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Decision support system for solving multi-criteria problems using CoCoFISo method

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Abstract

The Combined Compromise For Ideal Solution (CoCoFISo) method is a hybrid approach designed to intelligently combine the trade-off between criteria with the proximity to an ideal solution. It was developed to address certain limitations observed in existing approaches and to achieve a more reliable and consistent final ranking of alternatives. In this context, Compromise Solver was developed, a multi-criteria decision support system implementing the CoCoFISo algorithm. Users can import or enter data into the system and obtain a final ranking of alternatives. An experiment on food availability for the period 2017–2022 was conducted for Madagascar to test the software's capabilities. The results showed that 2016 and 2017 offered the best food availability, whereas 2020 and 2022 presented a worrying food situation. The findings could serve as a basis for decision-making by the Ministry of Agriculture in Madagascar. Compromise Solver has successfully transformed the mathematical formulas into a computer tool and will soon be available to the public to facilitate the application of the CoCoFISo method.

Keywords: CoCoFISo method; Decision support system; Compromise Solver; Food availability

1. Introduction

In a complex and rapidly changing world, decision-makers face multifaceted challenges that require a structured and informed approach to decision-making. Many decisions must be made whilst considering several criteria that are sometimes contradictory, making it difficult to identify the best solution. This needs to rationalise and validate decisions has led to the development of multi-criteria decision-making (MCDM) methods. These methods enable the analysis and comparison of different alternatives across several dimensions simultaneously. The application of multi-criteria decision-making methods is widespread across various fields as they facilitate the evaluation of solutions based on multiple objectives.

However, choosing the most suitable method remains a major challenge, as it depends on numerous factors, including the nature of the criteria, the number of alternatives and the decision-maker's preferences. Furthermore, existing approaches differ in terms of principles, performance and applicability, making their selection even more complex.

In this context, the Combined Compromise For Ideal Solution (CoCoFISo) method stands out for its ability to balance trade-offs with proximity to an ideal solution [1]. It aims to minimise the discrepancies between each alternative and a reference solution, whilst incorporating the necessary trade-offs. CoCoFISo was developed to address certain limitations identified in the Combined Compromise Solution method [2], notably errors initially arising during normalization and the issue of a criterion having the same value for all alternatives. Furthermore, aggregation problems occur when an alternative has the worst values for all criteria.

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However, despite its theoretical merit and algorithmic improvements, the practical application of CoCoFISo remains limited due to the lack of an interactive tool to facilitate its use by analysts and decision-makers. In response to this issue, this article aims to address this gap by developing Compromise Solver, a multi-criteria decision support system that implements the CoCoFISo method and can handle any multi-criteria problem. The objective is to make this method more accessible and operational through an intuitive interface and features tailored to users' needs.

To demonstrate the effectiveness of this tool, a case study on food availability in Madagascar for the period 2016 to 2022 will be discussed. This is a relevant use case for decision-makers in the agricultural. This application will help identify years of food sufficiency and food insufficiency, thereby providing concrete evidence to guide public policy on food security.

The remainder of this article is organized as follows: after this introduction, Section 2 presents a review of the literature on the application of the CoCoFISo method. Section 3 details the methodology, including the mathematical formalization of the method, the implementation of Compromise Solver and a description of the datasets. The following section presents the results obtained and offers an in-depth discussion. Finally, the last section concludes the article and suggests avenues for improvement.

2. Literature review

A literature review was conducted using the OpenAlex database. The search term used was CoCoFISo. OpenAlex returned 34 documents, comprising 16 articles, 12 datasets, 3 preprints and 3 others. We therefore chose to analyse the 16 articles [1,3–17]. Of these 16 articles, 12 are open access. After reviewing each of these 16 articles, we found that in each case the authors had applied the CoCoFISo method. There are 33 authors of these articles, spread across 27 institutions in 11 countries, including China, France, India, Madagascar, Algeria, Spain, the United Kingdom of Great Britain and Northern Ireland, the Islamic Republic of Iran, Lithuania, Pakistan, and Turkey. Figure 1 below shows the connections between these authors, with 22 links.

