Chapter 92

Multicriteria support in the prioritization of resources in cartographic works: a study in databases

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ABSTRACT
The objective of the present work is to evidence the usefulness of the multicriteria methods in the prioritization of resources in the production of cartographic information. For this, a systematic review of the literature in scientific databases was carried out in the period from 2007 to 2022. Concepts and procedures related to the characterization of scientific production on prioritization and multicriteria decision support methods were observed in the literature, examining the contributions of different countries, journals, authors and research trends. The analysis of the works showed a significant preponderance of the AHP and MCDA-C multicriteria methods.

Keywords: Cartography, Geoinformation, Multicriteria, Decision Support, Prioritization.

1 INTRODUCTION

Geographic information, one of the main products of a cartographic work, is increasingly important in the present days and the understanding of its relevance increases with the course of time. In Brazil, cartographywas already relevant since the period of the beginning of colonization, when the explorers of that historical moment needed data on the terrain to help the various works and activities to be developed. Among such activities, planting, mining, the establishment of cities and fortifications for the defense of the territory can be carried out. In this context, geographic information was presented as the basis for the planning and execution of these actions.

Over the centuries, other purposes, as well as the increase in their degree of importance and complexity, have been attributed to geographic information. The methods and procedures for obtaining them have also accompanied the scientific and technological evolutionof the time s. Geographic information has contributed to human development by enabling the study and implementation of the complex economic, political, military and social activities of the time of its acquisition.

However, the improvement of mapping techniques did not eliminate the possibility of improvements and practices that enable efficiency gains in their processes, particularly with regard to the efficient allocation of the small public resources available for the execution of the cartograficos work.

Since public management is correlated with territory management, access to Geoinformation is indispensable when it is aimed at subsidies for strategic, managerial and operational decision-making. Geoinformation, in this context, is presented as a decision support tool where the computers employed would assist in the representation of spatially referenceddata (CÂMARA; MONTEIRO, 2001).

In the first decades of the 21st century, a company cannot, in any industry, be subject to old and out-of-date concepts regarding the search for better levels of productivity and efficiency. The gains with the increase of productive efficiency, customer satisfaction and the level of contentment with the attributes of the generated produtos, through the optimized allocation of available resources in the cartographic activities considered more relevant, based on the opinions of the decision-makers of the institution and on modern concepts of multicriteria support to that of would be one of the ways to contribute to the better effectiveness of geographic information generation procedures.

In this tuning point, we can clarify that the methods of multicriteria support to decision-making were elaborated in order to mark a reference p byan alternative, classify options in a small number of categories or classify existing preferences in some subjective order of priority, constituting a way of addressing complex problems. Such methods essentially relatedto the fractionation of problems into menores, to evaluate the established considerations and to make judgments on the smaller parts. Subsequently, the smaller parts are reconstituted in order to present solutionsthat put it to decision-makers. (MARDANI, *et al*., 2015).

In the search for the support of technological innovation, it is convenient to promote an alignment with the conception of permanent technological improvements, which would include the constant search for better physicaland human resources, as well as the search for modern productive technologies. Thus, institutions that are able to direct this refinement sparse, would benefit from relevant competitive progress, based on operational characteristics or versatility in production processes (GONÇALVES et al., 2006).

In present times, institutions are constantly being constantly improving motivated by the advent of occurrences such as the expectation ofprompt and rapid responses to changes in market conditions, competitive threats and numerous customer demands. Among the greatest challenges to be faced, in the current millennium, it is observed the precision ofcommitment and rigorous use of economic mechanisms, aiming at obtaining products and services with the delivery of a maximum possible quality, where speed is a relevant and primordial competitive advantage (TACHIZAWA; FARIA, 2008).

Thus, with the understanding that there are alternatives of improvements related to productive efficiency and process optimization, abundant in the academic environment and capable of being applied to cartographic works, we can justify the interesse in the present study.

In the performance of cartographic work, through a structured sequence of processes and the use of various materials, specific products are generated to serve the most varied customers. For sist ematic cartography, the objective is the representation of the Brazilian territorial space by means of letters, elaborated selectively and progressively, according to theconjunctural priorities, according to terrestrial, nautical and aeronautical cartographic patterns.

Briefly, conforme seen in Da Penha, Morita and Cerqueira (2012), we can point out as a sequence of processes for obtaining a topographic chart: i) Realization of photogrammetric flight to obtain Aerial Photographs; (ii) Evaluation of aerial photographscovering the region to be mapped; iii) Field Point

Surveys; iv) Acquisition of Vectors; v) Reambulation; vi) Validation; vii) Continuous Area Generation; and viii) Edition.

