



**HAL**  
open science

# Multi-criteria Evaluation of Madagascar's Regions in the Context of Employment Using the CoCoFISo Method

Hantamalala Nirinarivelo, Rôlin Gabriel Rasoanaivo

## ► To cite this version:

Hantamalala Nirinarivelo, Rôlin Gabriel Rasoanaivo. Multi-criteria Evaluation of Madagascar's Regions in the Context of Employment Using the CoCoFISo Method. *Spectrum of Decision Making and Applications*, 2024, 2 (1), pp.135-156. 10.31181/sdmap21202514 . hal-04764267

**HAL Id: hal-04764267**

**<https://hal.science/hal-04764267v1>**

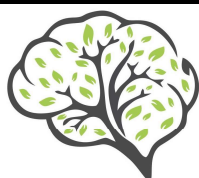
Submitted on 6 Nov 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



SCIENTIFIC OASIS

## Spectrum of Decision Making and Applications

Journal homepage: [www.dmap-journal.org](http://www.dmap-journal.org)  
ISSN: 3042-1462



# Multi-criteria evaluation of Madagascar's regions in the context of employment using the CoCoFISo method

Hantamalala NIRINARAIVELO<sup>1</sup>, [0009-0008-0519-8921], Rôlin Gabriel RASOANAIVO<sup>2,3,\*</sup> [0000-0002-2496-2672]

<sup>1</sup> Université de Toamasina, Toamasina, Madagascar

<sup>2</sup> Université Toulouse Capitole, Toulouse, France

<sup>3</sup> Équipe ADRIA, Département Intelligence Artificiel, Institut de Recherche en Informatique de Toulouse, France

### ARTICLE INFO

#### Article history:

Received 14 September 2024

Received in revised form 12 October 2024

Accepted 25 October 2024

Available online 29 October 2024

#### Keywords:

Employment sector, Madagascar, Multi-criteria Decision-Making, CoCoFISo method

### ABSTRACT

The evaluation of regions in terms of employment provides decision-makers with a valuable tool for pursuing the development of each region. Furthermore, it facilitates the decision-making process for the working-age population, enabling them to identify locations where they wish to settle on a long-term basis to pursue employment opportunities. The objective was to evaluate Madagascar's twenty-three regions in accordance with thirteen pre-established criteria. The multi-criteria mean weight (MW) and Combined Compromise For Ideal Solution (CoCoFISo) decision-making methods were employed to calculate the relative importance of the criteria and to perform a comparative ranking of the regions. The weights of the criteria were equalised using the MW result. The CoCoFISo method revealed that the first seven regions are successively Atsimo Andrefana, Analanjirifo, Boeny, Vakinakaratra, Alaotra Mangoro, Diana and Analamanga. Our analysis of the results demonstrates that these regions display elevated percentages, with 54% to 69% of the criteria exhibiting above-average values. Additionally, the values of their criteria are generally stable in comparison to the others, which are dispersed.

## 1. Introduction

According to the general population and housing census carried out in 2018, Madagascar had a population of 25,674,196. The population aged 15 and over numbered 15,076,670. This represents 58.7% of the working-age population [1]. The population in question has increased from 28,915,653 in 2021 to 29,611,714 in 2022 [2]. The present article focuses on the years 2021 and 2022. During this period, the national labour force participation rate was 58.8%. This figure represents the country's production potential in terms of the working-age population. According to the International Labour Office, the unemployment rate in Madagascar is 6.6%. Furthermore, most employment is concentrated in the agricultural sector, which accounts for 60.7% of all jobs. There are considerable regional variations in terms of access to employment opportunities. Uneven economic growth, a

\* Corresponding author.

E-mail address: [rolin-gabriel.rasoanaivo@ut-capitole.fr](mailto:rolin-gabriel.rasoanaivo@ut-capitole.fr) / [Rolin.Rasoanaivo@irit.fr](mailto:Rolin.Rasoanaivo@irit.fr)

<https://doi.org/10.31181/sdmap21202514>

shortage of infrastructure and services in some regions exacerbate this problem. These remain a challenge for decision-makers seeking to develop effective employment policies.

Employment is becoming increasingly important in regional policies. But traditional approaches to assessing regional performance often fail to take account of the complexity and diversity of factors influencing the labour market. Conventional methods, which are often centred on a limited number of indicators, can result in analyses that are partial or biased. Such analyses may neglect crucial dimensions, including job quality, access to opportunities, and the dynamics of long-term change. In this context, what methodology can be used to develop an evaluation method that takes multiple criteria into account? What method will be capable of providing a comprehensive and balanced analysis of regional employment performance? To what extent can one method offer a more nuanced and relevant assessment of regional disparities in employment? How can this assessment inform public policy to reduce regional disparities?

It is therefore essential to use a sophisticated assessment tool that facilitates a comprehensive and complex examination of regional employment dynamics. Given its novelty, we would like to experiment the performance of the Combined Compromise For Ideal Solution (CoCoFISo) multi-criteria method [3]. Firstly, this method makes it possible to integrate multiple performance criteria. Secondly, it considers the preferences of stakeholders. Also, it offers a more complete and balanced perspective from which to obtain our result. Its ability to solve a multi-criteria problem was demonstrated in a recent study for the case of evaluating Madagascar's universities [4].

The principal objective of this study is using the CoCoFISo method to conduct a multi-criteria evaluation of regional employment performance in Madagascar. This will initially make it easier to identify regional disparities. Secondly, to provide decision support to Madagascar's regional leaders. Finally, to enable the further development of public policies focused on efficiency in this area.

In the following sections, we present a review of the literature. Describe the methodology employed in this research. Provide a detailed account of the experimental data. Present the results and their analysis. Discuss and conclude by outlining future work.

## **2. Literature review**

Multi-criteria decision-making (MCDM) represents an indispensable methodology for decision-making in complex contexts, wherein the evaluation of multiple criteria must be conducted concurrently [5]. This approach entails the utilisation of multi-criteria decision-support methodologies. In the literature, there are several multi-criteria decision-making methods, the oldest of which is the Weighed Sum Method (WSM) [6], the "Élimination Et Choix Traduisant la Réalité" (ELECTRE) method [7], the Analytic Hierarchy Process (AHP) [8], the Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE) [9]. Additionally, more contemporary methodologies have been developed, including the "Faire Un Choix Adéquat" (FUCA) [10], the Opinion Weight Criteria Method (OWCM) [11], and the Combined Compromise for Ideal Solution (CoCoFISo) [3].

Each method possesses distinctive advantages and limitations. The AHP method is an intriguing approach that enables the prioritisation of criteria and the ranking of alternatives. However, this approach becomes challenging when the number of criteria or alternatives to be implemented is substantial. This is because each criterion or alternative must be compared individually using a numerical scale. In contrast, the PROMETHEE method enables the decision-maker to influence their preference based on the criteria. Nevertheless, it has been observed that this method may be complex for novice decision-makers due to the necessity of selecting parameters.

However, the optimal choice of method depends on the specific problem being addressed. These methods can be broadly classified into two categories: multi-attribute decision-making methods and multi-objective decision-making methods [12]. Subsequent to the advancement of the classification of these methods [13,14], Arslan grouped them into three categories in accordance with the criteria, alternatives and solutions defined in the decision structure: basic methods, simple analytical methods and hybrid methods [15]. These multicriteria decision-making methods have been extensively employed in a multitude of fields, including environmental management [16,17], urban planning [18,19], resource allocation [20,21]. Furthermore, this method has been observed in numerous other areas.

In recent times, multi-criteria decision-making approaches have been employed to evaluate regions in a range of countries according to a variety of sectors. These include socio-economic factors, as demonstrated by studies conducted by Mahmudah and her colleagues, Zhukov and her colleagues [22,23], which have utilised the Fuzzy Analytic Hierarchy Process (F-AHP), Fuzzy Vlse Kriterijumska Optimizacija I Kompromisno Resenje (F-*VIKOR*), and Socio-Ecological-Economic Systems (SEES) methods, respectively. The use of Analytical Network Process (ANP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) methods for the purpose of sustainable development has been identified as a promising approach [24]. Similarly, the integration of the PROMETHEE and the allocation of 100 points, has been shown to be effective in the context of health [25,26]. Also, the application of the Hierarchical Fuzzy Axiomatic Design method has been demonstrated to be a valuable tool in the assessment of transport systems [27].

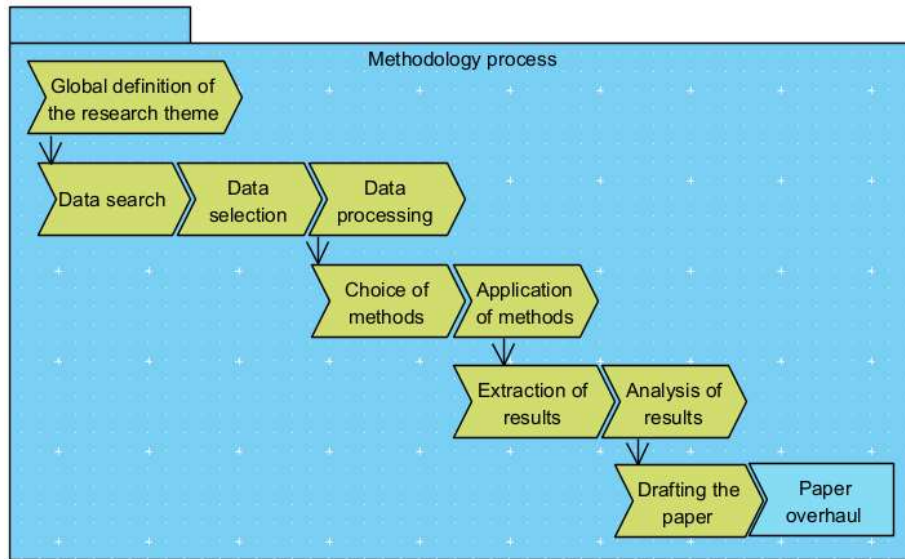
Considering the aforementioned work, which underscores the significance of employing multi-criteria decision-making methodologies to assess regional performance, this article explores the potential of utilizing such methods to evaluate these regions in the context of employment in Madagascar. The CoCoFISo method was selected for evaluation of Madagascar's regions. Created in 2024, this novel approach merits investigation. As is often observed, experience is a significant factor in determining the efficacy of a method. The objective is to ascertain the extent to which the CoCoFISo method can effectively address a multi-criteria problem. These selected methodologies will be elucidated in the subsequent section.

