

A Methodological Approach of a Hinterland Planning Project Decision Support

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Abstract In the framework of territory planning, decision-makers are often confronting the analysis of a long report containing at the same time quantitative and qualitative information. In this context, this paper will be useful in the development of a decision support system leading to an optimal organization of a hinterland based on sustainable development. Our modest contribution aims at suggesting a methodological approach of decision support of a hinterland planning project in multi-criteria and multi actor's frame in the most favorable conditions to the environment, to the economic efficiency and the social fairness. The suggested methodological approach allows, on the one hand, the reinforcement sharing of knowledge on the territory and analyzing multisource criteria on the other hand. Such a decision support tool for a planning project does not exist anymore in the literature. This work may help in filling this gap. The preoccupations of this work are showing the best decision to make among many identified ones and this is against the objectives and the criteria fixed by the actors intervening in the process of decision making. This methodological approach can be used as a decision support tool available to the decisional authority when making the necessary decisions.

Keywords Complexity, Criteria, Logistics, Territory planning, Constraints, Optimization of transport and logistics, PROMETHEE, Multi-criteria analysis, Mathematical optimization model

1. Introduction

This territory planning decision support problem was discussed in the work of [1] as a multi-criteria problem. This paper will be oriented towards the suggestion of a decisional model.

The objective of this paper is the suggestion and the experimentation of a decision support system to solve the problem of the territory planning based on the choice of a good compromise satisfying a group of criteria.

The objective matches the operational approach of synthesis upgrading by partial aggregation methods.

In this paper, we will deal with a GIS¹, namely, MAPINFO for the extraction of geo-referenced data which will be later analyzed through the use of a multi-criteria support method AMCD, namely, the PROMETHEE method.

This paper deals with the following questions:

- What are the principal constraints of a hinterland project?
- What are the specific criteria of a hinterland performance?
- How can we cut out the criteria into representative components (indicators)?

To answer these questions, we will adopt the following procedure. In the first section:

- We identify our methodological approach.
- We identify the constraints encountered during the territory planning by integrating logistics optimization constraints.
- We name the criteria and indicators of sustainable development in the framework of our problem.

In the second section, we elaborate a model of mathematic optimization for certain links of the logistic chain.

In the third section, we will follow the following steps:

- We describe in details the PROMETHEE method which was held to carry out the comparisons
- We justify our geographic tool choice MAPINFO.

Finally, we have validated the adopted methodological approach to a case study.

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In the territory planning studies, we must respect the different types of constraints, mainly:

- Geographic constraints.
- Functional constraints.
- Logistic constraints [2].

Also, we must optimize a group of criteria:

- Environmental criteria.
- Social criteria
- Economic criteria.

2. Constraints

We have shown in the paper [1] the interest of the multi-disciplinary approach of a territory planning project. Also, the identification and analysis of the constraints linked to a project are important. They lead to the elimination of unacceptable solutions.

We below name the constraints of a territory planning project. The constraints list stems from a synthesis work of different knowledge basis reflecting [1-2,12,14]. We group all these constraints into three major classes, each of which gathers various internal constraints. Table 1 below illustrates the hinterland planning project constraints.

Table 1. Hinterland Planning Project Constraints

Type of constraints	Name of criteria
Geographic constraints	Type of soil
	Laws
Functional constraints	Expenditure control
	Deadline control
	Social impacts
	Environmental respect
Logistic constraints	Economic
	Technical

These constraints impose various technical specifications that must be satisfying during the planning of the hinterland. They affect the selected choice, impose achievement difficulties, and could cause judicial remedies generally linked to conflicts of use and occupation in the framework of works.

2.1. Geographic Constraints

The principal geographic constraints are linked to spatial parameters [9].

The «type of soil» is a constraint to consider during territory planning project because the implantation of logistics buildings and transport infrastructure is not possible on all the soil types.

The principal constraints of « laws » are related to national regulatory requirements leading to laws, decrees or local laws. This general regulatory framework aims at précising the territory management modalities oriented towards beneficial environmental ends.

2.2. Functional Constraints

They are generally constraints imposed by the specification sheet. These constraints set against various technical specifications which must be satisfying during the territory planning.

In this framework, we distinguish four types of constraints.

- Constraints related to «expenditure control» relative to the different financial posts must respect
- Budgetary evaluation mentioned in the specifications sheet.
- Constraints related to «deadline control» of the project planning implementation mentioned in the specifications sheet.
- «Social» constraints related to the potential conflicts of the territory occupation and use. These conflicts can be linked to the discomfort caused by freight transport or territory planning works on local activities.
- «Environmental respect» constraints related to environmental impacts caused by planning operations and transport. The best environmental practice is related to the desired minimization of the impacts on vegetation and residents.

2.3. Logistic Constraints

The importance of the integration of logistic chain actors within the territorial decisional process is crucial. Hence, we have integrated logistic constraints which must be taken into consideration during decision making in the hinterland planning project.

Among the objectives to fix in the framework of the hinterland territory planning project is ensuring the exchange of physical flows while respecting some logistic constraints. When these constraints considered, the deadline for freight marketing is reduced and the transport service quality is improved. Therefore, logistic providers succeed in satisfying the customer's needs and reducing costs, even all the logistic chain partners.

In this framework, we distinguish two types of constraints:

- «Economics» constraints aim at minimizing the logistic chain costs. They integrate the costs related to freight transport from the port towards consumption pole going through logistic buildings and vice versa.
- The "technical" constraints related to the structure of logistics buildings (storage capacity, storage conditions, etc.).

3. Criteria

Criteria are quantitative and qualitative expressions of the objectives or the constraints allowing the evaluation of the alternatives [3]. According to [4], a family of criteria is coherent if it meets two characteristics:

- Completeness: all criteria must be taken into

consideration.

