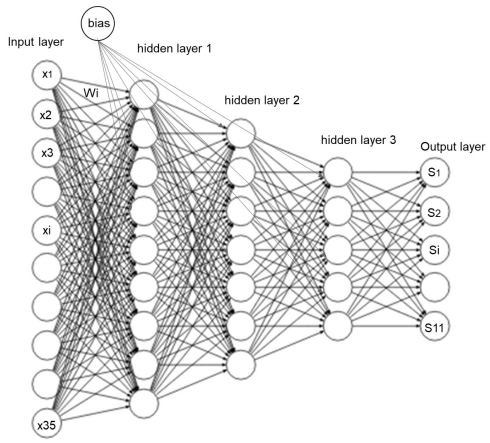

Fig.1.Neural Network Classifier with a Bias Unit.

In supervised learning, target values are provided to the network and predictions (outputs) are then generated through the network. The mathematical representation for updating the weights (w) and bias values (b) for the network is expressed as follows:

$$S = \sum_{i-1}^{n} (wi * xi) + b \qquad (1)$$

ANNs are often used for classifying input data into categories. The accuracy of the classification depends on the efficiency and depth of the learning. The knowledge gained through the learning experience is stored in the form of connection weights, which are used to make decisions on new inputs. When designing a specific application of an ANN, three fundamental characteristics must be determined:

- The topology of the network;
- The activation function of neurons

Furthermore, a network can have several "layers" of neurons and each layer contains various possibilities in term of the number of neurons.
The final network generated for this study is made up of 35 inputs (selection criterion), three hidden layers and single output layer with 11 probabilities (choice of area).
The three hidden layer are made up of “adam” as activating functions to generate and predict the trend in the data set.
Then, the generated outputs are then introduced to the Softmax function to
Categorized in different probabilities (Figure2).
This function is described by the following mathematical expression:

$$f(x)i = \frac{e^{si}}{\sum_{j=1}^{11} e^{sj}} \qquad (2)$$

3.2.2. ANN training

As illustrated in the Figure1; a supervised learning technique is performed to generate the most accurate output by a set of adjustment and connection adaptations.
This change and adjustment of the network connection weights is based on the values of the ‘Accuracy’ and the Categorical Cross Entropy (CCE) as loss function. The CCE, is mathematically defined as:

$$CCE = -\sum_{i}^{11} y_i \log(\hat{y}_i) \qquad (3)$$

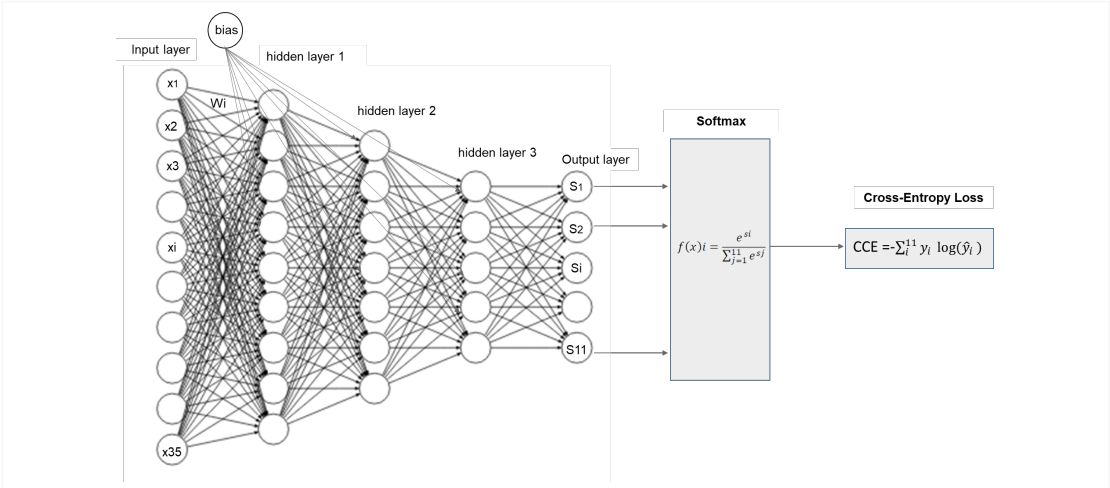

Fig2: Proposed neural network classifier with softmax output function and loss function.