### **3. Research methodology**

This research methodology is comprised of two sub-sections: the approach followed during the research and the presentation of the chosen method.

#### *3.1. Research process*

The process undertaken throughout the course of this research can be broadly categorised into ten distinct stages. The initial stage entailed defining the overarching theme of the research project. Following this, the theme was subjected to a process of refinement considering feedback provided by the reviewers. **Figure 1** below provides a comprehensive illustration of this process.



**Figure 1.** Research process

### 3.2. Overview of methods

Multicriteria problems can be classified into three categories: choice problems, allocation problems, and ranking problems [28]. In the case of the multicriteria evaluation of the regions of Madagascar, we want to rank the regions in a more coherent manner, thus facilitating their evaluation. This situation thus constitutes a component of the problem of ranking within the context of multi-criteria analysis. In this article, we put forward the application of multicriteria decision-making methods as a potential solution.

In general, multi-criteria methods are employed for the purpose of calculating the weights of criteria and evaluating alternatives. Thus, the initial step was to select a multicriteria decision-making method for evaluating the criteria and determining their respective weights. Subsequently, an additional method was required to extract the performance of the alternatives, which in this case are the regions.

To prioritise the criteria, the Mean Weight (MW) method was selected to guarantee the neutrality of the research by ensuring equal weighting for all criteria. Consequently, the resulting evaluation process is objective. It is recognised that this result will inform subsequent decision-making about the situation in each region. Previous work showing the importance and success of using this method led us to choose it [29–31]. The weighting of the criteria is obtained using the following Eq. (1):

$$w_j = 1/n \text{ where } n \text{ is the number of criteria and } \sum w_j = 1 \quad (1)$$

Despite its recent inception, the CoCoFISo method holds considerable promise for facilitating a more balanced and robust analysis. The method has been developed with the intention of overcoming some of the limitations of conventional multi-criteria methods, offering a more stable and adaptable solution. The application of this method to the case of Madagascar will not only contribute to the existing literature on the subject but will also provide practical recommendations for improving employment in the country's most disadvantaged regions. The CoCoFISo method was implemented in this way to rank the regions, given that it was created in 2024. The method will be evaluated in a variety of contexts to ascertain its efficacy in addressing multi-criteria issues. The following section presents the algorithm of the CoCoFISo method [3].

- Availability of the performance matrix and criteria weights.
  - o Performance matrix made up of  $n$  criteria and  $m$  alternatives

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \quad (2)$$

- o Criteria weights

$$w_j \text{ dont } \sum_{j=1}^n w_j = 1 \quad (3)$$

- Performance matrix normalization

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m (x_{ij})^2}} \quad (4)$$

- Comparability sequence weighting

$$S_i = \sum_{j=1}^n (w_j r_{ij}) \quad (5)$$

$$P_i = \sum_{j=1}^n (r_{ij})^{w_j} \quad (6)$$

- Deduction of aggregation strategies from comparability sequences

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^m (P_i + S_i)} \quad (7)$$

$$k_{ib} = \left( \frac{S_i + P_i}{1 + \frac{S_i}{1 + S_i} + \frac{P_i}{1 + P_i}} \right) \quad (8)$$

$$k_{ic} = \frac{\lambda(S_i) + (1 - \lambda)(P_i)}{(\lambda \max_i S_i + (1 - \lambda) \max_i P_i)}; 0 \leq \lambda \leq 1 \quad (9)$$

- Determining the final score

$$k_i = (k_{ia} k_{ib} k_{ic})^{\frac{1}{3}} + \frac{1}{3} (k_{ia} + k_{ib} + k_{ic}) \quad (10)$$

## 4. Data and results

In this section we will first present the research data that is the subject of our study. We will then present the results obtained after applying the research methodology.

### 4.1. Survey data

The data used in this study are available for download on the website of the Institut National de la Statistique de Madagascar (<https://www.instat.mg/>). This is a report on the periodic household survey 2021-2022 [32], published in 2024, which serves as a guide to understanding the complex realities facing Malagasy households in a constantly changing context. Among the various proposed chapters, we are particularly interested in the section on employment. This section employs the international standards defined by the International Labour Organization for labour statistics. As this is secondary data that has been pre-processed by analysts and statisticians at the Institut National de la Statistique de Madagascar, we have recovered it in accordance with our specific requirements. The processing that we have carried out involved the elimination of data that was not deemed to be useful for our study. Finally, we have selected thirteen distinct data sets pertaining to the regions of Madagascar, which will be considered as significant criteria enabling us to evaluate these regions.

We will be evaluating Madagascar's twenty-three (23) regions according to thirteen criteria relating to employment. These regions and their legends are shown in **Table 1** below.

**Table 1**

Madagascar's twenty-three (23) regions

Region		Region		Region	
<b>R1</b>	Alaotra Mangoro	<b>R9</b>	Atsinanana	<b>R17</b>	Itasy
<b>R2</b>	Amoron'i Mania	<b>R10</b>	Betsiboka	<b>R18</b>	Melaky
<b>R3</b>	Analamanga	<b>R11</b>	Boeny	<b>R19</b>	Menabe
<b>R4</b>	Analanjirifo	<b>R12</b>	Bongolava	<b>R20</b>	Sava
<b>R5</b>	Androy	<b>R13</b>	Diana	<b>R21</b>	Sofia
<b>R6</b>	Anosy	<b>R14</b>	Fitovinany	<b>R22</b>	Vakinankaratra
<b>R7</b>	Atsimo Andrefana	<b>R15</b>	Haute Matsiatra	<b>R23</b>	Vatovavy
<b>R8</b>	Atsimo Atsinanana	<b>R16</b>	Ihorombe		

The evaluation criteria for these regions are set forth below.

- **Population of working age (PAT):** these are the individuals aged 15 or over in the Malagasy population. It represents the potential supply of labour force within an economy, making it possible to assess the qualities and shortcomings of this population.
- **Labour force participation rate (TPMO):** this is a measure of the proportion of the working-age population actively participating in the labour market, either by working or looking for work. It gives an indication of the size of the labour supply available to participate in the production of goods and services, relative to the working-age population.
- **Sector of activity:** these are the three sectors of activity: **primary sector (SP), secondary sector (SS) and tertiary sector (ST)**. The data represent the percentage of people employed in each of these sectors.
  - **Primary sector (SP):** made up of agricultural activities proper, forestry, livestock farming, fishing and aquaculture.
  - **Secondary sector (SS), tertiary sector (ST):** made up of trading activities, extraction activities, manufacturing activities, construction, transport, scientific activities, public

administration, education, health, the arts, activities of extra-territorial organisations and bodies, etc.

- **Underemployment linked to working hours (SEDT):** refers to the proportion of individuals who are involuntarily employed for fewer than the standard number of hours and who are seeking additional work or who are available for additional work during a specified reference period. In Madagascar, the standard working week is 40 hours.
- **Average monthly wage income (RSM):** refers to the gross cash remuneration paid to employees for their work, as expressed in Ariary. This figure excludes benefits such as rent paid by the employer, servants made available to workers, fuel, transport, bonuses not included in the wage, and other similar expenses.
- **Mean size of non-agricultural businesses (TMENA)** is defined as the mean number of employees in non-agricultural businesses.
- **Structure of non-agricultural businesses** is defined by the branch of activity in which they operate. This encompasses production units engaged in processing, trade, and service activities, which are managed by private households. The production function of these businesses is closely linked to the consumption function of the owner household. The data set forth the proportion of non-agricultural businesses engaged in each branch of activity, with a particular focus on **primary non-agricultural businesses (ENAPHA), industry (ENAI), commerce (ENAC), transport and storage (ENATE), and other services of non-agricultural businesses (ENAAS).**

It can be seen, therefore, that each region is assigned a value in accordance with the criteria. The performance matrix, which is used to assess the regions in question, is presented in **Table 2** below.

**Table 2**

Performance matrix

Region	PAT	TPMO	SP	SS	ST	SEDT	RSM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R1	5,00	64,60	68,80	7,80	23,40	13,30	154 164,00	1,70	16,50	18,40	46,00	5,10	13,90
R2	4,10	40,00	53,60	19,30	27,20	6,70	163 822,00	1,30	1,50	51,00	30,40	0,00	17,00
R3	15,60	66,80	40,70	21,50	37,80	10,30	238 724,00	1,90	2,80	32,50	46,20	2,50	16,00
R4	4,60	47,60	49,30	20,20	30,50	13,00	286 099,00	1,30	14,00	27,70	36,10	6,00	16,30
R5	2,80	55,50	56,70	10,00	33,40	11,60	96 244,00	1,30	2,60	26,10	47,90	2,00	21,40
R6	2,40	70,70	61,90	14,40	23,70	6,60	122 528,00	1,40	5,90	42,70	37,90	1,00	12,40
R7	6,50	57,40	53,60	17,60	28,80	19,40	192 593,00	1,40	19,00	22,10	41,30	3,40	14,20
R8	4,10	43,90	62,90	7,00	30,10	17,50	112 956,00	1,30	6,90	32,80	38,10	0,70	21,40
R9	6,30	62,10	66,50	7,20	26,30	5,40	180 786,00	1,40	19,50	15,30	42,50	3,50	19,30
R10	1,50	59,80	27,20	57,00	15,80	5,50	225 995,00	2,40	76,00	6,00	15,40	0,00	2,60
R11	2,90	61,70	68,30	11,50	20,30	13,60	299 828,00	1,40	20,00	25,10	33,70	7,10	14,10
R12	2,60	73,70	84,90	6,80	8,40	5,00	118 530,00	1,50	27,40	26,50	32,30	3,50	10,30
R13	3,50	63,50	54,40	18,30	27,30	7,90	243 151,00	1,40	21,70	15,00	44,30	3,40	15,60
R14	2,50	54,30	61,60	13,20	25,20	17,80	104 866,00	1,70	13,20	37,00	4,50	2,70	12,50
R15	5,50	40,60	54,30	16,50	29,20	10,00	145 367,00	1,60	0,80	48,10	31,80	1,50	17,90
R16	1,70	57,50	63,70	16,00	20,40	14,50	162 502,00	2,00	26,00	22,80	39,50	1,30	10,50
R17	3,70	74,50	82,80	6,90	10,20	4,00	135 989,00	1,50	0,40	30,90	58,70	0,90	9,20
R18	1,20	56,20	76,90	9,70	13,40	8,60	169 309,00	1,30	7,80	36,00	33,30	4,00	18,80
R19	2,70	65,80	64,60	13,00	22,30	13,10	131 603,00	1,60	9,20	29,30	43,40	3,10	15,00
R20	4,60	60,10	71,40	10,40	18,20	8,20	349 941,00	1,70	0,60	37,10	44,70	5,40	12,20
R21	6,00	56,30	76,10	6,70	17,20	9,80	341 851,00	1,70	5,50	30,10	46,60	2,40	15,40
R22	7,80	63,10	70,80	11,50	17,60	13,90	133 510,00	2,10	8,20	29,10	36,40	11,10	15,10
R23	2,70	42,30	40,80	42,70	16,60	8,60	164 921,00	2,00	30,20	46,00	20,70	0,00	3,10



It is important to note that the utilisation of multi-criteria methods offers the distinct advantage of encompassing all pertinent criteria within the evaluation process. Furthermore, they can be beneficial when the presence of a performance matrix makes it challenging to assess the alternatives without additional information. As illustrated in **Table 2**, the performance matrix in the present case does not allow for the determination of which region will be put forward first or vice versa. It is thus necessary to employ a method to facilitate the evaluation process.