- No redundancy: duplication must be avoided in order not to give importance to a criterion due to its redundancy [5].

In order to conform to the concept of sustainable development, we must be based on three criteria where each criterion subdivided into sub-criteria.

Hence, we name some criteria to be considered during territory planning.

- The consideration of environmental criteria: It aims at allowing the actors intervening to take favorable decisions to the ecosystem. These criteria are presented through the emission of various pollutants and noise pollution.
- The consideration of social criteria is represented through the social impacts of the hinterland planning project.
- The consideration of economic criteria represented through logistic optimization criteria as well as financial criteria.

The table 2 below illustrates the construction of a family of criteria meeting the sustainability context.

Table 2. Criteria list

Type of criteria	Name of criteria
Economic	C1 : transport and logistic optimization
	C2 : Balance sheet
Environmental	C3 : environmental quality
	C4 : Ecosystem Destruction
Social	C5 : Employment rate
	C6 : Satisfactions levels

4. Indicators

Indicators generally correspond to cardinal information contrary to the criteria which correspond to ordinal information.

Our study [2] leads to the obtaining of performance indicators of the hinterland. Based on this study and taking inspiration from achieved works in the framework of territory planning, we will mention below a list of indicators classified according to criteria already mentioned in the previous section.

4.1. Environmental Indicators

Figure 1 shows the principal environmental indicators.

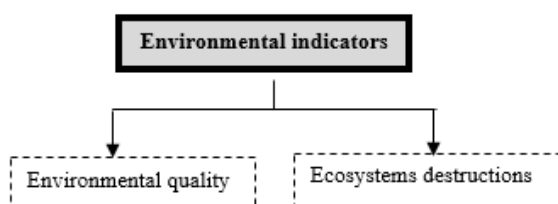


Figure 1. Environmental indicators

4.1.1. Environmental Quality

Various indicators allow the appreciation of the negative effects caused by a hinterland planning project. Among the environmental impacts, we have retained the emission of pollutants and noise pollution which affect the quality of the environment.

- Air quality:

It is determined according to the concentration rate of the atmospheric pollutants. Impacts on the quality of air come from two sources:

- Exhaust gas coming from mobile machinery: We will focus on this framework to the emissions issued after works rather than those related to the site because according to (Engis), "Emissions related to the site are not considered as a significant factor of the air quality deterioration".
- Thin particles (dust, smoke): They can cause negative effects on the health of riparian (respiratory problems), generate traffic accident risks (decreased visibility) and have an impact on plants (reduction of the photosynthetic activity, therefore, the decrease of their growth rate).

- Noise pollution:

Noise pollution is the main inconvenience affecting the riparian near the logistic buildings. Noise sources are different. They react mainly from:

- Mobile machinery noise.
- Sound horns noise.
- Work equipment noise (during works): for this type of noise, impact noise is restricted during the period of works.

A study carried out by (Engis) where the medium level of the sound generated in the site environment is calculated in the table 3 below.

Table 3. Level of Noise Generated In the Site Environment (Engis)

Distance between transmitter and the receiver	100 m	200 m
Machine movement	61 dB ²	52dB

4.1.2. Ecosystems Destruction

This indicator relies on heritage protection by laws.

4.2. Social Indicators

Figure 2 shows the main social indicators.

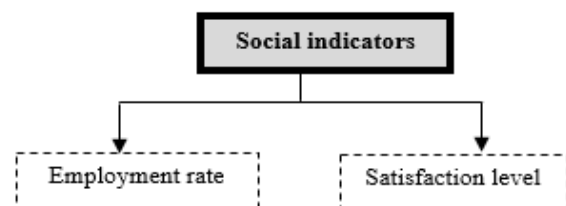


Figure 2. Social indicators

4.2.1. Employment Rate

The human resources needed in the construction and exploitation of the logistic buildings can be divided into two types, manpower, and logistic chain actors.

Direct social impacts are assessed through jobs created and incomes.

4.2.2. Level of Satisfaction

It is evaluated by the level of indirect social impacts on the residents and the supply chain actors.

Indirect impacts represent:

- Extension and maintenance of the roads and railways within the framework of the hinterland planning project.
- Traffic network quality service.
- Interruption of the already exploited roads. Generally, this problem is resolved through the implantation of substitution and planning roads (walkway, bridge, underground passage, etc.)
- Creation, of indirect jobs: they represent the activities created by the logistic chain upstream and downstream.

4.3. Economic Indicators

The figure 3 illustrates the principal economic indicators:

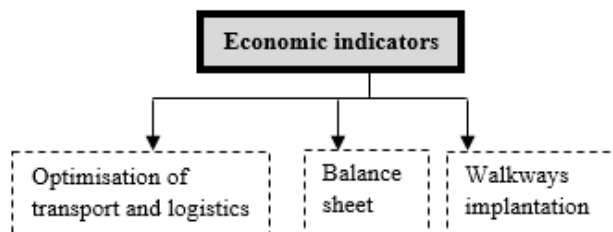


Figure 3. Economic indicators

4.3.1. Optimization of Transport and Logistics

The logistic chain is made of the following links: supplier, Production Company, logistic provider (warehouse and transporter) and customer. In this paper, we consider that the links (supplier, production company and customer) as consumption groups.

Links «consumption groups» are evaluated according to their proximity to the logistic platform. Movements of the means of transport of freight in the hinterland lead to a heavy impact on the network which is already loaded on certain walkways. Hence, the proximity of consumption groups (Production Company, supplier or final customer) to the logistic building is an important criterion.

Links «logistic provider» are evaluated through technical indicators (of functioning) and indicators related to the transport service.

4.3.2. Balance Sheet

This criterion gathers the different financial indicators related to a planning project of the hinterland: income, loads (installation and maintenance, etc.). The last two ones are not considered as sub-criteria but they are financial posts.

