

## Recruitment of research lecturers in Madagascar by a multicriteria group decision support system

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### ABSTRACT

The recruitment of permanent Lecturers for higher education is a major challenge for all universities. Given the absence of defined hiring criteria, this article will suggest some and support the recruitment committees at the Ministry of Higher Education in Madagascar. Three methods will be implemented in a decision support system. Each recruitment committee member will assess the importance of each criterion. The Rank Sum weight method is used to determine the weightings of the criteria. The Combined Compromise for Ideal Solution (CoCoFISo) method ranks the candidates. The Minimum of rank (MIRA) method will aggregate the several rankings of candidates. Three fundamental criteria were selected: experience in university teaching, time elapsed since obtaining the teacher's opinion, and number of research publications. These criteria were assessed according to their importance by six members of the recruitment committee. The weights assigned to the criteria vary from one criterion to another and from one decision-maker to another. Applying these weights to the CoCoFISo method resulted in six rankings of the candidates. The rankings of the candidates varied from one decision-maker to another, except for the candidate in first place and the candidate in last place. The MIRA method successfully merged these six rankings into a final ranking for each candidate. The Kendall rank correlation coefficient between the MIRA method and the six rankings obtained using the CoCoFISo method varies between 0.80 and 0.97, thus confirming the validity of the rankings. This new technique will solve the challenge of hiring temporary lecturers as permanent lecturers in Madagascar universities, thanks to the transparency of the process, and will assist the Ministry of Higher Education in its decision-making.

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### 1. INTRODUCTION

In Madagascar, the recruitment process for a permanent lecturer-researcher position initially takes place at the university and is finalized by the Ministry of Higher Education. At the university, two entities are responsible for processing applications for teaching and research positions: the department and the university president's office. The process begins with the Department, where the candidate submits their application. The Department's college of lecturer-researchers then meets to decide on the application. They assess the application in relation to teaching needs, awarding points for specialization, teaching qualifications, and other criteria. Once the candidate meets the criteria, the college issues a favorable opinion and forwards the application to the university presidency. Otherwise, it informs the candidate of the reason for rejecting their application. The second phase of processing the file is carried out by the university presidency, where the university president generally gives a favorable opinion on the application once it has been approved by the teaching staff. The file then leaves the university and moves on to the next stage at the Ministry of Higher Education. The Ministry is responsible for recruiting lecturer-researchers working in all public universities in

Madagascar. The universities merely propose candidates. It should be noted that recruitment is not based on a competitive examination or interview, but simply on the selection of applications. To approve an application, the Ministry generally bases its decision on the availability of budgetary posts allocated to it and the priorities of the universities. There is also a specialized committee responsible for selecting applications at the Ministry. Once the application has been approved by this committee, it goes through various stages to establish a decree appointing the candidate to the position of permanent lecturer-researcher. Figure 1 below summarises this recruitment process.

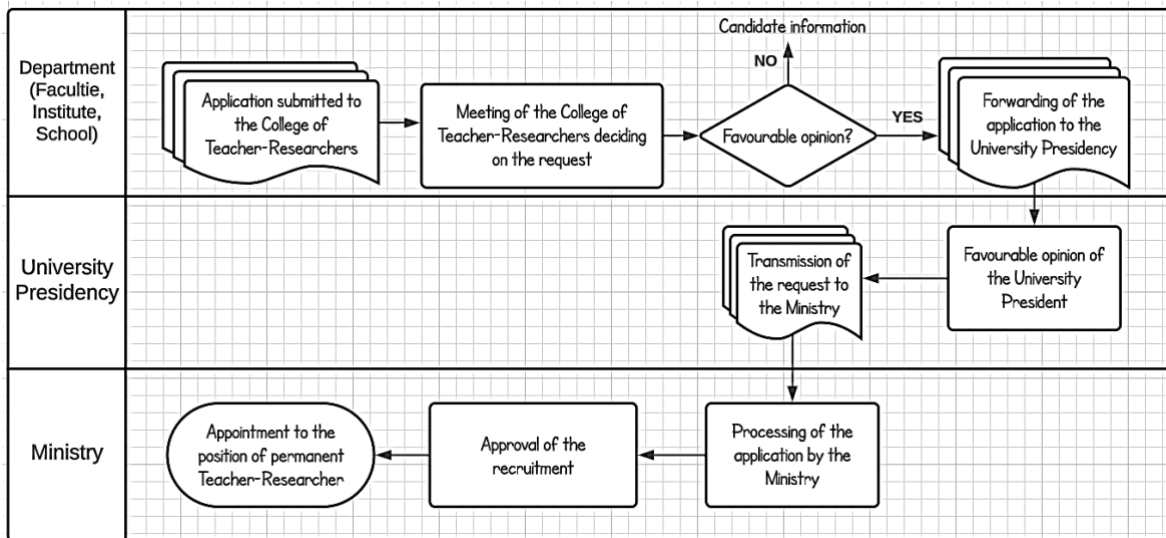


Figure 1. Recruitment process for research professors

It is evident that this process gives rise to recurrent issues, most notably when files are processed by the Ministry. These include the unequal distribution of budgetary posts available at each university and the lack of transparency in the criteria for approving file selection. Regarding the initial problem, certain universities are favored in terms of the number of teachers recruited, while others are neglected. Comparing the two academic years 2021-2022 and 2022-2023, the number of students per teacher varies from 44 to 176 and 54 to 188, respectively. This shows an inequality in the recruitment of teachers at public universities in Madagascar. The low number of students per teacher compared to other universities means that the university in question has more teachers than the other. As a result, the University of Antananarivo remains in first place in the number of teachers recruited, while the University of Fianarantsoa is in last place. The following Figure 2 provides a detailed overview of the situation.