With the performance matrix now available, the chosen methods can be employed to obtain the requisite result.

#### 4.2. Results and analysis

To obtain the result, two distinct methods will be employed. The initial step is to calculate the weight of the criteria by the mean weight method. Secondly, the CoCoFISo method will be employed for the evaluation of the regions. The results will then be presented in turn.

##### 4.2.1. Weight of the criteria using the Mean Weight (MW) method

Given that there are 13 criteria, it is appropriate to apply the Eq. (1):

$$w_j = \frac{1}{13} \quad w_j = 0,08$$

An equal weight has been attributed to each of the criteria. This will prove beneficial for the remainder of the procedure. Let us now proceed to an examination of the regional rankings.

##### 4.2.2. Evaluation of the Regions using the CoCoFISo method

All calculations were conducted using Microsoft Excel. The initial step was to calculate the normalised matrix, as illustrated in **Table 3** below.

**Table 3**

Normalized matrix

Region	PAT	TPMO	SP	SS	ST	SEDT	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R1	0,20	0,23	0,23	0,08	0,20	0,24	0,16	0,22	0,16	0,12	0,25	0,27	0,20
R2	0,16	0,14	0,18	0,20	0,24	0,12	0,17	0,17	0,01	0,33	0,16	0,00	0,24
R3	0,62	0,24	0,14	0,23	0,33	0,19	0,25	0,24	0,03	0,21	0,25	0,13	0,22
R4	0,18	0,17	0,16	0,21	0,27	0,24	0,30	0,17	0,14	0,18	0,19	0,31	0,23
R5	0,11	0,20	0,19	0,11	0,29	0,21	0,10	0,17	0,03	0,17	0,26	0,10	0,30
R6	0,10	0,25	0,21	0,15	0,21	0,12	0,13	0,18	0,06	0,28	0,20	0,05	0,17
R7	0,26	0,20	0,18	0,19	0,25	0,35	0,20	0,18	0,18	0,15	0,22	0,18	0,20
R8	0,16	0,16	0,21	0,07	0,26	0,32	0,12	0,17	0,07	0,22	0,21	0,04	0,30
R9	0,25	0,22	0,22	0,08	0,23	0,10	0,19	0,18	0,19	0,10	0,23	0,18	0,27
R10	0,06	0,21	0,09	0,60	0,14	0,10	0,24	0,31	0,73	0,04	0,08	0,00	0,04
R11	0,12	0,22	0,23	0,12	0,18	0,25	0,31	0,18	0,19	0,16	0,18	0,37	0,20
R12	0,10	0,26	0,28	0,07	0,07	0,09	0,12	0,19	0,26	0,17	0,17	0,18	0,14
R13	0,14	0,22	0,18	0,19	0,24	0,14	0,25	0,18	0,21	0,10	0,24	0,18	0,22
R14	0,10	0,19	0,20	0,14	0,22	0,32	0,11	0,22	0,13	0,24	0,02	0,14	0,18
R15	0,22	0,14	0,18	0,17	0,25	0,18	0,15	0,20	0,01	0,32	0,17	0,08	0,25
R16	0,07	0,20	0,21	0,17	0,18	0,26	0,17	0,26	0,25	0,15	0,21	0,07	0,15
R17	0,15	0,26	0,27	0,07	0,09	0,07	0,14	0,19	0,00	0,20	0,32	0,05	0,13
R18	0,05	0,20	0,26	0,10	0,12	0,16	0,18	0,17	0,08	0,24	0,18	0,21	0,26
R19	0,11	0,23	0,21	0,14	0,19	0,24	0,14	0,20	0,09	0,19	0,23	0,16	0,21
R20	0,18	0,21	0,24	0,11	0,16	0,15	0,37	0,22	0,01	0,24	0,24	0,28	0,17
R21	0,24	0,20	0,25	0,07	0,15	0,18	0,36	0,22	0,05	0,20	0,25	0,13	0,22
R22	0,31	0,22	0,23	0,12	0,15	0,25	0,14	0,27	0,08	0,19	0,20	0,58	0,21
R23	0,11	0,15	0,14	0,45	0,14	0,16	0,17	0,26	0,29	0,30	0,11	0,00	0,04

It has been observed that the initial data in **Table 2** relate to different units of measurement. Most of the criteria are expressed in percentages (**PAT, TPMO, SP, SS, ST, SEDT, ENAPHA, ENAI, ENAC, ENATE, ENAAS**), but there are also those expressed in numbers (**TMENA**) and in currency (**RSMM**, here in Ariary). The aim of normalising the matrix in **Table 3**, as its name suggests, is to obtain similar data to simplify the evaluation.

The weights of the comparability sequences presented are then extracted from this standardised matrix. Once these are available, the aggregation strategies will be calculated. The following **Table 4** illustrates the weighting and aggregation strategies.

**Table 4**  
 Weighted comparability sequences and aggregation strategies

Region	Si	Pi	Region	Kia	Kib	Kic
R1	0,20	11,43	R1	0,0444	5,5821	0,9901
R2	0,16	10,39	R2	0,0402	5,1391	0,8982
R3	0,24	11,49	R3	0,0447	5,5555	0,9983
R4	0,21	11,51	R4	0,0447	5,5966	0,9979
R5	0,17	11,23	R5	0,0435	5,5236	0,9708
R6	0,16	11,21	R6	0,0434	5,5292	0,9684
R7	0,21	11,51	R7	0,0447	5,5979	0,9978
R8	0,18	11,25	R8	0,0436	5,5254	0,9727
R9	0,19	11,38	R9	0,0441	5,5680	0,9843
R10	0,20	10,35	R10	0,0402	5,0705	0,8980
R11	0,21	11,48	R11	0,0446	5,5870	0,9950
R12	0,16	11,24	R12	0,0435	5,5363	0,9705
R13	0,19	11,43	R13	0,0443	5,5839	0,9889
R14	0,17	11,24	R14	0,0435	5,5277	0,9712
R15	0,18	11,23	R15	0,0435	5,5090	0,9709
R16	0,18	11,34	R16	0,0439	5,5581	0,9803
R17	0,15	10,97	R17	0,0424	5,4342	0,9469
R18	0,17	11,26	R18	0,0436	5,5391	0,9724
R19	0,18	11,37	R19	0,0440	5,5713	0,9828
R20	0,20	11,30	R20	0,0438	5,5158	0,9785
R21	0,19	11,37	R21	0,0441	5,5561	0,9841
R22	0,23	11,51	R22	0,0448	5,5747	0,9992
R23	0,18	10,46	R23	0,0406	5,1533	0,9055

Once the weights of each criterion have been integrated into the normalised matrix and all the values of the weighted criteria have been added together, the weighted comparisons (**Si, Pi**) provide an overall score for each region. The distinction between the two lies in the algorithms employed: **Si** utilises the weighted sum algorithm, whereas **Pi** employs the weighted product algorithm. The objective remains unchanged: to obtain a score in which the criteria weights have been incorporated.

To utilise the disparate scores yielded by **Si** and **Pi**, the three strategies, **Kia, Kib** and **Kic**, proceed to implement techniques for aggregating these two sequences. This process yields three new scores for each region: **Kia, Kib**, and **Kic**.

Once the aggregation strategies have been identified, the final score can be calculated, which represents the last step in the CoCoFISo method. This will enable the evaluation of the regions in question. **Table 5** below presents the final score and the corresponding rank for each region.

**Table 5**  
 Score and rank of regions

	Region	Ki	Rank		Region	Ki	Rank
<b>R7</b>	Atsimo Andrefana	2,8431	1	<b>R12</b>	Bongolava	2,7993	13
<b>R4</b>	Analanjirofo	2,8427	2	<b>R20</b>	Sava	2,7979	14
<b>R11</b>	Boeny	2,8370	3	<b>R8</b>	Atsimo Atsinanana	2,7970	15
<b>R22</b>	Vakinakaratra	2,8356	4	<b>R14</b>	Fitovinany	2,7966	16
<b>R1</b>	Alaotra Mangoro	2,8314	5	<b>R6</b>	Anosy	2,7950	17
<b>R13</b>	Diana	2,8311	6	<b>R5</b>	Androy	2,7948	18
<b>R3</b>	Analamanga	2,8278	7	<b>R15</b>	Haute Matsiatra	2,7895	19
<b>R19</b>	Menabe	2,8218	8	<b>R17</b>	Itasy	2,7433	20
<b>R9</b>	Atsinanana	2,8217	9	<b>R23</b>	Vatovavy	2,6073	21
<b>R21</b>	Sofia	2,8171	10	<b>R2</b>	Amoron'i Mania	2,5964	22
<b>R16</b>	Ihorombe	2,8149	11	<b>R10</b>	Betsiboka	2,5709	23
<b>R18</b>	Melaky	2,8018	12				

To obtain the final score (**Ki**), a three-step process was employed, as outlined in **Eq. (10)**. Initially, the values of **Kia**, **Kib** and **Kic** were combined using the weighted sum algorithm, followed by the weighted product algorithm. Subsequently, the two results are added together. The final score is employed for the purpose of evaluating the regions.

This result presents an innovative approach to evaluating Madagascar's regions in terms of employment, utilising the Malagasy household survey conducted between 2021-2022 and employing the Mean Weight and CoCoFISo methods.

