Evaluation system of the regional directorates of national education through public primary school resources

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Abstract: Effective resource allocation in the education sector requires a comprehensive understanding of the current situation. This study aims to support the Ministry of National Education in Madagascar in distributing resources more equitably among the 23 Regional Directorates of National Education (DREN). To achieve this, we developed a decision support system (DSS) using the multi-criteria methods Centroidous to assign importance to the criteria and combined compromise for ideal solution (CoCoFISo) to rank the DREN. The evaluation considered nine criteria related to the availability of human and material resources and their impact on student performance in examinations. The system analysed data from primary schools across Madagascar for the 2022–2023 academic year. The Centroidous method prioritise the criteria in divergent manners, thus resulting in fluctuations in the rankings of the DRENs according to the CoCoFISo method. This variation was observed to be contingent upon the criteria weights and the availability of resources in each primary school. Notably, the Analamanga DREN is in a leading position. The analysis revealed that the distribution of resources among the DRENs was found to be inequitable. Consequently, the findings of this study could assist the head of the Ministry of National Education in Madagascar in making more informed and equitable decisions regarding resource allocation.

Keywords: Resource allocation; Primary school; Decision support system; CoCoFISo; Centroidous.

1. Introduction

Primary education constitutes the foundational level of education for most pupils worldwide. The vast majority of a nation's population has previously undergone primary education prior to assuming various roles in the workforce. In certain countries, primary education is compulsory for all children as part of the national education policy (Khan, 1998; Southworth, 2003; Subiyakto & Mutiani, 2020; Vincent, 2021). In Madagascar, statistical data from the 2022-2023 school year pertaining to primary schools offers a comprehensive perspective. The nation currently boasts a total of 27,176 primary schools, encompassing 86,145 classrooms that collectively accommodate 4,108,804 pupils. This indicates a pupil-to-classroom ratio of 47. Among children aged 6 to 10, the net enrolment rate was 97.97%. The proportion of the student population enrolled in primary schools represents 70.81% of the total student population, including pre-school and high school students. The complete set of statistical information is contained in a document entitled "*Annuaire statistique 2022-2023*" (MEN, 2023) which is published annually by the Ministry of Education. This document contains a wealth of information on the static availability of resources for pre-schools, primary schools, secondary schools and high schools in Madagascar.

The present study focuses on analysing the resources available at these primary schools, given that the majority of the population attends them. The central research question that prompted our interest is as follows: would it be feasible to evaluate regional directorates of education using primary school data? If so, what evaluation method would allow all this information to be considered? The intention is to determine the rank of the regional directorates of national education based on the resources available to them individually. This is because the national education directorates, which are spread across all the

regions of Madagascar, aim to successfully implement national education policy.

Nine criteria were identified that illustrate the presence of human and material resources, as well as the success of pupils in examinations. These criteria appeared to be essential and interdependent for the operation and development of primary schools. The absence of material resources would prevent human resources from carrying out their tasks, and conversely, the absence of human resources would render the future of material resources uncertain. It was concluded that the presence of both human and material resources was necessary for the achievement of satisfactory results at the end of each school year.

Given the conflicting criteria, we found that this situation is part of a multi-criteria problem (Bouyssou & Perny, 1997). This is how we decided to apply multi-criteria decision-making methods to evaluate the regional directorates of national education in Madagascar. The literature contains a variety of multi-criteria decision-making methods applied in various sectors. The following are just a few examples. In the context of the efficiency of public procurement, the Technique of Order Preference Similarity to the Ideal Solution (TOPSIS) method was used to evaluate the member countries of the European Union (Milosavljević et al., 2021). The Combined Compromise For Ideal Solution Gray number (CoCoFISo-G) method was used to select organic suppliers (Sen & Toksoy, 2024). The Analytic Hierarchy Process (AHP) and VlšeKriterijuska Optimizacija I Komoromisno Rešenje (VIKOR) methods were used to guarantee the accuracy of a long-range rifle shot (Aleksić et al., 2024). The AHP and Combined Compromise Solution (CoCoSo) methods were combined to optimise the choice of the ideal waste management site (Yazdani et al., 2025). The Mean Weight and Combined Compromise For Ideal Solution (CoCoFISo) methods were used to assess Madagascar's employment regions (Nirinarivelo & Rasoanaivo, 2025). The Centroidous and the Multi-Objective Optimization on the basis of Simple Ratio Analysis (MOOSRA) methods have been used to evaluate the drones (Mohamed et al., 2025a).