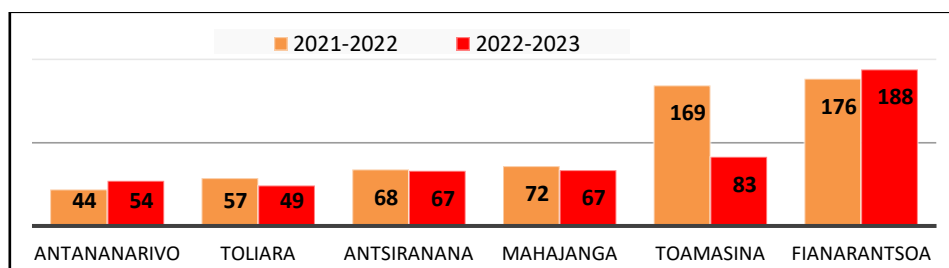


Figure 2. Students assigned by a teacher

A further issue that has been identified in the process of recruiting lecturers-researchers is the absence of a structured candidate selection process. Consequently, a proportion of applications are not processed by the Ministry for extended periods of time. This is due to the committee's failure to consider the date on which the College of lecturers-researchers issued its recommendation. It is notable that some candidates have received a favorable opinion from the College of Teachers at a more recent date than others and have been appointed to the position of teacher-researcher. This situation has been shown to have a detrimental effect on morale and can lead to demotivation among temporary teachers. For the aforementioned reasons, we would like to assist the Ministry of Higher Education in Madagascar during the selection process for validating applications.

Firstly, the fundamental criteria for evaluating the applications received by the Ministry will be proposed. The subsequent stage of the process will be the application of a scientific method that will take into account the various proposed criteria. The implementation of a decision support system is intended to provide a sustainable solution. In the ensuing sections, a concise literature review is presented, wherein the proposed solution is outlined. The methodology to be employed is then selected, and the experimental data and results are analyzed. The study is concluded with the proposition of a new research direction.

## 2. LITERATURE REVIEW

Multicriteria decision-making methods (MCDM) assert that the two applications offered are as follows: firstly, the calculation of the weighting of criteria; and secondly, the evaluation of alternatives. Recent literature reviews have demonstrated the application of these methods in a variety of fields, including cybersecurity [1], the circular economy [2], the industrial environment [3], the supply chain [4], and others [5]. In this section, recent work from 2025 will be cited, with some of these methods being employed in the field of higher education. The multi-criteria methods used by the authors in this context fall into two categories. A distinction is made between methods that calculate the weights of the criteria, including: Analytic Hierarchy Process (AHP), Best-Worst Method (BWM), Criteria importance assessment, Criteria Importance Through Inter-criteria Correlation (CRITIC), Entropy, Logarithmic Percentage Change-driven Objective Weighting (LOPCOW), Measuring-Attractiveness by a Category-Based Evaluation Technique (MACBETH), Measurement of Alternatives and Ranking according to the Compromise Solution (MARCOS), Rank Order Centroid (ROC), Rank Sum (RS). The second category comprises methods that evaluate alternatives, including: COmbinative DIstance-based ASsessment (CODAS), Combined Compromise For Ideal Solution (CoCoFISo), Combined Compromise Solution (CoCoSo), Multi-Attributive Border Approximation area Comparison (MABAC), Multi-Attributive Ideal Real Comparative Assessment (MAIRCA), Multi-Objective Optimization on the basis of a Ratio Analysis plus the full MULTIplicative form (MUTLIMOORA), Occupational Repetitive Actions (OCRA), Preference Panking Organisation Method for Enrichment Evaluations (PROMETHEE), Simple Additive Weightage (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR), Weighted Aggregated Sum Product Assessment (WASPAS), Weighted Product method (WPM). Table 1 below lists the studies that have used these methods.

Table 1. Works using MDCM in higher education

Studies	Criteria Priority	Alternative evaluation	Reference
Faculties evaluation	Spherical Fuzzy AHP, Grey MARCOS, LOPCOW	AHP, TOPSIS	[6]
	MACBETH	Fuzzy Filter Ranking	[7]
University ranking	Rank Order Centroid, Rank Sum	MABAC, MAIRCA	[8]
	Criteria importance assessment	WASPAS	[9]
Quality of teaching	(No method used)	SAW, AHP, TOPSIS	[10]
University development strategy	Entropy	PROMETHEE	[11]
	FullEX, AHP, BWM	(No method used)	[12]
	CRITIC	MULTIMOORA	[13]
Teacher performance	Spherical Fuzzy AHP	Grey MARCOS, Grey OCRA, Fuzzy VIKOR, Fuzzy MARCOS, Fuzzy CoCoSo, Fuzzy MABAC	[14]
Teacher selection	AHP	CODAS	[15]
	(No method used)	Weighted Product method	[16]
Student selection	(No method used)	C-IF CoCoFISo	[17]