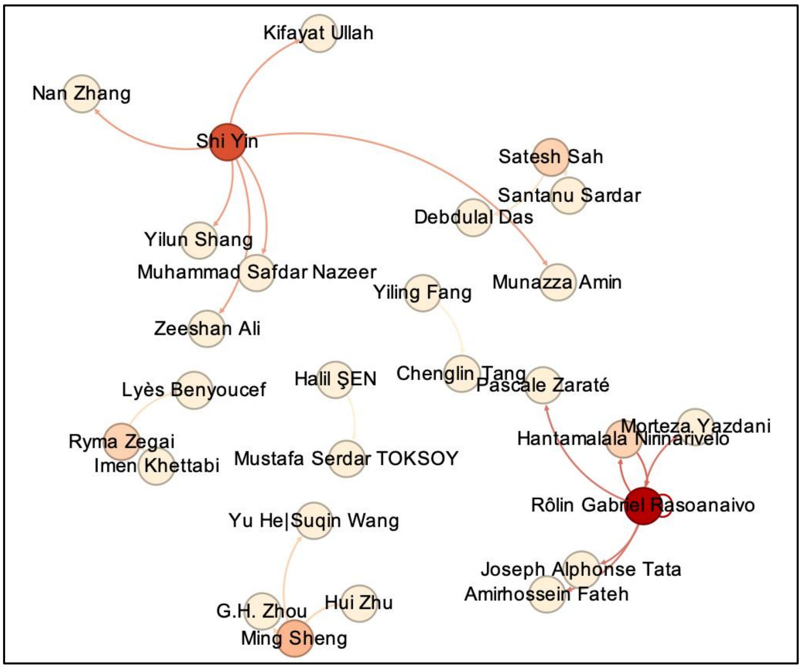


Figure 1 CoCoFISo authors' network

The collaboration network associated with the Combined Compromise for Ideal Solution (CoCoFISo) method reveals a structured yet moderately fragmented research landscape. The graph highlights key contributors, thematic clusters, and the flow of intellectual influence within this domain. At the core of the network, two highly central researchers Shi Yin and Rôlin Gabriel Rasoanaivo emerge as dominant hubs. Their prominence is indicated by the higher density of connections and stronger link intensities, suggesting that they play a critical role in advancing and disseminating CoCoFISo-related methodologies. These central figures likely contribute foundational work or serve as primary collaborators across multiple studies. Surrounding these hubs are distinct collaboration clusters. The cluster centred on Shi Yin includes researchers such as Nan Zhang, Yilun Shang, and Muhammad Safdar Nazeer, reflecting a cohesive subgroup with frequent internal collaboration. Similarly, the cluster associated with Rôlin Gabriel Rasoanaivo encompasses contributors like Hantamalala Nirinarivelo, Morteza Yazdani, and Joseph Alphonse Tata, indicating another concentrated research stream within the CoCoFISo framework. In addition to these major clusters, smaller sub-networks are visible, representing specialized or emerging lines of research. For instance, localized groupings around Ming Sheng and Lyès Benyoucef suggest focused contributions that may address niche applications or methodological extensions of CoCoFISo. Importantly, several intermediary researchers act as bridges between otherwise disconnected clusters. Individuals such as Debdulal Das and Pascale Zaraté facilitate knowledge integration across subgroups, enhancing the overall coherence of the research field. These connectors are crucial for the diffusion of ideas and the cross-fertilization of approaches within the CoCoFISo paradigm.

These articles focus on six fields, namely Decision Science, Computer Science, Energy, Engineering, Business, Management and Accounting. Twelve (12) different methods for weighting criteria, combined with CoCoFISo, have been identified in these articles. These methods include Centroïdous, full consistency method (FUCOM), criteria importance through intercriteria correlation (CRITIC), ranking comparison (RANCOM), equal weight (EQW), principal component analysis (PCA), entropy weight (ENW), criteria importance through inter-criteria correlation (CRITIC), method based on removal effects of criteria (MEREC), symmetry point of criterion (SPC), logarithmic percentage change-driven objective weighting (LOPCOW), Rank Sum weight (RSW) and picture fuzzy step-wise weight assessment ratio analysis (PF–SWARA). All these factors suggest that, despite having been in existence for only two years, the CoCoFISo method is already well established and widely cited in the academic literature.

When integrating the CoCoFISo method into a decision-support system, we identified three systems in the literature, each tailored to a specific context. A system called MadUrank was designed to evaluate universities in Madagascar [18]. Another system, MADREN, intended to rank the regional education authorities in Madagascar, was also developed [19]. A system for selecting part-time lecturers in higher education has recently been proposed [20]. These systems demonstrate the importance of decision support system in ensuring the availability and smooth operation of CoCoFISo. However, they are designed to address a specific problem. It is therefore crucial to develop a system capable of managing all types of multi-criteria problems using the CoCoFISo method, an innovation that has not yet been

3. Materials and Methods

This section will provide a detailed description of the CoCoFISo algorithm implemented in the software and outline the methodological process to develop Compromise Solver.