- The learning algorithm;

Here, xi = inputs to the network, wi = weight of each input value, b = bias and n = number of variables.

Here, $\hat{y}_i$ the ith probability value of y_{ith} real output.

When forming this network, weights and bias values are updated with each batch (epoch) until the lowest CCE value is reached and the higher Accuracy is reached.
This is achieved through a set of hyperparameter used to perform our network (Table4).

Table.4. The approved Hyperparameter combinations

Number of Hidden Layers	Hidden layer 1	Hidden layer 2	Hidden layer 3
Number of neurons in each hidden layer	64 neurons in the first hidden layer	42 neurons in the second hidden layer	21 neurons in the third hidden layer
Drop Out	0		
Learning rate	0,001		
Optimizer	adam		

The optimal solution based on the hyperprameter tuning is achieved through the IT research services. Indeed, the IT research services strives to provide the core IT resources researchers require to effectively conduct their data-driven research.
The goal of this simulation is to observe the variation of accuracies of ANN to classify various numbers of hidden layers and epochs and to make the comparison between the accuracies.
The simulation was performed through using NeuroDiffEq wich is a Python package built with PyTorch [30] that uses ANNs to solve ordinary and partial differential equations.

3.3.3. ANN evaluation

The formation of the ANN begins once the network architecture is well established and the raw data set is divided into the following three sets:

- **Training set:** this data set is used during the network learning state to update the network weights according to its CCE value.
- **Validation set:** this data set is used for the generalization of the network. It stops network formation once the generalization value stops improving.

In this study, 70% of the dataset are chosen at random for actual network training, and 30% of the data for validation.
The training and validation steps yield accuracy increasing while decreasing the loss function (figure3) until they achieve the best result (loss function=0, 29 and the Accuracy= 93, 5%).

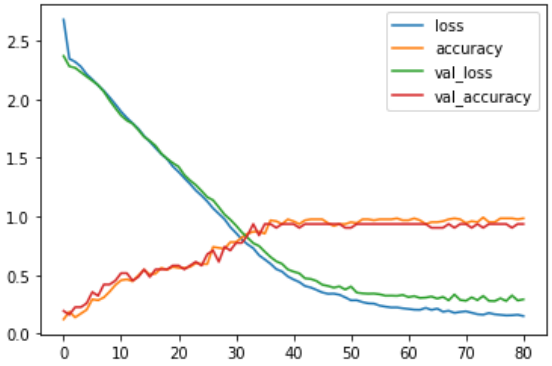

Figure3: Loss function and Accuracy Evolution

4. RESULTS AND DISCUSSION

As mentioned earlier, establishing a new textile facility is an important and strategic decision problem. To cover it, we have revealed several studies focus on plant location selection using (multi-criteria decision-making model) MCDM in generic manner for various sectors [4]–[6], [31], however, and in spite of the fact that this industry is critically important for the economy of many countries, within of them Morocco, there are very few customizing the area choice in a specific country and rarely who had applied the ML techniques.

Then, to apply the developed model, a team of investors, with the support of the REMTEX Lab, conducted a practical case. The objective was to define the area most suitable to their preference in terms of criteria for the establishment of a textile and clothing factory.
The table below (Table5) illustrates the importance degree that was attributed to each criterion.