The «balance sheet» of the planning indicates the load and the income from the phase of investment to the achievement of the planning works. It does not allow the anticipation of the evaluation of the return (benefits) on the investments appearing later on.

4.3.3. Walkways Implantation

It is evaluated by the distance between consumer groups and roads or railways lines.

We mention in the table 4 below, for information only, some indicators must be considered in the process of territory planning.

Table 4. Indicators

Type of criteria	Criteria	Indicator	Explanation	Unity	Objective to achieve
Environmental	Environmental quality	Air quality	Exhaust gas coming from mobile machinery	Eq.C ³	Minimize
			Thin particles transmitted in the air	PM ⁴	Minimize
		Noise pollution	Mobile machinery noise	dB	Minimize
			Sound horns noise	dB	Minimize
			Work equipment noise	dB	Minimize
	Ecosystems destructions	Natural ecosystems Preservation	Land zone surface exploited	km ²	Minimize
			Surface exploited in the protected zones	km ²	Minimize
Social	Employment rate	Created Jobs	Number of job opportunities	Number	Increase
			Number of employees	Number	Increase
		Income	Number of working hours	Number	Increase
			Remuneration	Monetary	Increase
	Satisfaction level	Improvement of the ingratitude	Walkways made and used by the residents	Km	Increase
			Maintenance of the roads and railways	year	Increase
		Traffic network quality	Walkways number of the communes	Number	Minimize

³ Carbon Equivalent

⁴ Particulate matter

Type of criteria	Criteria	Indicator	Explanation	Unity	Objective to achieve
Economic	service	Residents access	Substitution itinerary	Km	Increase
			Interrupted itinerary	Km	Minimize
			Planning (walkway, bridge, underground passage, etc.).	Km	Increase
		Creation of indirect employment	Number of job opportunities	Number	Increase
			Number of employees	Number	Increase
	Optimization of transport and logistics	The proximity of the site to consumption groups (supplier, production company, customer)	Distance between site and the consumption groups	Km	Minimize
		Storage cost	Average storage cost/ container	Monetary	Minimize
		Filling rate of the platform	Level of stock in the logistic building	Ton	Minimize
		Transport deadline	Delivery deadline or supplying	hour	Minimize
	Balance sheet	Capacity of the transport	Authorized Total weight	Ton	Maximize
		Transport cost	Average load / pick up.	Ton/Km	Minimize
		Income	Recipes related to the process of hinterland planning.	Monetary	Increase
	Walkways Implantation	Accessibility	Distance between site and motorways lines	Km	Minimize
			Distance between the site and railway roads	Km	Minimize

5. Mathematical Optimization Model

In this section, we suggest explaining the adopted decision support approach. It is a sequence of optimization of different links making a logistic chain.

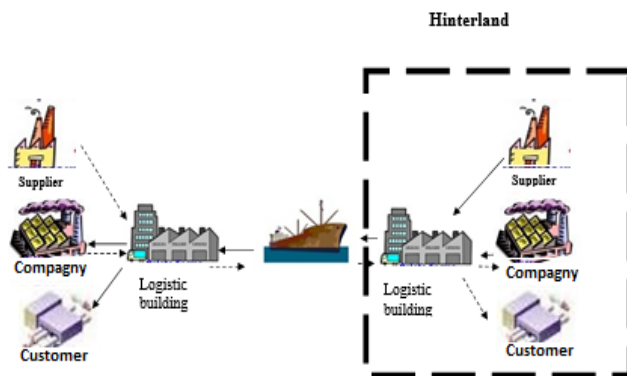


Figure 4. Adopted distribution network

We consider the logistic chain made up of suppliers, Production companies, customers and logistics providers (which ensure the function of transportation and warehousing).

In this section, we deal with the conception problem of the logistic chain as an allocation problem aiming at the

optimization of flows exchange between the harbor, «logistic building⁵» and «consumer groups⁶». However, links conception «logistic provider» is considered as a problem of localization-allocation since it is the selection of the best site to implant the logistic building and to optimize the exchange of the flow. Figure 4 shows the adopted distribution network.

We name for each link, the different hypotheses and the components of the mathematical model. We opt for linear programming to formulate the optimization models.

5.1. Link Optimization «Logistic Provider»

5.1.1. «Transportation» link

Transportation is an essential link in the harbor distribution; indeed, transport costs represent a major part of the selling and buying price.

To simplify this modeling, we adopt a direct delivery network where the company delivers directly the product to the customer without going through a warehouse of storage and distribution.

We limit our study to road transportation knowing that the reality of transport is multimodal. Our problem consists essentially in minimizing the cost of transportation in the hinterland between the harbor and the logistic building, at the level of:

⁵ Logistics platform or warehouse

⁶ Supplier, production company and customer

- Upstream logistic: from supplier to the production.
- Downstream logistic: From production company to the customers.

5.1.1.1. Indices

G: Set of consumption groups $g, g \in \{1 \dots G\}$
 T: Set of means of transport $t, t \in \{1 \dots T\}$
 D: Set of transport deadlines $d, d \in \{1 \dots D\}$

5.1.1.2. Parameters

QT_d: Quantity of transported freight in a deadline d.

UC_{dt}: Unitary cost of freight transport between the harbor and the logistic building with a means of transport t.

UC'_{gdt'}: Unitary cost of freight transport between the logistic building and the consumption group with a means of transport t'.

TAWC_t: Total authorized weight in charge of the means of transport used between the harbor and the logistic building.

TAWC_{t'}: Total authorized weight in charge of means of transport t' used between the logistics building and the consumer pole.

FP_t: Freight percentage related to the consumption group transported by a means of transport t.

FQ_{gd}: Freight quantity related to a consumption group aiming at being transported in a period d.

DDS_g: Delivery deadline or freight supplying expressed by consumption group g.