3.1. CoCoFISo method algorithm

To apply the CoCoFISo method, a performance matrix is required, which describes the values of the alternatives in relation to the criteria. The weights of the criteria must also be available. It is assumed that the performance matrix consists of m alternatives and n criteria and takes the form described in Equation (1) below.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{\mathrm{mn}} \end{bmatrix}; i = 1,2,\dots,m; j = 1,2,\dots,n \quad (1)$$

Before any calculation process, it is essential to normalise the values of the criteria so that they can be expressed on the same scale. The normalisation of the matrix according to CoCoFISo is given in Equation (2) below.

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

Where x_{ij} is the raw value of alternative i for criterion j and r_{ij} is the normalised value.

Once the matrix has been normalised, the two scores shown in equations (3) and (4) below must be calculated.

$$S_i = \sum_{j=1}^{n}\left(w_j r_{ij}\right) \quad (3)$$

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

Where w_j represents the weight assigned to the criterion.

Subsequently, three aggregation strategies are used to combine the Si and Pi scores of the alternatives, each with specific characteristics set out in equations (5), (6) and (7) below.

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m}(P_i + S_i)} \tag{5}$$

$$k_{ib} = \left(\frac{S_i + P_i}{1 + \frac{S_i}{1+S_i} + \frac{P_i}{1+P_i}}\right) \tag{6}$$

$$k_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{(\lambda \max_i S_i + (1-\lambda)\max_i P_i)}; where\ \ 0 \le \lambda \le 1 \tag{7}$$

This third variant in equation (7) introduces a parameter (λ) that allows the importance of the scores Si and Pi to be weighted. Generally, this parameter is set to 0.5 unless the decision-maker intervenes.

Finally, an overall score is calculated for each alternative by combining the three previous approaches.

$$k_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}) \tag{8}$$

The alternative with the highest Ki score is considered the best.

3.2. Methodological process

To implement the CoCoFISo method algorithm in a decision support system, a methodological process presented in the figure 2 below was followed.

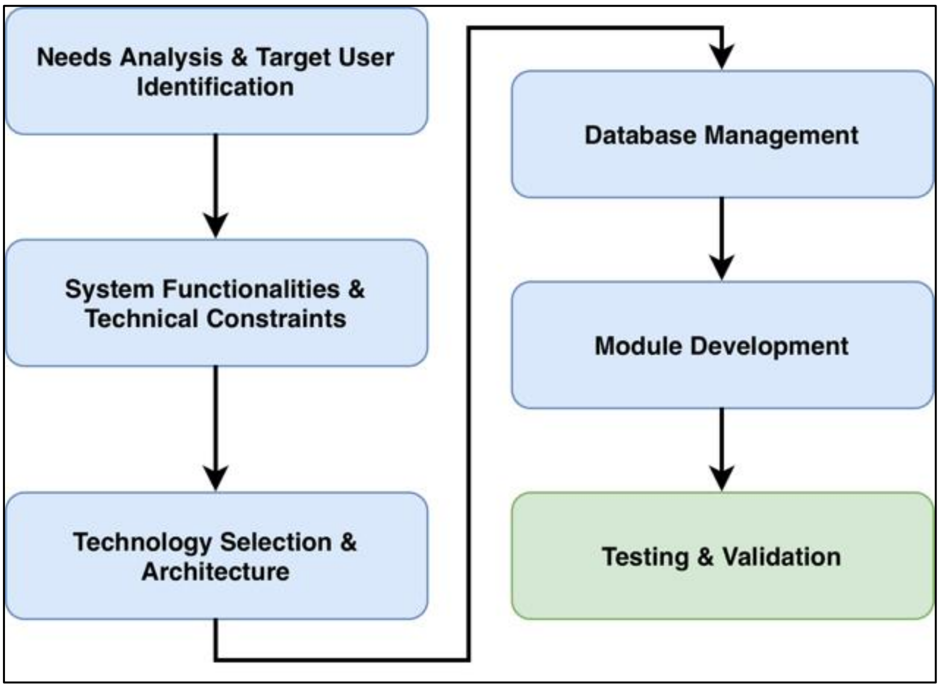


Figure 2 Methodological process for implementing CoCoFISo

The first methodological step is the needs analysis and target user identification. The Compromise Solver software is designed for a wide range of users from various fields. Each user group has specific expectations depending on their area of expertise and their needs regarding multi-criteria decision-making. These include researchers and academics, decision-makers and analysts, engineering and decision sciences students, developers and integrators. The development of Compromise Solver aims to provide a powerful, interactive and user-friendly tool for analyzing and simulating multi-criteria problems. Its objective is to offer software that enables users to model complex situations and compare several alternatives based on specific criteria. The features offered include modelling and simulation of multi-criteria problems using the CoCoFISo method, interactive display of results, and the ability to export and share analyses. Consequently, the main features included in the application are as follows:

- Management of criteria, alternatives and weightings allows the addition, modification and deletion of elements to be analyzed;
- Multi-criteria simulation: Applies the CoCoFISo method to the data provided;
- Visualization of results: Presents the results in the form of interactive dynamic tables, making them easier to understand;
- Export of results: Generates PDF files to facilitate the communication and sharing of analyses.