Table 5. Weight assigned to each choice criterion by investors

Criteria	C1	C2	C3	C4	C5	C6
Weight	4	4	5	5	5	2
Criteria	C7	C8	C9	C10	C11	C12
Weight	2	2	3	4	2	2
Criteria	C13	C14	C15	C16	C17	C18
Weight	4	4	5	3	5	3
Criteria	C19	C20	C21	C22	C23	C24
Weight	2	2	3	3	5	3
Criteria	C25	C26	C27	C28	C29	C30
Weight	4	5	5	4	4	1
Criteria	C31	C32	C33	C34	C35	
Weight	4	5	5	5	5	

As illustrated in the table, the "Reserved for infrastructures, Not usable, Water quality, availability, Electricity, Cost of the MO, Type of activities, Nationality of the companies, unemployed population, Tax incentives and exemptions, Telephone network, Internet connection" were evaluated as the Extremely important criteria to select an industrial area for a textile plant in Morocco, contrary to what has been noted for other countries, where the "Proximity to railway", "Proximity to highway", "Proximity to shopping centre" and "Proximity to airport" are ranked as the most important criteria, while the "Proximity to population" was considered with less importance [4]. Also, the "Proximity or not to the waterway, Total surface area, Occupied area, Aisles _width and surface, Street lighting, Nature of investments, Number of employees, Average age, workforce, Amenities (Restaurants, supermarket, banks...) Connected or not to the railway, Connection to sewerage networks (sewers.), Natural gas, Price per m², Number of establishments already installed, were considered with a high and very high importance, but the "Nearest urban center, Nearest highway, Connected or not to the railway, Availability of public transportation, Type of buildings (Levels), Coefficient of right-of-way on the ground were ranked as criteria with a moderate importance.

With the use of our trained and validated neural network model, the most suitable industrial area to establish a textile factory is the SETTAT area.

For a broader range of options, and according to the classification results, the rankings of areas are sorted as follows (excluding the SETTAT area): Tetouane, Oujda zone franche, Kenitra, Meknes, Al Hoceima-Ait Youssef ou Ali, Casa-Nouacer, El jadida (Jorf Lasfar), Mohammedia, Tanger Automotive city than Tanger Zone Franche.

On the basis of the results, we can see that the ranks of the first two industrial areas are very close.
Thought this case, other decision-makers could simulate their choice of location, especially if their ranking is similar to the presented case. The Settat and Casa areas would be the most appropriate choices.
Therefore, and to further refine the choice of the area, additional criteria specific to a particular activity in the textile sector (finishing, dyeing, clothing...) and the preferences of the company could be added in future studies.

5. CONCLUSION

Even though it is a very important decision to establish a textile manufacturing facility, there are very few studies on the location selection of the textile manufacturing facility [1].
Establishing a textile manufacturing facility in any city of a country is a crucial decision, as it will have a significant economic and social impact on the region affiliated with the chosen area and on the country as a whole.
Although it is a very important decision, there are very few studies on the location selection of the textile manufacturing facility [4] and more rarely in Morocco.

Although the method is given in figure..., to fully understand the results, it is relevant to know that the following steps were followed:

- A set of criteria confirmed by investors in Morocco has been defined and cited by the literature
- A customizable selection tool that can be used anywhere in the world

Moreover, it can help governments understand which macro area invest to increase the country's resilience, especially after the pandemic.
For this propose, this study aims to propose a validated neural network model based on generic database of weight given, by managers, to each

criterion in their selection of their current industrial zone.

35 criteria used in this study. A large online survey with several investor was conducted to obtain criteria weights. Then, a trained Neural Networking Model was used to rank suitable areas for a textile manufacturing facility in Morocco. According to the results SETTAT area was determined as the most suitable area.
This study aims to fill the research gap for the establishment of an industrial facility in one of the most attractive countries for investment, and more specifically a textile facility by designing a robust decision model.

As future scope of this research can be extended by including other relevant criteria.
In addition, the proposed contribution constitutes an original starting point for further studies on plant location selection in developing countries to create a decision loop using a hybrid model by integrating the proposed ANN model with an auto-encoder network or a DEA method to get the criteria ranking, by setting the industrial area as input data.

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