5.1.1.3. Decision Variables

Q_{dt}: Transported freight quantity between the harbor and the logistic building in a period d and by the means of transport t.

Q_{gdt'}: T Transported freight quantity between the logistic building and the consumption group g during a period d and by the means of transport t'.

5.1.1.4. Transportation Objective Function

The function (1) aims at minimizing the transportation costs between the harbor and the logistic building as well as the transportation costs between the logistic building and the pole of consumption.

$$\text{Min} \left(\sum_{d=1}^D \sum_{t=1}^T UC_{dt} * Q_{dt} + \sum_{g=1}^G \sum_{d=1}^D \sum_{t'=1}^{T'} UC'_{gdt'} * Q_{gdt'} \right) \quad (1)$$

5.1.1.5. Constraints

Constraints related to transportation loads:

The constraints (2) and (3) suggest that the transported quantity must not exceed the total authorized weight in charge of means of transport.

We must signal that a means of transport t can transport freight related to the different groups of consumers. For this reason, we multiply the transportation capacity by the transported freight percentage related to a studied consumption group.

$$Q_{dt} \leq TAWC_t * FP_t, \forall t, d \quad (2)$$

$$Q_{gdt'} \leq TAWC_{t'} * FP_{t'}, \forall g, t', d \quad (3)$$

$$Q_{dt}, Q_{gdt'} \geq 0, \forall g, t, t', d \quad (4)$$

The constraint (4) indicates that the quantities are positive or null.

5.1.2. «Logistic Building» Link

This link gathers the functioning operations of «logistic building». Function (6) aims at minimizing the cost of storage which gathers the group of costs related to the functioning operations of the logistics building.

5.1.2.1. Parameters

SC_d: Storage cost in the logistics building in the period d.

PS_g: Freight percentage stored related to a consumption group g.

Q_{dt}: Quantity of freight transported between the harbor and the logistic building in the period d and by the means of transport t.

Q_{gdt'}: quantity of freight transported between the logistic building and the consumption group g during the period d and by the means of transport t'.

5.1.2.2. Decision Variables

SR_d: Storage rate in the logistic building in a period d.

5.1.2.3. The Objective Function of the Functioning

The function (6) aims at minimizing the cost of storage in the logistic building.

$$\text{Min} \left(\sum_{d=1}^D SC_d * SR_d \right) \quad (6)$$

5.1.2.4. Constraints

Constraints related to the rate of storage:

The constraint (7) determined the rate of storage in a deadline d. It is calculated by the level of freight stored in the logistic building rightly (d-1) by adding the input quantity and minimizing the output quantity.

$$SR_d = SR_{(d-1)} + \sum_{t=1}^T Q_{dt} - \sum_{t'=1}^{T'} Q_{gdt'} \quad (7)$$

The constraint (8) precise if the storage rate is positive or null.

$$SR_d \geq 0 \forall d \quad (8)$$

Constraints related to the logistic building size:

The constraint (9) indicates that the storage rate must not exceed the capacity of the storage of the logistic building CSLB. The logistic building gathers the freight-related to many consumer groups. For this reason, we multiply the percentage of stored freight related to each group by the storage capacity of the logistics building.

$$SR_d \leq CSLB * PS_g \quad (9)$$

5.2. Link Optimization « Consumption Groups »

This link gathers the functioning operations of the “consumption groups”. This function (10) aims at minimizing the costs of supplying or delivery of the freight-related to a group of consumers.

5.2.1. Parameters

Csuppdeliv_g: Supplying cost or of the delivery of freight-related to a group of consumption *g* of the period *d* (transportation cost and the freight value).

5.2.2. Decision Variables

FQ_{gd}: Freight quantity related to a group of consumption aiming at being transported in a period *d*.

5.2.3. The Objective Function of Functioning

$$Min \left(\sum_{g=1}^G \sum_{d=1}^D C_{suppdeliv_g} * FQ_{gd} \right) \quad (10)$$

6. Multi Criterion Analytical Approach Issue Choice

In this paper, we suggest a hybrid model by combining GIS and MCA to optimize simultaneously the territory planning decisions and the logistic chain.

In the multi-criteria decision support domain, we generally try to find an «optimal solution », so it is probably that this solution may exist in the theory but it can't be achieved on the territory as a possible solution. For this reason, it is necessary to note that we are looking for «the best compromise » by taking into consideration all the selection criteria. According to [6] «The compromise solution does not bring optimization to each criterion».

We must note that the best compromise is changeable according to the preferences of the implied actors (The importance of criteria given by actors).

6.1. Decision Support Multi-Criteria Methods

According to [12-13], the notion of multi-criteria is related to the concept of decision support; and many criteria (inputs) influence the decision made by a decision-maker who is an actor among others in the process of a decision while considering the point of views of the other implied actors. Our choice of this type of method comes from the possibility of treating multiple objective problems while considering diverse criteria and often heterogeneous.

We should also mention that the multi-criteria methods are numerous. We note that in this framework, decision support multi-criteria basis references are numerous: American school and European school.

We don't intend to develop these different schools of which we only propose the definitions of these two schools.

These two schools are quite different:

- American school: It uses the additive utility function. It is based on the combination of utility values in a global note for the action. The action global note is the note weighted sum of each criterion multiplied by its weight.
- European school: It is based on ranking methods between potential actions. The most used methods are ELCTRE and PROMETHEE. Actions' final ranking is represented in a raking graph.

Multi-criteria analysis methods are distinguished according to the problem to be treated [7]. We present in the table 5 below the different types of problems basing on the work of Roy.