The choice of technologies used in the development of this software was guided by key criteria such as performance, compatibility, maintainability and ease of use. These technologies were selected to ensure a robust and scalable architecture. Below is an overview of the main technologies used. The primary programming language used in this project is Java, a preferred choice due to its robustness, portability and mature ecosystem. Portability is made possible by the Java Virtual Machine (JVM), which executes Java code independently of the underlying hardware platform. The application's graphical user interface was developed using Java Swing, a graphical user interface (GUI) component library that enables the creation of interactive, modern user interfaces. Swing is used for its flexible architecture and its ability to provide a rich graphical interface whilst remaining relatively straightforward to implement. The decision engine is based on the implementation of the CoCoFISo method, an advanced approach used for multi-criteria problem-solving. The algorithm is directly integrated into the software and is used to analyse and rank alternatives based on the data entered by the user. To enable the export and printing of results, iText has been integrated into the system. This Java library, which specialises in generating PDF documents, allows the reports produced by Compromise Solver to be structured efficiently. Thanks to iText, users can save and share results in a standardised format, thereby ensuring better traceability of the decisions taken.

The system's software architecture follows a modular approach and is divided into different layers, making it easier to develop, test and maintain. It is based on an MVC (Model-View-Controller) structure, which separates the concerns of the user interface, business logic and data. The Model manages all data and business logic; it includes database management via MySQL, as well as the main algorithm of the CoCoFISo method. The View is the user interface, which is built using Java Swing. It allows the user to enter data and view the simulation results. The Controller acts as the link between the View and the Model. It receives user actions from the graphical interface and passes them to the Model for processing. It then retrieves the results and displays them to the user via the View. To meet these requirements, the MySQL database management system was chosen for several reasons. Firstly, MySQL is renowned for its performance and speed, particularly when executing complex queries and managing large volumes of data. Furthermore, its reliability and robustness make it an ideal choice for ensuring the integrity of stored information. Its seamless integration with Java, via the JDBC connector, facilitates interaction between the application and the database, thereby ensuring efficient and secure data handling.

A few screenshots of the modules developed will be shown below. Figure 3 below shows the main user interface.

