

**A Thesis Submitted in Partial Fulfilment of the Requirements for
Master degree**

Specialty: Audit and Management Control

Title:

**Multi-criteria analysis as a tool for
budgetary decision-making
CAS: SARL GARDEN CLEAN**

Submitted by:

Mr. MEKIDECHE Youcef

Mr. BENOUROUAR Mohamed Fouad

Supervised by:

Mrs. BOUDOUR Nasrine

Promotion

2025-2026

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Dedications

We dedicate this work to:

Our parents

And to our brothers and sister

And our grandmothers and grandfathers

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List of symbols and abbreviations

Symbols:

Symbol	Meaning
Φ	Net flow (PROMETHEE II)
Φ^+	Positive flow
Φ^-	Negative flow
A1	Alternative 1 New Trucks
A2	Alternative 2 Marketing Panels
A3	Alternative 3 New Product Launch
C1	Criterion 1 Profit
C2	Criterion 2 ROI Time
C3	Criterion 3 Cost
C4	Criterion 4 Risk
$\succ$	Outranks / is preferred over
P	Preference threshold (V-shape function)

Abbreviations:

Abbreviation	Full Form
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision-making
PROMETHEE	Preference Ranking Organization Methods for Enrichment Evaluation
ELECTRE	Élimination et Choix Traduisant la Réalité
GAIA	Geometrical Analysis for Interactive Aid
AHP	Analytic Hierarchy Process
MAUT	Multi-Attribute Utility Theory
MAVT	Multi-Attribute Value Theory
SMART	Simple Multi-Attribute Rating Technique
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
UTA	Utility Theory Additive

EVAMIX	Evaluation of Mixed Criteria
ROI	Return on Investment
DZD	Algerian Dinar
SARL	Société à Responsabilité Limitée
SNC	Société en Nom Collectif
SME	Small and Medium Enterprise
CEO	Chief Executive Officer
BDL	Banque de Développement Local
BADR	Banque de l'Agriculture et du Développement Rural
SGA	Société Générale Algérie
AGB	Algerian Gulf Bank
BNP	Banque Nationale de Paris

Abstract

Budgetary decision-making in organizations increasingly requires the simultaneous consideration of multiple financial and non-financial criteria, making traditional mono-criteria approaches insufficient in the face of growing complexity. This thesis explores how multi-criteria analysis, as a decision-support tool integrated within management control, can improve the quality and rationality of budgetary decisions. In this work, we present the PROMETHEE method. A practical application conducted at SARL GARDEN CLEAN illustrates the theoretical developments, evaluating three strategic investment alternatives against four criteria.

Key words: Management Control, Budgetary Decision-Making, Multi-Criteria Analysis, PROMETHEE Method.

Résumé

La prise de décision budgétaire au sein des organisations nécessite de plus en plus la prise en compte simultanée de plusieurs critères financiers et non financiers, rendant les approches traditionnelles mono-critère insuffisantes face à une complexité croissante. Cette thèse explore comment l'analyse multicritère, en tant qu'outil d'aide à la décision intégré au contrôle de gestion, peut améliorer la qualité et la rationalité des décisions budgétaires.

Dans ce travail, nous présentons la méthode PROMETHEE. Une application pratique réalisée au sein de la SARL GARDEN CLEAN illustre les développements théoriques, en évaluant trois alternatives d'investissement stratégique selon quatre critères.

Mots clés : Contrôle de gestion, prise de décision budgétaire, analyse multicritère, méthode PROMETHEE.

General Introduction

In an economic environment characterized by increasing uncertainty, budgetary constraints, and growing pressure on organizational performance, companies are required to make complex decisions regarding the allocation and use of their financial resources. In such a context, management must ensure not only the achievement of strategic objectives (effectiveness) but also the optimal use of available resources (efficiency). Budgetary decision-making therefore represents a critical component of organizational performance.

Traditionally, budgetary decisions have been largely based on financial criteria such as costs, revenues, and profitability. However, this monocriteria approach has shown its limitations in environments where decisions must also take into account nonfinancial dimensions such as risk, strategic alignment, operational feasibility, and long-term sustainability. As a result, relying on a single indicator is no longer sufficient to support sound budgetary choices.

Within this framework, management control plays a central role by providing information, tools, and analyses that support planning, monitoring, and decision-making processes. Nevertheless, the growing volume and diversity of information handled by management control systems may complicate budgetary arbitrations, especially when multiple and sometimes conflicting criteria must be considered simultaneously.

Multi-criteria analysis has thus emerged as a relevant decision support tool capable of addressing this complexity. It enables decision-makers to evaluate and compare budgetary alternatives based on several criteria both financial and nonfinancial while structuring preferences and priorities in a rational and transparent manner. By integrating multi-criteria analysis into management control, organizations can improve the quality, coherence, and relevance of their budgetary decisions.

Based on these considerations, this thesis focuses on the following topic:

“Multi-criteria Analysis as a Tool for Budgetary Decision-making.”

The choice of this topic is motivated by several factors:

- Its strong connection with our specialization in Audit and Management Control.
- The growing importance of advanced decision support tools in budgetary and managerial processes.

Study Objectives

The main objective of this study is to analyze the contribution of multi-criteria analysis to the improvement of budgetary decision-making within organizations. More specifically, this research aims to examine how multi-criteria analysis can support management control in evaluating budgetary alternatives, allocating resources efficiently, and enhancing the overall quality of decisions.

To achieve this objective, the study seeks to answer the following research question:

To what extent does the PROMETHEE method improve the rationality and reliability of budgetary decisions compared to traditional financial approaches within SARL Garden Clean?

Research Sub Questions

In order to address this central question, the following sub questions are proposed:

What is the role of management control in the decision-making process?

How does multi-criteria analysis contribute to the evaluation and comparison of budgetary alternatives?

Research Hypotheses

Based on the research questions, three main hypotheses are formulated:

H1: Management control tools improve the quality of budgetary allocation decisions.

H2: The budgetary investment decisions of SARL Garden Clean require the simultaneous consideration of both financial and non-financial criteria.

H3: Multi-Criteria Decision-Making methods improve the rationality and transparency of budgetary decisions.

Research Methodology

- Type of Study: This research is a qualitative case study. Gathering data from Interview.

- **Justification of Case Selection:** SARL GARDEN CLEAN was selected as the case study because it frequently faces budgetary investment decisions involving multiple competing alternatives.
- **Methodological Protocol:** The study is structured into two main parts. The theoretical part is based on a literature review covering management control, decision-making, and multi-criteria decision analysis. The empirical part focuses on the application of the PROMETHEE method to a budgetary decision-making problem within SARL GARDEN CLEAN. The empirical investigation relied on a semi-structured interview conducted with the management controller of the company. The interview was carried out during the internship period and lasted approximately 60 minutes. An interview guide composed of questions was used to collect information about investment evaluation criteria. In addition to the interview, internal company documents during the internship were used to complement the collected data.
- **Data Collection Conditions:** The interview was conducted within the company. The management controller was selected as the respondent because of his direct involvement in budget planning, investment evaluation, and aid in decision-making.
- **Analysis Techniques:** The collected data was analyzed using the PROMETHEE method, applied through Visual PROMETHEE software. The analysis included the construction of a multi-criteria evaluation matrix, the computation of positive, negative, and net preference flows, and the generation of visual outputs including the PROMETHEE network, ranking, GAIA plane, and walking weights tool. A sensitivity analysis was also conducted to test the robustness of the results under varying weight configurations.
- **Methodological Limitations:** First, the analysis is based on three investment decisions previously made by the company, which means the PROMETHEE method was applied retrospectively. Second, some data used in this study, such as the cost of the marketing panels alternative, are based on estimations provided by the management controller rather than exact financial figures. Third, this study focused exclusively on quantitative financial criteria such as cost, revenue, and profitability, without incorporating any non-financial criteria.

Work Plan

To ensure clarity and coherence, this thesis is structured into two main chapters:

Chapter 1: Management Control and Multi-criteria Decision-making

- **Section 1:** The Concept of Management Control
- **Section 2:** Decision-making
- **Section 3:** Multi-Criteria Decision-making

Chapter 2: Application of the PROMETHEE Method to Budgetary Decision-making

- **Section 1:** Presentation of the studied organization
- **Section 2:** Application of the PROMETHEE Method to the Budgetary Decision Problem at SARL GARDEN CLEAN

Chapter 01: Management Control and Decision-Making

Introduction

In search of a tool that ensures better achievement of objectives in an environment characterized by uncertainty and intense competition, this has led to the emergence of management control.

The term "management control" refers to a process aimed at ensuring that the strategic decisions of executives are consistently implemented at all levels of the company by managers.

The objective of this section is to thoroughly understand the concept of management control. And decision-making in addition to MCDA.

Section 1: The Concept of Management Control

To better understand management control, this section covers its history, process and objectives

1. History and Definition of Management Control

The control of organizational activities, and the field of management control that emerged from it, is closely linked to the industrialization period of the late 19th and early 20th centuries. It developed alongside economic and technological progress, particularly through Taylor's work (1905) on productivity, Gantt's studies (1915) on cost structures, and the adoption of divisional structures by companies such as General Motors (1923) and SaintGobain (1935). At that stage, management control mainly focused on production activities, although it was not yet formally defined as such.¹

The function of management control began to take shape in the United States between the two World Wars. Its official recognition dates back to 1931 with the establishment of the Controllers Institute of America. Following World War II, the discipline expanded significantly in the United States and gradually spread to Europe, becoming an essential function within modern organizations. Due to its relatively recent emergence, management control remains a dynamic concept, originally rooted in accounting practices.

Initially, the controller's role was largely limited to accounting functions. However, over time, this role evolved beyond simple financial recording. In 1947, David R. Anderson described the controller's function as encompassing the collection and use of relevant information to protect company assets, ensure compliance with legal and reporting requirements, and provide management with useful data for planning and operational control.

Later, Robert N. Anthony played a major role in structuring and formalizing management control during the 1960s. With the expansion of multinational companies, it became necessary to delegate decision-making while maintaining effective oversight. This led to the development of centralized management control systems aimed at ensuring that organizational objectives were achieved.

¹ C.ALAZARD et S.SEPARI (2010), *Contrôle de gestion Manuel et application*, édition Dunod, Paris, P 5.

Over time, the perception of management control has evolved. It was once seen as a strict monitoring mechanism, sometimes referred to as the “watchdog,” but later became associated with a “thermostat” role, alerting managers to deviations and enabling corrective actions. Today, "management control" has evolved into "performance steering," defined as « a process that helps organizations progressively achieve performance goals while aligning efforts across all units »¹

2. Definition of Management Control

Management control has been defined in various ways, reflecting the continuous evolution of the concept over time.

1.2.1. The Meaning of "Control"

To control can mean three things:²

First, it means "to verify." In this sense, management control checks if actions and behaviors follow a set of rules, goals, or budget standards. Control always involves comparing actual results to what was planned.

Second, to control can mean "to master." Management control then ensures a company can handle changes and problems from its environment. This idea relates to steering or piloting the company.

Third, to control can also mean "to influence." This is about guiding or directing people's behaviors so they work toward the organization's goals.

1.2.2. Some Fundamental Definitions

With the evolution of the environment, the management control function has taken on numerous definitions, each addressing a particular aspect.

Considered the father of management control, R. Anthony defines it as « the process by which managers ensure that resources are obtained and used effectively and efficiently to achieve the organization's objectives »³

¹ Charles Horngren et al (2006), *contrôle de gestion et gestion budgétaire*, 3ème édition Pearson éducation, France, P 20.

² AUGÉ.B et NARO.G (2011), *Mini manuel de contrôle de gestion*, édition Dunod, Paris, P 4.

³ Robert Anthony (1999), Cité in : Le Duff R, Cliquet G, Valhen C-A, *Encyclopédie de gestion et de management*, Dalloz, Paris, P 194.

This process aims to motivate managers and encourage them to carry out activities contributing to the achievement of the strategic objectives set by the entity, thus appearing as a guarantee against the waste of resources entrusted to a manager. With this definition, R. Anthony was the first in 1965 to theorize the discipline, which then attained the status of a conventional "universal" definition.

The focus of the control function on a purely accounting and financial aspect led the same author, in the 1980s, to revise the previous definition to expand it

Focusing the control function solely on accounting and financial aspects led the same author, in the 1980s, to change his earlier definition in order to expand it as follows: « Management control is a process by which the leaders of an organization influence its other members to implement the organization's strategies »¹

- ❖ « Management control is the process by which managers influence other members of the organization to implement the organization's strategies ».²
- ❖ According to A. Khemakhem (1976), management control is: « the process implemented within an economic entity to ensure an effective and permanent mobilization of energies and resources in order to achieve the objective that this entity aims for »³
- ❖ In 1997, M. Gervais added the notion of relevance and defined management control as « the process by which managers ensure that resources are obtained and used with efficiency, effectiveness, and relevance, in accordance with the organization's objectives, and that ongoing actions align well with the defined strategy »⁴

¹ Robert Anthony (1999), *Op Cit*, P 194

² Anthony R.N. & Govindarajan V. (2007), *Management Control Systems*, 12th Edition, McGraw-Hill/Irwin, Boston, P.6.

³ KHEMAKHEM.A (1976), *La dynamique de contrôle de gestion*, édition Dunod, Paris, P 16.

⁴ Gervais Michel (1997), *contrôle de gestion*, 6ème Edition, Economica, Paris, P 13.

2. Roles, Objectives and limits of Management Control

2.1 Management Control Role

Management control plays five main roles:¹

- **Enable decentralization of responsibilities**

Decentralization is essential in real business life. Management control makes it possible by giving decision-making power to different units. But these units are not fully independent they work together as part of the company.

- **Promote coordination among operational managers**

The consistency of actions from different managers is achieved through a permanent coordination system. Management control aims to achieve this coordination by having operational staff examine the consistency between different objectives, the adequacy between objectives and action plans, by highlighting the necessary means to achieve objectives, and by encouraging dialogue among all operational staff.

- **Encourage operational staff to think ahead**

The company deals with customers wanting ongoing relationships, loans to repay, investments to monitor, and more. So operational staff must think about the future.

Management control helps them ask and answer key questions to shape that future. Examples include: What will we do? Who will do it? When? How? With what resources? Can we get those resources? Will we succeed?

Through setting and discussing objectives, action plans, and analyzing results against goals, management control constantly pushes operational staff to focus on the future.

¹ *Ardoin Jean-Loup, Jordan H (1976), le contrôleur de gestion, Flammarion, Paris, P 22.*

- **Motivate operational staff to act in line with the company's interests**

Management control helps align personal and company goals. It evaluates managers individually and rewards or corrects them based on their work for company projects.

- **Help operational staff learn to improve their performance**

After identifying gaps and errors, the management controller recommends corrective measures to address the situation and prevent recurrence. While occasional mistakes are inevitable, their repetition is unacceptable. therefore, continuous learning and improvement are essential.