Table 5. Problems Classification

Problems	Results	Objective
Alpha (α)	A choice or a selection procedure	Choosing the most satisfying action
Beta(β)	Sorting or an assignment procedure	Gathering actions according to categories (good, not so good, bad)
Gamma (γ)	The ranking or a procedure of classification.	Classifying actions according to their order of merit and choosing actions number among the best ones.
Delta(δ)	A description or a cognitive procedure	

6.2. Multi-Criteria Analysis Process

All these methods are based on four steps, of which the three first ones are common for all the methods [8].

- Name a list of potential actions.
- Name a list of criteria to take into consideration.
- Fix a performance table.
- Aggregate performances (establish a global preferences model on a group of potential actions).

6.2.1. The Selection of Potential Actions

The selection of actions is based on two analysis scales:

- Territory: at the territory scale, the method is made of a double input: quantitative and qualitative to determining the possibilities of platform implantation.
- The logistic platform: According to the previously carried out experiences, the implantation of logistic platform plays a role in practice determine: The link between the harbor and the enterprises, storage locations, parking spaces for means of transport, handling conditions are the key points determining the performance of a logistic platform.

This step must allow the selection of a study perimeter and illustrate the information about the topic.

6.2.2. Criteria Construction Process

According to [9], the criteria allowing the distinction between scenarios (actions). The criteria are often in conflict with each other [10]. For example, the economic criteria «less costly action» can be in contradiction with respecting laws. For this reason, in this context, the optimality (the choice of the best solution) is possible since a solution can be optimized according to certain criteria without being so according to others [10].

6.2.3. Evaluations Matrix

Evaluations matrix is a double input table:

- Columns: represent the selection criteria.
- Rows: represent the potential actions.

It gives actions to the group of evaluation according to their criteria.

The implied actors give importance to the selection criteria. The weight is two types.

- Ordinal weight: It represents the importance order of a criterion relative to other criteria (very important, important and less important).
- Cardinal weight: it gives more precision to the importance of criteria. It takes the form of a number or a percentage.

Actors concerned with sustainable development agreed on the fact that impacts have not the same weight. However, an agreement around their weight is complicated to get. Different actors and stakeholders are of the same resource. They must result in a compromise concerning the strategy of territory management.

6.2.4. Aggregation

Actions will be classified according to their utility value. The latter is an aggregation process data giving a value of preference to each action. Therefore, determining the rank. Table 6 below illustrates the operational approaches and aggregations.

Table 6. Operational approaches and aggregations

Approach	Aggregation
Synthesis unique criterion approach	Complete aggregation
Synthesis upgrading approach	Partial aggregation
local judgment approach	Local aggregation

Performance aggregation methods depend on the type of approach:

- Synthesis unique criterion operational approach: It is based on the optimization by returning on one criterion.
- Synthesis upgrading operational approach: First, it is based on a side-by-side comparison of actions. Then, the development of synthesis through the exploitation of the ranking method.
- Local judgment approach: It means putting into play a limited number of actions with no rule. Indeed, the

interaction between the decision-maker and the study man is organized due to a protocol.

6.3. PROMETHEE

The choice of a decision support multi-criteria method depends on the nature of the problem [11].

Our choice is based on two methods «PROMETHEE» through the problem « alpha » which allows the selection of the most satisfying action. This choice is justified by the upgrading synthesis approach accepting incomparability (partial aggregation). This choice comes due to the exclusion of the unique criterion approach which treats the mono-criterion analysis problem and the local judgemental approach which does not lead to finding the best actions.

We must note that the digital application is based on the establishment of indicators from evaluations, a rank without appealing to weights of the criteria. Indeed, the choice of weights of the criteria returns to the decision-maker while considering the opinion of the actors.

For this decision problem, and due to the absence of weights of the criteria, we have relied on the method of PROMETHEE which allows the replacement of upgrading by a large preference notion.

The advantage behind the partial aggregation methods is the possibility of using heterogeneous criteria, in other words without the obligation of converting them into a common unity.

It gathers for each solution (resource) evaluations for each criterion of scales of preference. These criteria must be increasing (value to maximize) or decreasing (value to minimize).

7. Model Experimentation

This study aims at the conception of a decision support tool for the territory planning and more precisely the problem of site localization for the establishment of a logistic platform site to serve a harbor.

The objective of this paper is to experiment with the decisional model and to present a case study with a discussion of the obtained results.

7.1. Model Development Tools

The achievement of this tool required different tools and analysis and development software.

- MapInfo: Is a tool of type Geographic information system. It allowed, in our study, to visualize and modify the different geographic data basis used according to the need. Also, it allowed as to localize correctly the study zone as well as environmental zones. It let us collect essential data such as the hinterland, traffic, vast lands, urbanism, etc.
- PROMETHEE: It is a multi-criteria analysis approach of the problem presenting actions number (or decisions) evaluated according to many criteria. It is associated

with the descriptive approach, allowing the visualization of conflicts and synergies between criteria. This tool lets the analysis, study and suggests actions in terms of obtained results regarding criteria.

7.2. Case Study and Experimental Results

In this study, the treated problem in localization which consists of finding the most satisfactory ground to some criteria.

7.2.1. Study Parameter Delimitation

The study zone of our case study is situated around Rades harbor in the north of Tunisia; indeed, although that Tunisia owns many harbors, we opted for Rades harbor and its surrounding area. The GIS, as shown in the figure 5 below, allows having an overall view of the studied zone.



Figure 5. Detailed presentation of Rades harbor

Upon, we can see Rades harbor and its surroundings. We noticed as well important road traffic around the harbor, as well as a vast stretch of water used in the transportation of freight. So; it is crucial to building a platform correctly able to serve this port. Figure 6 shows a global view of rades harbor.



Figure 6. A Global view of Rades harbor

Here, we can see globally the surroundings of Rades harbor. The red circle represents the hinterland, its radius is approximately about 50 km. In this radius, we will determine the potential zones in the construction of the platform.