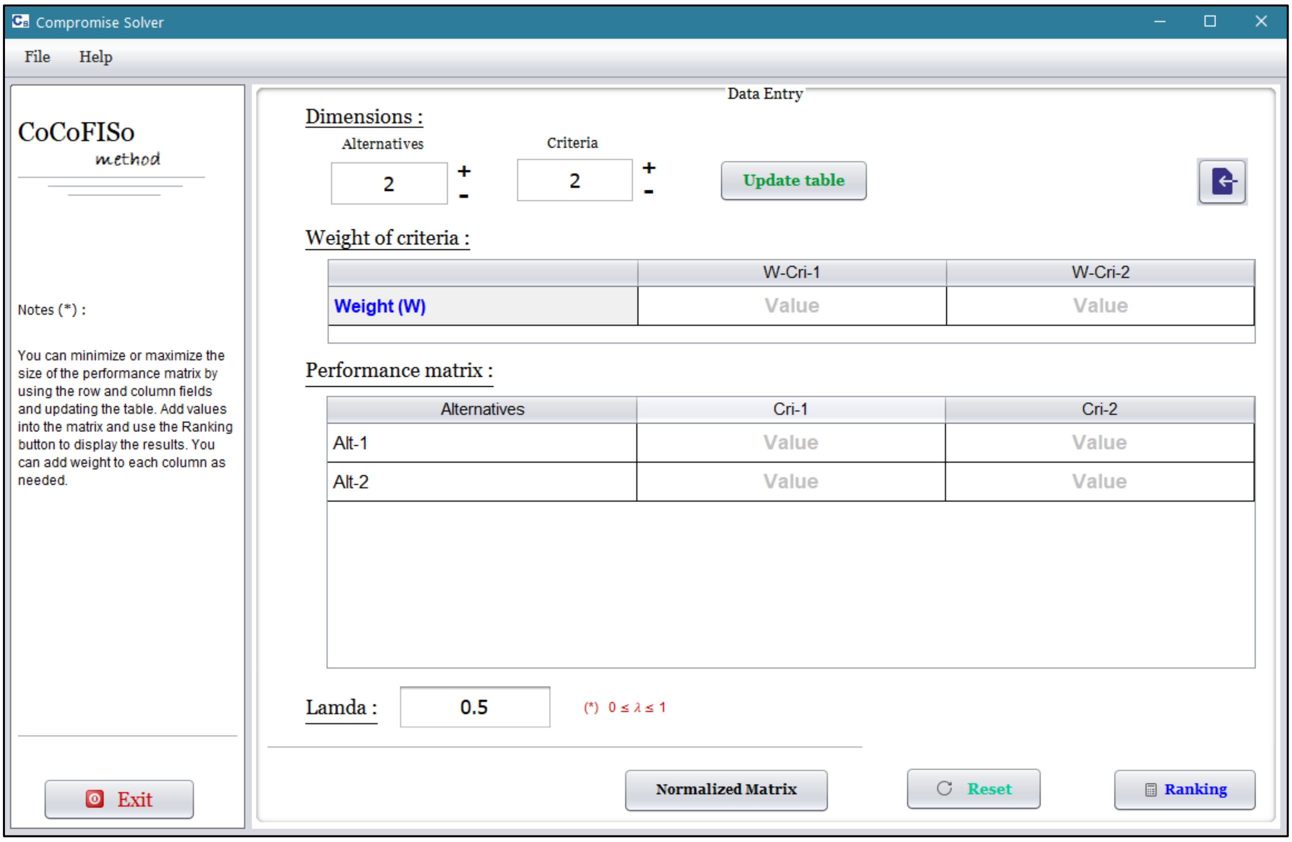


Figure 3 Compromise Solver main menu

To add data, the user has two options: manual entry or import. Similarly, to view the results, there are two options: either click directly on the 'Ranking' button to see the final ranking or follow the steps of the CoCoFISo method by clicking the 'Normalized Matrix' button.

4. Experimental data

The data used in this study were provided by the Ministry of Agriculture and Livestock, in collaboration with the National Institute of Statistics of Madagascar. These data are drawn from Madagascar's food balance sheets for the period 2016 to 2022. This report compiles detailed information on the country's food availability, consumption and dietary balance over the years. The aim of this study is to analyse food availability in Madagascar from 2016 to 2022, to identify years of food sufficiency and food insufficiency. To this end, Compromise Solver will be used to process the data using a multi-criteria approach, enabling the performance of each year to be assessed based on 20 criteria weighted according to their relative importance presented in table 1 below.

Table 1 Evaluation criteria

Criteria					
C1	Cereals	C8	Pulses	C15	Offal
C2	Roots and tubers	C9	Vegetable oils	C16	Spices
C3	Fruit	C10	Fish and seafood	C17	Oilseeds
C4	Vegetable	C11	Alcoholic beverages	C18	Miscellaneous product
C5	Milk	C12	Stimulants	C19	Nuts
C6	Sugar and sweeteners	C13	Eggs	C20	Animal fats
C7	Meat	C14	Sugar crops		

These criteria cover the key categories set out below:

- Agricultural production and food availability: cereals, roots and tubers, fruit, vegetables, pulses, sugar crops, oilseeds, nuts and miscellaneous products;
- Animal products: milk, meat, fish and seafood, eggs, offal and animal fats;
- Processed products and stimulants: sugar and sweeteners, vegetable oils, alcoholic beverages, stimulants and spices.

To ensure a neutral and balanced assessment, the equal weight (EQW) method was used. This method assigns mean weight to each criterion, thereby avoiding bias and ensuring that all criteria are treated fairly. It is particularly useful when precise information on the relative importance of the criteria is not available, or when one wishes to remain neutral in the weighting, to obtain an objective assessment of performance across the different years studied. Previous studies [21] have demonstrated the effectiveness of this method, which is why we chose to use it in our research. The weighting of the criteria is calculated using the following equation (9):

$$w_j = {}^{1}\!/_{n} \quad \text{where } n \text{ is the number of criteria and } \sum w_j = 1 \qquad (9)$$

The annual overview of food availability is presented in Table 3 below. This table records the value of each food product. It also serves as the performance matrix that will be used to compare food availability.