In addition to this work, multi-criteria methods have already been used in the recruitment of research professors. Fuzy AHP and Fuzzy TOPSIS were combined to recruit maritime training teachers [18]. An

example of recruiting assistant professors using the method Grey Relational Analysis was proposed [19]. Seven candidates for the position of assistant professor were ranked using the VIKOR method [20]. The application of the AHP method has been proposed for the selection of teachers at Universitas Nahdlatul Ulama Sunan Giri [21]. In order to recruit students for teaching positions, the MAUT method was implemented in the case of Makassar State University [22]. Finally, to recruit excellent lecturers, AHP and TOPSIS methods were used.

Although their research refers to the recruitment of teachers, the techniques selected by the authors are complex for decision-makers to implement, as they are not necessarily experts in multi-criteria decision-making. The AHP method, which is used to determine the weights of the criteria, requires decision-makers to make comparisons between the criteria using a comparison matrix whose number of rows and columns corresponds to the number of criteria. This results in a laborious task for the decision-maker. Particularly for the Fuzzy AHP method, the decision-maker’s workload is tripled as they must assign three values to each criterion. Thus, three evaluations are carried out for each criterion. It is better to look for simple methods to make it easier for decision-makers to take action. Furthermore, all these studies have treated the issue of teacher recruitment as a classic multi-criteria problem involving a decision-making process. It is a group decision-making problem, as it is the committee members who make the decision jointly. It follows that a collective decision-making approach will need to be implemented.

### 3. METHOD

#### 3.1. Selection Process for Researcher-Lecturers

The approach we propose is at the stage where the files of temporary teachers have been submitted to the Ministry of Higher Education. More specifically, with regard to the candidate selection process conducted by the Ministry, which appears somewhat vague. We therefore suggest that the files be managed in three phases once they have arrived at the Ministry.

First, the recruitment committee should organize a meeting to determine the precise criteria for hiring permanent lecturers. Once the criteria have been selected by the committee, each member ranks them from first to last according to their importance. It is preferable to allow each member to rank the criteria according to their own judgment to avoid differences of opinion among the team. This is the interest of group decision-making, where several decision-makers participate in the evaluation of the criteria. Obviously, the evaluation will vary for each member. The weighting of the criteria is determined by applying a multi-criteria approach. The various weightings of the criteria are noted according to the number of members in the committee. These criteria weights will be essential for the rest of the process.

The next step involves evaluating temporary teachers according to criteria determined by the members. The first phase consists of establishing the performance matrix, which is the goal of categorising temporary teachers. This grid simply represents the candidates' positions according to all of the criteria. At this point, we recommend developing a performance matrix for each university in order to rank candidates for each one. It is therefore essential to apply another multicriteria decision-making method considering the various weights of the criteria obtained in the previous step to rank candidates. Ultimately, for each university, we have various rankings of candidates based on the number of committee members who evaluated the criteria. This is how we obtain the initial ranking of candidates.

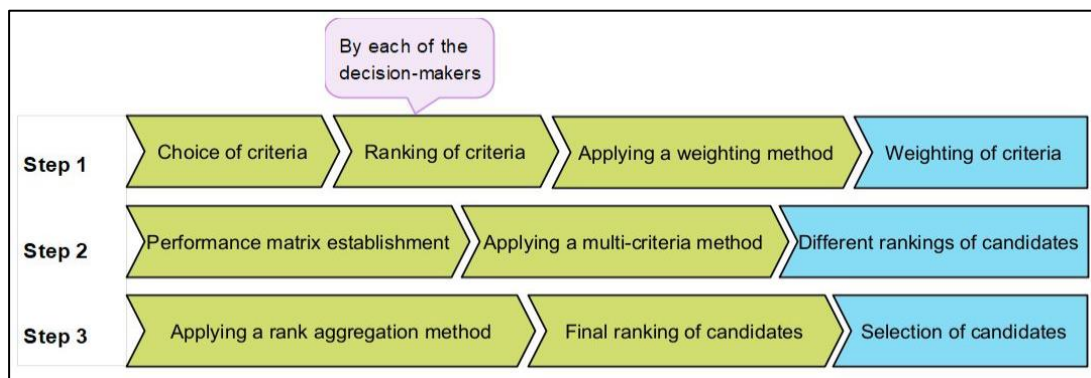


Figure 3. Proposed recruitment process for research lecturers at the Ministry

The final step is to consider all the previous candidate rankings and consolidate them to establish the final ranking of teachers to be hired. A ranking aggregation method must therefore be applied to aggregate the candidate rankings. Following this phase, we now have the final ranking of temporary teachers by university. The method we suggest begins with the selection of evaluation criteria for temporary teachers by the

committee. It gives committee members a certain degree of autonomy to prioritize the criteria according to their preferences and rank candidates according to their specific context. The following Figure 3 summarises this method.