In this context, there is afocus on prioritizing technical activities considered more relevbefore for a institution that developer of cartographic works, on the efficient and optimized execution of them and on the limited amount of resources available to institutions, the question is: What are the multicriteria models most used to prioritize the technicalactivities of a institution producing cartographic products?

As a way to answer these questions, we have to use the resources of bibliometry, enabling the development of such a theme to be identified, collaborating with information about the relevant questions and verifying possible gaps that may also result in the exploration of new research aiming at contributing to the construction of knowledge about the point in question (SU; LEE, 2010).

This article aimed to characterize the scientific production about hierarchy, prioritization and multicriteria methods, through research and analysis ofcontributions from various countries, journals, authors and research themes.

2 METHODS OF MULTI-CRITERIA SUPPORT TO DECISION

Multi-criteria support methods limit two-step decision support, formulation and evaluation, which seek to establish the best alternative, i.e., the optimal solution among the options previously defined, according to a set of objectives determined in a precise way, where the decision-making elements have reduced or noparticipation (BACK; SSLIN EN; ENSSLIN, 2012).

In the literature review of Velasquez and Hester (2013), the most frequent multicriteria support methods for decision-making were identified, mainly concentrated in areas related to operational research and management science, which highlighted the AHP - *Analytic Hierarchy Process* methods; CBR - *Case-Based Reasoning*; DEA - *Data Envelopment Analysis*; ELECTRE - *Elimination et Choix Traduisant la Réalité* (Elimination and Choice Translating reality); *Fuzzy Set Theory*; GP - *Goal Programming*; MAUT - *Multi-Attribute Utility Theory*; PROMETHEE - *Preference Ranking Method for Enrichment Evaluation*; SAW - *Simple Additive* Weighting; SMART - *Simple Multi-Attribute Rating Technique* and TOPSIS - *Technique for Order Preference by Similarity to Ideal Solution*.

The methods of multi-criteria support to decision-makingcould then offer better understandingof the intrinsic particularities of decision problems, favor the role of participants in decision-making procedures, provide collective commitments and decisions and provide adequate structures aimed at understandingand understanding models and analysts in realistic conjunctures (BALTAZAR *et al.*, 2014).

3 METHODOLOGY

The present work constitutes a bibliometric study, which can be described as a research area where, through quantitative analyses, several bibliographic data are observed and recorded, such as the origin of the authors, year and origin of journals, among others (MERIGÓ, *et al.* 2018). The use of bibliometric

studies was originally proposed in 1922 at the University of Cambridge under the name of statistical bibliography (HULME, 2018).

In order to obtain the bibliometric data, it was made option for investige in the databases CAPES, SciELO, Web of Science and Google Academic, considered relevant in the scientific community, as well as the databases of the Journals Online Production and Industrial Management.

For the analysis and selection of studies that will support the choice of models or methods of multicriteria support to the decision, and taking as reference the guidelines for the development of systematic reviews described by Kitchenham and Charters (2007), a format of review methodology was constituted.

For the systematic review methodology adopted, six stages were established: (1) Preparation of the protocol, that is, the present sequence of procedures, (2) Eligibility and Selection of Studies, (3) Strategies for the searchof relevant people, (4) Research Selection Process, (5) Quality Assessment and (6) Results.

In the research, the main objective was to focus on how to contribute to optimization and to increase efficiency in the development of cartographic works. Posteriormente, the following research-directed question was defined:

- What is the best way to hierarchize the technical activities (cartographic) of an institution, aiming at the distribution of available resources?

At the time of the systemreview, the search for works dealingwith methods of multicriteria support to decision was emphasized, particularly the texts alrelated to hierarchization and prioritization.

The theme of application of the methods, in the articles, was not taken into account seeking themand verify, preliminary, the methodologies employed and the possibility of using them in the resolution of the main proposed question. During the review, searches were focused on studies published in the Portuguese english languages. Regarding the question youmporal in the selection of studies, it was not initially considered with a view to the primary focus on finding texts that addressed possible answers to the proposed questions, letting the *research strings* make the selections. Such fact that it was proven to be by observing that the search strings returned reduced amounts of results.

3.1 FIRST GROUP SEARCH STRATEGIES

In the first group, the followingdatabases of publications were consuted: a) Portal Periódicos CAPES, b) Revista Produção Online and c) Revista Gestão Industrial. For the searches in the databases, we initially tried to establish terms that would better define the themes of interesse.