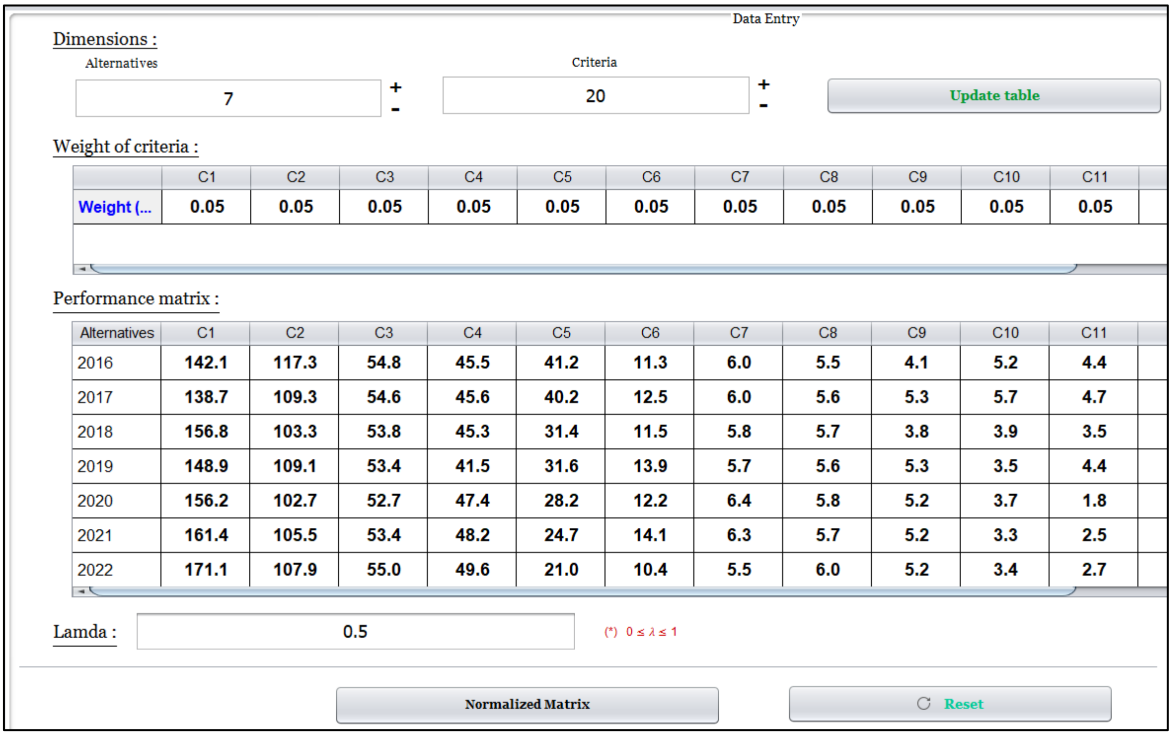
Table 2 Performance matrix

Year	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**	**C19**	**C20**
2016	142,1	117,3	54,8	45,5	41,2	11,3	6,0	5,5	4,1	5,2	4,4	3,7	1,1	1,2	1,3	0,8	1,2	0,5	0,4	0,1
2017	138,7	109,3	54,6	45,6	40,2	12,5	6,0	5,6	5,3	5,7	4,7	3,6	1,7	1,2	1,2	0,6	0,7	0,7	0.4	0,2
2018	156,8	103,3	53,8	45,3	31,4	11,5	5,8	5,7	3,8	3,9	3,5	3,6	1,7	1,2	1,0	0,6	0,7	0,9	0,4	0,2
2019	148,9	109,1	53,4	41,5	31,6	13,9	5,7	5,6	5,3	3,5	4,4	2,6	1,0	1,2	0,9	1,0	0,6	0,4	0,0	0,1
2020	156,2	102,7	52,7	47,4	28,2	12,2	6,4	5,8	5,2	3,7	1,8	1,6	1,0	1,2	0,9	1,0	0,6	0,4	0,0	0,2
2021	161,4	105,5	53,4	48,2	24,7	14,1	6,3	5,7	5,2	3,3	2,5	2,2	1,1	1,2	0,9	0,9	0,5	0,6	0,0	0,1
2022	171,1	107,9	55,0	49,6	21,0	10,4	5,5	6,0	5,2	3,4	2,7	3,6	1,1	1,2	0,8	0,5	0,5	0,4	0,0	0,1

5. Results and discussion

As CoCoFISo requires the weights of the criteria to be available in conjunction with the performance matrix, the first result to be presented is the weight of the criteria. Applying equation (9), the criterion weight is 0.05 for all criteria.

To add the data to Compromise Solver, it was decided to import it from an Excel file. This data includes the performance matrix and the criterion weights. It should be noted that if the sum of the weights does not equal 1, it is not possible to import the data into this software; alternatively, if the user has chosen to enter the data manually, it will not be possible to proceed to the next step. Figure 4 below shows the result of importing the data into Compromise Solver. This is an excerpt from the main menu, as there are normally 20 criteria, as shown at the top of the screen.