Among these methods, the Centroidous (Vinogradova-Zinkevič, 2024) was selected for the prioritisation of criteria, and the CoCoFISo (Rasoanaivo et al., 2024) was employed for the evaluation of regional directorates of national education in the context of this study. This decision was made based on the effectiveness of Centroidous and CoCoFISo in solving multi-criteria problems (Chang, 2025; Fujita, 2025; Mohamed et al., 2025b; Rasoanaivo & Tata, 2024).

The subsequent section presents the algorithmic processes of these two methods. Following this, an analysis of the data is conducted to obtain the evaluation result. Finally, a discussion of the results and a proposal for future work is provided.

2. Research methodology

It is essential to recognize that the implementation of multi-criteria decision support methods relies on establishing of a hierarchical structure for the criteria, prior to the evaluation of the available alternatives. In this section, an exposition is provided on the algorithmic underpinnings of the Centroidous method and the CoCoFISo method, with the objective of elucidating their operational mechanisms. A significant benefit of the Centroidous method is that it avoids the need for the decision-maker to intervene during its use. The approach is founded on the premise of the performance matrix's availability. The CoCoFISo method has been found to be particularly compelling in that it has effectively addressed the limitations of the combined compromise solution method by enhancing the latter's algorithm. Both methods are based on the presence of a performance matrix of *n* criteria and *m* alternatives in **Formula 1** below.

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

2.1 Centroidous method

The Centroidous (Vinogradova-Zinkevič, 2024) method is an objective approach to evaluating the relative importance of criteria. It operates without the need for a decision-maker to establish a hierarchical structure for the criteria. The method is based on the availability of the performance matrix and aims to identify a compromise solution for the weights, based on a centre of gravity of the data for each criterion. The following **Formulas 2 to 6** describes the process.

- Performance matrix normalization using L_1norm

$$\widetilde{x_{ij}} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{2}$$

- Centre of gravity obtained as average of each criterion i

$$c_i = \frac{1}{n}\sum_{j=1}^{n} \widetilde{x_{ij}} \tag{3}$$

- Euclidean distance between the alternative j and centre of gravity

$$d_j = \sqrt{\sum_{i=1}^{m}\left(\widetilde{x_{ij}} - c_i\right)^2} \tag{4}$$

- Euclidean distance normalization

$$\widetilde{d_j} = \frac{j^{\min(d_j)}}{d_j} \tag{5}$$

- Criteria weight

$$w_j = \frac{\widetilde{d_j}}{\sum_{j=1}^{n} \widetilde{d_j}} \tag{6}$$

2.2 CoCoFISo method

CoCoFISo (Rasoanaivo et al., 2024) is a recent multi-criteria decision-making method that has been developed as an improvement on the combined compromise solution method. It is based on the assembly of solutions derived from various multi-criteria methods, and its algorithm is based on four phases detailed in **Formulas 7 to 13** below.

- Performance matrix normalization using L_2 norm

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}(x_{ij})^2}} \tag{7}$$

- Comparability sequence weighting using weighted sum and weighted product

$$S_i = \sum_{j=1}^{n}\left(w_j r_{ij}\right) \tag{8}$$

$$P_i = \sum_{j=1}^{n}(r_{ij})^{w_j} \tag{9}$$

- Deduction of aggregation strategies from comparability sequences

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m}(P_i + S_i)} \tag{10}$$

$$k_{ib} = \left(\frac{S_i + P_i}{1 + \frac{S_i}{1+S_i} + \frac{P_i}{1+P_i}}\right) \tag{11}$$

$$k_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{\left(\lambda \max_i S_i + (1-\lambda)\max_i P_i\right)} \quad (12)$$

$0 \leq \lambda \leq 1;\ \lambda$ is chosen by decision $-$ makers (usually $\lambda = 0.5$).