With regard to the technique employed, it is important to emphasise that the resulting score is objective and reflects the reality of the regions in question, as evidenced by the data published by the Institut National de la Statistique de Madagascar in 2024 [32]. Indeed, the Mean Weight method assigned an equal value to all criteria, thereby enabling the CoCoFISo method algorithm to be freely employed throughout the process.

The **Table 5** delineates the subject of our study, namely the specific evaluation of Madagascar's regions regarding the employment sector based on the thirteen criteria selected. According to this result, the Atsimo Andrefana Region (**R7**) was ranked as the best region, while the Bestiboka Region (**R10**) was ranked last.

Consequently, Madagascar's twenty-three regions are ordered from best to worst as follows: Atsimo Andrefana (**1<sup>st</sup>**), Analanjirofo (**2<sup>nd</sup>**), Boeny (**3<sup>rd</sup>**), Vakinakaratra (**4<sup>th</sup>**), Alaotra Mangoro (**5<sup>th</sup>**), Diana (**6<sup>th</sup>**), Analamanga (**7<sup>th</sup>**), Menabe (**8<sup>th</sup>**), Atsinanana (**9<sup>th</sup>**), Sofia (**10<sup>th</sup>**), Ihorombe (**11<sup>th</sup>**), Melaky (**12<sup>th</sup>**), Bongolava (**13<sup>th</sup>**), Sava (**14<sup>th</sup>**), Atsimo Atsinanana (**15<sup>th</sup>**), Fitovinany (**16<sup>th</sup>**), Anosy (**17<sup>th</sup>**), Androy (**18<sup>th</sup>**), Haute Matsiatra (**19<sup>th</sup>**), Itasy (**20<sup>th</sup>**), Vatovavy (**21<sup>st</sup>**), Amoron'i Mania (**22<sup>nd</sup>**) and Betsiboka (**23<sup>rd</sup>**). It would be of interest to analyse this assessment using the CoCoFISo method.

#### 4.2.3. Analysis of the results

To conduct this analysis, it is essential to refer to the performance matrix in **Table 2**, as it provides the initial evaluation data. It should be noted that, in contrast to optimisation methods, which seek to achieve a maximum or minimum result, the outcome of multi-criteria methods represents a satisfactory result, namely a compromise among all the applied criteria.

Therefore, the designation of "best region" does not signify a region with optimal values for all criteria. Instead, it denotes a region that is satisfactory from the perspective of employment in

relation to the values for all criteria. To justify this discrepancy in outcomes, we have extracted from the performance matrix the regions with the highest and lowest values for each criterion and subsequently calculated the mean value for each criterion, as illustrated in **Table 6** below.

**Table 6**  
 Maximum, minimum and average values for criteria

	PAT	TPMO	SP	SS	ST	SEDT	SMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS	
Max <sup>1</sup>	15,60	74,50	84,90	57,00	37,80	19,40	349 941,00	2,40	76,00	51,00	58,70	11,10	21,40	
	R3	R17	R12	R10	R3	R7	R20	R10	R10	R2	R12	R22	R8	
	1,20	40,00	27,20	6,70	8,40	4,00	96 244,00	1,30	0,40	6,00	4,50	0,00	2,60	
Min <sup>2</sup>	R18	R2	R10	R21	R12	R17	R5	R4 R2 R16 R5 R8	R17	R10	R14	R10 R2 R23	R10	
	Ave <sup>3</sup>	4,36	58,17	61,38	15,88	22,75	10,62	185 881,70	1,60	14,60	29,90	37,03	3,07	14,10

<sup>1</sup>Maximum value, <sup>2</sup>Minimum value, <sup>3</sup>Average value

To illustrate, the Betsiboka Region (R10) was ranked last by the CoCoFISo evaluation. As evidenced by **Table 6**, the Betsiboka Region (R10) exhibits the most pronounced advantages in relation to the criteria with the highest values (**SS**, **TMENA**, **ENAPHA**). However, this ranking is a consequence of the necessity to consider all criteria when employing multi-criteria decision-support methods. Additionally, it is noteworthy that this region (R10) exhibits low percentages not only in the primary sector (**SP**), but also in non-agricultural sectors such as industry (**ENAI**), transport and storage (**ENATE**), and other non-agricultural business services (**ENAAS**).

To gain further insight into the circumstances of this region (R10), we have compiled a detailed overview of its performance across all the criteria presented in **Table 7**. This allows us to make a comparative analysis with the values in **Table 6**, thereby elucidating the reasons behind its low ranking in the CoCoFISo assessment of Madagascar's regions.

**Table 7**  
 Situation in Betsiboka Region (R10)

Region	PAT	TPMO	SP	SS	ST	SEDT	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
<b>R10</b>	1,50	59,80	27,20	57,00	15,80	5,50	225 995,00	2,40	76,00	6,00	15,40	0,00	2,60

In summary, with respect to the situation of the Betsiboka Region, as illustrated in Table 7, while it has been ranked last among the other regions, it is crucial to acknowledge that it possesses distinctive characteristics. The average monthly salary (**RSMM**) is 225,995.00 Ariary. This figure is noteworthy because the minimum monthly salary is Ariary. The minimum monthly salary is 96,244.00, while the maximum is 249,941.00. The average monthly salary is 349,941.00.

In terms of sectoral distribution, this region exhibits a notable prevalence of secondary sector activities, accounting for over half of the total. The primary sector, on the other hand, represents approximately a quarter of the total, while the tertiary sector constitutes the remaining portion. This is why primary non-agricultural businesses (**ENAPHA**) accounted for up to 76% of the total, in comparison to other types of non-agricultural businesses (**ENAI**, **ENAC**, **ENATE**, **ENAAS**). It thus appears that there is a dearth of non-agricultural transport and storage businesses (**ENATE**) in this region.

**Table 6** reveals that the Betsiboka Region (R10) has a low percentage (1.50%) of the total population of working age (**PAT**) in Madagascar, while the remaining regions reach up to 15.60%. The population in question exhibits a labour force participation rate (**TPMO**) of 59.80%, accompanied by an underemployment rate linked to working hours of 5.5%. This appears to be an adequate

percentage, given that the minimum is 4%. In all cases, the Betsiboka Region (R10) was assigned the lowest ranking according to the CoCoFISo method.

This allows the position of each region, as ranked by the CoCoFISo method, to be interpreted. We shall now proceed to analyse the results by examining the case of the Atsimo Andrefana Region (R7), which was ranked first in our assessment using the CoCoFISo method. To achieve this, **Table 8** below presents the situation of the region in question regarding all the aforementioned evaluation criteria.

**Table 8**

Situation in Atsimo Andrefana Region (R7)

Region	PAT	TPMO	SP	SS	ST	SED	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R7	6,50	57,40	53,60	17,60	28,80	19,40	192 593,00	1,40	19,00	22,10	41,30	3,40	14,20

As illustrated in **Table 2**, the Atsimo Andrefana Region (R7) is the third region in Madagascar (after Analamanga and Vakinankaratra) with a high working-age population rate (**WAP**) of 6.50%. This contrasts with the minimum rate in Madagascar, which is 1.20%, and the average rate, which is 4.36%. The **Table 8** indicate that 57.40% of the population is engaged in the labour force (**TPMO**). The primary sector (**SP**) remains the dominant economic activity in this region, with a rate of 57.40%. The tertiary sector (**ST**) occupies the second position, with a rate of 28.80%. The remaining activities are situated within the secondary sector (**SS**). Consequently, in this region, 41.30% of non-agricultural businesses are engaged in commerce (**ENAC**), 22.10% in industry (**ENAI**) and 3.40% in transport and storage (**ENATE**). The mean monthly wage income of the population is Ar. 192,593.00, which is higher than the national average. However, this region has a high underemployment rate of 19.40%, making it the region with the highest rate in this study. Furthermore, it was observed that most of the evaluation criteria for this region are higher than the national average. Conversely, certain criteria exhibit a performance that is marginally below the country average, yet markedly above the minimum (**TPMO, SP, TMENA, ENAI**). In light of these considerations, the Atsimo Andrefana Region (R7) emerges as the most exemplary in Madagascar with regard to employment outcomes, as evidenced by the CoCoFISo method.

We will now examine the case of the Analanjirofo Region (R4), which was ranked second in our evaluation based on the selected criteria and the CoCoFISo method. As previously stated, **Table 9** illustrates the situation of this region about all the evaluation criteria.

**Table 9**

Situation in Analanjirofo Region (R4)

Region	PAT	TPMO	SP	SS	ST	SED	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R4	4,60	47,60	49,30	20,20	30,50	13,00	286 099,00	1,30	14,00	27,70	36,10	6,00	16,30

The **Table 9** illustrates that the Analanjirofo Region (R4) is among the regions with the highest average monthly salary income. This represents a sum of 286,099.00 Ariary, which is well above the general average for the country (185,881.70 Ariary) and close to the maximum (349,941.00 Ariary).

The region's working-age population (**PAT**) constitutes 4.60% of the total population, which is slightly higher than the national average (4.36%) and still higher than the minimum (1.20%). A total of 47.60% of the population is engaged in the workforce of its region (**TPMO**). This figure is below the national average (58.17%), but above the regional minimum (40%). In this region, the primary sector is the most prominent, accounting for 49.30% of the total, followed by the tertiary sector (30.50%) and the secondary sector (20.20%).

About non-agricultural businesses, trade is the predominant sector (36.10%), followed by industry (27.70%).

Additionally, the region boasts a presence of businesses in the transport and storage sector (6%). Nevertheless, a considerable proportion of the workforce is engaged in underemployment, with working hours representing a significant contributing factor (13%). What factors contribute to the Analanjirofo Region (R4) ranking second in comparison to the Atsimo Andrefana Region (R7)?