The role of management control also varies according to the type of company (small, medium, and large enterprises), distinguished as follows:¹

Role in small and medium enterprises (SMEs): Management control in SMEs primarily aims to monitor the achievement of financial objectives and the completion of tasks delegated by management or supervisors.

Role in large enterprises: The specific characteristics of corporate groups require an adapted management control system. The need to oversee numerous subsidiaries of significant size, often geographically distant, leads to the development of consolidated budgets and reporting systems. The role of management control is to assist functional managers in decision-making and operational staff in controlling their actions.

¹ *Les outils de contrôle de gestion dans le contexte des PME : cas des PMI au Liban, (2005), Comptabilité et connaissances, France, P 06.*

2.2 Management Control Objectives¹

Management control has the same goals for all organizations, no matter their industry or size: coordination, help, monitoring, control, and aid in making decisions.

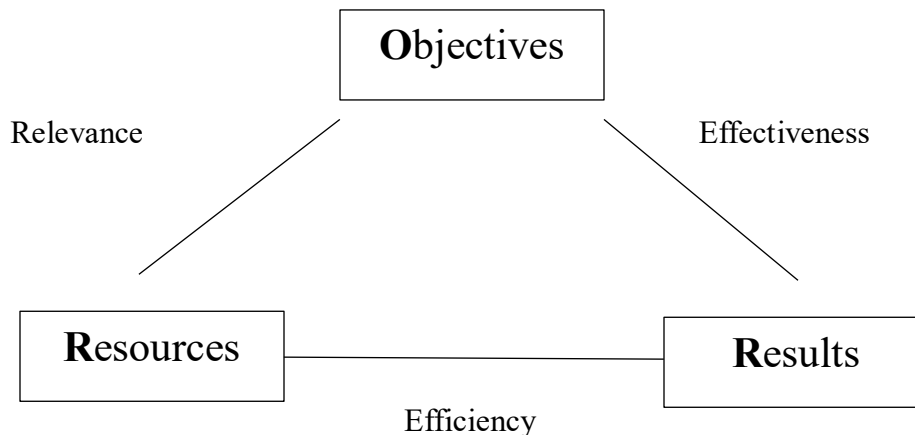
It keeps actions aligned with main goals. It stops strategic thinking during daily work so teams can focus on current tasks. This way, it regulates activities and trains people to stay alert and make good decisions. In global management control targets: (Fig. 01)

Relevance: Involves considering the organization's strengths and weaknesses when setting objectives (lowest cost, quantity and quality meeting standards, right time and place).

Effectiveness: Describes the situation where results match the predetermined objectives.

Efficiency: Consists of achieving assigned objectives while respecting cost constraints.

Figure 01 : The Management Control Triangle



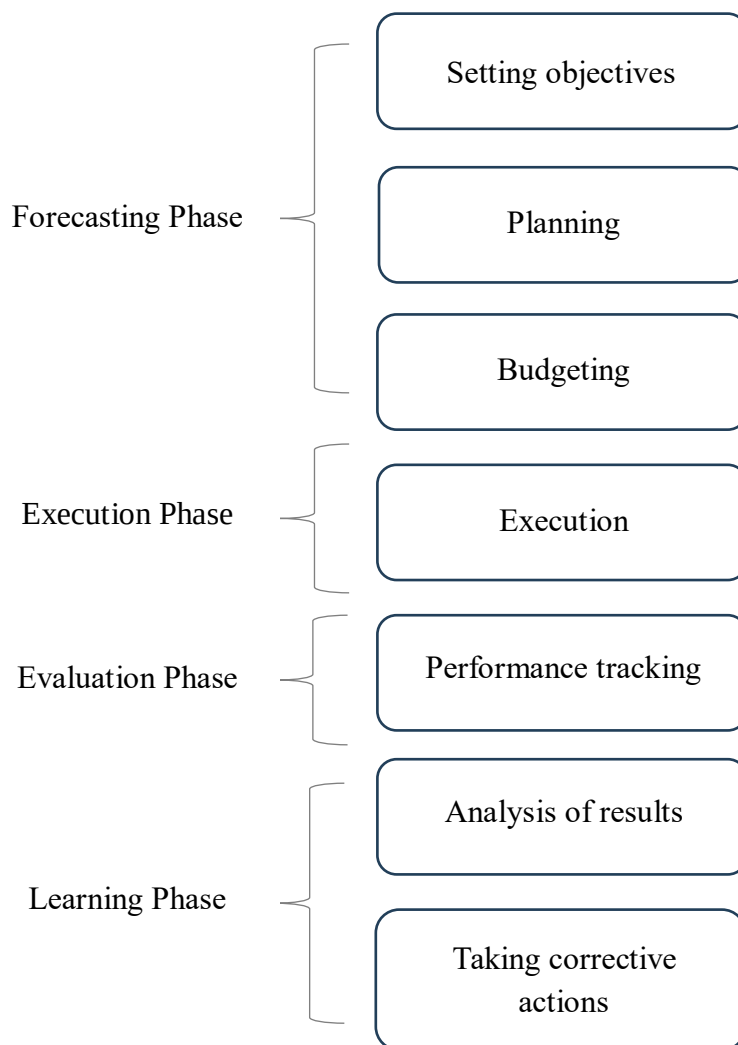
SOURCE : Hélène, LÖNING (2003), *Le contrôle de gestion, organisation et mise en œuvre*, 2ème édition, Dunod, Paris P 6

¹ AISSANOU Souhila, ADRAR Dihia, (2013), *Le contrôle de gestion par l'élaboration d'un système Budgétaire*, mémoire d'un master en sciences commerciales en Université Abderrahmane Mira De Bejaia, P 38.

2.3 Management Control as a Process

The management control process divides into four traditional phases: forecasting, execution, evaluation, and learning.

Figure 02 : Steps of Management Control



Source : *H.Loning, V.Malleret, et autres,le contrôle de gestion, organisation outils et pratique, 3éme édition,Dunond.*

2.3.1. Forecasting Phase

This phase depends on the strategy defined by the organization. Management sets objectives, budgets, planning, and forecasts the necessary resources to achieve predetermined goals.

2.3.2 Execution Phase

In this phase, entity managers implement the allocated resources. They rely on an information system that helps them better distinguish the organization's actions and functions.

2.3.3 Evaluation Phase

To assess organizational performance, the organization compares actual results with preestablished forecasts. This reveals variances that require justification through corrective measures.

2.3.4 Learning Phase

In this final phase, after identifying potential weaknesses, the entity adopts corrective measures. This builds a database for use in future forecasts.

2.4 Limits of Management Control

There are numerous fundamental limitations to management control:¹

- Once an indicator is chosen, it quickly becomes a goal in itself, limiting the trust that can be placed in the management control system.
- Managers should not rely solely on these indicators. They must also regularly check onsite what is happening in the company's units and with customers, since indicators do not detect everything.
- Control effectiveness also depends on leadership competence. This includes top management, supervisors, operational staff, and controllers who use it, as well as how it functions. Implementing management control is a matter of organizational knowhow.

¹ CLAUD ALAZARD, SABINE SEPARI (2010), *contrôle de gestion manuel et application*, 2Ed, DUNOD, P 42

Conclusion:

In conclusion, management control has evolved from a simple accounting function into a comprehensive system for performance management. It plays a crucial role in ensuring the efficient and effective use of resources while aligning organizational actions with strategic objectives. Through its processes, tools, and indicators, management control supports planning, coordination, and decision-making within the company. However, despite its importance, it presents certain limitations that require managerial judgment and adaptation. Overall, it remains an essential function for improving organizational performance in a complex environment.

Section 2: Decision-making

Depending on the nature and purpose of the organization, leaders must make key decisions for each specific mission, as they form the foundation for business success and growth. To do this, decision-makers need complete information to handle uncertainty and avoid negative outcomes from their choices.

In this section, we will explore the concept of decision-making, the context of decisions within organizations, and finally present the tools that aid decision-making.

1.The Definition of The Decision

A decision can be defined in several ways. Most authors agree that it involves selecting one alternative from several options to achieve an objective.

- ❖ According to Mintzberg A decision is « the commitment to an action, that is, an explicit intention to act. The purpose of a decision is to resolve a problem occurring in the organization or for the individual »¹
- ❖ « Decision-making refers to making choices among alternative courses of action which may also include inaction »².
- ❖ A decision is « a process during which an individual makes a choice between several options to provide a satisfactory solution to an identified problem. This notion of choice indicates that all behavior involves a choice conscious or unconscious selection among all the actions that are materially feasible by the actor and by the people over whom he exercises his influence or authority »³
- ❖ According to Lemoigne: « The taking and execution of decisions are the fundamental purposes of any organization or management. Every organization depends structurally on the nature of the decisions made within it, whether by individual or collective decision-makers »⁴

¹ MINTZBERG Henry (2003), *Structure et dynamique des organisations, Organisation, Paris, P26*

² Carpenter M., Bauer T., Erdogan B. (2012), *Principles of Management, P 512*

³ LEUREBOURG Claire et Rodney (2014), *Prise de décision complexe en lien avec la supervision pédagogique chez les directions d'école francophone en situation de valorisation linguistique et culturelle, Revue canadienne de l'éducation, volume 2, P 06.*

⁴ Lemoigne J (1974), *Les systèmes de décision dans les organisations, 1er Ed, PUF, Paris, P 38.*

- ❖ From these definitions, decision-making stands out as :
 - ✓ A clear process with several linked steps.
 - ✓ A real problem needing a fix, either for a person or company.
 - ✓ More than one option ready to pick from.

2. Decision Problems¹

➤ Choice problem

This type of problem focuses on selecting the most suitable option, or narrowing down a set of alternatives to a smaller group of equally acceptable or noncomparable choices. For example, a manager may need to choose the best candidate for a specific project.

➤ Sorting problem

In this case, alternatives are assigned to predefined and ordered categories. The objective is to group options that share similar features or behaviors for purposes such as organization, description, or prediction. For instance, employees might be classified into groups like “high performers,” “average performers,” and “low performers.” Such classifications can guide appropriate managerial actions. Sorting approaches are especially useful in repetitive or automated contexts and can also serve as a preliminary filtering step before further analysis.

➤ Ranking problem

This problem involves arranging alternatives from most to least preferred based on scores, comparisons, or other evaluation methods. The ranking may be complete or partial when some options cannot be directly compared. A common example is ranking universities using criteria such as teaching quality, research output, and employment prospects.

¹ Alessio Ishizaka Philippe Nemery (2013), *Multi-Criteria Decision Analysis Methods and Software*, Wiley, P 3

➤ **Description problem**

The aim here is to provide a detailed understanding of the available options and their potential outcomes. This step is often carried out at the beginning of the decision process to clarify the nature of the problem and its components.

Beyond these four problems, the multi-criteria decision analysis (MCDA) field has introduced additional types

➤ **Elimination problem**

Proposed by Bana e Costa (1996), this problem represents a specific form of sorting where options are progressively removed based on certain criteria.

➤ **Design problem**

As described by Keeney (1992), this type focuses on developing or identifying new alternatives that align with the decision-maker's objectives and preferences.

3. Decision typologies

Decision typologies classify choices based on factors like frequency, impact, hierarchy level, and uncertainty.

3.1 Classification by Decision Timeframe¹

3.1.1 Long-term Decisions

This grouping sorts decisions by how long they last. These tie directly to the company's investment plans, like buying big assets or expanding operations.

Long-term decisions stand out from daily operations because they cover one to five years, or even more in tough cases. They lock up company resources for a long time like money, people, and

¹ CHABI Tayeb (2007), *L'impact de l'information comptable sur la prise de décision de l'entreprise de production : une approche systémique cas d'un échantillon d'entreprises algériennes*, Thèse de doctorat, Université de Béjaïa, Béjaïa, P 42.

equipment. The goal is to set the firm's future path, such as entering new markets or building key capabilities that last for years.

The upsides of these decisions are mainly:

- Higher potential returns: Investments often generate greater benefits over time.
- Competitive advantage: Longterm planning can position a company ahead of competitors.

While they drive major progress, they come with clear downsides:

- Corrective actions are difficult, slow, and costly.
- The preparation of these decisions is relatively long.
- High risk and uncertainty, Forecasts can miss big changes, like economic shifts, causing losses

3.1.2 Medium-term Decisions

Medium term decisions, also called tactical ones, cover 6 months to 23 years. They bridge the gap between long-term and daily tasks.

They differ from long-term choices by being less risky and more flexible.

Advantages

- Balanced risk: Lower stakes than long-term, with faster feedback to improve.
- Flexibility: Easy shifts if markets change a bit.

Disadvantages

- Coordination issues: Can lead to inconsistencies between short term actions and long-term strategy.
- Missed big impact: Not as transformative as strategic moves.

3.1.3 Short Term Decisions

Short term decisions tie to a company's daily operations within one accounting year, with a maximum span of one year. They encompass things like handling routine tasks or quick adjustments.

Here are their main features:

- Quick decision-making: You decide fast, often in hours or days, using current data.
- Immediate but short effects: Results hit right away but fade quickly, lasting only for that period.
- Easy fixes: You can step in fast with corrections if something goes wrong no big costs or delays.

3.2 Classification by Hierarchical Levels¹

This approach sorts decisions by the level in a company's structure where they happen. It splits them into top, middle, and lower tiers, matching the org chart. Each level has unique roles, time spans, and scopes.

Higherups handle broad strategy, while lower levels focus on details.

3.2.1 Operational Decisions

Operational decisions are made every day and can come from any level of responsibility in the company, from frontline workers to managers. They keep the business running smoothly by handling routine tasks that support bigger plans.

These choices stand out because they are often repetitive, with effects that show up right away and results you can predict ahead of time. Unlike the strategic or the tactical ones, they focus on the here and now.

3.2.2 Tactical Decisions

Tactical decisions, also known as administrative decisions, focus on managing the company's resources effectively. They involve solving problems and allocating production factors like staff, budget, and equipment in the best possible way to support overall goals.

These choices can be made in a decentralized manner, meaning department heads or middle managers often handle them without needing top level signoff.

¹ BURGER-HELMCHEN (T) et HUSSLER (C), MULLER (P) (2019) *Management. Le manuel complet du management*. Vuibert, Paris, P 286.

3.2.3 Strategic Decisions

Strategic decisions set the overall direction for the company, shaping its long-term path and competitive position. They rely mainly on information from the external environment, like market trends, competitor moves, and economic shifts, rather than just internal data.

These choices are made at the top level by general management or executives, with no decentralization. They are often irreversible once committed, and high stakes impact on the entire organization.