Subsequently, the terms established in the English language were translated and then the research was carried out with the combination of the defined terms. The strings created were five:

01. multicriteria AND resources

02. hierarchization AND resources

03. multicriteria AND hierarchization

04. multicriteria AND hierarchization AND resources

05. multicriteria hierarchy

The Publications found in the CAPES Periodic Portal, using the "*Strings*" of Search number 01 to 04 above, were listed in Table 01 below:

Table 01 - Total Publications found in capes periodic database.

"Strings" search	**Findings**
multicriteria AND resources	10.146
hierarchization AND resources	1.293
multicriteria AND hierarchization	32
multicriteria AND hierachization AND resources	14
TOTAL	**11.485**

Source: The authors.

With the selection of the Topic "*Engineering*", available as a tool in the CAPES Periodic Portal, the final "*String*" "*multicriteria AND hierachization AND resources*" went from 14 to 06 results.

For the databases contained in the Revista Produção Online and in the Journal Gestão industrial, the "*String*" ofResearch of number ero 05 "multicriterion hierarchization" was used and all the results incontract were considered forstudy in view of the relatively small amount of work identified. Table 02 shows the total number of publications found in the databases of the CAPES Periodic Portal, the Revista Produção Online and the Revista Gestão Industrial, after the *application of the "Strings*" of research.

Table 02 - Total Publications found by Database 01.

Search Database	**Total Publications**
CAPES Periodic Portal	06
Online Production Magazine	11
Industrial Management Magazine	10

Source: The authors.

3.2 FIRST GROUP PUBLICATIONS SELECTION PROCESS

Initially, for the first group, publications from the databases pointed out inTable 02 were analyzed. As the first filter of the searches, it was established the reading of the titles found, initially aiming to select articles from the pre-established search strings.

Later, as the second filter of the researches, the abstracts of the texts were made. The abstracts of the publications that did not present potential answers to the research-directing questions defined in the Applied Protocol were not considered to deepen the reading in order not toaddress the themes of interest established.

As the third and last etapa, the publications found in the databases were read in full. For selection purposes, we also considered only the texts that were in accordance with the questions of the researchirecionadores defined in the Applied Protocol. The amount of 2 1 (twenty-one) publications was selected and used.

In view of the relatively small amount of the set of texts analyzed, 27 (twenty-seven), it was possible toreread all the articles and identify, in their body, the existence or not of potential solutions to the proposed questions.

It was also observed that the systematic, in this particular case, of sequentially eliminating the articlesthrough the reading of the titles, the abstracts selected by the titles and, finally, the texts selected by reading the abstracts would not becompletely efficient in order to eliminate articles with possible possibilities of employment.

For the articles currently worked, it was noticed that, in some of them, only the titles and their respective abstracts did not clearly indicate the tools and techniques used in their themes, making it necessary to complete read the texts to identify the above-mentioned tools and techniques, as well as their employment potential for the research proposed in this work.

However, it is observed that in other studies, where the quantity of texts found and available for analysis and selection is higher, the systematic and sequential elimination of articles starting with the reading of titles, abstracts and texts tends to be necessary and more effective.

On the occasion of the selection process in the CAPES Periodic Portal, despite the significant amount of relathes for the theme *"multicriteria"*, the use of *the terms "hierarchization"* and *"resources"*, as well as the combination of them, led to a considerable reduction in the number of studies available.

Table 03 shows the number ofresearches filtered at each stage of the selection process.

Table 03 - Searches filtered by step of the selection process 01.

Identification	
In databases	**27**
Triage	
Excluded by title	**09**
Selected by title	**18**
Deleted by summary	**07**
Selected by the summary	**20**
Eligibility	
Deleted by reading	**06**
Selected by reading	**21**

Source: The authors.

3.3 SEARCH STRATEGIES OF THE SECOND DATABASE GROUP

In the second group, the following databases of publications were consulted: a) SciELO, b) Web of Science and c) Google Scholar. For database searches, we also tried to establish terms that better defined the topics of interest. Later, already in a more targeted way, aiming at a restriction of thesample space for purposes of greater objectivity about the results to be found, the research was carried out using the same combination of the most restrictive terms used in the research conducted with the CAPES Periodic Portal. The "*String*" used was:

- multicriteria AND hierarchization AND resources AND Engineering

For these studies, the temporal restriction was also added for the year 2022. It is observed that, in this group of investigations, no return of publications was obtained in the SciELO database and that the other results in thecontract were considered for study, considering the relatively small amount of studies identified.

Table 04 shows the total number of publications found in the SciELO, Web of Science and Google Scholar databases, after the application of the "*String*" of research.

Table 04 - Total Publications found by Database 02.