7.2.2. Criteria Definitions

Once the study perimeter is designed, it is important to establish criteria. This step consists of the definition of the factors taken into consideration during the multidisciplinary decision. This family of criteria must meet the coherence condition: Criteria must be exhaustive and non-repetitive. The selected criteria are:

- The surface of the selected zone: It is a criterion to be maximized. The more it is raised, the more favorable the implantation platform is.
- Proximity to a roadway: This criterion is to be minimized because we must optimize the fluidity of transportation around the dock.
- Distance regarding the harbor: It is an important criterion to be minimized because it is a way to go by a vehicle between the harbor and the platform. It is important to precise that the distance is measured by the road distance traveled on a principal way.

Figure 7 shows the application of the suggested approach.

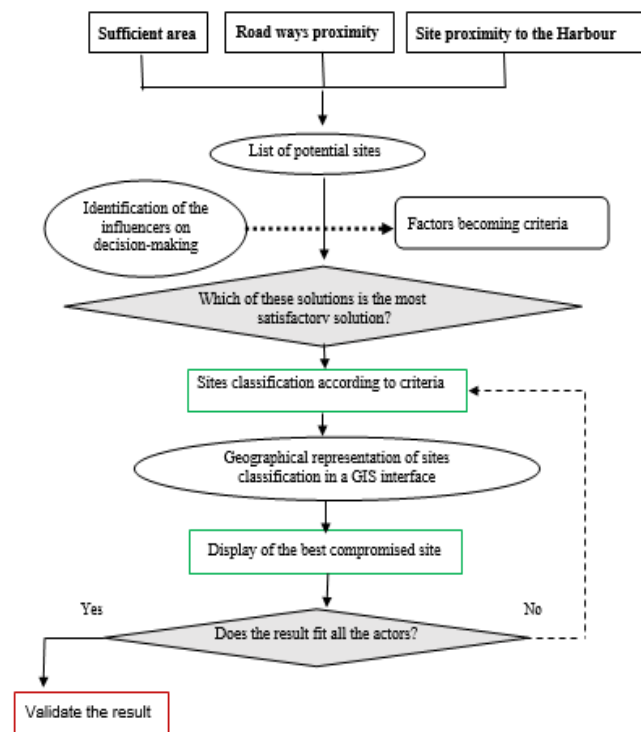


Figure 7. Application of the suggested approach

7.2.3. MCA Implementation

Once the geographic data are collected and the criteria are established, we must move to the phase of coupling with a multi-criteria analysis. For that, as previously mentioned, we use the method PROMETHEE. This method owns a ranking system named PROMETHEE Ranking, and a tool allowing the application of a scenario.

First, we must insert the collected data, mainly zones, and criteria. Figure 8 is a screen print.

Figure 8. Insertion of zones

In the figure 9, we can see the way the selected zones are inserted in the software, we insert the name, the image, and geographic details. Then, we insert the predefined criteria.

Figure 9. Criteria selection

Here, we can notice the insertion of criteria. We insert the name, abbreviation, description, unity, etc. All these data help in the classification of results.

Then, we must enter the acquired data due to GIS, namely, details, distance (distance compared to harbor and roadways) as mentioned in the figure below).

<input checked="" type="checkbox"/>	zoneA		32400,000	433,000	32,00
<input checked="" type="checkbox"/>	zoneB		109626,000	772,000	27,00
<input checked="" type="checkbox"/>	zoneC		1812522,000	182,000	20,00
<input checked="" type="checkbox"/>	zone D		40040,000	147,000	18,00

Figure 10. Zones data

In the figure 10, in the first column, we can see the values of the zones' surface. It is expressed in (m²). The second column represents the distance compared to roadways expressed in meter (m). The last column represents the distance compared to the harbor, expressed in (Km). As we can see, certain numbers are in red, others are in green, the software starts by classifying zones and criteria from the biggest to the smallest.

There are as well other indications to add when we insert criteria, there are data specifications. These specifications allow the software to establish a ranking and analyze the information we have inserted. Figure 11 is a screen print.





Preferences					
Min/Max	max	min	min		
Weight	1,00	1,00	1,00		
Preference Fn.	V-shape	Linear	V-shape		
Thresholds	absolute	absolute	absolute		
- Q: Indifference	n/a	5,000	n/a		
- P: Preference	15,000	30,000	2,00		
- S: Gaussian	n/a	n/a	n/a		
Statistics					
Minimum	32400,000	147,000	18,00		
Maximum	1812522,000	772,000	32,00		
Average	498647,000	383,500	24,25		
Standard Dev.	759162,614	249,958	5,58		
Evaluations					
<input checked="" type="checkbox"/>	zoneA		32400,000	433,000	32,00
<input checked="" type="checkbox"/>	zoneB		109626,000	772,000	27,00
<input checked="" type="checkbox"/>	zoneC		1812522,000	182,000	20,00
<input checked="" type="checkbox"/>	zone D		40040,000	147,000	18,00

Figure 11. Data specifications

The interface is divided into three big tables. The latter is already explained, the first represents the specifications (the criteria is to be maximized or minimized, the latter weight, evolution over time, etc.). The second indicates the result. The last phase represents the last step of criteria insertion. In the next section, we will dissect, analyse and draw conclusions relative to our problem.

7.2.4. Analysis and Results

In this part, we will pass to the analysis and interpretation of results. The PROMETHEE software owns an analysis tool of ranking in the function of input data. We will dissect some of these tools and try to draw some conclusions.

In the figure 12, the tools below, show that the rating making the PROMETHEE tool, with the help of criteria named Phi. From this method, we can see that zones C and D are equal with 0.5556 whereas zone B and zone A are increasingly below respectively with -0.333, and -0.7778.

According to the raking method, we can infer that it is advantageous to choose zone C and zone D rather than zones B and A for the implantation of our platform. Figure 13 is a screen print.