Table 01: Decision Levels

Level of Decision	Examples of Decision	Who Typically Makes Decisions
Strategic Decisions	Should we merge with another company? Should we pursue a new product line? Should we downsize our organization?	Top management teams, CEOs, and boards of directors
Tactical Decisions	What should we do to help facilitate employees from the two companies working together? How should we market the new product line? Who should be let go when we downsize?	Managers
Operational Decisions	How often should I communicate with my new coworkers? What should I say to customers about our new product? How will I balance my new work demands?	Employees throughout the organization

Source : Carpenter M., Bauer T., Erdogan B. (2012), Principles of Management, P 516

The following table illustrates the different levels of decision-making within a company:

Table 02: The Differences Between Decision Levels

Nature of Decisions	Strategic	Administrative	Operational
Decision Domain	Strategy	Management	Operations
Time Horizon	Medium and long-term	Short term	Very short term
Corrective Actions	Impossible	Difficult	Easy
Problem	Choosing product ranges and markets likely to yield optimal returns on firm investments.	Structuring the firm's resources to ensure optimal success.	Operations under conditions that optimize capital profitability
Nature of Problem	Judicious allocation of resources among products and markets.	Organization, acquisition, and development of resources.	Budget allocations to departments, resource allocation planning,
Key Decisions	Definition of strategic objectives. Diversification measures. Expansion measures.	Resource acquisition and development: financing, equipment, personnel, raw materials.	Operational objectives. Production planning and inventory management.
Characteristics	Centralized. Affected by partial ignorance. Nonrepetitive. Nonprogrammable.	Conflict between strategy and operations. Conflict between individual and collective goals. problems. Semiprogrammable.	Decentralized. Involving risks and uncertainties. Repetitive. Very numerous. Programmable.
Examples	Organizational choices and restructuring. Investment and financing.	Sales forecasting. Production programs.	Inventory management. Production scheduling

Source : Ansoff H.I (1984), *Stratégie du développement de l'entreprise*, 1er Ed, Ed d'organisation, Paris, P 30.

3.3 Classification by Variable Nature¹

Decision variables can be classified into two categories according to their nature: quantitative and qualitative. When variables are quantitative, they can be formally incorporated into a decision-making model. In contrast, when variables are qualitative, it becomes difficult if not impossible to represent them within a formal model. In such cases, it relies more on cognitive judgment. Therefore, decision variables can be broadly divided into these two types.

3.3.1 Programmable (Structured) Decision

Programmable decisions are relatively simple decisions that involve a limited number of quantitative variables, making it possible to formalize them through the development of an algorithm. These decisions generally address structured problems, where the decision-making process can be executed automatically by following predefined procedures.

Programmed decisions are repetitive and routine in nature. For such decisions, specific procedures are established to handle them systematically, thereby avoiding the need to reconsider them each time they arise.

3.3.2 Non programmable (Unstructured) Decision

This type of decision is more complex, as it involves numerous qualitative variables that are difficult to incorporate into a mathematical model. As a result, it is generally impossible to standardize the decision-making process.

¹ *BURGER-HELMCHEN (T) et HUSSLER (C), MULLER (P) (2019), Op.cit. P 286.*

4. The actors involved in the decision-making process

The actors involved in a decision-making process are :¹

- The decision-maker
- The study expert or analyst, or decision engineer
- The operational and technical staff of the system
- The actors affected, who benefit from or are impacted by the decisions made.

The key actors considered here are the decision-maker and the analyst. These roles do not necessarily correspond to a single person. The decision-maker could be a board of directors, all the managers of an organization, or a similar group. Meanwhile, the analyst may be a team composed of engineers, mathematicians, economists, psychologists, sociologists, and others. The analyst participates only when the decision-maker engages them. They may be part of the social system or external to it. If external, they could be a consulting firm brought in to examine a specific problem.

4.1 The decision-maker

The decision-maker is the individual or collective authority responsible for selecting among alternative courses of action within an organization or social system.

He has several Roles the main ones are:

- Define the objectives and strategic priorities of the system.
- Evaluate alternatives based on available information and anticipated outcomes.
- Make final choices and authorize their implementation.
- Oversee and monitor the results of decisions to ensure alignment with objectives.
- Engage experts or analysts when necessary to support informed decision-making.

¹ Bertrand M (2002), Article: " Introduction aux problèmes de décision et d'évaluation", Université de Bruxelles, P 16.

4.2 The Analyst

The analyst is responsible for defining the decision-making model, conducting the decision process, and presenting the results to the decision-maker. The analyst's activities therefore involve both the qualitative and quantitative formulation and analysis of the problem. The interaction between the analyst and the decision-maker is an intrinsic feature of the decision-making process. The extent of this interaction generally depends on the decision-maker's level of knowledge, their willingness to participate in the process, the decision rules to be applied, and the nature of the problem.¹, as mentioned in the definition his main roles are :

- Defining the Decision Model: Design and structure the framework through which the decision problem can be analyzed.
- Conducting the Decision Process: Guide the analysis, organize data, and apply methodological tools to evaluate alternatives.
- Formulating the Problem: Translate the decision context into qualitative and quantitative terms suitable for systematic study.
- Analyzing Alternatives: Assess the potential outcomes, risks, and tradeoffs of different options.
- Presenting Results: Communicate findings, recommendations, and analyses to the decision-maker clearly and effectively.
- Facilitating Interaction: Collaborate with the decision-maker, adjusting the process according to their knowledge, involvement, and the problem's complexity.

4.3 The operational and technical staff of the system

The operational and technical staff are the people who carry out the decisions. They use their skills and knowledge to make sure actions are done correctly and the system works as planned. Such as Factory workers, IT technicians, engineers.

¹ Telc A, Duckstein L (1991), *Concepts on multi-criteria decision-making, presented at the international post graduate course, Wageningen, The Netherlands, P 19.*

4.4 The Actors Affected

People or groups who are influenced, positively or negatively, by the decisions made they could be Customers, employees, or even citizens.

5. The Difference Between the Decision-maker and the Analyst

When dealing with a system quantitatively, the decision-maker almost always relies on the support of an analyst. The reason is that the day to day responsibilities of the decision-maker such as overseeing operations, managing personnel, and maintaining communication with external partners rarely allow sufficient time or focus to develop the specialized mathematical and analytical frameworks required for constructing a decision model. The analyst, therefore, plays a crucial role in translating complex data and problem structures into a form that the decision-maker can use effectively. This collaboration ensures that decisions are based on thorough analysis while allowing the decision-maker to concentrate on strategic objectives and the overall management of the system. This Table demonstrates the difference between these two actors.

Table 03: Roles of the Decision-maker and Analyst

THE DECISION-MAKER	THE ANALYST
Decision: Final choice that commits resources and actions	Analysis: Detailed study of information to reveal patterns and options
Reality Deals with actual conditions, uncertainties, and real-world constraints	Model: Simplified representation of reality for testing scenarios
Responsibility Bears accountability for outcomes and risks	Aid, assistance: Provides support without owning the final call
Factors of influence Considers external and internal pressures shaping the choice	Functions, constraints: uses mathematical equations
Objectives Sets end goals aligned with organizational strategy	Evaluation criteria: Establishes measurable standards for option ranking

Source : Laurent F, Bougon (2005), *Pratiques de la décision*, 1er Ed, Ed Dunod, Paris, P 28.

6. Decision-making Approaches¹

Decision-making approaches are different ways to tackle choices in organizations. They split into systemic, analytical/prescriptive, and descriptive types, each suited to certain situations.

6.1 Systemic Approaches to Decision-making

Decision-making can be seen as a complex process of handling information step by step, which reflects how the whole organization works. In other words, a decision cannot be separated from the overall functioning of the organization. This view is known as systemic modeling.

In the systemic approach, each individual is considered to have mental structures that help them deal with complex decision situations. Therefore, systemic modeling aims to create methods that can describe and analyze these ways of thinking.

6.2 Analytical or Prescriptive Approaches

Analytical or prescriptive approaches, originally developed by economists, aim to provide mathematical tools that help decision-makers choose the best possible option in a given situation. These approaches are widely used in several fields, such as medicine (for selecting treatments or clinical interventions) and environmental sciences (for choosing sustainable development policies). They are also commonly applied in engineering and management to support decision-making.

These approaches rely on normative and prescriptive models that use various mathematical tools, such as linear and nonlinear programming, to guide the decision-maker toward an optimal choice. Decision-making is therefore viewed as a structured selection process that involves evaluating several alternatives, each defined by different parameters, and choosing the best solution based on specific performance criteria.

These methods are particularly effective when the assumptions of the models match real world situations. However, they have limitations when decision-making takes place in a constantly

¹ ABDELKADER Adla (2010), *thèse doctorale, Aide à la Facilitation pour une prise de Décision Collective : Proposition d'un Modèle et d'un Outil*, l'Université Toulouse III - Paul Sabatier, France, PP 9-11.

changing environment, or when human behavior introduces biases that differ from the assumptions of rationality used in the models.

6.3 Descriptive Approaches

Descriptive approaches in organizational modeling were developed to address situations where decision-making takes place in a changing environment, or where rational models of beliefs and preferences are strongly influenced by human behavior. These approaches originate from fields such as cognitive psychology and information theory, and aim to describe, analyze, and, when possible, make use of the decision-making processes of individuals.

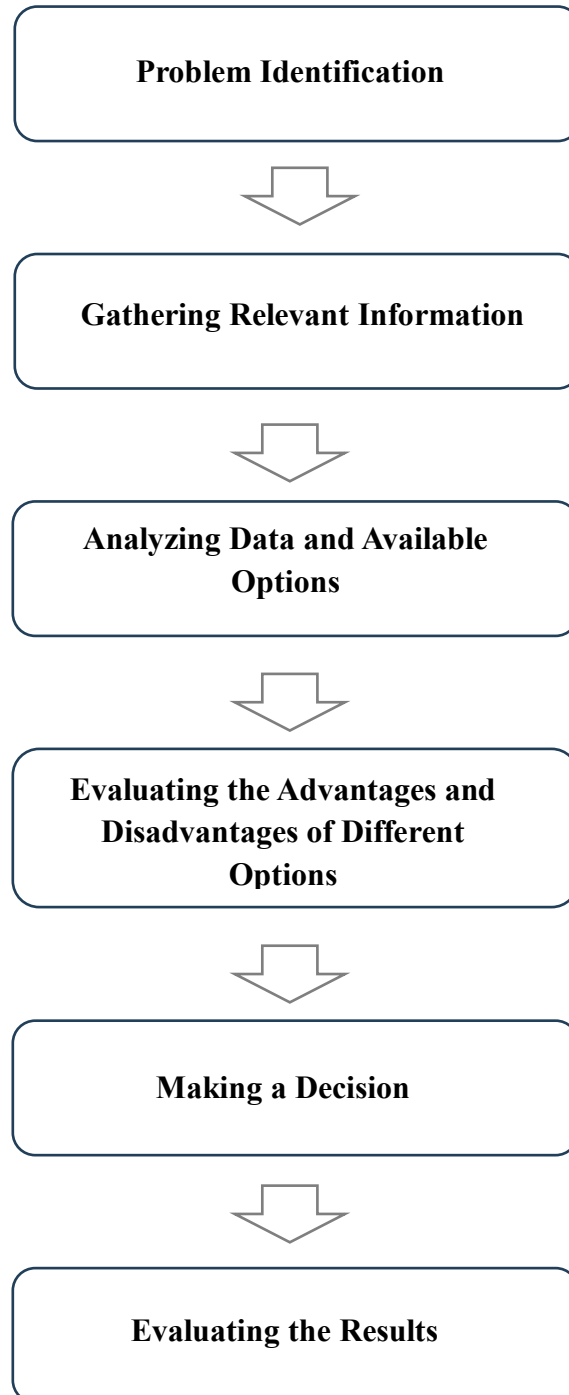
They are widely applied in areas such as social sciences, information sciences, and cognitive sciences.

7. Decision-making process

The decision-making process can be defined as the set of steps through which a decision-maker goes in order to make and implement a decision. These steps encompass various actions such as information gathering and consultation, while taking into account the organization's objectives as well as the constraints related to the decision-making situation. In essence, it's process can be viewed as a sequence of transformations aimed at converting inputs into outputs in the form of decisions.¹ Here are the general steps of the decision-making process :

¹ BERNARD Flora GENAIVRE Marion (2021), *La prise de décision. Un peu de philosophie pour les pros qui veulent décider autrement*, Dunod, P 134.

Figure 03: The Process of Decision-making



Source: Own elaboration

7.1 Problem Identification:

This step involves identifying the problem that needs to be solved and defining the objectives to be achieved. It is an important stage because a clear understanding of the problem helps in making better decisions.

There are two main types of problem identification. The first is proactive (or anticipatory) identification, where the problem is detected before it happens. This is done by monitoring the environment, analyzing trends, and using forecasts to prevent future issues.

The second type is reactive identification, where the problem is recognized after it has already occurred. In this case, the organization responds to a situation that has already affected its performance.

7.2 Gathering Relevant Information:

This step involves collecting all the necessary information to make an informed decision. First, it is important to define the objective of the decision and identify the most relevant sources of information.

The information should be collected in a systematic and organized way. Then, it must be analyzed carefully to evaluate its relevance and reliability. It is also important to consider different perspectives in order to have a complete understanding of the situation.

Finally, decision-makers should focus on the most important elements by prioritizing the information. Following a structured and organized process helps in making more effective and well informed decisions.

7.3 Analyzing Data and Available Options:

Once the necessary information has been gathered, the decision-maker examines it carefully. This involves looking at each available option.

7.4 Evaluating the Advantages and Disadvantages of Different Options:

Each option is then compared based on the criteria that matter most to the organization. The decision-maker looks at the potential benefits and risks of each one, as well as how it might affect the people involved, in order to identify the most suitable choice.

7.5 Making a Decision:

Making a decision is the final step in the informed decision-making process. It involves choosing the option that provides the best balance between advantages and disadvantages, based on relevant decision criteria, the values and principles of the organization or individual, and ethical and social considerations.

It is important to minimize risks as much as possible. After the decision is made, it should be monitored and reevaluated over time to ensure that it continues to meet the objectives of the organization or individual.

7.6 Evaluating the Results:

Evaluating the outcome is an important step in the informed decision-making process. It allows decision-makers to assess the results of the decision, gather feedback from stakeholders, and learn lessons for future decisions.

This evaluation should be considered from the beginning of the process to guide decisions toward the desired outcomes. It can help identify the successes and failures of the decision, the factors that contributed to these results, and opportunities for improvement in future decisions.

Finally, evaluating the outcome helps improve the overall process and increases the chances of success for future decisions.

Conclusion:

Decision-making represents a central activity within organizations, as it directly influences their performance and development. It is a structured process that involves identifying problems, analyzing alternatives, and selecting the most suitable solution. Given the diversity of decisions and their levels, it requires both accurate information and appropriate analytical tools. The interaction between decision-makers and analysts further strengthens the quality of decisions. Therefore, its process is essential for ensuring effective management and achieving organizational goals.

Section 3: Multi-Criteria Decision-making

1. Introduction

In an increasingly complex decision-making environment, organizations are faced with problems that require the consideration of multiple, often interdependent factors. Multi-criteria decision aid emerges within this context as a set of approaches and methods designed to address various classes of decision problems, while taking into account several criteria that are frequently conflicting and not directly comparable. This approach aims to model as accurately as possible the preferences and values of the decision-maker, in order to support consistent and well adapted decisions.