- Determining the final score

$$k_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}) \quad (13)$$

3. Data and results

In the context of an investigation into the decentralised national education departments present in each region of Madagascar, consultation was made of the information published by the Ministry of National Education on its website[23]. This consultation revealed a document entitled "Annuaire statistique 2022-2023" (MEN, 2023), published on an annual basis[24] by this ministry, which lists the resources available in each district and region of Madagascar, followed by school results. We have chosen to use data from the 2022-2023 school year because it is the most recent information available on this website. In other words, this information reflects the current state of resource availability in schools. Among the information presented in this document, the decision was thus taken to opt for data on primary schools and select nine criteria based on data availability. These criteria fall into three categories, including the availability of material resources, human resources and examination results for each educational establishment. **Table 1** below describes the different criteria we will be using.

Table 1. Description of evaluation criteria

Criteria group	Criretia	Description
Human resource	Student	This is the total number of students enrolled for an academic year in all the primairy schools in each decentralised directorate.
	Teacher	Teachers are distinguished by their employment contract. There are four categories of teacher: those who are civil servants, those on contract paid by the state, those on contract and temporary paid by parents, and those who are volunteers. Given this diversity, the objective of this study is to determine the percentage of teachers paid by the state budget. Therefore, the term "teacher" in this study refers to all civil servants and contract teachers paid by the state, represented as a percentage compared to the other categories.
	Staff	These are the administrative and technical staff responsible for managing primary schools.
Material resource	School	These are the numbers of primary schools operational at each decentralised directorate.
	Classroom	This figure denotes the number of classrooms designated for or allocated to primary schools for a single academic year.
	Board	The quantity of blackboards in each primary school classroom is a matter of interest.
	Seating	This is the total number of existing seats in all the bench tables, which is the capacity for students.

[23] https://www.education.gov.mg/

[24] https://www.education.gov.mg/ressources/annuaires-statistiques/

	Manual	These are textbooks in various subjects provided by the state to primary schools.
Admission	Success	This is the percentage of students admitted to higher classes. Originally, the data concerned the number of students repeating a year, but we have processed them in relation to the number of students enrolled in order to obtain this percentage.

There are twenty-three regional education directorates that require assessment. Each of these directorates is located in a specific region of Madagascar and is designated by the name of the region in which it is situated. **Figure 1** below presents a list of these 23 DRENs in alphabetical order. **Figure 2** below illustrates the twenty-three regions along with their respective criteria values. This figure represents the performance matrix. The screenshot of the system that has been developed is presented herewith.

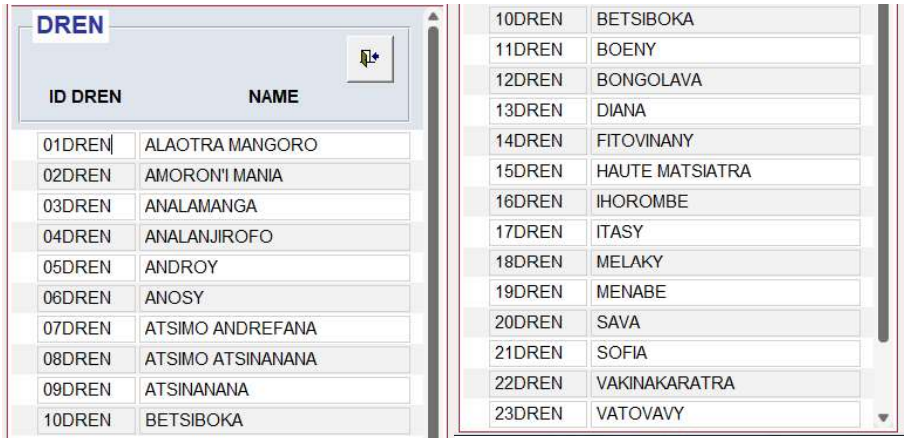
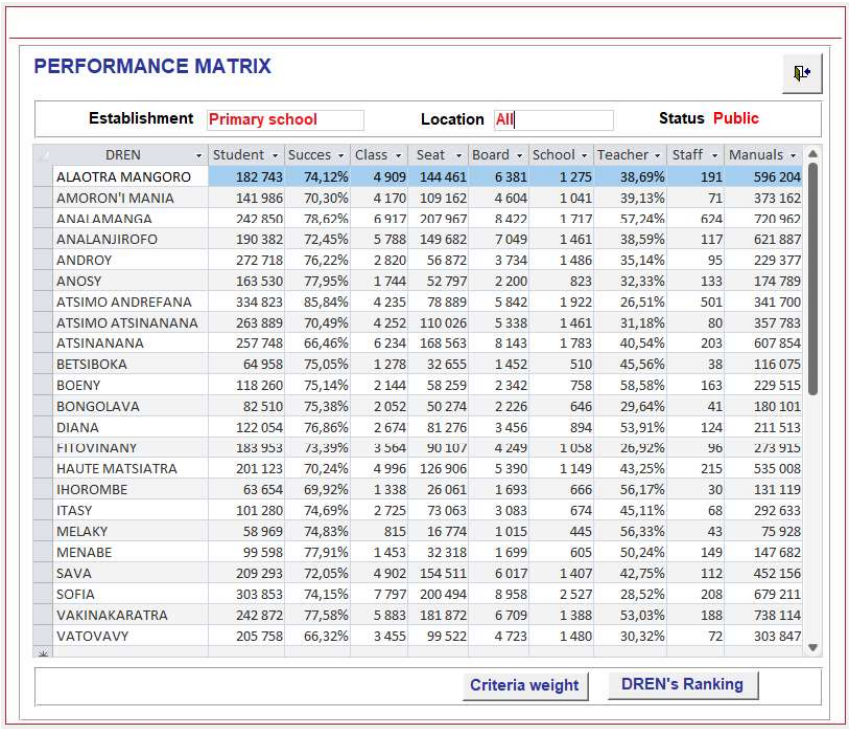