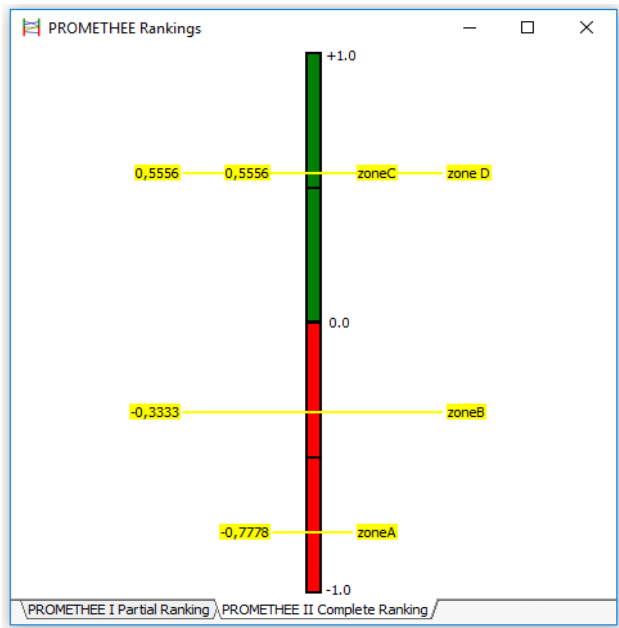


Figure 12. Zones rating

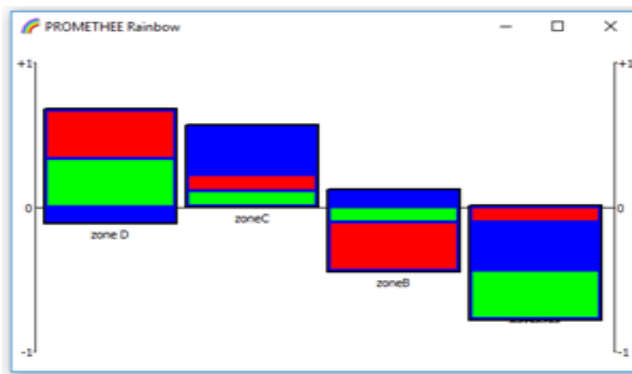


Figure 13. Rainbow PROMETHEE

This tool is called «Rainbow PROMETHEE». It is a multicolor diagram representing the 4 zones in the form of 4 rectangles. These zones are ranked according to the method of ranking seen previously. The advantage of this tool allows us to have an evaluation precision of the criteria. In other words, it compares criteria against others. The red color represents the proximity of the roadway. The bigger the red surface is, the nearer the zone to the main roadway is. The green color symbolizes the distance opposite the harbor. The bigger the green surface is, the nearer the zone to the harbor is, namely, Rades harbor.

Finally, the blue zone represents the surface. The more it is important, the bigger the reception platform is. We can as well note that there is a benchmark made of a horizontal axis plus two vertical ones. Hence, the higher the zone surface is, the better regarding others is. For example, zone D has a red rectangle and a green one reaching upwards more than the ones of zone C. That is to say, for zone D, distance regarding roadways compared to the harbor are smaller than the ones of zone C. We can as well note this in the figure below.

<input checked="" type="checkbox"/>	zoneA		32400,000	433,000	32,00
<input checked="" type="checkbox"/>	zoneB		109626,000	772,000	27,00
<input checked="" type="checkbox"/>	zoneC		1812522,000	182,000	20,00
<input checked="" type="checkbox"/>	zone D		40040,000	147,000	18,00

Figure 14. Zones Data

In figure 14, analysis tools allow the comparison of results in function of criteria weight. They let us measure the impact weight change criteria on the final ranking of the zones.

In the figure 15 below, we can see the initial ranking while all the criteria are having the same weight. Zones D and C are ahead followed by zones B and A.

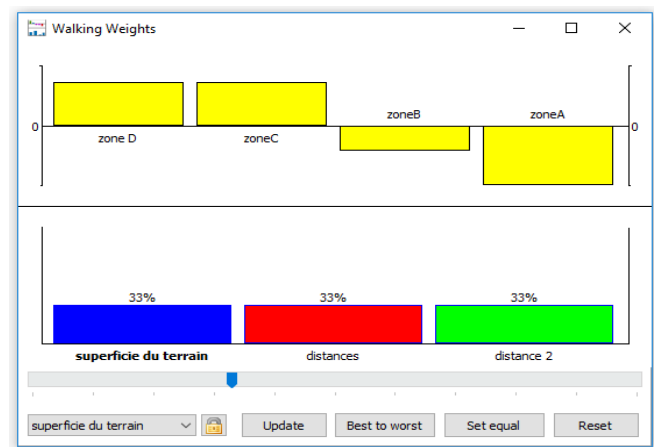


Figure 15. Initial ranking

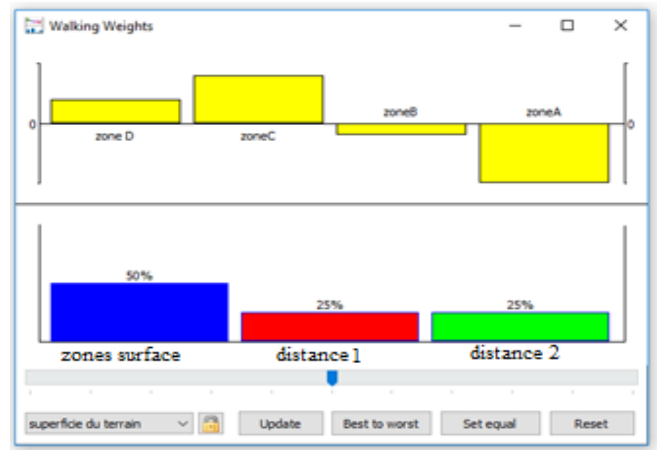


Figure 16. Ranking by adding weight to the surface

Then, in the figure 16 above we can make some changes by increasing the percentage (weight) appportioned to each criterion. We will first increase the one corresponding to the surface.