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Weight (...	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
2016	142.1	117.3	54.8	45.5	41.2	11.3	6.0	5.5	4.1	5.2	4.4
2017	138.7	109.3	54.6	45.6	40.2	12.5	6.0	5.6	5.3	5.7	4.7
2018	156.8	103.3	53.8	45.3	31.4	11.5	5.8	5.7	3.8	3.9	3.5
2019	148.9	109.1	53.4	41.5	31.6	13.9	5.7	5.6	5.3	3.5	4.4
2020	156.2	102.7	52.7	47.4	28.2	12.2	6.4	5.8	5.2	3.7	1.8
2021	161.4	105.5	53.4	48.2	24.7	14.1	6.3	5.7	5.2	3.3	2.5
2022	171.1	107.9	55.0	49.6	21.0	10.4	5.5	6.0	5.2	3.4	2.7

Figure 4 Importing data into Compromise Solver

This screen in Figure 4 shows the main steps for tackling multi-criteria problems using Compromise Solver. Now that all the information is available, it is possible to view the results. To demonstrate Compromise Solver's ability to execute the CoCoFISo algorithm, the results will be presented step by step. Consequently, the normalised matrix is shown in Figure 5. This matrix was obtained by implementing equation (2).

Alternativ...	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
2016	0,3489	0,4106	0,3838	0,3721	0,4874	0,3462	0,3802	0,3646	0,3158	0,4686	0,4642
2017	0,3405	0,3826	0,3824	0,3729	0,4756	0,3830	0,3802	0,3712	0,4082	0,5137	0,4959
2018	0,3850	0,3616	0,3768	0,3704	0,3715	0,3524	0,3675	0,3778	0,2927	0,3515	0,3693
2019	0,3656	0,3819	0,3740	0,3394	0,3739	0,4259	0,3612	0,3712	0,4082	0,3154	0,4642
2020	0,3835	0,3595	0,3691	0,3876	0,3336	0,3738	0,4056	0,3845	0,4005	0,3334	0,1899
2021	0,3962	0,3693	0,3740	0,3942	0,2922	0,4320	0,3992	0,3778	0,4005	0,2974	0,2638
2022	0,4201	0,3777	0,3852	0,4056	0,2484	0,3187	0,3485	0,3977	0,4005	0,3064	0,2849

Figure 5 Normalized matrix by Compromise Solver

Data normalisation aims to adjust values to between 0 and 1 to simplify their handling, given that the data was raw. The next stage of the CoCoFISo method involves determining the two values Si and Pi using equations (3) and (4). Figure 6 below illustrates the results of these quantities.

Alternatives	Si	Pi
2016	0,4072	19,1006
2017	0,4229	19,1452
2018	0,3991	19,0861
2019	0,3404	18,0378
2020	0,3338	18,0083
2021	0,3317	18,0134
2022	0,3172	17,9698

Figure 6 Si and Pi weighting strategy

Using these weighting techniques, it is possible to identify the most favourable and least favourable alternatives based on the values of these parameters. As shown in Figure 6, 2017 achieves the maximum values for Si and Pi, unlike 2022. Let us continue the process of CoCoFISo method by presenting the values for the three aggregation strategies Kai, Kib and Kic in Figure 7 below obtained by the equations (5), (6) and (7).

Alternatives	K_ia	K_ib	K_ic
2016	0,1479	8,7103	0,9969
2017	0,1483	8,7064	1,0000
2018	0,1477	8,7163	0,9958
2019	0,1393	8,3483	0,9392
2020	0,1390	8,3463	0,9373
2021	0,1391	8,3521	0,9375
2022	0,1386	8,3574	0,9345

Figure 7 Kia, Kib and Kic aggregation strategies

According to this result, for the Kia and Kic parameters, 2017 represents the highest value, whilst for the Kib parameter, 2026 records the maximum value. As regards the minimum values, the year 2022 is taken as the reference for Kia and Kic, whilst for Kib, it is the year 2020. In this context, the final stage of the CoCoFISo method will involve combining these three values using equation (8), which is incorporated into Compromise Solver. Figure 8 below illustrates this value and the corresponding ranking for each year.

Alternatives	Score Ki	Rank
2017	4,3739	1
2018	4,3730	2
2016	4,3720	3
2019	4,1722	4
2021	4,1717	5
2022	4,1704	6
2020	4,1693	7

Figure 8 Ranking of alternatives by Compromise Solver

This study proposes an innovative approach to assessing food availability in Madagascar using a Compromise Solver. Years are ranked according to their Ki score, which represents an overall indicator based on twenty criteria related to food availability. A year with a high score indicates better food availability, whilst a year with a low score reflects a more challenging situation. An analysis of food availability between 2016 and 2022 reveals significant fluctuations across different product categories. These variations are the result of several factors, including local agricultural production, trade (imports and exports), climatic conditions, natural disasters, and agricultural and trade policies. Furthermore, consumer demand and changes in purchasing power have also played a decisive role. Overall, availability has increased for certain product categories, whilst others have seen a notable decline.