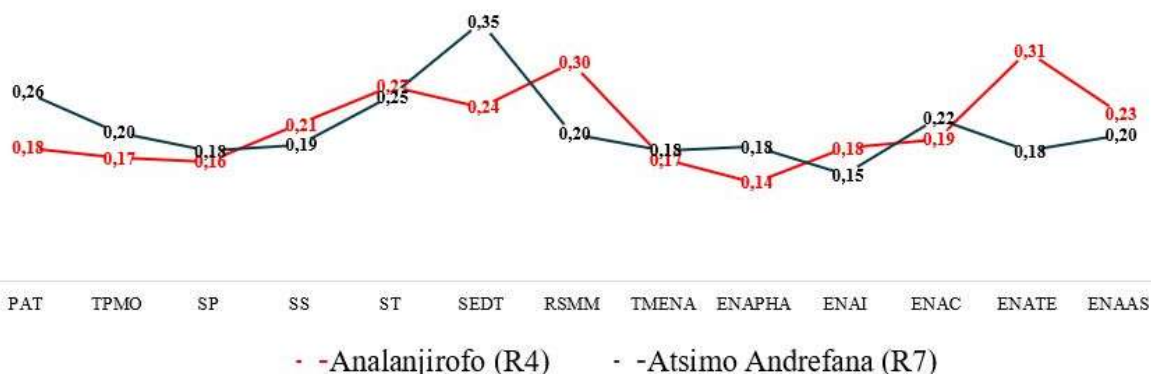
To gain insight into this phenomenon, it is necessary to examine the circumstances prevailing in these two regions (R4 and R7). **Table 10** below presents a synthesis of the data pertaining to these two regions.

**Table 10**

Situation in Analanjirofo Region (R4) and Atsimo Andrefana Region (R7)

Region	PAT	TPMO	SP	SS	ST	SED	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R4	4,60	47,60	49,30	20,20	30,50	13,00	286 099,00	1,30	14,00	27,70	36,10	6,00	16,30
R7	6,50	57,40	53,60	17,60	28,80	19,40	192 593,00	1,40	19,00	22,10	41,30	3,40	14,20

**Table 10** illustrates that these two regions are grouped according to the predominance of sectors of activity, ranging from primary (SP) to tertiary (ST) and secondary (SD). However, the percentage data reveals notable distinctions between the two regions. They also exhibit similarities in the structure of non-agricultural businesses, with trade (ENAC) and industry (ENAI) representing the predominant sectors in varying proportions. To gain a comprehensive understanding of the differences between the two regions, we will utilise the normalized matrix in **Table 3** and examine them in the diagram below.



**Figure 2.** Comparison of R4 and R7 using the normalised matrix

**Figure 2** illustrates that the Analanjirofo Region exhibits superior performance relative to the Atsimo Andrefana Region across six of the thirteen evaluation criteria. Conversely, it is situated within the minority on seven of these criteria. Consequently, the Analanjirofo Region exhibits superior performance in terms of average monthly wage income (RSMM), two sectors of activity (SS and ST), and three types of non-agricultural business, specifically industry (ENAI), transport and storage (ENATE), and other non-agricultural business (ENAAS), when compared to the Atsimo Andrefana Region.

However, the underemployment rate according to working hours (SEDT) in the Analanjirofo Region is relatively low in comparison to that of the Atsimo Andrefana Region, which reflects an advantage for the Analanjirofo Region.

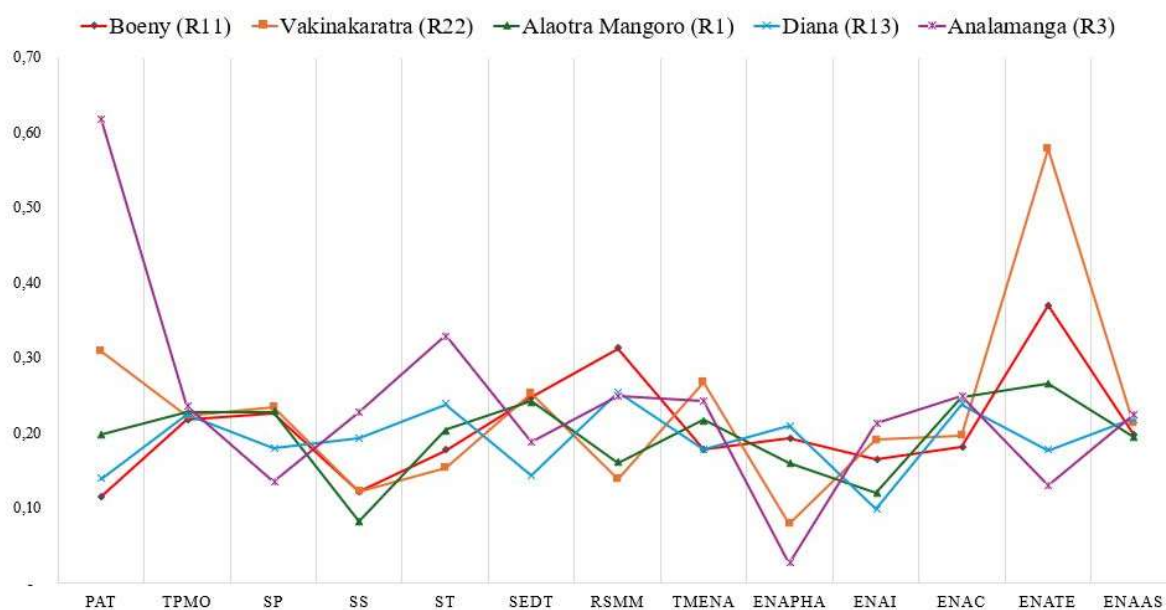
Conversely, the Analanjirofo Region displays deficiencies in comparison to the Atsimo Andrefana Region with respect to the number of individuals of working age (PAT) and the labour force participation rate (TPMO) of this demographic. This is similarly evident in the sectors of activity, including the primary sector (SP) and the three categories of non-agricultural businesses, namely

**TMENA, ENAPHA and ENAC.** Despite the presence of six superior criteria to those of the Atsimo Andrefana Region, the Analanjirofo Region (R4) ranked second when evaluated using the CoCoFISo method, which assesses the value of all thirteen (13) criteria. This result contrasts with the ranking of the Atsimo Andrefana Region (R7), which was first.

The ranking of each region can thus be elucidated by a comparison of the values of the criteria in the performance matrix with those of the others, to ascertain the rationale behind the CoCoFISo method's ranking. To facilitate interpretation and provide decision support to regional managers, the figures below show the fluctuations in the values of the normalised matrix (**Table 3**), which includes five regions and their respective ranks. The use of a diagram to present the normalised matrix in the figures below allows for the visualisation of the situation of a criterion from one region to another.

In other words, this enables the identification of whether a given criterion is present at a higher or lower level in one region than in another. It also allows for the measurement of the number of criteria that differ between regions. However, to correctly interpret the reality of the regions, it is essential to base this analysis on the performance matrix (**Table 2**), which reflects the initial situation of the regions.

**Figure 3** illustrates the fluctuations in the values of the normalised matrix from the third to the seventh position of the regions, specifically Boeny (R11), Vakinakaratra (R22), Alaotra Mangoro (R1), Diana (R13) and Analamanga (R3).



**Figure 3.** Variation in criteria from third to seventh position in the regions

To provide a concise overview of the variation in criteria illustrated in **Figure 3**, the number of higher and lower criteria observed between regions has been tabulated in **Table 11** below. To illustrate, we may consider the case of the Boeny Region (R11), which was ranked third. The region in question exhibits four criteria with higher values than the Vakinakaratra Region (R22), and eight criteria with lower values. In comparison to the Alaotra-Mangoro Region (R1), the Vakinakaratra Region (R22) exhibits six higher and seven lower criteria.

**Table 11**  
 Higher and lower criteria from third to seventh position in the regions

Region	Criteria	Region				
		R11	R22	R1	R13	R3
R11	Higher		4	5	4	5
	lower		8	8	8	8
R22	Higher			6	5	4
	lower			7	8	9
R1	Higher				7	3
	lower				6	10
R13	Higher					4
	lower					9

To gain a deeper comprehension of the higher and lower criteria, and most importantly, their actual values, we have presented the circumstances pertaining to these five regions in **Table 12** below.

**Table 12**  
 Situation in R11, R22, R1, R13 et R3

Region	PAT	TPMO	SP	SS	ST	SEDT	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R11	2,90	61,70	68,30	11,50	20,30	13,60	299 828,00	1,40	20,00	25,10	33,70	7,10	14,10
R22	7,80	63,10	70,80	11,50	17,60	13,90	133 510,00	2,10	8,20	29,10	36,40	11,10	15,10
R1	5,00	64,60	68,80	7,80	23,40	13,30	154 164,00	1,70	16,50	18,40	46,00	5,10	13,90
R13	3,50	63,50	54,40	18,30	27,30	7,90	243 151,00	1,40	21,70	15,00	44,30	3,40	15,60
R3	15,60	66,80	40,70	21,50	37,80	10,30	238 724,00	1,90	2,80	32,50	46,20	2,50	16,00

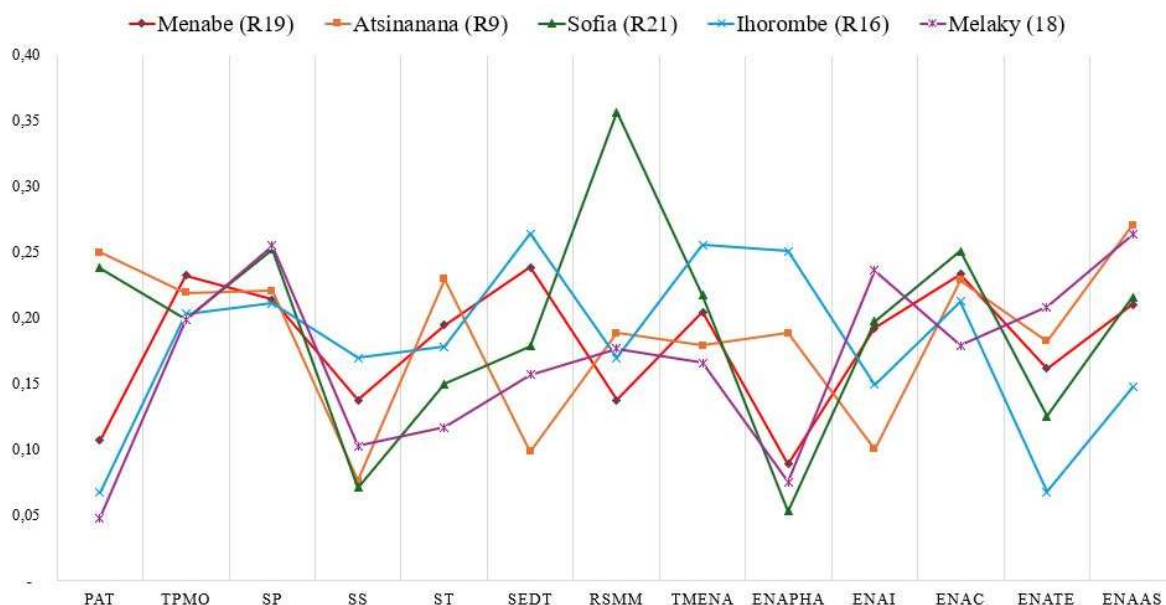
Table 12 reveals that the Boeny Region (R11) exhibits a comparative advantage over the Vakinakaratra Region (R22) with respect to the tertiary sector (**ST**), the rate of underemployment linked to working hours (**SEDT**), average monthly wage income (**RSMM**), which is twice that of Vakinakaratra, and the type of non-agricultural primary business.