In this section, we will define the concept of decision aid and its main process. We will then present the famous methods of MCDA and compare between them.

2. History of the Multi-criteria Decision-making Approach¹

The history of multi-criteria decision-making dates back to the 18th century, when Marquis de Condorcet published his work on it by majority voting. Early developments in voting systems are also attributed to JeanCharles de Borda (1733–1799). However, earlier contributions include Ramon Llull, who introduced pairwise comparison, and Nicolaus Cusanus, who proposed weighting methods centuries before Borda. Additionally, a letter from Pliny the Younger (~AD 105) suggests early forms of approval voting. These foundational ideas show strong similarities with modern concepts such as utility theory and outranking methods.

In 1896, Vilfredo Pareto established a key foundation for analyzing decisions involving multiple criteria through the concept of efficiency. This was later extended by Tjalling Koopmans (1951), who introduced the notion of the efficient set. The development of utility theory by John von Neumann and Oskar Morgenstern (1944) further contributed to the methodological foundations of modern decision-making. A major shift occurred with Herbert Simon, who introduced the concept of bounded rationality, emphasizing that decision-makers seek satisfactory rather than optimal solutions.

¹ BELARIBI Fatima Zohra (2020), *Utilisation des méthodes d'aide multicritère à la décision dans la gestion des ressources en eau : Application de la méthode PROMETHEE à la sélection d'un procédé de dessalement de l'eau de mer*, Thèse de doctorat, Université Abou Bakr Belkaid, Tlemcen, PP 25-26

During the 1960s, multi-criteria analysis began to develop its own theoretical framework. Abraham Charnes and William Cooper (1961) proposed goal programming, while Peter Fishburn (1965) extended utility theory to multiple criteria. In Europe, Bernard Roy (1968) introduced outranking methods, marking the emergence of the European school of multi-criteria decision-making.

The field gained international recognition with the first conference in 1972 and the influential work of Ralph Keeney and Howard Raiffa (1976), which integrated uncertainty and multiple objectives into decision theory. From the 1980s onward, interactive computer based methods improved decision support, and the field expanded significantly with advances in information technology and artificial intelligence.

Multi-criteria approaches are broadly divided into two main schools: the European school, which focuses on providing decision support through outranking methods, and the American school, which emphasizes utility based models aimed at identifying an optimal solution based on axiomatic principles.

3. Definition of Multi-criteria Decision Aid

- Philippe Vincke defines it as “Multi-criteria decision aid aims, as its name suggests, to provide a decision-maker with tools that allow progress in solving a decision problem in which several, often conflicting, points of view must be taken into account.”¹

For a long time, decision-making tools assumed that one single objective was enough to guide a choice. This works well mathematically, but real life decisions are rarely that simple. Most situations involve several competing factors that a single criterion cannot capture. That is why multiple criteria approaches have emerged to better reflect how decisions are actually made in practice

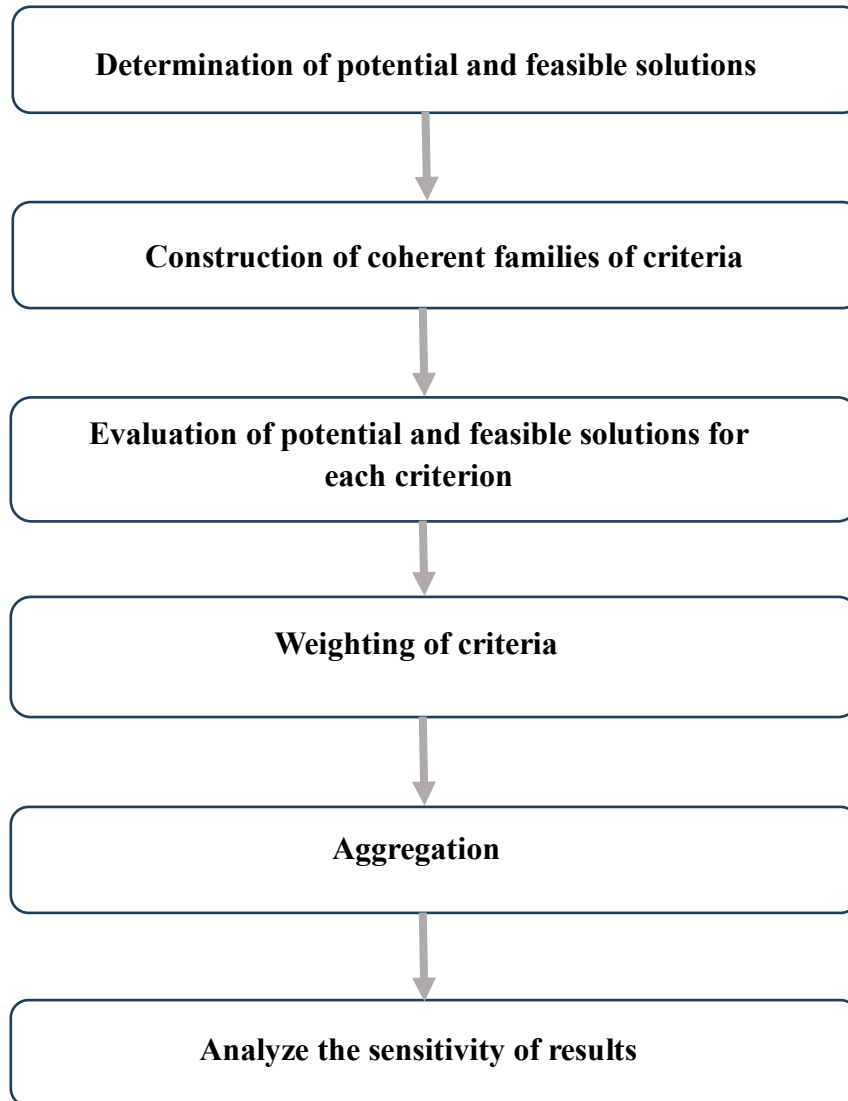
- According to Denis Bouyssou (1993), the commonly used argument that reality is inherently multidimensional and therefore requires the consideration of multiple perspectives through multi-criteria methods is not, by itself, sufficient to justify the adoption of a multi-criteria approach to decision aid. Relying solely on this argument would

¹ Philippe Vincke (1989), *L'aide multicritère à la décision*, 1er Ed, Ed de l'université de Bruxelles, Belgique, P 18.

reduce the monocriteria approach to a mere limiting or degenerate case of the multi-criteria framework.¹

4. The Process of Multi-criteria Decision Aid²

Figure 04: The Process of MCDA



Source: Own Elaboration

¹ Roy B, Bouyssou D (1993), *Aide multicritère à la décision : méthodes et cas*, Economica, Paris.

² BELARIBI Fatima Zohra (2020), *Op.Cit*, PP 27-29

1. Determination of Potential and Feasible Solutions

This step involves identifying all possible actions that could address the decision problem.

Feasibility is assessed to ensure that only realistic and implementable solutions are considered. It provides a foundation for systematic evaluation.

2. Construction of Coherent Families of Criteria

Criteria are grouped into coherent families to reflect different aspects of the decision objectives.

This organization ensures consistency and clarity in evaluating alternatives. It allows decision-makers to focus on relevant dimensions of performance.

3. Evaluation of Potential and Feasible Solutions for Each Criterion

Each alternative is assessed according to the defined criteria, using qualitative or quantitative measures. This step highlights how well each solution meets specific objectives. It forms the basis for comparison and prioritization.

4. Weighting of Criteria

Criteria are assigned weights to reflect their relative importance in the decision process. This ensures that critical factors have a stronger influence on the final evaluation. Weighting balances tradeoffs among competing objectives.

5. Aggregation

The evaluations and weights are combined to produce an overall score or ranking for each alternative.

6. Analyze the Sensitivity of Results

Sensitivity analysis examines how changes in weights or assumptions affect the outcome. This ensures the robustness and reliability of the chosen solution. It identifies which factors have the most influence on the final decision.

5. A comparison between Monocriteria and Multi-criteria

The existence of multi-criteria approaches is due to the imprecision of monocriteria methods and their incapability of capturing the complexity of real-world decision problems. Relying on a single criterion often leads to oversimplified conclusions. Therefore, multi-criteria analysis emerges as a

more suitable framework for handling such complexity. The main criticisms of the monocriteria approach to a decision problem are as follows:¹

- It does not take into account situations where two options cannot be compared, which is common in real life. For example, choosing between a phone with a good camera and another with a long battery life is unfair because each one is better in a different way, so you may not know which one to choose. Cause you are judging based on one criteria.
- It also ignores cases where indifference is not consistent.

On the other hand, the multi-criteria approach takes these factors into account, among others, to improve decision-making and the quality of conclusions. Bernard Roy describes the multi-criteria paradigm as « a new way of thinking to understand or act on a system » considering that :²

- Decisions involve several criteria at the same time
- These criteria can sometimes conflict with each other.
- Tradeoffs are needed to balance the criteria and find a solution that works reasonably well for all of them.

6. Classification of multi-criteria Methods

Multi-criteria decision-making methods can be organized into different categories based on how they process and compare criteria. This classification helps to better understand their underlying logic and the way they support it. (MCDM) methods are generally classified into three main categories:³

6.1 Methods based on Mult Attribute Utility Theory (Single Synthesis Criterion Approach):

These methods combine all criteria into one single function, which is then optimized to choose the best alternative. They focus on how to mathematically build and use this global function. Common methods include MAUT, SMART, UTA, TOPSIS, AHP, and Goal Programming.

¹ Alain Schärli (1985), *Décider sur plusieurs critères : Panorama de l'aide à la décision multicritère*, 1er Ed, Presse polytechniques romandes, Lausanne, P 38.

² Jérôme Costa, Negar Armaghan, Jean Renaud, Michel Martinez (2006), *Article: Connaissances industrielles et analyse multicritère*, France, P 134.

³ BELARIBI Fatima Zohra (2020), *Op.Cit.* PP 39-53

Although these methods are rigorous, they can be complex and may ignore some good solutions because they allow compensation between criteria. The famous methods are :

➤ SMART Method (Simple Multi-Attribute Rating Technique)

Edwards argued that modeling preferences can be complex, especially due to measurement errors. Therefore, he proposed simplifying the process by using a straightforward procedure to capture the decision-maker's subjective preferences. This led to the development of the SMART method. He showed that simple additive models can provide results nearly as accurate as more complex nonlinear models, while being much easier to use.

➤ MAVT Method (Multi-Attribute Value Theory)

This method is based on the idea that a decision-maker tries, often unconsciously, to maximize a function that combines all attributes. MAVT builds a separate value function for each attribute, where the best option gets a value of 1 and the worst gets 0. By asking the decision-maker questions, these partial value functions are defined and then combined into a global value function based on their preferences.

➤ MAUT Method (Multiple Attribute Utility Theory)

MAUT follows the same principle as MAVT, but it is used when the evaluation of alternatives is affected by uncertainty.

➤ Methode AHP (Analytic Hierarchy Process): (Saaty 1980)

AHP is designed to help decision-makers solve complex problems by structuring information in a hierarchical way. It is widely used in areas such as planning, resource allocation.

➤ Methode TOPSIS : Technique for order preference by similarity to ideal solution (Hwang et Yoon 1981)

TOPSIS is a multi-criteria decision-making method based on the idea that the best alternative should be the one closest to the ideal solution and farthest from the negative ideal solution. The

ideal solution represents the best performance on all criteria, while the negative ideal represents the worst performance.

➤ Methode UTA : Utility Theory Additive (JacquetLagrezze 1982)

We assume the decision-maker knows a subset of actions. The goal is to estimate an additive utility function that best fits their preferences. The decision-maker ranks the actions, identifies the criteria, and evaluates each action on these criteria. These inputs are used to build a utility function that approximates the real one, with a small estimation error.

➤ EVAMIX method : Evaluation of Mixed Criteria (VOOGD 1983)

EVAMIX is a multi-criteria method that handles both ordinal and cardinal evaluations. It compares actions by calculating two dominance indices: one for ordinal criteria and one for cardinal criteria. These indices are then normalized and combined into a single overall measure of dominance. Finally, a global score is computed for each action to rank them.

Table 04: Summary of Single Criterion Synthesis Methods

METHOD	Advantages	Inconvenient	REMARK
TOPSIS	Easy to apply	Depends on decision-maker's judgment	Cardinal nature
SMART	Easy to apply	Requires prior articulation of preferences	Cardinal scale / Additive form
MAVT	Partial value function (0–1) for each attribute	Construction of value functions is not always easy and can be difficult	Maximizes a value function / Additive form can be difficult
MAUT	Stochastic utility function approach	Checking mutual independence	Cardinal scale
UTA	Additive form like MAVT, but with decomposition of the total utility function	Requires cardinal data	Compensatory method
AHP	System thinking (problem simplification, hierarchy) and causal thinking (actors judgments)	Large number of pairwise comparisons, rank reversal, use of numerical scale with semantic judgments may introduce bias	Very popular

Source : Jeonghwa AN. (2011), Le choix d'un système de transport durable : analyse comparative des systèmes de transport guidé de surface, Thèse de doctorat de l'Université ParisEst, P 77

6.2 Outranking Methods (Outranking Synthesis Approach):

These methods compare alternatives to determine which one is preferred over another. They build an outranking relation based on the decision-maker's preferences, using thresholds such as indifference and preference. This relation is not always complete or perfectly consistent. These methods are practical and well adapted to real decision situations. The most known ones are ELECTRE and PROMETHEE. Unlike the traditional (utilitarian) model, these methods doesn't assume that a preference relation over decisions is total, transitive, or even preexisting. Multi-criteria decision aid is rather considered as a process of constructing a preference structure.

➤ The ELECTRE Methods :

These methods were developed by **Roy B. et al. (1971)**. They initiated a whole family of so called outranking methods based on pairwise comparisons of alternatives. These methods require relatively little information to be implemented; moreover, this information is easily accessible to the decision-maker, which allows them to produce solid results.

ELECTRE I is a method used to choose the best option.

- It keeps the good options (N)
- It removes the bad options (A/N) (those beaten by others)

It compares options using:

- Agreement (concordance)
- Disagreement (discordance)

At the end, it gives a small group of options that are hard to compare but may contain the best one.

ELECTRE II is used to rank all options from best to worst (with possible ties).

- It compares options using concordance (agreement) and discordance (disagreement)
- It uses two types of comparisons:

Strong outranking (more certain)

Weak outranking (less certain)

Unlike ELECTRE I, it does not choose one best option, but orders all options from best to worst.

ELECTRE III improves on ELECTRE II mainly by introducing a more flexible and realistic way of comparing alternatives. Instead of using only strong and weak outranking, it evaluates the **degree of credibility** of the outranking relation on a scale from 0 to 1, which allows for more nuanced judgments. It also incorporates **thresholds of indifference, preference, and veto**, making it possible to better handle uncertainty and reflect the decision-maker's preferences more accurately.

ELECTRE IS is an improved version of ELECTRE I. Its main improvement lies in its ability to handle both quantitative and qualitative criteria more effectively, making it more flexible and better suited for real world decision-making situations.