Figure 1. Regional directorates of national education (DREN) in Madagascar



DREN	Student	Succes	Class	Seat	Board	School	Teacher	Staff	Manuals
ALAOTRA MANGORO	182 743	74,12%	4 909	144 461	6 381	1 275	38,69%	191	596 204
AMORON'I MANIA	141 986	70,30%	4 170	109 162	4 604	1 041	39,13%	71	373 162
ANALAMANGA	242 850	78,62%	6 917	207 967	8 422	1 717	57,24%	624	720 962
ANALANJIROFO	190 382	72,45%	5 788	149 682	7 049	1 461	38,59%	117	621 887
ANDROY	272 718	76,22%	2 820	56 872	3 734	1 486	35,14%	95	229 377
ANOSY	163 530	77,95%	1 744	52 797	2 200	823	32,33%	133	174 789
ATSIMO ANDREFANA	334 823	85,84%	4 235	78 889	5 842	1 922	26,51%	501	341 700
ATSIMO ATSINANANA	263 889	70,49%	4 252	110 026	5 338	1 461	31,18%	80	357 783
ATSINANANA	257 748	66,46%	6 234	168 563	8 143	1 783	40,54%	203	607 854
BETSIBOKA	64 958	75,05%	1 278	32 655	1 452	510	45,56%	38	116 075
BOENY	118 260	75,14%	2 144	58 259	2 342	758	58,58%	163	229 515
BONGOLAVA	82 510	75,38%	2 052	50 274	2 226	646	29,64%	41	180 101
DIANA	122 054	76,86%	2 674	81 276	3 456	894	53,91%	124	211 513
FITOVINANY	183 953	73,39%	3 564	90 107	4 249	1 058	26,92%	96	273 915
HAUTE MATSIATRA	201 123	70,24%	4 996	126 906	5 390	1 149	43,25%	215	535 008
IHOROMBE	63 654	69,92%	1 338	26 061	1 693	666	56,17%	30	131 119
ITASY	101 280	74,69%	2 725	73 063	3 083	674	45,11%	68	292 633
MELAKY	58 969	74,83%	815	16 774	1 015	445	56,33%	43	75 928
MENABE	99 598	77,91%	1 453	32 318	1 699	605	50,24%	149	147 682
SAVA	209 293	72,05%	4 902	154 511	6 017	1 407	42,75%	112	452 156
SOFIA	303 853	74,15%	7 797	200 494	8 958	2 527	28,52%	208	679 211
VAKINAKARATRA	242 872	77,58%	5 883	181 872	6 709	1 388	53,03%	188	738 114
VATOVAVY	205 758	66,32%	3 455	99 522	4 723	1 480	30,32%	72	303 847

Figure 2. Performance matrix

Following the implementation of the Centroidous and CoCoFISo algorithms within the system, the

results can be viewed by clicking on one of the Criteria weight or DREN's ranking buttons displayed in **Figure 2** above. Consequently, **Figure 3** below displays the weights of the criteria calculated by the centroid method, and **Figure 4** shows the ranks of the DRENs according to the CoCoFISo method.