Conversely, the data indicates low rates for labour force participation, the primary and secondary sectors, the average size of non-agricultural businesses, and the types of non-agricultural businesses, except for primary non-agricultural businesses. Furthermore, the Boeny Region exhibits a notable average monthly wage income in comparison to the Alaotra Mangoro (R1), Diana (R13) and Analamanga (R3) regions. Furthermore, the five regions (R11, R22, R1, R13, R3) exhibited a comparable pattern in the distribution of activities, with the primary sector, the tertiary sector and the secondary sector receiving successive priority. However, each of these regions has its own particular characteristics.

Given the variation in the criteria values of these five regions, the CoCoFISo method has evaluated and ranked them according to their respective rankings, ranging from third to seventh.

We shall now proceed with the analysis of the regions that were ranked eighth to twelfth in the evaluation. **Figure 4** below illustrates the fluctuations in the values of the normalised matrix for the five regions in question. The regions in question are Menabe (R19), Atsinanana (R9), Sofia (R21), Ihorombe (R16) and Melaky (R18).





**Figure 4.** Variation in criteria from eighth to twelfth position in the regions

A comparison of the Menabe Region (R19) with the Atsinanana Region (R9) reveals six criteria with greater variations and seven criteria with lesser variations. In light of the aforementioned comparison, it can be observed that the Atsinanana Region (R9) exhibits a similar distribution of high and low criteria as the Sofia Region (R21). Conversely, a comparison with the Ihorombe Region (R16) reveals that the Sofia Region (R21) exhibits eight key criteria and five weak criteria.

A comparison between the Ihorombe Region (R16) and the Melaky Region (R18) reveals that seven criteria are of key importance, while six are relatively weak. To obtain further insight into these pivotal and less significant criteria, **Table 13** below provides a detailed account of their respective values.

**Table 13**

Situation in R19, R9, R21, R16 et R18

Region	PAT	TPMO	SP	SS	ST	SEDT	SMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
<b>R19</b>	2,70	65,80	64,60	13,00	22,30	13,10	131 603,00	1,60	9,20	29,30	43,40	3,10	15,00
<b>R9</b>	6,30	62,10	66,50	7,20	26,30	5,40	180 786,00	1,40	19,50	15,30	42,50	3,50	19,30
<b>R21</b>	6,00	56,30	76,10	6,70	17,20	9,80	341 851,00	1,70	5,50	30,10	46,60	2,40	15,40
<b>R16</b>	1,70	57,50	63,70	16,00	20,40	14,50	162 502,00	2,00	26,00	22,80	39,50	1,30	10,50
<b>R18</b>	1,20	56,20	76,90	9,70	13,40	8,60	169 309,00	1,30	7,80	36,00	33,30	4,00	18,80

Firstly, the Menabe, Atsinanana, Sofia, Ihorombe and Melaky regions demonstrate a comparable pattern in terms of the prioritisation of activities according to the type of sector, namely primary (SP), tertiary (ST) and secondary (SS).

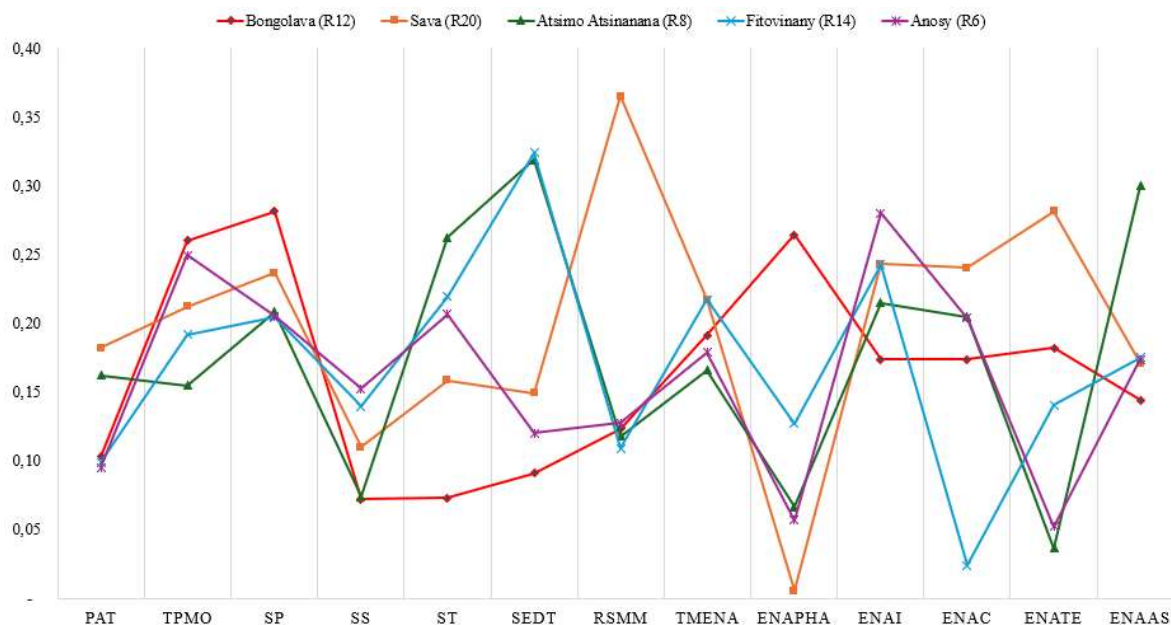
Regarding the specific characteristics of each region, the Menabe region exhibits a higher labour force participation rate (TPMO), whereas the Atsinanana region displays a higher rate of working-age population (PAT) and a higher incidence of working-time-related underemployment (SEDT).

Additionally, the Sofia region exhibits a notably elevated average monthly wage income (RSMM), whereas the Ihorombe region displays a noteworthy average size of non-agricultural businesses.

Consequently, the Ihorombe region exhibits a higher prevalence of primary non-agricultural enterprises (ENAPHA). It is also noteworthy that Melaky has the highest proportion of companies engaged in the transport and storage sector (ENATE). In this manner, the CoCoFISo method has positioned these five regions (R19, R9, R21, R16 and R18) between eighth and twelfth in this

assessment, taking into account the aforementioned variations in the criteria and the distinctive characteristics of each region.

We will now proceed to analyse the results for the regions ranked thirteenth to seventeenth in this assessment. **Figure 5** illustrates the fluctuations in the values of the standardised matrix for the regions: Bongolava (R12), Sava (R20), Atsimo Atsinanana (R8), Fitovinany (R14) and Anosy (R6).



**Figure 5.** Variation in criteria from thirteenth to seventeenth position in the regions

**Figure 5** illustrates that the values of the criteria for each region are dispersed, as none of the lines are stable. A comparison of the Bongolava Region (R12) with the other regions reveals that it has a competitive advantage in terms of the labour force participation rate (**TPMO**), as well as in the primary sector (**SP**), the type of primary non-agricultural business (**ENAPHA**) and underemployment linked to working hours (**SEDT**).

Conversely, the Sava Region (R20) exhibits a notable concentration of the working-age population (**PAT**), a relatively high average monthly wage income (**SRMM**), and a favourable profile in non-agricultural enterprises within the trade (**ENAC**) and transport and storage (**ENATE**) sectors. A relatively small percentage of primary non-agricultural businesses (**ENAPHA**) are present in this region.

About the Atsimo Atsinanana Region (R8), it is notable for its relatively low rate of labour force participation (**TPMO**) and the presence of non-agricultural businesses in the transport and warehousing sectors (**ENATE**).

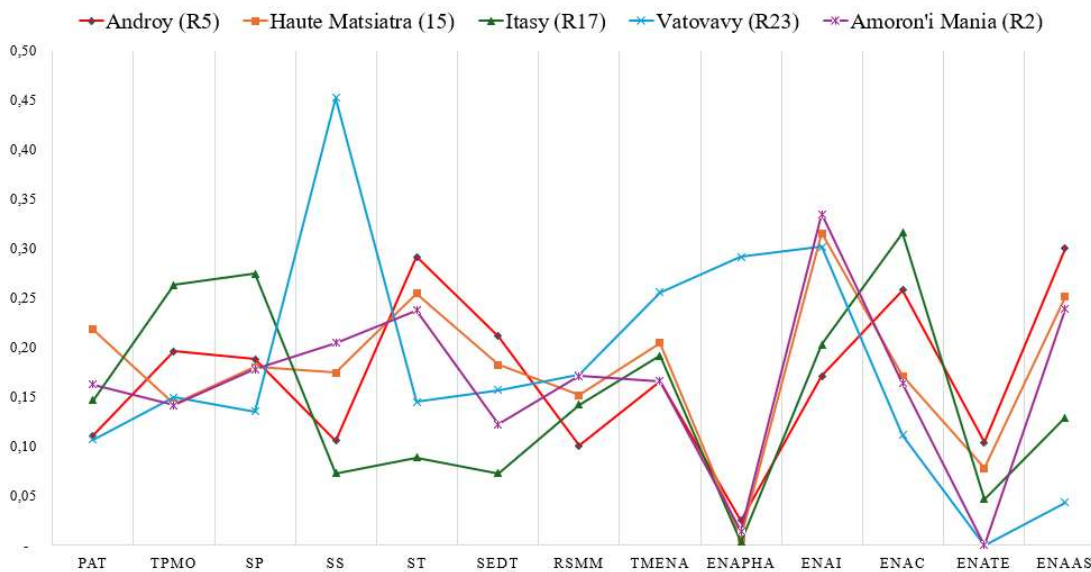
However, it has advantages in the tertiary sector (**ST**) and other non-agricultural business services (**ENAAS**). About the Fitovinany Region (R14), the criteria are, for the most part, characterised by average values in comparison to the other regions. Nevertheless, the high rate of underemployment linked to working hours (**SEDT**) and the low percentage of non-agricultural trade businesses (**ENAC**) do deviate from this trend. In the case of the Anosy Region (R6), the criteria are generally comparable to those observed in other regions, apart from the secondary activity sector (**SS**) and non-agricultural businesses of the industrial type, which exhibit elevated rates.