### 3.2. Choice of multi-criteria methods

As each phase requires the use of an appropriate method according to the three phases to follow, this involves applying three distinct methods. There are many multi-criteria methods, but we will have to select some. Therefore, based on a review of the literature, we chose the Rank Sum weight method [23], the Combined Compromise For Ideal Solution (CoCoFISo) method [24], and the Minimum of Rank (MIRA) method [25]. For the first time in the field of multi-criteria decision support, this research will apply all three of these methods simultaneously. This in itself represents a significant step forward in the application of these techniques.

The selection of each of these methods has aroused our interest, as it is essential to involve decision-makers in the recruitment process from the outset. The choice of the Rank Sum method is justified by the fact that it belongs to the category of subjective methods. The CoCoFISo method differs from other multi-criteria approaches by combining various techniques from different methods to arrive at a compromise solution. And the MIRA method, which takes into account all the rankings produced by the multi-criteria methods.

We opted for the Rank Sum weight method to determine the weighting of criteria, due to its simplicity and effectiveness, in order to involve each decision-maker in establishing the hierarchy of criteria. Recent research comparing methods for calculating criterion weights has shown that the Rank Sum method is among those that come closest to the optimal solution [26]. The process for this method begins by ranking the criteria from first to last (1, ... n), according to their importance to the decision-maker (each member in our case). Once the classification has been obtained, the following equation (1) is used to determine the weights of the criteria. Here  $r_j$  is the rank of the  $j^{\text{th}}$  criterion and  $j = 1, \dots, n$ .

$$w_j = \frac{n-r_j+1}{\sum_{k=1}^n n-r_k+1} \quad (1)$$

We chose the CoCoFISo method primarily to rank candidates, based on its ability to solve multi-criteria problems in several areas [27][28][29]. Therefore, recruitment is the first trial of the CoCoFISo method. In order to apply the CoCoFISo method, it is essential to arrange the weights of the criteria, verifying the condition shown in equation (1). For the first time, we have the performance matrix made up of n criteria and m alternatives, as shown in equation (2) below.

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

This is how we can proceed with the various steps of the method presented in equations (3) to (9) below. Performance matrix normalization is obtained using equation (3). Comparability sequence weighting is calculated using equations (4) and (5).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m (x_{ij})^2}} \quad (3)$$

$$S_i = \sum_{j=1}^n (w_j r_{ij}) \quad (4)$$

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

Deduction of aggregation strategies from comparability sequences yields the following three equations (6), (7), and (8).

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^m (P_i + S_i)} \quad (6)$$

$$k_{ib} = \left( \frac{S_i + P_i}{1 + \frac{S_i}{1+S_i} + \frac{P_i}{1+P_i}} \right) \quad (7)$$

$$k_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{(\lambda \max S_i + (1-\lambda) \max P_i)} \quad (8)$$

where  $0 \leq \lambda \leq 1$ ;  $\lambda$  is chosen by decision-makers (usually  $\lambda = 0.5$ ). Equation (9) below is used to determine the final score.

$$k_i = (k_{ia} k_{ib} k_{ic})^{\frac{1}{3}} + \frac{1}{3} (k_{ia} + k_{ib} + k_{ic}) \quad (9)$$

In addition, the MIRA approach will be used to obtain the final ranking of candidates. In fact, to its success in group decision-making, its specificity lies in the consideration of candidate evaluations carried out using the CoCoFISo method. In order to aggregate the different ranks, it is essential to form a composite rank matrix consisting of the  $d$  ranks of the  $m$  candidates. Where  $d$  rank represents the ranking result of the  $m$  candidates using the CoCoFISo method according to the decision-makers, as shown in the following equation (10).

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \dots & r_{1d} \\ r_{21} & r_{22} & r_{23} & \dots & r_{2d} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & r_{m3} & \dots & r_{md} \end{bmatrix} \quad (10)$$

The MIRA method algorithm suggests examining the correlations of the various ranks before and after their aggregation to determine whether the ranks to be aggregated have the same correlation or not. Below is the equation (11) used to calculate the Kendall's correlation coefficient test, and equation (12) to obtain the rank aggregation. Where  $con$  is the number of concordant pairs,  $dis$  is the number of discordant pairs, and  $m$  is the number of alternatives.

$$k = \frac{2(con - dis)}{m(m-1)} \quad (11)$$

$$M_i^+ = \sum_{j=1}^d r_{ij} \quad (12)$$

To obtain the final score for the alternatives using the MIRA method, equation (12) below will be used. For the MIRA method, alternatives with low scores are ranked higher.

### 3.3. Data

For confidentiality reasons, the data we will use refers to the situation of temporary teachers. This is fictitious data that we have created. Nevertheless, it reflects the real situation of temporary teachers. In this article, three potential criteria have been taken into account to develop a new recruitment technique that prioritizes transparency and equal treatment when recruiting temporary teachers for permanent teaching positions. In Madagascar, there are three types of qualifications that allow candidates to apply for Teacher-researcher positions: the Master's degree, the Doctorate, and the Accreditation to Supervise Research (HDR). These qualifications confer the titles of Higher Education Assistant, Senior Lecturer, and Professor, respectively. Normally, direct recruitment of a teacher-researcher is based on the first two degrees mentioned above. The third degree is intended for Teacher-researchers who already hold the grade of Senior Lecturer. We propose that recruitment be specified according to the teacher's grade. Therefore, regardless of the grade, it is always possible to take into account the criteria that we propose below because they consider the wishes of the members of the Association of Temporary Lecturers in Higher Education in Madagascar (AEVESM), but we have added a criterion relating to the candidate's research qualifications.