When we add weight to the surface criterion, zone C becomes the preferable one compared to zone D. However, when we choose another criterion such as distance to the harbor, we obtain another result. Figure 17 shows the results when adding weight to the distance against the harbor.

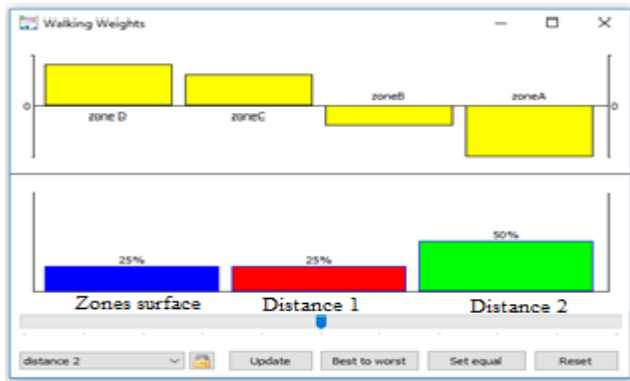


Figure 17. Results when adding weight to the distance against the harbor

As we can see, zone D becomes favorable against other zones. The result analysis does not depend only on the value assigned to criteria but as well as to the weight of the later ones.

To conclude, we can claim that zone D is the optimal zone for the implantation of our platform since it is ranked first.

8. Conclusions

In this paper, we have first presented the constraints and relative criteria in territory planning. These criteria are were characterized due to:

- Indicators describing their situation.
- Parameter giving a measured indication.

Mathematical optimization models developed in the previous section lead to the enrichment of the methodological approach suggested for a hinterland planning and the suggested logistic chain. These models help in the process of decision making at the levels:

- Strategic: relative to the localization of logistic building.
- Tactic: relative to the optimization of physical flow exchanges in the hinterland.

We have chosen the formulation of a mathematical model for each link instead of an integrated model because the first model is:

- Much less complex.
- It meets the progressive character of the logistic chain.

Obviously, we can note, as perspective, the possibility of the resolution of these mathematical models through a linear programming software. This paper allows us to focus on the criteria of logistics optimization in the framework of territory planning, particularly, the hinterland.

The main challenge in this work is to preserve the territorial resource, limit the effects due to the misuse of this resource and bring a quality service concerning the exchanged of freight flow in the hinterland.

We have also demonstrated that the integration of the logistic constraints, it seems inevitable in the framework of sustainable development because it allows the optimization of physical flows between links and it helps in the resolution

of the localization problem.

Like any other work, this study has some limits. We have restricted our bibliographic research to a selection of some recent works due to the complexity in the development of a multidisciplinary review of literature since the territory planning problem has been treated through various approaches: Mathematic, economic, informatics and geographic approaches.

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REFERENCES

- [1] Sassi, E., Hammani, N., Benabdelhafid, A., & Hammami, S. (2016). Evaluation Methodology Development of a framework for sustainable transport capacities evaluation. The 5th IEEE International Conference on Advanced Logistics and Transport (ICALT), Kraków, Poland, 68-71.
- [2] Sassi, E., Benabdelhafid, A., & Hammami, S. (2017). A typology of dashboard for a territorial industrial ecosystem, the 6th IEEE International Conference on Advanced Logistics and Transport (ICALT), Bali, Indonesie, 47-52.
- [3] Simon, J.-C. (1989). Introduction in "from pixels to features". V-X North, Holland Amster-dam.
- [4] Roy, B. (1985). Méthodologie multicritère d'aide à la décision. Economica, Paris.
- [5] Maystre. (1999). Aide la négociation multicritère Pratiques et conseils. Collection Gérer l'environnement Presses Polytechniques et universitaires romandes.
- [6] OCDE/JRC. (2005). Handbook on Constructing Composite Indicators: Methodology and User Guide. OECD Statistics Working Paper, Paris.
- [7] Roy, B. (1985). Méthodologie multicritère d'aide à la décision. Economica, Paris.
- [8] Roy, B. (1975). Combinatorial Programming: Methods and Applications. Reidel Publishing Company, Dordrecht, Holland, NATO Advanced Study Institutes Series. Series C: Mathematical and Physical Sciences, Vol. 19, 459-497.
- [9] Sarsam,S., Daham,A., Mahdi, A., Implementation of Close Range Photogrammetry to Evaluate Distresses at Asphalt Pavement Surface, International Journal of Transportation Engineering and Traffic System.
- [10] Schärli, A. (1985). Décider sur plusieurs critères: panorama de l'aide à la décision multicritère. Presses Polytechniques et Universitaires Romandes, Lausanne.
- [11] Joerin, F. (1998). Decider sur le territoire: proposition d'une approche par utilisation de SIG et de méthodes d'analyse multicritere. thèse no 1755, DGR-EPFL, Lausanne.

- [12] SASSI, E., Benabdelhafid, A., Hammami, S., Evaluation of transport system capacity: Strategies and framework, 10 International seminar on Logistics and Supply Chain Management (LOGISTIQUA), Rabat, Maroc, 2017.
- [13] Jahanshahi, D., Minaei, M., Kharazmi, O., A., Minaei, F., Evaluation and Relocating Bicycle Sharing Stations in Mashhad City using Multi-Criteria Analysis. International Journal of Transportation Engineering, Vol.6, No.3.
- [14] Yerramilli, S., A Hybrid Approach of Integrating HEC-RAS and GIS Towards the Identification and Assessment of Flood Risk Vulnerability in the City of Jackson, American Journal of Geographic Information System, 2012, 1(1): 7-16.