Compromise Solver has enabled to classify years according to their overall food security situation. Years can be categorised into two groups: those with better food availability and those where food availability is critical.

Among the years analysed, 2017 stands out as the year with the best food availability, with a score of 4.3739. This performance indicates a more favourable situation compared to the other years assessed. Although cereal availability decreased slightly compared to 2016, the stability of the supply of pulses and meat contributed to this high ranking. The year 2018 ranked second with a score of 4.3730, representing a significant increase in cereal availability. This situation bolstered the overall index. However, the decline in dairy products remains a major concern. As for 2016, it ranked third with a score of 4.3720. This period was characterised by good availability of dairy products and cereals. However, the decline in roots and tubers had a negative impact on the overall dietary balance.

In contrast to more favourable years, certain periods have been marked by increased food insecurity. Among these, 2022 ranks sixth with a score of 4.1704. Despite record availability of cereals, the sharp decline in dairy products, sugar and meat had a significant impact on the overall ranking. The year 2020, meanwhile, comes in last place with the lowest score 4.1693 according to CoCoFISo, indicating severe food insecurity. This year was marked by limited availability of dairy products, stagnation in cereals and a decline in protein sources. This situation can be partly attributed to the effects of the COVID-19 crisis, which affected imports, led to rising unemployment and reduced households' financial capacity.

Given this situation, food security in Madagascar must be improved by implementing a number of measures. Firstly, it is essential to support the local production of goods in short supply by providing financial and technical assistance to producers of milk, meat and pulses. This measure would help to boost domestic production and reduce dependence on imports. Secondly, dietary diversification must be encouraged to limit heavy reliance on cereals and ensure a better nutritional balance. To achieve this, the consumption of pulses and local animal proteins should be promoted.

Furthermore, rigorous monitoring of food availability must be implemented through a real-time surveillance system. This tool would enable the anticipation of potential food crises and the adaptation of import and distribution strategies accordingly. Finally, it is crucial to adapt agricultural policies to on-the-ground realities by utilising observed trends and the findings of this study. Such an approach would facilitate the adjustment of agricultural strategies, the optimisation of resource allocation and improved access to essential foodstuffs.

6. Conclusion

This article has outlined all the stages involved in developing decision-support software based on the CoCoFISo method. The project began with an in-depth study of the method, followed by its conversion into a computer tool capable of solving any type of multi-criteria problem, depending on the number of criteria and alternatives selected by the user. The main objective was to make the CoCoFISo method more accessible and easier to use. Compromise Solver can carry out all stages of the decision-making process, from data normalisation to the final ranking of alternatives. This software has been designed to be simple and intuitive, so that it can be used by students, teachers, researchers, as well as decision-makers and analysts, without requiring in-depth programming skills. It can also serve as a teaching tool to better understand multi-criteria decision-making methods and facilitate their application in practical contexts.

The study conducted using Compromise Solver assessed food availability in Madagascar over the period 2016–2022, using a rigorous multi-criteria approach. The analysis highlighted significant fluctuations, revealing periods of both food sufficiency and food insufficiency. The results demonstrated the tool's effectiveness in ranking the years studied and provided relevant information to decision-makers regarding food resource management. The years 2017 and 2018 stand out as the most favourable in terms of availability, whilst 2020 and 2022 present worrying indicators, particularly due to the decline in certain essential commodities. This analysis provides a strategic basis for public authorities, particularly the Ministry of Agriculture, to adjust agricultural policies and anticipate food crises. Furthermore, by providing a detailed and objective assessment, Compromise Solver has proven to be an effective decision-support tool for ensuring sustainable and resilient food security during this pilot study.

Another important point is to make the software freely available on the University of Toamasina's website to demonstrate a commitment to sharing the results of this work with a wide audience, and to encourage the use of digital tools in the fields of teaching and research.

Although the CoCoFISo approach has yielded reliable results, a limitation has been identified in Compromise Solver, namely its reliance on external methods for criterion weighting. These limitations open opportunities for improvement, initially through the integration of modules for calculating criterion weights. In particular, a very interesting future development would be the creation of a web-based version of Compromise Solver. This new version would allow the software to be used directly from a web browser, without prior installation, on any device. This would make it even more convenient, accessible remotely, and compatible with modern digital tools.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest exists among the authors

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