ELECTRE IV improves the previous methods by removing the need to give weights to criteria, which is often difficult and subjective. Instead, it uses simple thresholds to compare options.

ELECTRE TRI improves the previous ELECTRE methods by changing the way alternatives are evaluated. Instead of comparing options with each other, it assigns each option to a predefined category based on reference levels. This makes the method more stable and less sensitive to changes between alternatives.

Table 05: ELECTRE Procedures Comparison Table

	I	II	III	IS	IV	Tri
Possibility of considering indifference and/or preference threshold	No	No	Yes	Yes	Yes	Yes
Need to assign weights to criteria	Yes	Yes	Yes	Yes	No	Yes
Number and nature of outranking relations	1	2	1 fuzzy	1	5	1 fuzzy
Decision problem	Choice (P. α)	Ranking (P. γ)	Ranking (P. γ)	Choice (P. α)	Ranking (P. γ)	Sorting (P. β)
Final result	Kernel	Partial preorder	Partial preorder	Kernel with concordance indices and discordance levels	Partial preorder	Assignment to ordered categories

Source : BELARIBI Fatima Zohra (2020), *Op Cit*, P 52

➤ **The PROMETHEE Methods:**

represent an improvement over ELECTRE methods by providing a clearer and easier way to rank alternatives from best to worst. They use a system of preference functions that makes comparisons more understandable and less complex. This allows decision-makers to obtain results that are more transparent and easier to interpret.

6.3 Interactive Methods (Interactive Local Judgment Approach):

These methods involve the decision-maker throughout the process. They alternate between calculation steps and discussions to gradually refine preferences. They are often used in Mult objective optimization problems and are flexible for handling complex decisions.

Table 06: Summary of the Three Families of Multi-criteria Decision-Making Methods

	Synthesis Criterion	Outranking	Iterative Judgments
Size of action sets to compare	Small to very large	Small to moderate	Very large to ∞
Compensation between criteria	Total	Partial	
Preference modulation	Intercriteria parameters (weights) and intracriteria (thresholds)	Intercriteria parameters (weights) and intracriteria (thresholds)	
Consideration of uncertainty in criteria values	Possible	Yes	
Detection of conflicts (incomparability)	No	Yes	
Level of interaction with the decision-maker	Low	Medium	High
Complexity of calculations	Low	Medium to high	Often high
Process automation	Yes	Yes	Case by case

Source : THOREL Mathieu (2014), *Aide à la décision multicritère pour la prescription de scénarios d'amélioration énergétique via une approche globale*, Thèse de doctorat, Université de GRONBLE, France. P 90

Conclusion:

As a conclusion, multi-criteria decision-making provides an effective framework for addressing complex decision problems involving multiple criteria. Unlike traditional approaches, it allows decision-makers to consider both quantitative and qualitative aspects in a structured manner. Therefore, MCDM represents a valuable tool for improving the quality and consistency of decisions in organizations.

Chapter II : Practical Case

Introduction to the chapter

After elaborating and illustrating the theoretical framework in this chapter, we will apply the acquired theoretical knowledge to a practical case study of SARL Garden Clean, where the internship was conducted. We will first present the organization, then proceed to an application of the PROMETHEE Method.

Section 01: Presentation of SARL GARDEN CLEAN MESTAR & Cie

In this section, we will present the definition of the company, its origin, its organizational structure, and its purpose.

1.1 Definition of the Company

SARL GARDEN CLEAN MESTAR & Cie is a medium sized economic entity specialized in the production of detergents. It is an independent company based on personal partnership. The company was established in 2006 with a capital of 140,000,000 Algerian dinars. Its headquarters is located at Intersection 49–52, Depot Zone ELHADADA, 18000 Jijel.

Garden Clean MESTAR is well known for its innovation and its strong collaboration with clients, subcontractors, and suppliers.

1.2 Technical Data Sheet of SARL Garden Clean¹

- **Company name:** SARL GARDEN CLEAN MESTAR & Cie
- **Partners:** MESTAR Sofiane, MESTAR Tarik, MESTAR Abdelouahid, MESTAR Djalal
- **Managers:** MESTAR Sofiane and MESTAR Tarik
- **Activity:** Manufacturing of detergents, cleaning products, cosmetics, and personal hygiene products
- **Head office:** 49–52 Depot Zone ELHADADA, 18000 Jijel, Algeria
- **Year of establishment:** 2006
- **Share capital:** 140,000,000 DZD
- **Partner banks:** BDL Jijel / BADR Jijel / SGA Jijel / AGB Jijel / BNP Paribas (Jijel, Bejaia)
- **Phone / Fax:** 034.47.91.60 / 0561.88.48.63

¹ Internal document of Sarl Garden Clean Master & Cie.

- **Approval for acquisition of residual assets:** 07/07/2018
- **Operating license:** 13/12/2020
- **Certificate of conformity:** 08/12/2020

1.3 History and Development of SARL GARDEN CLEAN¹

- **2006:** SNC GARDEN CLEAN was established, specializing in detergent production (only bleach at the beginning).
- **2007:** Increase in production and introduction of two new products (Sani Bon, Black Grésil).
- **2008:** Company rehabilitation and upgrading of facilities with semiautomatic machines.
- **2009:** Expansion of production to include new products (around 10 items).
- **2011:** Opening of a new unit in the ELHADADA area (production expanded to 25 products).
- **2013:** Opening of a plastic production unit with 7 PET and PEHD bottle blowing machines.
- **2016:** Further modernization with the upgrade of many machines, making them fully automatic.

1.4 Company Values

The company is based on eight fundamental values shared by all its employees:

- Respect for diversity
- Pursuit of excellence
- Pioneering spirit
- Passion for design and creativity
- Solidarity and team spirit
- Commitment to a fragrance free and dye free environment

¹ *Internal document of Sarl Garden Clean Master & Cie.*

- Efforts to reduce environmental impact
- Use of responsible and safe ingredients

1.5 The Mission of SARL GARDEN CLEAN

SARL GARDEN CLEAN MESTAR aims to share its passion, culture, and expertise in high quality products by offering innovative, value creating solutions that are original, refined, and reflect technical excellence.

1.6 Objectives of the Company

The main objectives of SARL Garden Clean are:

- Expansion of its core activity in the production of cleaning products
- Installation of advanced equipment and production of insecticides (with different scents and formats)
- Production of various products such as surface cleaners, industrial disinfectants, rust removers, and air fresheners
- Production of silicone sealants for different uses
- Production of insulating materials and trading of metals in various forms and sizes
- Production of polyurethane foam in different variants (new white tubes of 200g and 250g)

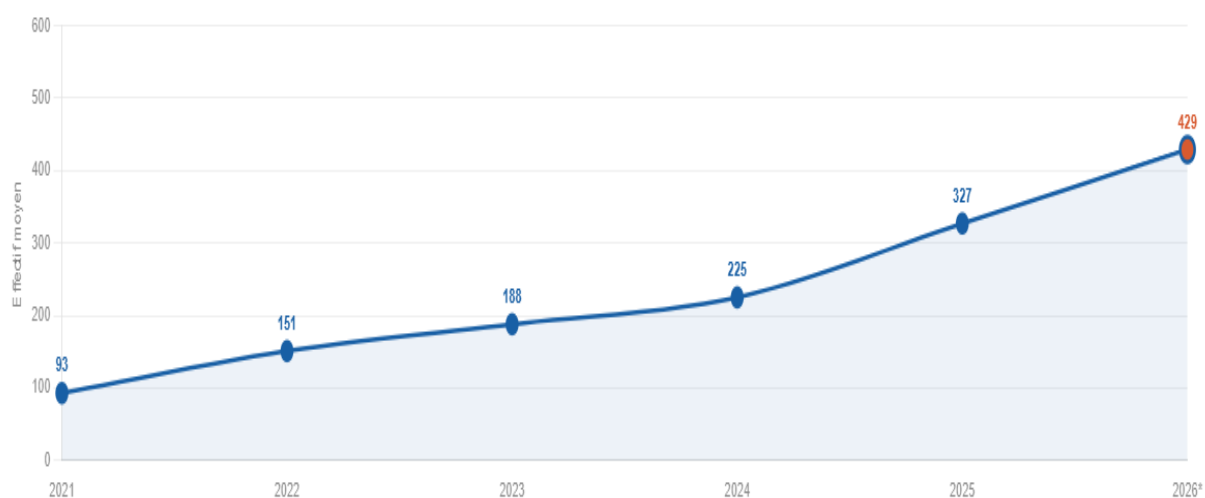
1.7 Company workforce:

Since its establishment, SARL Garden Clean has recorded a significant growth in its workforce, especially over the period 2021-2026.

Figure 05: Graphical Presentation of the Company's Workforce Evolution (2021-2026)

ÉVOLUTION DE L'EFFECTIF MOYEN PAR ANNÉE

Effectif moyen = (Effectif début + Effectif fin) ÷ 2



* 2026 partiel (jan.-mars).

Source: Internal document of SARL Garden Clean MESTAR & Cie.

1.8 Presentation of the Product Range

- **Detergent Range:**

Floor cleaner – Sani Sal

Laundry liquid – Hand soap

Dishwashing liquid – Drain cleaner

Degreaser – Nedhaf

- **Insecticide Range:**

Insecticide – Anticockroach

- **Air Freshener Range:**

Air freshener – Spray air freshener

1.9 Main Suppliers¹

SARL Garden Clean works with several suppliers around the world, including:

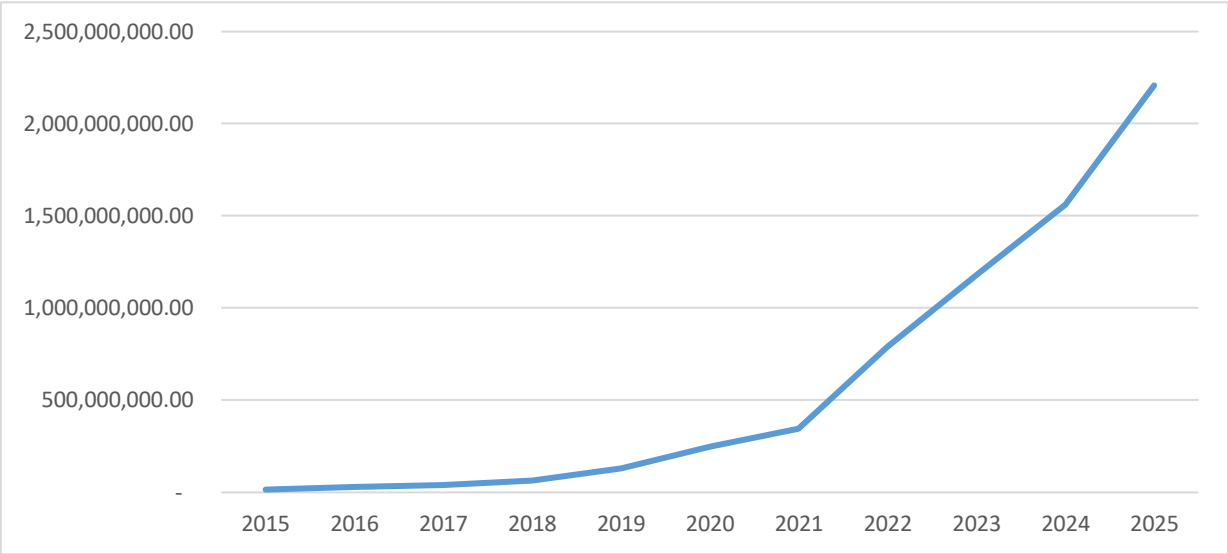
- **Givaudan (United Kingdom):** Supplies perfumes and fragrances
- **Gualapack (Italy):** Provides plastic packaging, sprayers, and caps
- **Transmare Chemie (Belgium):** Supplies chemicals and raw materials
- **General Emballage (Local company):** Provides cardboard packaging
- **Quimidrog (Spain):** Second supplier of chemicals and raw materials after Transmare Chemie
- **Sarten (Turkey):** Supplies aluminum packaging

1-10 Evolution of The Company's Revenue

Just as SARL Garden Clean has experienced steady growth in its workforce, the company has also recorded a continuous increase in its revenue since its establishment. The evolution of the company's revenue over the period 2015–2025 is presented below.

¹ Internal document of Sarl Garden Clean Master & Cie.

Figure 06: Evolution of the company’s revenue over the period 2015–2025

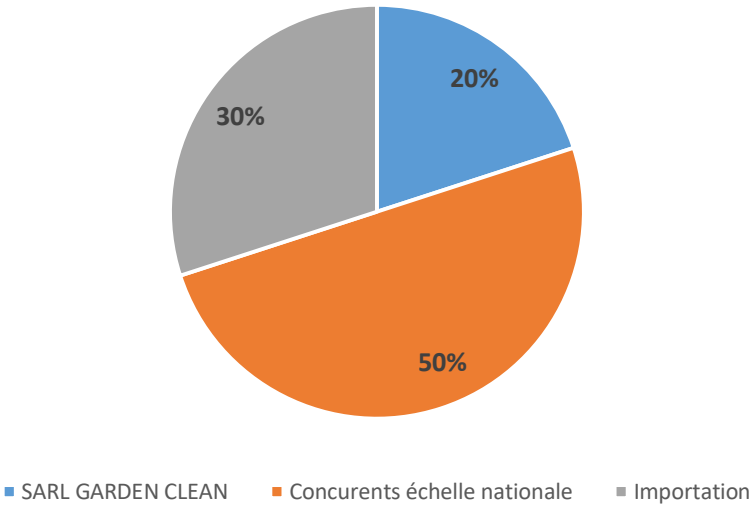


Source: Internal document of SARL Garden Clean MESTAR & Cie.

1.11 Market Share:

SARL Garden Clean’s market share has shown continuous growth following the introduction of new product lines such as detergents, air fresheners, and insecticides. The company’s market share for the year 2025 is presented below.

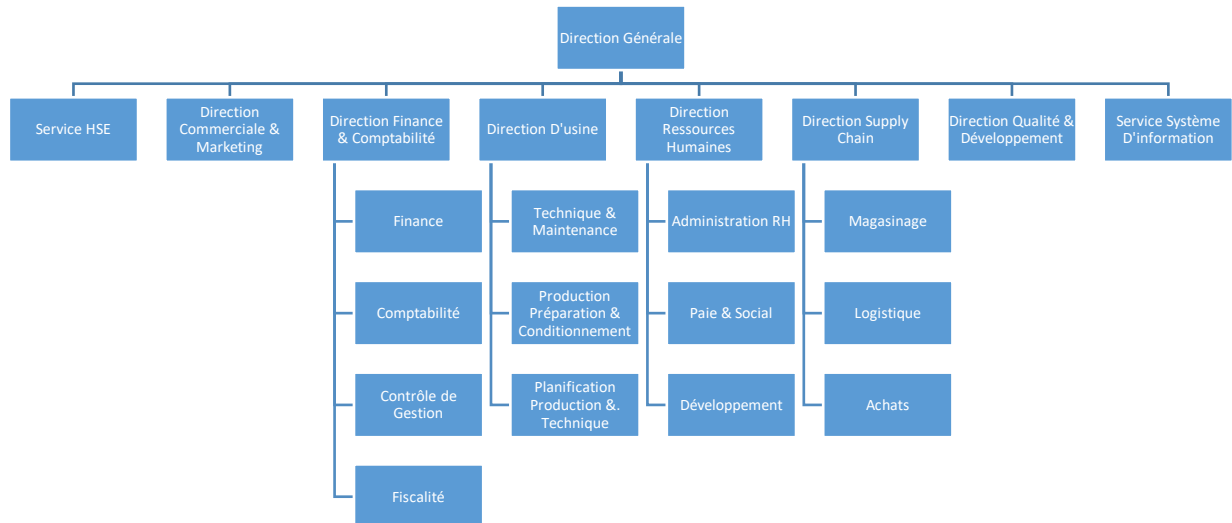
Figure 07: Graphical Representation of the Company’s Market Share in 2025



Source: Internal document of SARL Garden Clean MESTAR & Cie.