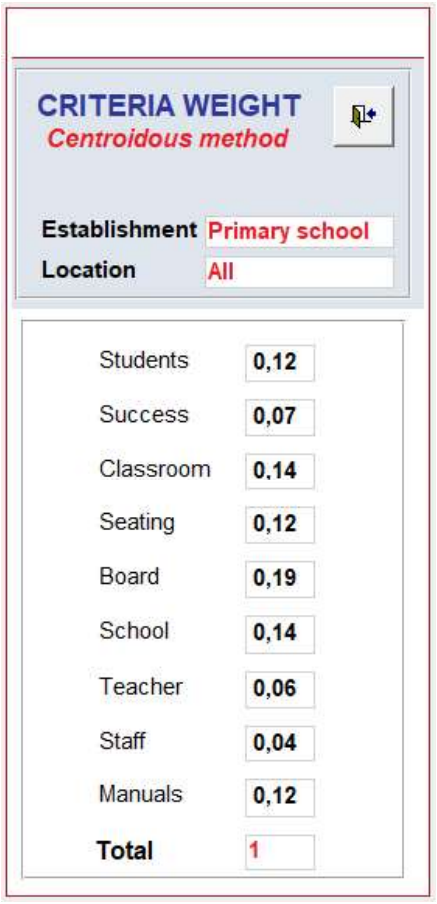
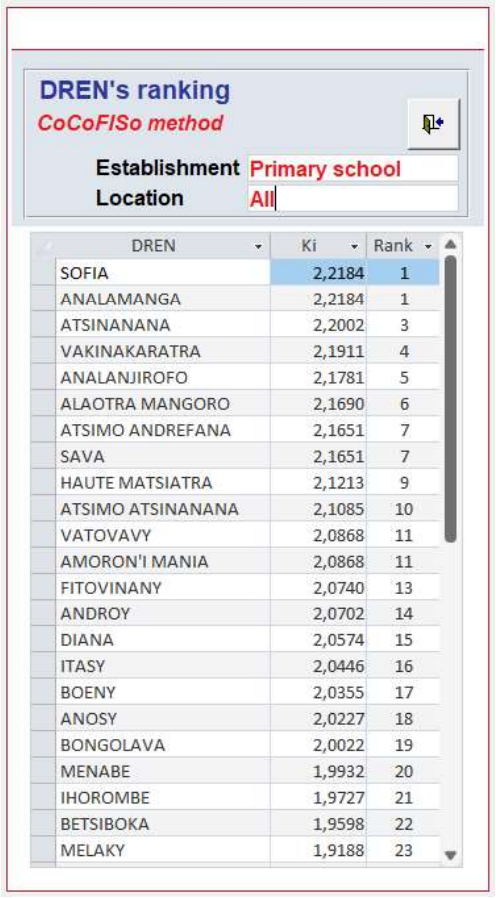