The first criterion is seniority in terms of the month of part-time teaching (TS). This is calculated based on the start date of teaching (SDT) in relation to today's date (TD), presented in equation (13) below. Today's date refers to the date on which the commission at the Ministry meets to decide on recruitment.

$$\text{Teaching seniority (TS)} = \text{today's date} - \text{start date of teaching} \quad (13)$$

The second criterion is seniority in terms of months since receiving a favorable opinion from the College of Teacher-Researchers (COS). This will be calculated based on the date of the favorable opinion from the College (COD) in relation to today's date (TD), as shown in equation (14) below.

$$\text{College's opinion seniority (COS)} = \text{today's date} - \text{College's opinion date} \quad (14)$$

As there is not yet a committee to assess the research quality of prospective teachers, we nevertheless propose the third criterion relating to the candidate's publications. In this case, candidates must provide references for their publications with their application in order to verify their number. This third criterion is the number of research publications produced by the candidate. It will be possible to add other criteria; those we have chosen are the basic ones.

In response to the challenges associated with recruiting permanent lecturers in higher education, the Association of Temporary Lecturers in Higher Education in Madagascar (AEVESM) was recently established and is now active in all of Madagascar's public universities. This association has called for the recruitment process to be made more transparent by providing a list of temporary lecturers to each university department. This list clearly states, for each temporary lecturer, the date on which they began their role as a temporary lecturer, as well as the date on which the Teaching Staff Committee gave a favorable recommendation. This is done with the aim of taking these circumstances into account when selecting applications for the recruitment of lecturers. In response to the AEVESM's request, we have proposed these criteria to meet the expectations of temporary teachers. Furthermore, these fundamental criteria must be taken into account.

Let us assume that the Ministry received 20 applications for the position of Senior Lecturer at a university. The Recruitment Committee meeting was held on 12 February 2026. There were six participants at the meeting. According to Table 2 below, each member ranked the three criteria differently in terms of priority.

Table 2. Priority of criteria by decision-makers (DM)

DM	Teaching seniority	The college's opinion of seniority	Publications
DM 1	1	2	3
DM 2	1	3	2
DM 3	2	1	3
DM 4	2	3	1
DM 5	3	1	2
DM 6	3	2	1

The ranking of the criteria carried out by the committee members will be useful for calculating the weighting of the criteria at a later stage. We then need to assess each candidate's standing in relation to the various criteria. Thus, Table 3 below shows the position of the 20 candidates in relation to the criteria mentioned by the committee.

Table 3. File received from the Ministry

Teacher	Start date of teaching	College's date opinion	Publications
E1	12/03/2013	29/11/2014	2
E2	15/12/2013	13/07/2015	4
E3	25/08/2021	30/11/2022	5
E4	10/05/2010	14/03/2011	2
E5	23/11/2014	12/12/2014	3
E6	02/02/2017	27/03/2018	6
E7	26/05/2018	03/02/2019	7
E8	15/06/2020	09/07/2023	5
E9	10/09/2010	23/06/2014	8
E10	13/04/2024	14/08/2024	6
E11	24/03/2014	17/05/2014	2
E12	07/01/2021	08/06/2022	3
E13	08/08/2015	07/12/2014	2

E14	09/07/2016	23/05/2017	5
E15	07/03/2023	25/09/2013	4
E16	09/02/2015	24/05/2014	6
E17	09/03/2019	23/01/2019	7
E18	24/07/2017	04/02/2017	2
E19	05/03/2022	15/12/2021	3
E20	23/04/2024	15/02/2024	9

Using the data in Table 3 and applying the formulas in equations (13) and (14), we can calculate the teaching seniority and the opinions of the teachers on the candidates' seniority. With this information, we are able to develop a performance matrix highlighting the seniority of these temporary teachers. This performance matrix is illustrated in the following Table 4, which takes the form of the mathematical formulas in equation (2). It will form the basis of our assessment.

Table 4. Performance matrix

Teacher	Teaching seniority	The college's opinion of seniority	Publications
E1	155	134	2
E2	145	126	4
E3	53	38	5
E4	189	178	2
E5	134	134	3
E6	108	94	6
E7	92	84	7
E8	67	31	5
E9	185	139	8
E10	21	17	6
E11	142	140	2
E12	61	44	3
E13	126	134	2
E14	115	104	5
E15	35	148	4
E16	132	140	6
E17	83	84	7
E18	102	108	2
E19	47	49	3
E20	21	23	9

We have noted that candidates' circumstances vary. Their teaching seniority in higher education ranges from 21 to 189 months. On the other hand, the favorable opinion from the College of teacher-Researchers' seniority ranges from 17 to 178 months. The number of articles published by the candidates ranges from 2 to 9. Consequently, it is difficult to select which teachers to hire without applying specific methods. This is because there are candidates with extensive teaching experience and a long track record of receiving a favorable opinion from the College of Teacher-Researchers, yet who have few publications (example: E1, E4, E9). Furthermore, there are many applicants who have extensive teaching experience and many published articles to their name. However, they have only just received a favorable opinion from the College of Teacher-Researchers (example: E3, E8, E10). We also see candidates who, although they have published numerous articles and previously received a favorable opinion from the College of Teacher-Researchers, have less teaching experience (example: E15, E16, E20). Furthermore, given the complexity of the selection process, we will attempt to assist the recruitment committee by presenting a ranking of the 20 candidates in the following section.