1.12 Presentation of SARL Garden Clean's Organizational Structure

The organizational structure of SARL Garden Clean is illustrated as follows:



Source: Internal document of SARL Garden Clean MESTAR & Cie.

Human Resources Department:

This department ensures the effective management of human resources, including systems and procedures, and provides staff training to meet the company's needs.

Procurement and Supply Department:

The procurement and supply managers are responsible for all purchasing operations related to raw materials and their supply. They are also involved in implementing an effective purchasing policy.

Finance and Accounting Department:

The finance department is essential to the organization. It is responsible for maintaining the company's financial health by ensuring sound investment decisions and preventing potential risks of loss. A weak financial department could lead to financial failure. It ensures the financial balance of SARL Garden Clean and prepares the company's cash flow plans.

National Sales Department:

This department monitors sales operations and proposes adjustments to optimize revenue. It is also responsible for recruiting and training its staff. The sales director negotiates and maintains close relationships with clients.

Production and Maintenance Department:

The production and maintenance manager is responsible for maintaining equipment. Their role includes ensuring the upkeep, repair, and improvement of production equipment to guarantee that production objectives set by management are achieved.

Section 02: Application of the PROMETHEE Method to the Budgetary Decision Problem at SARL GARDEN CLEAN

This section constitutes the core empirical contribution of the present work. Following the identification and presentation of the decision context, this section proceeds with a structured and comprehensive application of the PROMETHEE I and PROMETHEE II methods. The analysis is organized into sequential steps, from the formulation of the decision problem through the interpretation of final rankings and sensitivity analysis.

1.The PROMETHEE METHOD¹

1.1. Definition And Versions of The Method

PROMETHEE (Preference Ranking Organization Methods for Enrichment Evaluation) is a family of multi-criteria decision-making methods based on outranking theory, developed by Brans and Vincke in the mid1980s.

Designed as a simpler, more intuitive alternative to ELECTRE, PROMETHEE introduces a preference function for each criterion that captures how strongly a decision-maker prefers one alternative over another. It builds valued outranking relations but, unlike ELECTRE, drops the concept of discordance. The family comprises several variants, each designed to address a specific type of decision context ranging from partial and complete rankings to interval based comparisons, flexible weight assignment, and constrained optimization In what follows, five of the most commonly referenced versions of the PROMETHEE family are briefly presented, before focusing on the two variants retained for the purposes of this study PROMETHEE I and PROMETHEE II:²

PROMETHEE I (Partial Ranking)

PROMETHEE I produce a partial ranking of the alternatives. It is based on two flows: the positive flow $\Phi^+(a)$, which measures how much an alternative outperforms all others, and the negative flow $\Phi^-(a)$, which measures how much it is outperformed. An alternative A outranks alternative B when it has both a higher positive flow and a lower negative flow. The key advantage of PROMETHEE

¹ BELARIBI Fatima Zohra (2020), *Op-cit*, P 60

² *Ibid*, PP 66-69

It is that it preserves incomparability meaning that when two alternatives perform well on different criteria, the method honestly acknowledges that no clear preference can be established between them, rather than forcing an artificial ranking.

PROMETHEE II (Complete Ranking)

PROMETHEE II extends PROMETHEE I by producing a **complete ranking** of all alternatives, leaving no incomparability. This is achieved through the **net flow** $\Phi(a)$, calculated as the difference between the positive and negative flows:

$$\Phi(a) = \Phi^+(a) - \Phi^-(a)$$

The alternative with the highest net flow is considered the best overall. While PROMETHEE II is more decisive and easier to interpret, it is considered slightly less realistic than PROMETHEE I, since it eliminates incomparabilities that may genuinely exist in the data. Nevertheless, it remains the most widely used variant in practice due to its clarity and simplicity.

PROMETHEE III (Interval Ranking)

PROMETHEE III is an extension of PROMETHEE II that addresses a practical limitation: in PROMETHEE II, two alternatives with very close net flows are still ranked one above the other, even when the difference is negligible. PROMETHEE III solves this by replacing the single net flow value with an interval, allowing alternatives with similar flows to be declared indifferent rather than strictly ranked. This makes the method more nuanced and better suited to situations where small differences between alternatives should not be overinterpreted.

PROMETHEE IV (Weight Intervals)

In standard PROMETHEE, criteria weights must be fixed as precise values, which can be difficult and uncomfortable for decision-makers who are uncertain about the exact importance of each criterion. PROMETHEE IV addresses this by allowing the decision-maker to specify intervals for the weights rather than exact values. This gives more flexibility and better reflects the reality that weight assignment is rarely a perfectly precise exercise. The method then explores how the ranking changes across the range of possible weight combinations.

PROMETHEE V (Optimization Under Constraints)

PROMETHEE V combines the PROMETHEE ranking with additional constraints defined by the decision-maker. For example, a maximum budget may limit which alternatives can be selected simultaneously, or certain alternatives may be mutually exclusive. This variant is particularly useful in portfolio selection problems, where the goal is not simply to rank alternatives but to select the best combination of options that satisfies a set of practical constraints.

1.2. Steps of The Application of The PROMETHEE Method¹

Selection of Generalized Criteria

For each criterion $C_1, C_2 \dots C_n$, a generalized criterion is defined based on an appropriate preference function. This step also allows the elimination of scale effects between different criteria.

Establishment of an Outranking Relationship

In the second step, an outranking relationship between alternatives is determined using a preference index. This index measures the degree to which one alternative is preferred over another by quantifying the differences between them.

Evaluation of Preferences

Finally, the decision-maker's preferences are evaluated by calculating the positive and negative preference flows, which reflect the overall strength and weakness of each alternative.

1.3 Criteria and Weights

A criterion is a factor used to compare different alternatives. In the PROMETHEE method, each criterion is given a weight to show its importance. A preference function is then used to measure how much one alternative is better than another. These results are combined to create a relation that allows ranking the alternatives.

1.4 PREFERENCE FUNCTION TYPES²

Type I Usual Used when data is discrete or ranked you either prefer one option or you don't, no in between.

¹ Jean Marc Harventg (2005), Article: "Les méthodes de surclassement", L'université libre de Bruxelles, Belgique, P10

²BOUKHARI Sofiane (2017), La gestion durable des services d'eau potable et d'assainissement en Algérie, Thèse de Doctorat en sciences, Option Hydraulique. Université d'Annaba. P 48

Type II U-shape Used when there's a clear indifference zone. Small differences between alternatives are ignored; only beyond a certain threshold does preference kick in.

Type III V-Shape Used when differences are continuous and gradual. The bigger the gap between two alternatives, the stronger the preference no sudden jumps.

Type IV Level Used in special cases where an alternative is neither preferred nor equal to another. It gets a score of 0.5 sitting right in the middle.

Type V Linear Used when you have both an indifference threshold and a strict preference threshold. Between the two, preference increases steadily in a straight line.

Type VI Gaussian The most popular in real applications. Preference follows a smooth curve (bellshaped). Best when you have a large number of alternatives (30+) and requires calculating the standard deviation of your data.

Note: In this study, the V-shape preference function was adopted for all criteria: risk, profit, cost, and time. This choice is justified by the fact that the decision-maker's preference increases progressively with the difference between alternatives. Therefore, the larger the difference between two alternatives, the stronger the preference. This function is suitable because all selected criteria can be evaluated numerically and compared according to their intensity.

2. Problem Formulation and Definition of the Decision Context

The decision problem at SARL GARDEN CLEAN can be defined as follows: given three investment alternatives and four evaluation criteria, the company wants to know which option is the best.

2.1 Data Collection Methodology

The data required for the construction of the evaluation matrix, the assignment of criteria weights, and the selection of preference functions were collected through a semi-structured interview conducted with the management controller of SARL GARDEN CLEAN.

Interview Guide

General Information

- Position: DFC
- Company: SARL GARDEN CLEAN

Interview Questions

1. During the internship, we discussed several investment alternatives within the company. What if these alternatives were evaluated using decision-support software in order to determine which one would represent the best decision?
2. Which criteria do you consider the most suitable for evaluating these alternatives?
3. What level of importance does the company assign to each criterion?

2.2 The Three Alternatives

Following consultations with the management controller, three strategic alternatives were identified and retained for evaluation:

Alternative 1 New Trucks (A1)

This alternative involves the acquisition of a fleet of new delivery trucks to replace the current reliance on rented vehicles. The objective is to reduce recurring rental costs and improve availability.

Alternative 2 Marketing Panels (A2)

This alternative consists of investing in TV marketing panels in order to increase sales.

Alternative 3 New Product Launch (A3)

This alternative focuses on the development and launch of a new product, namely a rim block. The evaluation of this option is based on the investment required for acquiring the necessary production machinery.

2.3 Evaluation Criteria

In order to compare between these alternatives, four evaluation criteria were selected in collaboration with the management controller. These criteria are:

C1 Profit (Margin, Scale 1–10)

This criterion reflects the expected financial return generated by each alternative. It is a maximization criterion. In order to ensure consistency and fluidity across all evaluation criteria, the profit margin values originally expressed as percentages have been converted to a scale of 1 to 10. This transformation follows a simple proportional conversion, whereby each percentage value is divided by 10. Accordingly, a profit margin of 50% becomes 5. This rescaling allows all four criteria to be expressed on a comparable numerical scale, facilitating a more coherent and balanced application of the PROMETHEE method.

C2 Estimated ROI Time

This criterion measures the estimated time required for each alternative to recover its initial investment. It is a minimization criterion, as a shorter payback period is preferable. The original values, expressed in months, are as follows: 1 month for New Trucks (A1), 24 months for New Product Launch (A3), and 6 months for Marketing Panels (A2).

In order to maintain consistency with the uniform scale adopted for all criteria, these values have been converted to a scale of 1 to 10 using the following proportional transformation: each value is divided by the maximum observed value (24 months) and multiplied by 10. Accordingly, 24 months becomes 10, 6 months becomes 2.5, and 1 month becomes approximately 0.5. This rescaling preserves the relative differences between alternatives while ensuring comparability across all criteria.

C3 Cost (Billion DZD)

This criterion represents the total investment cost associated with each alternative, expressed in billions of Algerian Dinars (DZD). Unlike the Profit and Time criteria, the Cost values are used directly in their original unit without any rescaling.

C4 Risk (Scale 1 to 10)

This criterion evaluates the level of uncertainty and potential negative outcomes associated with each alternative. It reflects the degree to which an investment may fail to deliver its expected results due to internal or external factors, such as market volatility, operational complexity, supply chain disruptions, or demand unpredictability. Lower risk is preferred, making it a minimization criterion. The risk levels were assessed on a scale of 1 to 10 through direct consultation with the management controller of SARL GARDEN CLEAN.

2.4 Criteria Weights

The assignment of weights to criteria reflects the relative importance attributed by SARL GARDEN CLEAN management to each criterion. Weights were determined through a discussion with the management controller, following the principle of direct weighting used in the PROMETHEE framework. The weights are normalized so that their sum equals 1.

Table 07: Summary of Criteria, Units, Optimization Directions, Weights, and Preference Functions

Criterion	Unit	Min/Max	Weight	Preference Functions	Type
Profit	Margin	Max	0.40	V-shape	Quantitative
Time	Scale 110	Min	0.15	V-shape	Quantitative
Cost	Billion DZD	Min	0.15	V-shape	Quantitative
Risk	Scale 110	Min	0.30	V-shape	Quantitative

Source: Authors' elaboration

2.5 Preference Functions and Thresholds

A **V-shape** preference function is applied to all criteria.

Profit ($P = 1$)

A lower threshold is adopted to allow a finer distinction, as differences between alternatives are relatively smaller.

Cost (P = 2)

A higher threshold is selected since the deviations are more pronounced, making the model less sensitive to minor variations.

Time (P = 2)

The observed differences justify the use of a larger threshold without affecting the overall ranking.

Risk (P = 2)

Similar to cost and time, the variations are sufficiently large, so a higher threshold remains appropriate.

2.6 Construction of the Evaluation Matrix

The evaluation matrix constitutes the foundational dataset for the PROMETHEE analysis. It summarizes the performance of each alternative across all four criteria, as obtained from SARL GARDEN CLEAN's. The data presented below was given by the management controller during our interview.

Table 08: Multi-criteria Evaluation Matrix for the Budgetary Alternatives

Alternative / Decision	Profit (Margin)	Time (Scale 110)	Cost (Billion DZD)	Risk (Scale 110)
New Trucks (A1)	5 (50%)	0.5	5.28	4.00
Marketing Panels (A2)	2 (20%)	2.5	7.8	6.00
New Product Launch (A3)	3 (30%)	10	1.716	8.00

Source: Internal data provided by SARL GARDEN CLEAN

A1 (New Trucks) emerges as the strongest overall alternative, combining the highest profit margin (50%), the shortest ROI time (0.5 on the scale), and the lowest risk level (4/10). Its only relative weakness is its investment cost (5.28 billion DZD), which is moderate compared to the other options.

A2 (Marketing Panels) is the weakest alternative across most dimensions it records the lowest profit margin (20%), the highest total cost (7.8 billion DZD), and a moderate risk level (6/10). Only its ROI time (2.5) is average, offering no decisive competitive advantage over the other options.

A3 (New Product Launch) presents a mixed profile: it benefits from the lowest investment cost (1.716 billion DZD) and a moderate profit margin (30%), which may seem appealing at first glance. However, it is penalized by the longest ROI time (10) and the highest risk level (8/10), reflecting the inherent uncertainty associated with introducing a new product onto the market.

Table 09: Statistics of the criteria

Statistic	Profit (Margin)	Time (Scale 1–10)	Cost (Billion DZD)	Risk (Scale 1–10)
Minimum	2.00	0.50	1.716	4.00
Maximum	5.00	10.00	7.800	8.00
Average	3.33	4.33	4.932	6.00
Standard Deviation	1.25	4.09	2.496	1.63

Source: Visual PROMETHEE Software

On average, the projects yield a profit margin of 3.33 (33.33%), a moderate time commitment of 4.33/10, a cost of 4.932 billion DZD, and a risk level of 6/10 suggesting a profile that leans toward moderate to high risk with reasonable returns.