Figure 3. Criteria weight



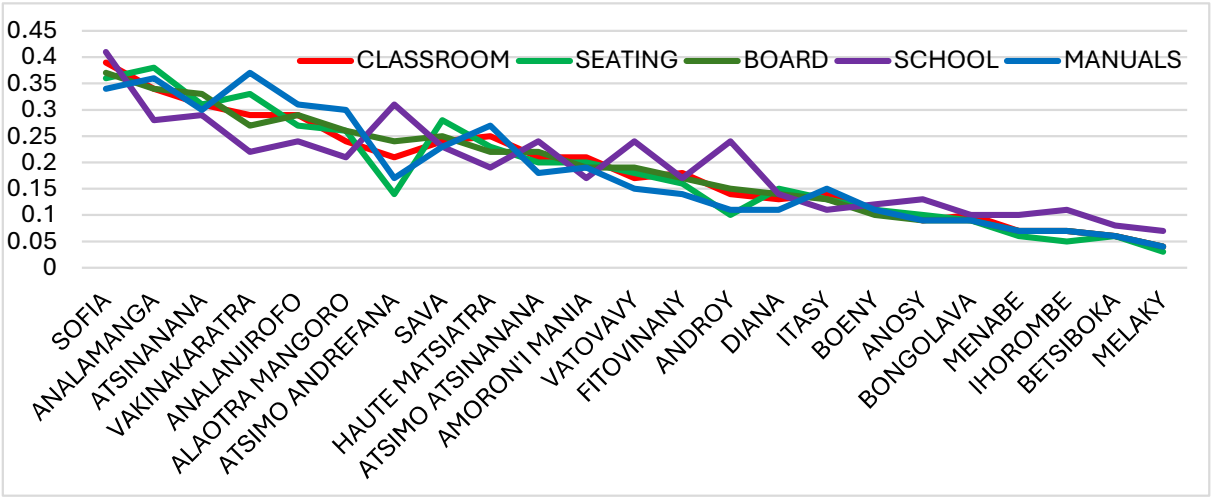
DREN	Ki	Rank
SOFIA	2,2184	1
ANALAMANGA	2,2184	1
ATSINANANA	2,2002	3
VAKINAKARATRA	2,1911	4
ANALANJIROFO	2,1781	5
ALAOTRA MANGORO	2,1690	6
ATSIMO ANDREFANA	2,1651	7
SAVA	2,1651	7
HAUTE MATSIATRA	2,1213	9
ATSIMO ATSINANANA	2,1085	10
VATOVAVY	2,0868	11
AMORON'I MANIA	2,0868	11
FITOVINANY	2,0740	13
ANDROY	2,0702	14
DIANA	2,0574	15
ITASY	2,0446	16
BOENY	2,0355	17
ANOSY	2,0227	18
BONGOLAVA	2,0022	19
MENABE	1,9932	20
IHOROMBE	1,9727	21
BETSIBOKA	1,9598	22
MELAKY	1,9188	23

Figure 4. DREN's ranking by primary school

Following a thorough analysis of the criteria, it is evident that those pertaining to material resources have been accorded a high priority. The *Board* criterion, with a weighting of 0.19, has been prioritised. The *Classroom* and *School* criteria have been allocated a second priority, with an identical weighting of 0.14. The *Seating* and *Manuals* criteria, which both occupy third priority, carry an identical weight of 0.12. At this point, we also identify the presence of the *Students* criterion in the human resources category, which also has a weight of 0.12. On the other hand, the other two human resources criteria have only minor weights, with *Teacher* at 0.06 and *Staff* at 0.04. It is also noteworthy that the *Success* criterion, with a weight of 0.07, holds greater precedence over the other two. As a result, the material resources criterion group has a total weight of 0.71, the human resources criterion group has a weight of 0.22 and admission to the examination has a weight of 0.07.

In accordance with the established criteria weightings (**Figure 3**) and performance matrix (**Figure 2**), the CoCoFISo method was applied to evaluate the twenty-three DRENs, as illustrated in **Figure 4** above. Consequently, the Sofia and Analamanga DRENs were positioned identically, at the top of the evaluation. Subsequently, DREN Atsinanana was placed third. The DREN Vakinakaratra, DREN Analanjirofo and DREN Alaotra Mangoro are positioned in fourth, fifth and sixth place respectively. DREN Atsimo Andrefana and DREN Sava obtained an identical evaluation and were both ranked seventh. DREN Haute Matsiatra and DREN Atsimo Atsinanana are positioned in ninth and tenth place respectively and son on. In contrast, the final five places in the ranking are occupied by the Bongolava DREN, the Menabe DREN, the Ihorombe DREN, the Betsiboka DREN and the Melaky DREN, which respectively occupy the nineteenth and twenty-third rankings.

This ranking is indicative of the availability of resources in the primary school for each DRENs. To illustrate the distribution of material resources among each DREN, reference was made to the normalised matrix obtained using the CoCoFISo method. This is because, due to the various values and units of measurement present in the initial data, the normalised matrix standardises the values of these data between 0 and 1 through its calculation method. **Figure 5** below shows this distribution according



to DREN rank.

Figure 5. Availability of material resources in primary schools for each DRENs

The findings reveal a consistent decrease in material resources from the first to the last rank, suggesting that the Sofia and Analamanga DRENs, occupying the top positions, possess a substantial amount of material resources in comparison to other DRENs.

Conversely, an analysis of the distribution of human resources at each primary school in the DRENs exposes significant variations across different DRENs. The subsequent **Figure 6** provides a visual representation of these variations.