#### 4. RESULTS AND DISCUSSION

We will present the results sequentially. Starting with the calculation of criterion weights using the Rank Sum weight method, based on decision-makers' priorities, moving on to the use of these weights in the performance matrix via the application of the CoCoFISo method, and finally to the synthesis of ranks using the MIRA method.

#### 4.1. Weighting of criteria using the Rank Sum weight method

To determine the weights of the criteria, the importance given to each of them by the six decision-makers was considered, applying mathematical formulas in equation (1) of the Rank Sum weight method. There are three distinct weights for the criteria, namely 0.17, 0.33, and 0.50, which differ from one criterion to another and from one decision-maker to another. The following Table 5 illustrates these weights according to the priority given by the decision-makers.

Table 5. Weighting of criteria

DM	Teaching seniority (TS)	College's opinion seniority (COS)	Publications
DM 1	0,50	0,33	0,17
DM 2	0,50	0,17	0,33
DM 3	0,33	0,50	0,17
DM 4	0,33	0,17	0,50
DM 5	0,17	0,50	0,33
DM 6	0,17	0,33	0,50

The varying weights given to the criteria illustrate the different perspectives of the committee members during the meeting. These are contradictory concepts, as the criteria vary in importance depending on the decision-maker. DM1 and DM2 seem to agree on the paramount importance of teaching experience over other criteria. They have confidence that professional experience is essential for a university teaching position. However, they have differing opinions on the importance of publication and the opinion of the Teaching Council. DM2 thinks that the dissemination of research is paramount compared to the opinion of the Teaching Council, while DM1 believes the opposite. Furthermore, DM3 and DM5 placed great importance on obtaining the opinion of the College of Teachers in order to gain access to the position of university lecturer. Subsequently, DM3 emphasized the importance of professional teaching experience, which contrasts with DM2's focus on research publication. Unlike these four decision-makers, DM4 and DM6 place strong emphasis on publishing research in order to obtain a position as a lecturer-researcher, as their names suggest. In addition to this research, according to DM6, the opinion of the College of Lecturers is more important than professional teaching experience, which distinguishes it from DM4. It is therefore essential to consider this diversity of ideas as an asset when hiring research lecturers. That is why we will take all these criterion weights into account when reviewing these 20 candidates.

#### 4.2. Ranking candidates using the CoCoFISo method

We then applied the CoCoFISo method by successively applying the mathematical formulas in equations (3) to (9), based solely on the performance matrix, to each of the six weights of the criteria determined by the priority of decision-makers. As a result, we obtained six separate scores based on the CoCoFISo method for each candidate, in accordance with the six decision-makers. These scores are shown in the following Table 6.

Table 6. Score of candidates using the CoCoFISo method

Candidat	DM1	DM2	DM3	DM4	DM5	DM6
E1	1,071	1,027	1,072	1,002	1,026	1,001
E2	1,095	1,074	1,096	1,060	1,075	1,061
E3	0,861	0,890	0,863	0,903	0,890	0,902
E4	1,149	1,088	1,153	1,054	1,096	1,058
E5	1,071	1,037	1,077	1,021	1,050	1,028
E6	1,044	1,053	1,046	1,061	1,057	1,062
E7	1,022	1,044	1,025	1,061	1,051	1,065
E8	0,870	0,902	0,870	0,913	0,889	0,901
E9	1,207	1,213	1,201	1,212	1,200	1,205
E10	0,753	0,802	0,757	0,823	0,809	0,826
E11	1,061	1,015	1,067	0,993	1,027	1,000
E12	0,851	0,857	0,852	0,859	0,856	0,856
E13	1,036	0,992	1,044	0,974	1,010	0,985

E14	1,050	1,047	1,053	1,047	1,053	1,050
E15	0,952	0,922	0,982	0,932	1,008	0,988
E16	1,123	1,114	1,132	1,115	1,133	1,126
E17	1,009	1,031	1,014	1,051	1,044	1,058
E18	0,977	0,943	0,984	0,932	0,959	0,941
E19	0,835	0,839	0,839	0,843	0,849	0,849
E20	0,807	0,876	0,810	0,916	0,886	0,923

These scores result in the candidates being ranked according to the order of priority of the six decision-makers. This leads us to assign six ranks to each candidate. Table 7 illustrates the various rankings of candidates for the position of permanent research professor.