The standard deviations reveal notable variability across metrics. Time shows the widest dispersion (4.09), indicating highly inconsistent project durations, while cost (2.496) also varies considerably. Profit is the most stable metric (1.25), suggesting returns are relatively predictable across projects, followed closely by risk (1.63).

2.7 The Use of The Visual PROMETHEE Software

Over the years, several software tools have been created to help apply the PROMETHEE methods, Such as Decision lab and D-sight. Most of them either have been discontinued like decision lab or only offer a limited free trial with restrictions on the number of alternatives and criteria you can work with, which makes them less practical for academic research. Visual PROMETHEE, and it offers a full academic version completely free of charge with no such limitations. This, combined with the fact that it includes all the visual tools we use in our analysis, made it the choice for our practical case.

2.8 Application of PROMETHEE

Here is the table of the data in the PROMETHEE Software:

Figure 08: PROMETHEE Model and Evaluation Matrix

		☒	☒	☒	☒
☒	Scenario1	Profit	Cost	Time	Risk
	Unit	Marge	Unit	Scale	Scale
	Cluster/Group	◆	◆	◆	◆
	Preferences				
	Min/Max	max	min	min	min
	Weight	0,40	0,15	0,15	0,30
	Preference Fn.	V-shape	V-shape	V-shape	V-shape
	Thresholds	absolute	absolute	absolute	absolute
	- Q: Indifference	n/a	n/a	n/a	n/a
	- P: Preference	1,00	2,000	2,00	2,00
	- S: Gaussian	n/a	n/a	n/a	n/a
	Statistics				
	Minimum	2,00	1,716	0,50	4,00
	Maximum	5,00	7,800	10,00	8,00
	Average	3,33	4,932	4,33	6,00
	Standard Dev.	1,25	2,496	4,09	1,63
	Evaluations				
☒	New Product	3,00	1,716	10,00	8,00
☒	Marketing	2,00	7,800	2,50	6,00
☒	Trucks Fleet	5,00	5,280	0,50	4,00

Source: Visual PROMETHEE Software

The table clearly show that the Trucks Fleet alternative dominates the others in most criteria, making it the strongest option. However, there is some uncertainty when comparing the New Product and Marketing alternatives, as their performances are quite close.

2.9 Presentation and Interpretation of Visual PROMETHEE Outputs

To make sense of the results beyond just numbers, we relied on five visual tools offered by the Visual PROMETHEE software. the PROMETHEE Table presents all flow values in a structured format, the PROMETHEE Network illustrates how alternatives relate to and outrank one another, and the PROMETHEE Ranking lines up all alternatives from best to worst in a single clear order. The GAIA Plane then offers a visual map of how the criteria interact and where the alternatives stand in relation to each other. Finally, the Walking Weights tool allowed us to check whether our results would hold up if the importance given to each criterion were to change. Used together, these five outputs gave us a complete picture of the decision.

1. PROMETHEE Flow Table

1.1 What It Is

The PROMETHEE Table is the most basic and important output of the entire analysis it is the first thing you look at. It presents the results in a structured format showing three values for each alternative: the positive flow Φ^+ , which tells you how much an alternative outperforms the others; the negative flow Φ^- , which tells you how much it gets outperformed; and the net flow Φ , which is simply the difference between the two and gives the final ranking.

In PROMETHEE I, an alternative A is considered better than B only if it has both a higher positive flow and a lower negative flow at the same time. If that double condition is not met, the two alternatives are declared incomparable. PROMETHEE II solves this by using the net flow alone to produce a complete ranking with no ties and no incomparability.

Table 10: PROMETHEE Flow Table

Alternative	Φ^+ (Positive Flow)	Φ^- (Negative Flow)	Φ (Net Flow)	PROMETHEE II Rank
A1 New Trucks	0.925	0.075	+0.850	1st
A3 New Product Launch	0.350	0.650	-0.300	2nd
A2 Marketing Panels	0.225	0.775	-0.550	3rd

Source: Visual PROMETHEE Software

1.2 Results Obtained

The table shows that Alternative A1 (New Trucks) is exceptionally dominant: its positive flow of 0.925 means it outperforms the other alternatives on nearly every pairwise comparison, while its negative flow of just 0.075 means it is barely outperformed by anyone. The resulting net flow of +0.850 clearly indicates that this alternative performs better overall than the other alternatives.

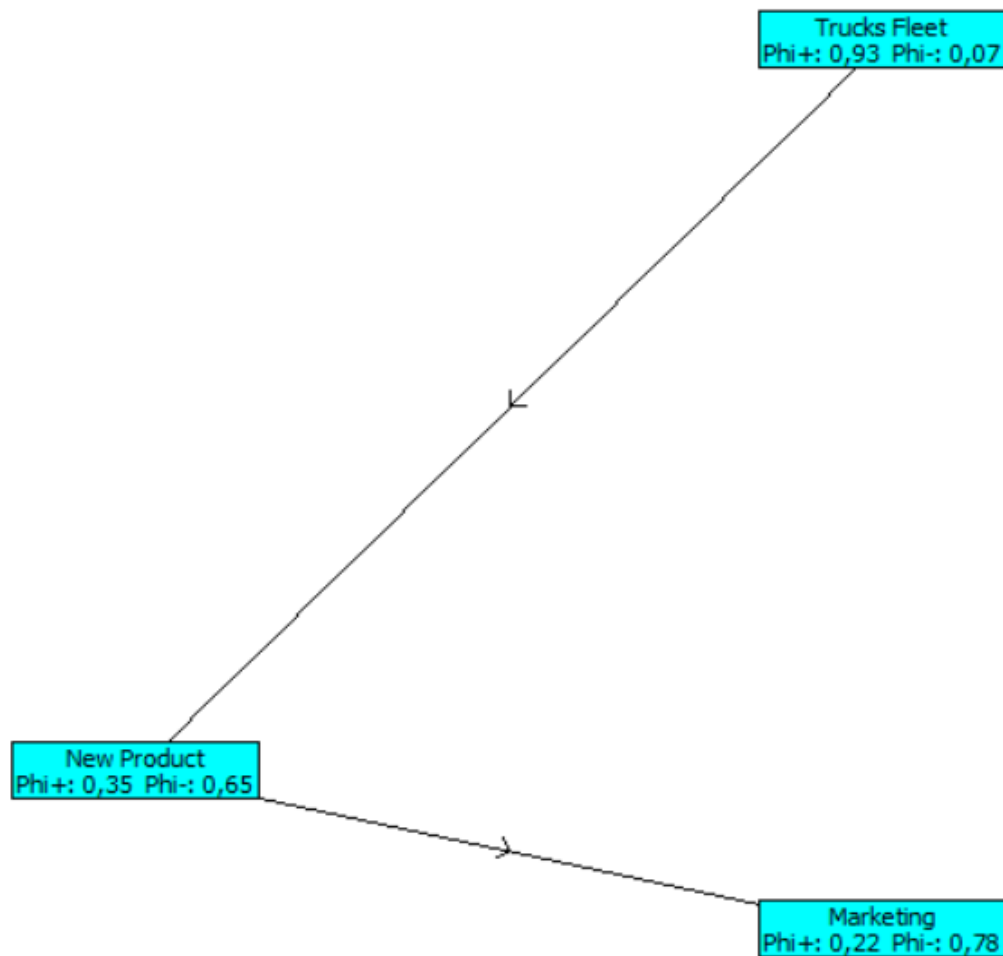
The gap between A3 (-0.300) and A2 (-0.550) confirms that the New Product Launch, despite its highest investment risk and longest payback time, is still preferable to the Marketing Panels primarily because its cost is the lowest by far of all three alternatives. Marketing Panels combine the highest cost, the lowest profit margin, and a mediocre risk profile.

2. PROMETHEE Network

2.1 What It Is

The PROMETHEE Network is a visual map that illustrates the dominance relationships among the alternatives. Each alternative is shown as a node, and arrows between nodes show outranking relationships. An arrow from A to B simply means A is preferred over B. The direction and strength of the arrows give you a quick and intuitive picture of the dominance structure in the decision problem. Importantly, the Network also allows you to immediately spot any incomparabilities between alternatives if two alternatives cannot be connected by an arrow in either direction, it means neither outranks the other under PROMETHEE I, and they are considered incomparable. In our case, no such situation exists, as every alternative is connected by a clear directional arrow, confirming that the ranking is complete and unambiguous.

Figure 09: PROMETHEE Network



Source: Visual PROMETHEE Software

2.2 Results Obtained

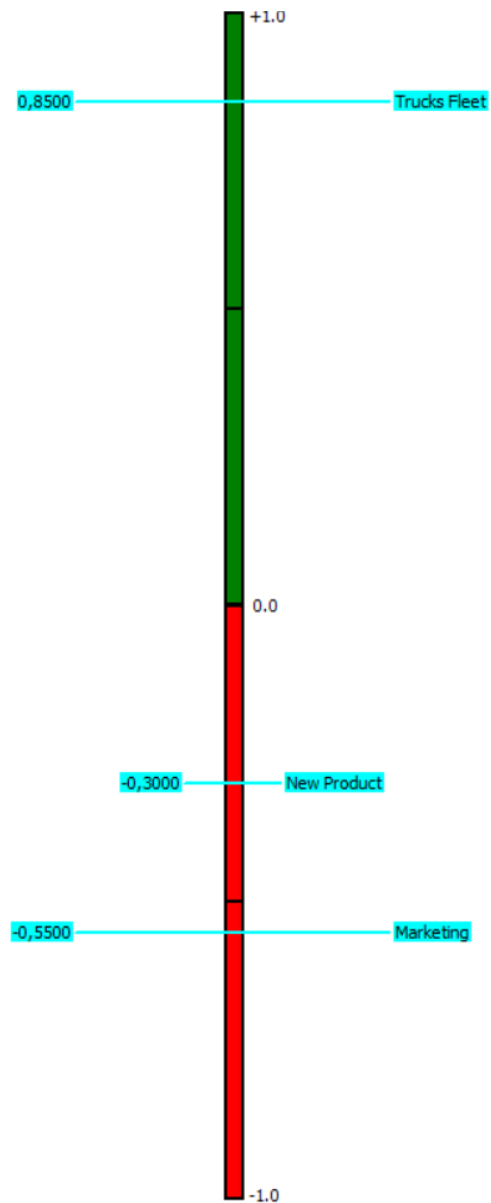
The network displays three nodes Trucks Fleet, New Product, and Marketing connected by arrows. Trucks Fleet sits at the top, with arrows pointing from it toward both New Product and Marketing, meaning it outranks both of them. New Product in turn has an arrow pointing toward Marketing, meaning it outranks it as well. The result is a clean, top to bottom hierarchy: Trucks Fleet $\succ$ New Product $\succ$ Marketing.

3. PROMETHEE Ranking

3.1 What It Is

The PROMETHEE Ranking is the most straightforward output of the analysis it simply lines up all alternatives from best to worst based on their net flow values.

Figure 10: PROMETHEE Rankings



Source: Visual PROMETHEE Software

3.2 Results Obtained

The ranking visual confirms a clear and unambiguous ordering of the three alternatives along a vertical axis that runs from +1.0 at the top to 1.0 at the bottom. Trucks Fleet sits at the top with a net flow of +0.85, firmly in the positive (green) zone, meaning it outperforms the other alternatives overall by a significant margin. New Product lands at 0.30, just below the zero line, and Marketing sits at the bottom at 0.55, both in the negative (red) zone.

The distance between Trucks Fleet and the other two alternatives is obvious. While New Product and Marketing are separated by only 0.25 points.

4. GAIA Plan

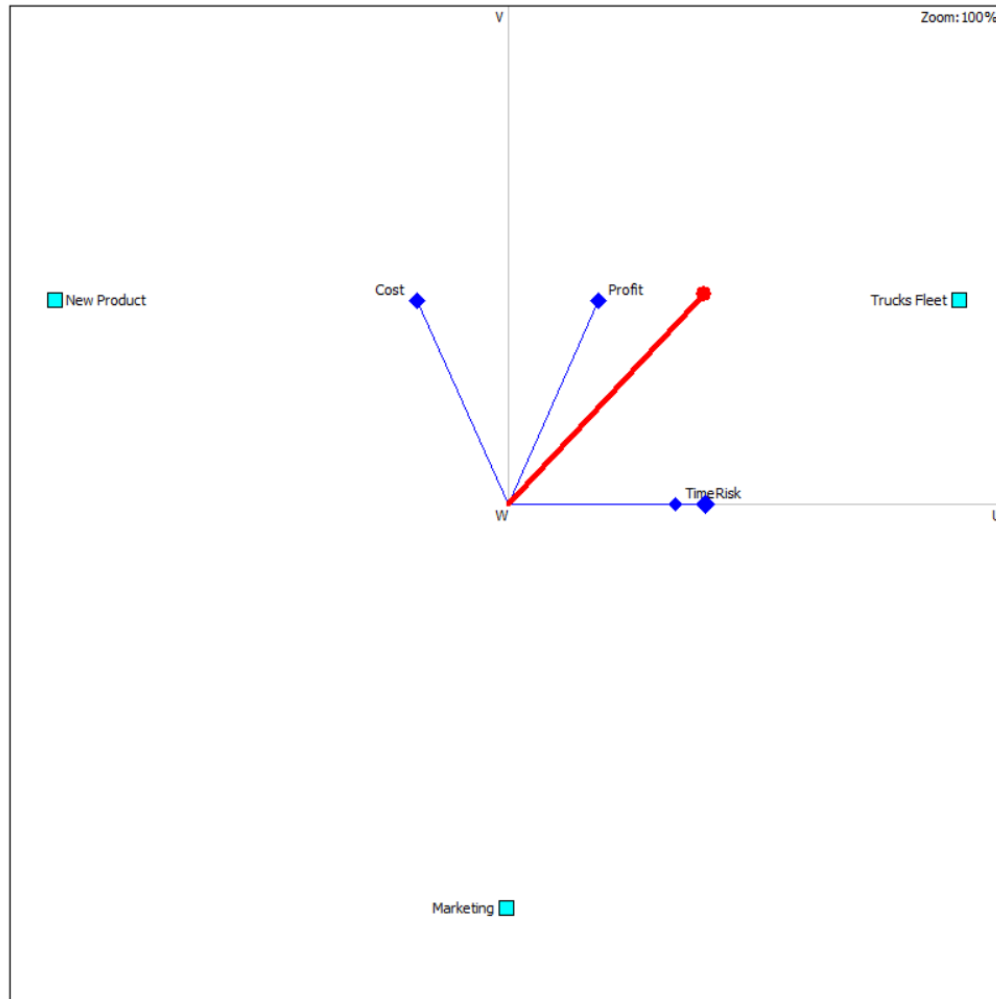
4.1 What It Is

GAIA (Geometrical Analysis for Interactive Aid), While the flow tables and rankings tell you who wins, they do not show you why, or what tensions exist between the criteria. That is exactly what the GAIA plan is designed to do.