To facilitate a more detailed comparison of the value of the criteria for these regions, **Table 14** below presents a detailed overview.

**Table 14**  
 Situation in R12, R20, R8, R14 et R6

Region	PAT	TPMO	SP	SS	ST	SED	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R12	2,60	73,70	84,90	6,80	8,40	5,00	118 530,00	1,50	27,40	26,50	32,30	3,50	10,30
R20	4,60	60,10	71,40	10,40	18,20	8,20	349 941,00	1,70	0,60	37,10	44,70	5,40	12,20
R8	4,10	43,90	62,90	7,00	30,10	17,50	112 956,00	1,30	6,90	32,80	38,10	0,70	21,40
R14	2,50	54,30	61,60	13,20	25,20	17,80	104 866,00	1,70	13,20	37,00	4,50	2,70	12,50
R6	2,40	70,70	61,90	14,40	23,70	6,60	122 528,00	1,40	5,90	42,70	37,90	1,00	12,40

To complete this analysis, we will examine the case of the regions which were ranked eighteenth to twenty-second in our evaluation. **Figure 6** illustrates the fluctuations in the values of the normalised matrix of these regions in accordance with the results obtained, including Androy (R5), Haute Matsiatra (R15), Itasy (R17), Vatovavy (R23) and Amoron'i Mania (R2).



**Figure 6.** Variation in criteria from eighteenth to twenty-second position in the regions

Let's start with the Androy region (R5), which is in eighteenth place. It has two favourable criteria and one less important criterion than the other regions. These are the tertiary sector (**ST**), other non-agricultural business services (**ENAAS**) and average monthly wage income (**RSMM**). The region of Haute Matsiatra (**R15**) has an advantage in the share of the working age population. However, its values for the other criteria are average compared with the others.

Next, the Itasy region (R17) has three criteria that are higher than those of the others, such as the employment rate (**TPMO**), activity in the primary sector (**SP**) and non-agricultural commercial enterprises (**ENAC**). On the other hand, it has three criteria that are lower than those of the other regions, namely activity in the secondary sector (**SD**), activity in the tertiary sector (**ST**) and underemployment linked to working time (**SED**T).

The region of Vatovavy (R23), in twenty-first place, has a higher level of activity in the secondary sector (**SD**) than the other regions. In this region, the average size of non-agricultural businesses and primary non-agricultural businesses outside agriculture is considerable. However, the proportion of non-agricultural enterprises in the primary sector (**SP**) and other services is low. For the Amoron'i Mania Region (R2), these criteria have intermediate values compared to the others, except for the employment rate, which is in the minority. In addition, there are no non-agricultural transport and storage enterprises (**ENATE**) in this region, but the proportion of non-agricultural industrial

enterprises is high compared with the other regions. For a more detailed comparison, **Table 15** below shows the actual situation in these five regions.

**Table 15**

Situation in R5, R15, R17, R23 et R2

Region	PAT	TPMO	SP	SS	ST	SEDT	RSMM	TMENA	ENAPHA	ENAI	ENAC	ENATE	ENAAS
R5	2,80	55,50	56,70	10,00	33,40	11,60	96 244,00	1,30	2,60	26,10	47,90	2,00	21,40
R15	5,50	40,60	54,30	16,50	29,20	10,00	145 367,00	1,60	0,80	48,10	31,80	1,50	17,90
R17	3,70	74,50	82,80	6,90	10,20	4,00	135 989,00	1,50	0,40	30,90	58,70	0,90	9,20
R23	2,70	42,30	40,80	42,70	16,60	8,60	164 921,00	2,00	30,20	46,00	20,70	0,00	3,10
R2	4,10	40,00	53,60	19,30	27,20	6,70	163 822,00	1,30	1,50	51,00	30,40	0,00	17,00

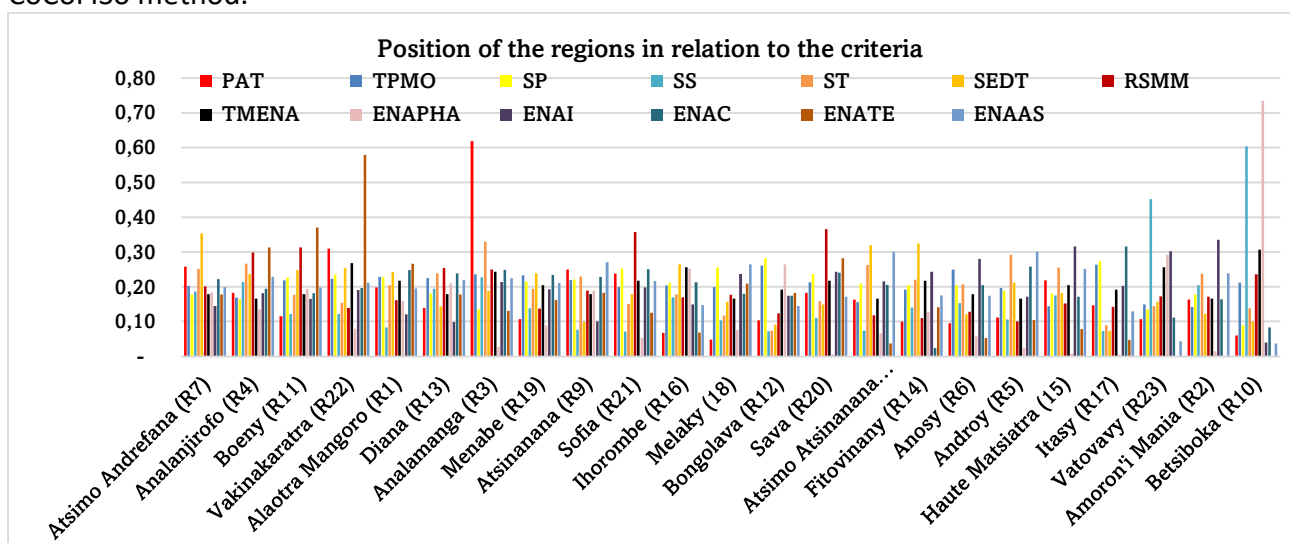
Let's conclude. We'll look at the next section.

### 5. Discussion, conclusion and prospects

The aim of this study is to evaluate the different regions of Madagascar in terms of employment according to several criteria. We therefore used multi-criteria decision support methods to solve this problem. The use of these methods has the advantage of facilitating the management of the criteria according to their weight.

It is therefore essential to select the methods to be used, as the result obtained depends on them. The Mean Weight (MW) method has been chosen to calculate the weights of the criteria, as it allows the weights to be equalised (neutralised) to give a better understanding of the situation of each region according to the value of its criteria.

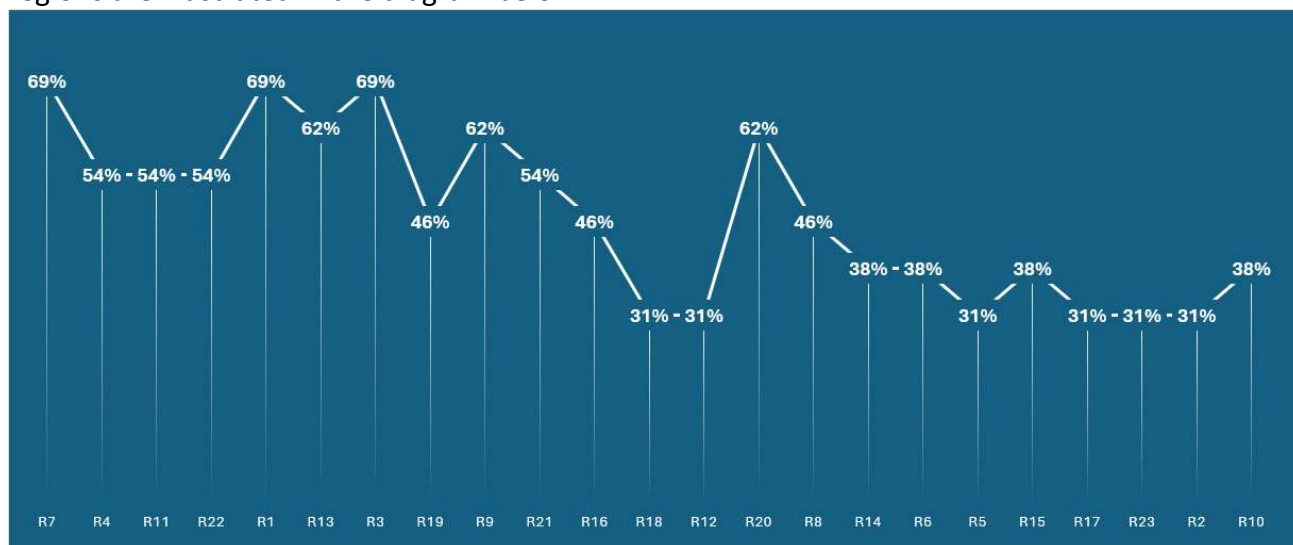
It should be noted that the criteria weights have an impact on the layout of the alternatives (regions). The CoCoFISo method was then used to rank the regions. As this is one of the new multi-criteria decision support methods, it is highly desirable to test it. After using these two methods, we found that the objective had been achieved when we carried out an evaluation of the twenty-three regions of Madagascar. Our study of the results clearly showed that the CoCoFISo method succeeded in classifying the regions, considering the diversity of criteria and the specificity of each region. In summary, **Figure 7** below shows the CoCoFISo ranking of Madagascar's twenty-three regions, from first (Atsimo Andrefana) to last (Betsiboka), according to the thirteen criteria available for evaluation. This figure is based on the matrix normalised according to the regional rankings obtained by the CoCoFISo method.



**Figure 7.** Results of CoCoFISo's assessment of Madagascar's 23 regions

So, just by looking at this figure, we can see that if a region's criteria values are average and not dispersed, it will have a good position in this evaluation. On the other hand, when a region's criteria values are highly variable, it will have no chance of a good ranking. This situation is evoked by the case of the Atsimo Andrefana Region (R7), which was in the lead. This is a region where most of these criteria have average values and are close to each other, except for the rate of underemployment linked to working hours (**SEDT**), which is slightly higher than the others. This contrasts with the Betsiboka Region (R10), where the bars indicating the values of the criteria are extremely different in size. This implies that the values of its criteria are dispersed. We even have one criterion (**ENAPHA**) which is clearly superior to all the other criteria and even to those of the other regions. However, we also noticed the absence of the **ENATE** criterion in this figure for this region. It is a criterion with no value (zero). This is why the Betsiboka Region (R10) was ranked last after the values of these criteria varied.