Table 7. Ranking of candidates using the CoCoFISo method

Candidate	DM1	DM2	DM3	DM4	DM5	DM6
E9	1	1	1	1	1	1
E4	2	3	2	6	3	6
E16	3	2	3	2	2	2
E2	4	4	4	5	4	5
E1	5	10	6	10	11	10
E5	6	8	5	9	8	9
E11	7	11	7	11	10	11
E14	8	6	8	8	6	8
E6	9	5	9	4	5	4
E13	10	12	10	12	12	13
E7	11	7	11	3	7	3
E17	12	9	12	7	9	7
E18	13	13	13	14	14	14
E15	14	14	14	13	13	12
E8	15	15	15	16	16	17
E3	16	16	16	17	15	16
E12	17	18	17	18	18	18
E19	18	19	18	19	19	19
E20	19	17	19	15	17	15
E10	20	20	20	20	20	20

Due to the varying weightings of the criteria and the different situations of the candidates, a disparity in the rankings can be observed. Only candidate E9, in first place, and candidate E10, in last place, managed to maintain their positions despite the different priorities given to the criteria by the decision-makers. For the other applicants, the stability of their positions varies between 4, 3, and 2 in relation to the decision-makers, with six candidates at each level of stability. E16 ranks second among candidates with four stable positions, and E2 ranks fourth, E14 ranks eighth, E3 ranks sixteenth, E12 ranks eighteenth, and E19 ranks nineteenth. On the other hand, the group of candidates with three stable positions includes E1 in tenth place, E11 in eleventh place, E13 in twelfth place, E18 in thirteenth and fourteenth place simultaneously, E15 in fourteenth place, and E8 in fifteenth place. On the other hand, the six candidates we are going to mention only have two consistent rankings, with one to three positions. It is worth noting that E4 ranks second, third, and sixth; E5 ranks eighth and ninth; E6 ranks fourth, fifth, and ninth; E7 ranks third, seventh, and eleventh; E17 ranks seventh, ninth, and twelfth; and finally, E20 ranks fifteenth, seventeenth, and nineteenth. Although these rankings are separate, it is possible to reach a consensus to establish the final ranking of candidates.

#### 4.3. Rank aggregation by MIRA

Table 7 takes the form of the mathematical formulas in Equation (10). The ranking of candidates varies from one decision-maker to another. Each ranking is important because it is based on a priority of criteria. Therefore, the MIRA method will provide a final ranking for each candidate as a tool to group decision-making. To implement the MIRA method, begin by examining the correlation between these

rankings using Kendall's correlation coefficient of the mathematical formulas in equation (11). Table 8 below shows the result.

Table 8. Kendall's correlation coefficient of the six ranks

	DM1	DM2	DM3	DM4	DM5	DM6
DM1	1,00	0,81	0,99	0,68	0,78	0,66
DM2		1,00	0,82	0,87	0,97	0,85
DM3			1,00	0,69	0,79	0,67
DM4				1,00	0,86	0,98
DM5					1,00	0,86

The coefficients indicate that these six rankings have the same correlation direction. Thus, the MIRA method can be implemented. Table 9 below shows the final ranking of candidates according to the MIRA method by applying the mathematical formulas in equation (12).

Table 9. Final ranking of temporary teachers by the MIRA method

	E9	E16	E4	E2	E6	E7	E14	E5	E1	E17	E11	E13	E15	E18	E8	E3	E20	E12	E19	E10
Score	6	14	22	26	36	42	44	45	52	56	57	69	80	81	94	96	102	106	112	120
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

It can be said that the rankings of candidates determined by the MIRA method are appropriate, as they consider the various positions of candidates based on the prioritization of criteria by decision-makers. Since all the ideas of the decision-makers are considered, there are no conflicts. These rankings accurately represent the situation of temporary teachers. To analyze the rank of each candidate, refer to the initial situation presented in Table 4. Let us take, for example, the cases of the top three and bottom three candidates in this assessment.

E9, E16, and E4 were placed in the top three final rankings due to their merit based on their situation. Candidates E9 and E4 are in an almost identical situation. Given their seniority in teaching, the recommendations of teachers, and their research publications, they occupy a favorable position (see Table 4). Although candidate E4 has solid professional experience and more seniority in the opinion of the Teachers' College than the first two applicants, he ranks third due to his very limited number of publications compared to the latter (see Table 4). Furthermore, it is worth examining the situation of E12, E19, and E10, which rank eighteenth, nineteenth, and twentieth, respectively, in this assessment. E12 and E19 are in a similar situation with regard to the publication of their research. Although E19 obtained the opinion of the College of Teachers five months before E12, its teaching experience is more recent than that of E12, which has a difference of 14 months. Thus, E12 outperformed E19. However, E10 has twice as many publications as E12 and E19. Nevertheless, considering the College of Teachers and teaching experience, he is the most recent among all applicants. This is why he ranks last in this evaluation. To confirm this ranking, it is essential to verify the correlation coefficient of the ranks obtained using the MIRA method in relation to the six distinct ranks. These Kendall correlation coefficients are illustrated in the following Table 10, applying the mathematical formulas in equation (11).