It works by placing both the alternatives and the criteria on a map. Each criterion appears as an arrow pointing in the direction that favors the alternatives performing best on it. Each alternative appears as a point on the same map. By simply looking at where things are positioned, you can see which alternatives are supported by which criteria.

The map also includes a special element called the piaxis, which is essentially a pointer showing the best overall choice given the current weights. The closer an alternative is to that pointer, the better it performs under the current weighting given to the criteria.

Figure 11: GAIA PLAN



Source: Visual PROMETHEE Software

4.2 Results Obtained

The Profit vector points toward the upper-right region, in the direction of Trucks Fleet, confirming that this alternative performs best on the most heavily weighted criterion. The Time and Risk vectors both point toward the right along the horizontal axis, also aligned with the Trucks Fleet region, reinforcing its advantage on these criteria. The Cost vector, however, points in the direction of the New Product which is consistent with A3 having the lowest investment cost by a significant margin. The angle between the Cost vector and the Profit/Risk/Time vectors is greater than 90° , confirming that the lowest cost alternative is neither the most profitable nor the least risky one.

The pi-axis, shown in red, points clearly toward the Trucks Fleet region, confirming that under the current weight configuration, A1 is the recommended choice.

5. Walking Weights

5.1 What It Is

The Walking Weights tool is the last step of the analysis, and its purpose is simple: it tests whether the ranking we obtained is solid or fragile. Up until this point, we assigned fixed weights to each criterion based on what the management controller told us. But what if those weights were slightly different? Would the ranking change? That is exactly what Walking Weights answers.

The tool works by letting you slide the weight of one criterion up or down while automatically adjusting the others, and then showing you in real time how the ranking reacts. If the ranking stays the same across a wide range of weight variations, the recommendation is strong. If it changes with even a small adjustment, it means the result is sensitive and should be interpreted with more caution.

The three scenarios we tested:

Table 11: Sensitivity Analysis, Ranking Robustness Under Weight Variations

Scenario	Weight Configuration	Resulting Rank	Interpretation
Scenario A (Base)	Profit 0.40, Risk 0.30, Time 0.15, Cost 0.15	A1 > A3 > A2	Current priorities favor operational reliability and financial return
Scenario B (Equal Weights)	All criteria 0.25	A1 > A3 > A2	Even without prioritization, A1 remains first its dominance is not weight dependent
Scenario C (Cost Focus)	Cost 0.65, Risk 0.15, Profit 0.10, Time 0.10	A3 > A1 > A2	the ranking A1 > A3 > A2 is robust against any weight configuration except those that place Cost as the primary criterion (Above 0.6), which is more than 60% of the global weight

Source: Visual PROMETHEE Software

5.2 Results Obtained

Scenario C is the only configuration across all tested scenarios in which A1 loses its first place position. When the Cost criterion is assigned a weight of 0.65 making it the single most important factor in the decision A3 moves ahead of A1, producing the ranking $A3 > A1 > A2$. This outcome is mathematically consistent: A3 carries the lowest investment cost by a significant margin (1.716 billion DZD against A1's 5.28 billion DZD).

Scenario C only make sense for a company whose primary concern is minimizing investment cost, with little regard for profitability, risk exposure, and how quickly the investment pays back.

Conclusion:

In this chapter, we first presented SARL GARDEN CLEAN and the budgetary decision problem. We then applied the PROMETHEE method by defining the evaluation criteria, assigning weights, and constructing the evaluation matrix for the three identified alternatives. Finally, we interpreted the results through the various visual outputs provided by the Visual PROMETHEE software.

Based on the results obtained, we found that Alternative A1 New Trucks clearly emerges as the best budgetary choice, combining the highest profit margin, the lowest risk, and the shortest ROI time. This conclusion remained stable across almost all weight configurations tested, confirming the robustness of the recommendation.

General Conclusion

In an economic environment characterized by increasing uncertainty, budgetary constraints, and growing pressure on organizational performance, companies are required to make complex decisions regarding the allocation and use of their financial resources. In such a context, relying on a single financial indicator is no longer sufficient to support sound budgetary choices. Multi-criteria analysis has thus emerged as a relevant decision support tool capable of addressing this complexity, enabling decision-makers to evaluate and compare alternatives based on several criteria simultaneously while structuring preferences and priorities.

Focusing on the following central question: How can the integration of multi-criteria analysis within management control improve budgetary decision-making? To address this question, we structured our work into two chapters.

The first chapter, entitled "Management Control and Multi-criteria Decision-making," laid the theoretical foundations of our study. We began by exploring the concept of management control its history, definitions, roles, objectives, and limitations before talking about the decision-making process, covering its typologies, actors and approaches. We then presented the field of multi-criteria decision analysis, detailing its main families of methods.

The second chapter, entitled "Application of the PROMETHEE Method to Budgetary Decision-making at SARL GARDEN CLEAN," constituted the empirical core of our research. We first presented the company its history, organizational structure, human resources, and market position before formulating the budgetary decision problem. Three strategic investment alternatives were identified in collaboration with the management controller: the acquisition of a new truck fleet (A1), the investment in marketing panels (A2), and the launch of a new product, namely a rim block (A3). These alternatives were evaluated against four criteria profit margin, ROI time, investment cost, and risk level each assigned a weight reflecting the priorities of SARL GARDEN CLEAN's management. The PROMETHEE method was then applied using Visual PROMETHEE software, and the results were interpreted through five complementary visual outputs: the flow table, the network, the ranking, the GAIA plane, and the walking weights tool.

The results of our analysis were clear. Alternative A1 (New Trucks) emerged as the best budgetary choice with a dominant net flow of +0.850, outperforming the other alternatives on the two most heavily weighted criteria: profit margin and risk. Alternative A3 New Product Launch ranked second despite its high risk and long payback period, primarily due to its significantly lower

investment cost. Alternative A2 Marketing Panels ranked last, penalized by its high cost, lowest profit margin, and mediocre risk profile. The sensitivity analysis confirmed that this ranking remains stable across virtually all weight configurations, with the sole exception of scenarios where cost is assigned more than 60% of the total weight a configuration that does not reflect the actual priorities of the company.

Based on the totality of these results, we are able to respond to our three research hypotheses.

Table 12: Summary of Hypothesis Testing

Hypotheses	Results	Interpretation
H1: Management control tools improve the quality of budget allocation decisions.	Validated	The interview and the empirical study showed that management control contributes to the decision-making process.
H2: Budget investment decisions require the simultaneous consideration of financial and non-financial criteria.	Not Validated	The application of the PROMETHEE method showed that the decision-making process mainly relied on financial criteria. The absence of non-financial criteria did not significantly affect the final decision.
H3: Multi-criteria decision-making methods improve the rationality and transparency of budget decisions.	Validated	The PROMETHEE method provided a clear ranking of alternatives and improved the interpretation and transparency of the decision-making process.

Our research demonstrates that the integration of multi-criteria analysis into management control represents a significant improvement. It brings structure, transparency, and comprehensiveness to arbitrations that would otherwise be handled intuitively or based on a single dominant indicator.

To conclude, our research entitled “Multi-criteria Analysis as a Tool for Budgetary Decision-making” could only be explored within certain limits, due to the complexity of the subject. One of the main difficulties encountered during this study was the lack of access to some detailed company data, so we just used estimations. In addition, the empirical analysis relied on a limited number of

investment alternatives and evaluation criteria, which restricted the scope of the application. Furthermore, this study focused exclusively on quantitative financial criteria such as cost, revenue, and profitability, without incorporating any non-financial criteria

Despite these limitations, the study made it possible to apply the PROMETHEE method and obtain meaningful results concerning the contribution of multi-criteria analysis to budgetary decision-making. The research therefore provided valuable insights into the usefulness of multi-criteria decision-support methods in improving the rationality, transparency, and structuring of investment decisions.

That said, several avenues remain open for future research:

1. Extension to other MCDM methods Future work could compare PROMETHEE with other multi-criteria methods such as AHP (Analytic Hierarchy Process), TOPSIS, or ELECTRE, applied to the same budgetary decision context, in order to identify which method best suits the specificities of management control.

2. Integration of a larger set of criteria and alternatives our study included three alternatives and four criteria. And took in consideration only financial criteria. Future research could enrich the model by incorporating additional alternatives and more criteria such as environmental impact

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IV. Divers

- Internal data provided by SARL GARDEN CLEAN

ANNEXES

Annexe 01 : Interview Guide

Interview Guide

General Information

- Position: DFC
- Company: SARL GARDEN CLEAN

Interview Questions

1. During the internship, we discussed several investment alternatives within the company. What if these alternatives were evaluated using decision-support software in order to determine which one would represent the best decision?
2. Which criteria do you consider the most suitable for evaluating these alternatives?
3. What level of importance does the company assign to each criterion?

Annexe 02 : Trucks Bill

INTELLI TECH TRADING CO., LIMITED			
INVOICE			
INTELLI TECH TRADING CO., LIMITED ROOM402.4F UNIT 1No.18TH BUILDING WUAI DISTRICT YIWU, CHINA		INVOICE NO: H2405W	DATE: JUNE 25, 2024
TO: SNC GARDEN CLEAN MESTAR ET CIE LOT 49, ZONE DE DEPOT EL HADDADA JIJEL ,ALGERIE NIF : 000618044275394		COUNTRY OF ORIGIN: CHINA	COUNTRY OF DESTINATION: ALGERIA
		FROM: CHINA MAIN PORT	TO: Djen Djen PORT, ALGERIA
		TERMS OF DELIVERY: CFR Djen Djen PORT, ALGERIA	
		TERMS OF PAYMENT: L/C, IRREVOCABLE AND CONFIRMED CREDIT LETTER AT SIGHT	
DESCRIPTION	QTY UNITS	UNIT PRICE USD	AMOUNT
CNHTC HOWO SIDE CURTAIN CARGO TRUCK - LHD MODEL : ZZ1257V5847B1 MOTEUR MODEL : WEICHAI /WP12.400E201 QTY: 02 UNITS ORIGIN: CHINA CHASSIS NUMBER 1-LZZ5BLSJ3RN296249 2-LZZ5BLSJXRN297091 AS PER PROFORMA INVOICE NO. H2405W DATED 25/06/2024 FREIGHT PREPAID SALE CONTRACT: CFR DJENDJEN PORT ALGERIA HS CODE:8704239199 LC NO : 00475CDI09097936	2	68000	136000
Société Générale Algérie AGENCE JIJEL 475 Domiciliation Importation 18.15.01 2024/3 10.00016 us\$ Date 30/09/2024 Société Générale Algérie Agence JIJEL Responsable des Opérations RAHMANI Siham		Société Générale Algérie Agence JIJEL Responsable des Opérations Nazek CHAKRO	
		TOTAL FOB AMOUNT : 136000 SHIPPING COST : 38000 INVOICE TOTAL COST AND FREIGHT TO Djen Djen PORT, CURRENCY USD : 174000	
SAY TOTAL US DOLLARS ONE HUNDRED AND SEVENTY-FOUR THOUSAND ONLY			
SELLER: A/C NAME: INTELLI TECH TRADING CO., LIMITED A/C NO.: OSA11009422817801 BANK NAME: PING AN BANK CO., LTD. HANGZHOU BR. SWIFT CODE: SZDBCNSHSHZB ADDRESS: 6F, BUILDING A, PING AN FINANCIAL CENTER, NO.280, MINXIN ROAD, JIANGGAN DISTRICT, HANGZHOU, CHINA		For and on behalf of INTELLI TECH TRADING CO., LIMITED 名大國際貿易有限公司 程加力 Authorized Signature(s)	
ROOM402.4F UNIT 1No.18TH BUILDING WUAI DISTRICT YIWU, CHINA TEL : +86-579-85374581 Attn:Cheng TEL: +86 15858988508			

Annexe 03 : Machine Bill

INTELLI TECH TRADING CO., LIMITED INVOICE					
INTELLI TECH TRADING CO., LIMITED ROOM402.4F UNIT 1No.18TH BUILDING WUAI DISTRICT YIWU, CHINA		INVOICE NO: R210228M		DATE: FEB 28, 2021	
TO: BNP PARIBAS EL Djazaïr BANK NAME: BNP PARIBAS EL Djazaïr Agence BEJAIA , ALGERIE ON BEHALF OF: SNC GARDEN CLEAN MESTAR ET CIE ADD: ZONE DE DEPOT EL HADDAÏA N49 JIJEL , ALGERIE NIF: 000618044275394 RCNO: 06B 0442753		COUNTRY OF ORIGIN: CHINA FROM: NINGBO PORT, CHINA TERMS OF DELIVERY: CFR ALGIERS, ALGERIA		COUNTRY OF DESTINATION: ALGERIA TO: ALGIERS, ALGERIA TERMS OF PAYMENT: - L/C , IRREVOCABLE AND CONFIRMED CREDIT LETTER AT SIGHT	
DESCRIPTION		UNIT	QTY	UNIT PRICE USD	AMOUNT
Blister Forming Machine		SET	1	66910	66910
Mould		SET	2	9620	19240
Automatic Rim Block Making Machine		SET	2	17030	34060
SHIPPING COST			1	6920	6920
INVOICE TOTAL COST AND FREIGHT TO ANY ALGERIAN PORT				CURRENCY: USD	127130
SAY TOTAL CFR ALGIERS, ALGERIA US DOLLAR ONE HUNDRED TWENTY SEVEN THOUSAND ONE HUNDRED THIRTY ONLY				SIGNATURE	
LC No: 09990LCA2100274 SELLER: A/C NAME: INTELLI TECH TRADING CO., LIMITED A/C NO.: OSA11009422817801 BANK NAME: PING AN BANK CO., LTD. HANGZHOU BR. SWIFT CODE: SZDBCNBSHZB ADD: 6F, BUILDING A, PING AN FINANCIAL CENTER, NO.280, MINXIN ROAD, JIANGGAN DISTRICT, HANGZHOU, CHINA 程加加					
ROOM402.4F UNIT 1No.18TH BUILDING WUAI DISTRICT YIWU, CHINA TEL:+86-579-85374581 FAX:+86-579-85374581 Attn:Cheng TEL:+86 15858988508					



BNP PARIBAS
EL Djazaïr
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Nacer - Bejaia
06000

BNP PARIBAS EL DIAZAÏR
Agence BEJAIA 7130
DOMICILIATION IMPORT
06.19.01
Le : 2021-02-10 00:55:11

Annexe 04 : INFORMATIONS TABLE

	P1	P2	P3
	LOGISTIQUE (04 CAMIONS)	01 MACHINE POUR UN NV PRODUIT (RIM BLOC)	MARKETING/DIFFUSI ON TV 6 MOIS
COUT/DA	52,800,000.00	17,160,000.00	78,000,000.00
TEMPT ROI ESTIMER	01 MOIS	24 MOIS	6 MOIS
ROI	50%	30%	20%