The graph presented in the following **Figure 8** provides a summary of the rationale behind the assigned rank for each region. The objective of this presentation is to illustrate the percentage of criteria that have values above the average. The regions are arranged in accordance with their respective rankings as determined by our evaluation. In the case of the Atsimo Andrefana region (R7), which occupies the first position, 69% of the criteria exhibit values that exceed the average. Conversely, the Betsiboka Region (R10), which is positioned at the lowest rank, exhibits a considerably lower proportion of criteria with values above the average, at 38%. The remaining regions are illustrated in the diagram below.



**Figure 8.** Percentage of criteria above the average for each region

In this article we have presented a new method for evaluating regions and we have dealt with the case of Madagascar in the context of employment. This study will make it possible to consider the cases of other countries in this field.

For this study, we found it difficult to meet the person in charge of the regions in Madagascar because of his heavy workload. For this reason, we opted for the Mean Weight (WM) method to objectively determine the weight of the criteria. As a result, the criteria were not ranked in order of importance. This represents the extent of the model that has been proposed. This is due to the fact that the implementation of a hierarchical approach to criterion classification will inevitably result in a different outcome. This is the outcome that we have sought to circumvent. It is our contention that the individual tasked with overseeing the regions is in a superior position to evaluate the criteria than we are.

So, regional managers, as decision makers, could be involved in the prioritisation of the criteria by using subjective methods to assess the importance of the criteria in future work. In this way, the criteria will be ranked according to the decision maker. In addition, for Madagascar, a multi-criteria assessment of the regions in sectors other than employment could be envisaged to define the situation of each region.

The application of multi-criteria analysis in several areas will remain a viable option for Madagascar. Among the numerous other entities, the Ministry of National Education is a key partner. In particular, an analysis of the position of each regional directorate of national education with regard to the actual situation of the primary schools, middle schools and high schools that it manages is required. This is crucial for the provision of assistance in the formulation of educational policies at the national level.

### **Conflicts of Interest**

The authors declare no conflicts of interest.

### **Reference**

- [1] INSTAT M. RGPH3 : Etat et Structure de la Population. 2021.
- [2] World Bank. World Bank Open Data. World Bank Open Data 2024. [https://donnees.banquemondiale.org/indicateur/SP.POP.TOTL?locations=MG&most\\_recent\\_year\\_desc=true](https://donnees.banquemondiale.org/indicateur/SP.POP.TOTL?locations=MG&most_recent_year_desc=true) (accessed September 13, 2024).
- [3] Rasoanaivo RG, Yazdani M, Zaraté P, Fateh A. Combined compromise for ideal solution (CoCoFISo): A multi-criteria decision-making based on the CoCoSo method algorithm. *Expert Systems with Applications* 2024;124079. <https://doi.org/10.1016/j.eswa.2024.124079>.
- [4] Rasoanaivo RG, Tata JA. A New Technique of Ranking Madagascar's Universities Using CoCoFISo Method in a Multi-Criteria Decision Support System: MadUrank. *International Journal of Scientific Research in Computer Science and Engineering* 2024;12:18–31.
- [5] Roy B. *Méthodologie multicritère d'aide à la décision*. Paris: Economica; 1985.
- [6] Zadeh L. Optimality and non-scalar-valued performance criteria. *IEEE Transactions on Automatic Control* 1963;8:59–60. <https://doi.org/10.1109/TAC.1963.1105511>.
- [7] Roy B. Classement et choix en présence de points de vue multiples. *Revue Française d'informatique et de Recherche Opérationnelle* 1968;2:57–75.
- [8] Saaty TL. A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology* 1977;15:234–81. [https://doi.org/10.1016/0022-2496\(77\)90033-5](https://doi.org/10.1016/0022-2496(77)90033-5).
- [9] Brans JP, Vincke Ph. Note—A Preference Ranking Organisation Method. *Management Science* 1985;31:647–56. <https://doi.org/10.1287/mnsc.31.6.647>.
- [10] Hoang XT. Multi-Objective Optimization of Turning Process by Fuca Method. *Strojnícky Časopis - Journal of Mechanical Engineering* 2023;73:55–66. <https://doi.org/10.2478/scjme-2023-0005>.
- [11] Mandil ADA, Salih MM, Muhsen YR. Opinion Weight Criteria Method (OWCM): A New Method for Weighting Criteria With Zero Inconsistency. *IEEE Access* 2024;12:5605–16. <https://doi.org/10.1109/ACCESS.2024.3349472>.
- [12] Mardani A, Jusoh A, MD Nor K, Khalifah Z, Zakwan N, Valipour A. Multiple criteria decision-making techniques and their applications – a review of the literature from 2000 to 2014. *Economic Research-Ekonomska Istraživanja* 2015;28:516–71. <https://doi.org/10.1080/1331677X.2015.1075139>.
- [13] Zardari NH, Ahmed K, Shirazi SM, Yusop ZB. *Weighting Methods and their Effects on Multi-Criteria Decision Making Model Outcomes in Water Resources Management*. Cham: Springer International Publishing; 2015. <https://doi.org/10.1007/978-3-319-12586-2>.
- [14] Zavadskas EK, Govindan K, Antucheviciene J, Turskis Z. Hybrid multiple criteria decision-making methods: a review of applications for sustainability issues. *Economic Research-Ekonomska Istraživanja* 2016;29:857–87. <https://doi.org/10.1080/1331677X.2016.1237302>.

- [15] Arslan H. Current classification of multi-criteria decision analysis methods and public sector implementation, 2017, p. 241–61.
- [16] Colapinto C, Jayaraman R, Ben Abdelaziz F, La Torre D. Environmental sustainability and multifaceted development: multi-criteria decision models with applications. *Ann Oper Res* 2020;293:405–32. <https://doi.org/10.1007/s10479-019-03403-y>.
- [17] Sohail SS, Javed Z, Nadeem M, Anwer F, Farhat F, Hussain A, et al. Multi-criteria decision making-based waste management: A bibliometric analysis. *Heliyon* 2023;9. <https://doi.org/10.1016/j.heliyon.2023.e21261>.
- [18] Ashofteh P-S, Pourali Dougaheh M. Ranking the optimal combination of low-impact urban development systems under climate change with the TODIM multi-criteria decision-making method. *Journal of Cleaner Production* 2024;434:140108. <https://doi.org/10.1016/j.jclepro.2023.140108>.
- [19] Sadovnikova N, Savina O, Parygin D, Churakov A, Shuklin A. Application of Scenario Forecasting Methods and Fuzzy Multi-Criteria Modeling in Substantiation of Urban Area Development Strategies. *Information* 2023;14:241. <https://doi.org/10.3390/info14040241>.
- [20] Namazi A, Khodabakhshi M. A novel game theoretic method on fair economic resource allocation with multiple Criteria. *International Journal of Management Science and Engineering Management* 2023;18:170–6. <https://doi.org/10.1080/17509653.2022.2043196>.
- [21] Rasoanaivo RG. Système d'aide à la décision multicritère pour l'allocation de logements étudiants. Thèse. 2023.
- [22] Mahmudah RSN, Putri DI, Abdullah AG, Shafii MA, Hakim DL, Setiadipura T. Developing a Multi-Criteria Decision-Making model for nuclear power plant location selection using Fuzzy Analytic Hierarchy Process and Fuzzy VIKOR methods focused on socio-economic factors. *Cleaner Engineering and Technology* 2024;19:100737. <https://doi.org/10.1016/j.clet.2024.100737>.
- [23] Zhukov RA, Kozlova NO, Manokhin EV, Myasnikova EB, Melay EA. Multi-Criteria Optimization as the Methodology of Ensuring Sustainable Development of Regions: Tula Region of the Russian Federation. | *International Journal of Sustainable Development & Planning* | EBSCOhost 2023;18:1057. <https://doi.org/10.18280/ijstdp.180408>.
- [24] Aragonés-Beltrán P, González-Cruz MC, León-Camargo A, Viñoles-Cebolla R. Assessment of regional development needs according to criteria based on the Sustainable Development Goals in the Meta Region (Colombia). *Sustainable Development* 2023;31:1101–21. <https://doi.org/10.1002/sd.2443>.
- [25] Pereira Barbosa H. Estimer la vulnérabilité des territoires aux impacts potentiels des changements climatiques sur la santé des populations : Développement et application d'un modèle d'aide multicritère à la décision à la région Bretagne, France. These de doctorat. Rennes, École des hautes études en santé publique, 2023.
- [26] Sánchez-Martínez F-I, Abellán-Perpiñán J-M, Martínez-Pérez J-E, Gómez-Torres J-L. Design of a multiple criteria decision analysis framework for prioritizing high-impact health technologies in a regional health service. *International Journal of Technology Assessment in Health Care* 2024;40:e21. <https://doi.org/10.1017/S0266462324000205>.
- [27] Jose E, Agarwal P, Zhuang J, Swaminathan J. A multi-criteria decision making approach to evaluating the performance of Indian railway zones. *Ann Oper Res* 2023;325:1133–68. <https://doi.org/10.1007/s10479-022-04866-2>.
- [28] Roy B. Decision Problems and Processes. In: Roy B, editor. *Multicriteria Methodology for Decision Aiding*, Boston, MA: Springer US; 1996, p. 3–6. [https://doi.org/10.1007/978-1-4757-2500-1\\_1](https://doi.org/10.1007/978-1-4757-2500-1_1).
- [29] Palit D, Prybutok VR. A Comparative Study of the Equal-Weight Method and Hierarchical Risk Parity in Portfolio Construction. *Finance & Economics Review* 2024;6:1–12. <https://doi.org/10.38157/fer.v6i1.609>.
- [30] Butler NA. A new class of equal-weight integration rules on the hypercube. *Numer Math* 2004;99:349–63. <https://doi.org/10.1007/s00211-004-0562-5>.
- [31] Yadav UK, Patnana N, Meena VP, Singh VP. Equal-weight and rank-sum-weight-based systematic diminution of higher-order continuous systems using grey wolf optimisation. *IJMIC* 2023;43:64–79. <https://doi.org/10.1504/IJMIC.2023.132102>.
- [32] INSTAT Madagascar. Enquête permanente auprès des ménages 2021-2022 2024. <https://www.instat.mg/p/epm-enquete-periodique-aupres-des-menages-2021-2022> (accessed August 11, 2024).