Table 10. Kendall's correlation coefficient of the MIRA method

MIRA					
DM1	DM2	DM3	DM4	DM5	DM6
0,80	0,97	0,81	0,88	0,96	0,86

All Kendall correlation coefficients are close to 1. This indicates that the ranking generated by the MIRA method has the same significance as that of the CoCoFISo method, taking into account the priorities selected by the six decision-makers. This situation indicates that the rankings of the candidates are confirmed. As the ranking of candidates is readily available, members of the recruitment committee can easily select which candidates to hire based on their position in the ranking. The number of posts to be filled is, of course, subject to budgetary constraints. For example, if there are twelve budgeted posts available, it is sufficient to hire the first twelve candidates listed in Table 9. The innovative method we suggest for assessing candidates

for research-teaching positions at public universities in Madagascar also applies to the recruitment of both Senior Lecturers and Associate Professors. The advantage is that, thanks to administrative transparency, it will also be possible to inform candidates of their ranking following the assessment of their applications.

The result we have presented is a prototype, but in a real-world teacher recruitment scenario, changes in ranking might be observed. These changes in ranking are caused by various factors, including: the number of criteria selected by the recruitment committee, the number of committee members present at the meeting, the assessment of the criteria carried out by each committee member, and the candidates' positions relative to all the criteria. However, to optimize the selection of teachers to be recruited, it would be appropriate in a practical context to take into account criteria such as teaching excellence and the impact of the applicants' research. These factors could make the model more effective.

We have just discussed the case concerning the applications of temporary lecturers from a single university whose files were submitted to the Ministry of Higher Education. In practice, the Ministry receives files from all universities in Madagascar. Thus, during the committee meeting at the Ministry to decide on the recruitment of lecturers, its members can follow the same procedure suggested in this article. Start by determining the selection criteria. Then, evaluate the criteria for each member. Move on to calculating the weights of the criteria using the Rank Sum Weight method. Next, rank the candidates using the CoCoFISo and MIRA methods. It is strongly recommended that applicants be ranked by the university in order to have an overview of the situation in each institution. It should be noted that the three methods (Rank Sum, CoCoFISo, MIRA) we have proposed are applicable regardless of the number of criteria or candidates.

The implementation of the system offers benefits such as reducing decision-making bias and ensuring fairness. The decision-support system we propose will enable decision-makers at the Ministry of Higher Education to rank part-time lecturers. Its aim is to act as a decision-making aid, not as the final arbiter. To minimize bias in decision-making, this system does not operate entirely on its own but requires the involvement of all decision-makers to rank the criteria according to their importance. It then assesses the weighting of the criteria based on the importance assigned to them by the decision-makers. It subsequently uses the CoCoFISo algorithm to rank the applicants. Finally, the implementation of the MIRA method within the system allows the different rankings of candidates to be adjusted according to the assessment of the criteria. Consequently, the system can ensure fairness, as each candidate is assessed equitably.

Thus, compared with the current recruitment process for permanent teachers, our method is transparent, as each stage is clearly defined. Furthermore, candidates, whether or not they are selected for recruitment, can find out why they received a particular outcome, a possibility that has never existed before. Moreover, taking into account the allocated budget, candidates can reasonably predict when they will be recruited.

## 5. CONCLUSION

The article in question deals with group decision-making using multi-criteria approaches. This concerns the recruitment of university lecturers in Madagascar. During the experiment, three criteria were selected, and the Ministry's recruitment committee consisted of six members. Three approaches were chosen and implemented successively, namely Rank Sum weight, CoCoFISo, and MIRA. As this is a group decision-making, each member was free to rank the criteria according to their order of importance. The Rank Sum weight method was used to calculate the weights of the criteria. As a result, we obtained six distinct weights for the criteria, in agreement with the six decision-makers (members). We then used the CoCoFISo method to rank the candidates, applying each weight of the criteria to the performance matrix. This method was used to rank the candidates, and we obtained six rankings for each candidate, considering the six decision-makers. To establish the final ranking of the candidates, the MIRA method was applied to aggregate the six ranks. Ultimately, we have a single rank for each candidate. Consequently, taking this ranking into account, the commission can determine which teachers to hire based on the available budgetary positions.

Our proposed method for selecting temporary teachers for recruitment as permanent teachers, presented in this article, will ensure fairness for each candidate thanks to its simplicity and transparency. Furthermore, human involvement is limited to the prioritization of criteria, while the other processes, from the calculation of criteria weights to the final ranking of candidates, will be carried out in a decision support system. This solution will enable the Ministry of Higher Education to facilitate its work and continue to operate with openness and innovation. The system we have designed is operational and can be applied to the recruitment of research lecturers in Madagascar, as well as in other countries with a recruitment process like that of Madagascar. However, the information discussed in this article is not real, but it accurately depicts the reality of the situation of temporary lecturers at universities in Madagascar. Furthermore, it only considers the case of one specific university, whereas the documents received from the Ministry cover all universities. In addition, only the proposed ranking of candidates was provided.

For future research, after ranking candidates by university, it would be relevant to suggest a method for allocating budgetary positions to each university to improve the student-teacher ratio for those with a low

ratio. It is therefore essential to design a recruitment plan to ensure an equitable distribution of the teachers to be recruited in all universities. The aim of this forthcoming study is to determine the number of years required to recruit teachers so that student-teacher ratios across all Madagascar universities can be brought closer together and aligned.

#### DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

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#### CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest to this work.

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