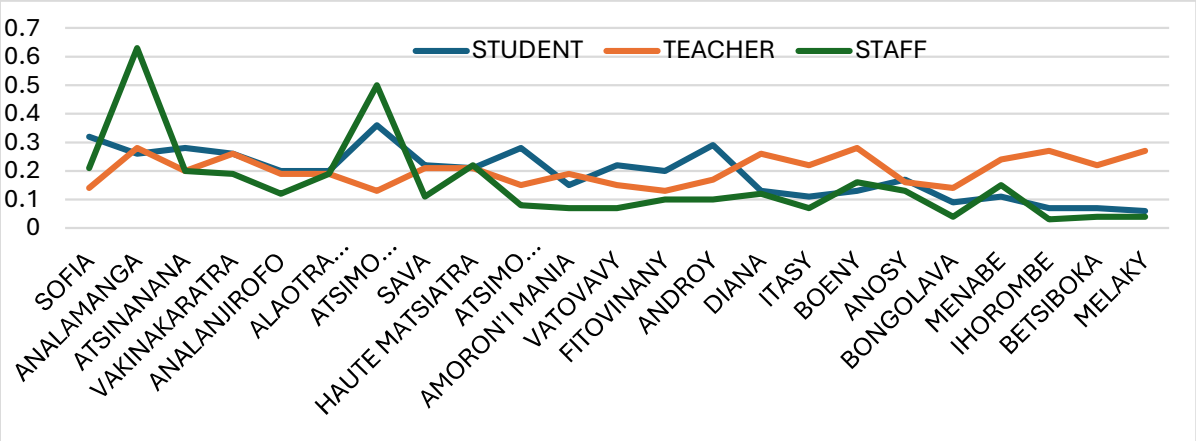


Figure 6. Availability of human resources in primary schools for each DRENs

The reliability of the DREN ranking method is evidenced by the initial weighting of the material resources criterion group at 0.71, in comparison to 0.22 for human resources. This results in a subsequent ranking of DRENs with primary schools that possess significant material resources, placing them higher in the evaluation. This is the reason why we find Melaky DREN at the bottom of our evaluation because these primary schools have low material resources compared to the others according to **Figure 5**.

4. Conclusions

The present study, which is focused on the evaluation of Madagascar's regional directorates of national education in terms of the availability of resources in primary schools, will indubitably be of

great assistance to Ministry of National Education officials when allocating resources. Multi-criteria decision-making methods were implemented based on the current state of human and material resources and examination results in primary schools located within the DREN. The Centroidous method was employed to establish the criteria weights, while the CoCoFISo approach was used to rank the DRENs. The findings demonstrated the efficacy of these two approaches in evaluating DRENs. To enhance the ease of application of these methods, these algorithms were integrated into a decision support system. The result discovered the disparity in the availability of resources between the primary schools in each DREN, in terms of both material and human resources. In this context, the equitable distribution of resources will be possible, thus ensuring that all Malagasy pupils in primary schools have an equal opportunity to access the same education. To illustrate this point, consider the distribution of resources, whether material or human, to primary schools. One approach would be to allocate resources based on the total number of pupils. However, a more comprehensive approach would involve the distribution of material resources to each DREN for primary schools, contingent on the total number of children aged 6 to 10 residing in the respective regions. This ensures that all children have access to educational opportunities. The allocation of human resources will then be based on the availability of material resources.

The present study focuses specifically on the case of public primary schools in Madagascar in order to evaluate the regional directorates of national education. In future research, it would be relevant to also consider the availability of resources in secondary schools and high schools when evaluating the DRENs. Above all, the overall evaluation of the DREN should consider the availability of resources in all three establishments. As soon as the DREN rankings for primary schools, secondary schools and high schools are available, this application will implement a method for aggregating the rankings to obtain an overall assessment of the DRENs. Another research direction could be to develop a decision support system predicting the distribution of resources within each DREN, for primary schools, based on the number of children aged 6 to 10 residing in the region in order to support the Ministry responsible for national education by proposing interventions on equitable education development across Madagascar.

Acknowledgements

The present study is indebted to the Madagascar's Ministry of National Education for its decision to make the statistical yearbooks available to the public. The acquisition of these data was instrumental in the successful execution of the research project.

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