Search Database	Total Publications
SciELO	00
Web of Science	02
Google Scholar	36

Source: The authors.

3.4 SECOND GROUP PUBLICATION SELECTION PROCESS

Initially, for this second group, publications from the databases pointed out in Table04 were analyzed. As the first filter of the searches, it was established the reading of the titles found, aiming to select articles from the "String" of pre-established search.

Later, as the second filter of theresearches, there were several readings of the abstracts of the texts. The abstracts of the publications that did not present potential answers to the research-directing questions defined in the Applied Protocol were not considered to deepen the reading with a view tonot addressing the themes of interest established.

As the third and last etapa, the publications found in the databases were read in full. For selection purposes, we also considered only the texts that were in accordance with thewriting scations ofthe research defined in the Applied Protocol. The number of 25 (twenty-five) publications was selected and used.

In view of the relatively small amount of the set of texts analyzed, 38 (thirty-eight), it was possible to read allthe air tigos and identify, in their body, the existence or not of potential solutions to the proposed questions.

Similarly to that observed in the first group of databases, it was found that the thematic sisof sequentially eliminating the articles through the reading of the titles, the abstracts selected by the titles and, finally, the texts selected by reading the abstracts was notcompletely efficient in order to eliminate articles withpossible possibilities of use.

For the articles of the second group of databases, it was also noticed that, in some of them, only the titles and their respective abstracts did not clearly indicate the tools and techniques used in their themes f while it was necessary to complete ly read the texts to identify the above-mentioned tools and techniques, as well as their employment potential for the research proposed in this work.

Finally, it wasalso observed that, in other studies, where the q uantitativo of texts found and available for analysis and selection is greater, the systematic and sequential elimination of articles starting with the reading of titles, abstracts andtexts tends to be necessary and more effective.

Table 05 shows the number of searches filtered at each stage of the selection process.

Table 05 - Searches filtered by step of the selection process 02.

Identification	
In databases	**38**
Triage	
Excluded by file unavailability/replay	**10**
Excluded by title	**12**
Selected by title	**16**
Deleted by summary	**05**
Selected by the summary	**23**
Eligibility	
Deleted by reading	**03**
Selected by reading	**25**

Source: The authors.

4 ANALYSIS OF RESULTS

For the realization of this part of the research, the studies selected for reading underwent a complete critical analysis. The articles had, in addition to the titles and abstracts, their contents read and analyzed. At the end of theanalysis of the articles, some were not used in order not to meet the objectives proposed for systematic review.

At the time of the studyof the 46 (forty-six) articles selected, it was perceived that they had a vast field of study to be associated with the topics of this systematic review. In the analysis of the themes, a relationship was perceived between them, particularly with regard to the methods of multicriteria support to decision-making.

Regarding the content of the selected publications, a wide spectrum of applications was observed in the most diverse areas of knowledge. The publications point out that the theme related to multicriteria support methods to decision-making allows the resolution of various demands in relation to questions of hierarchy, selection and prioritization.

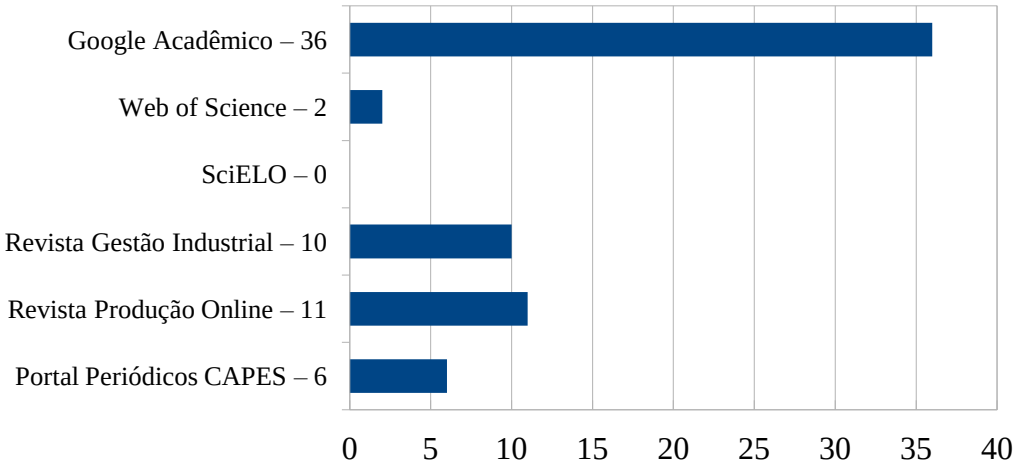
The proposal that led to the research work, whose main theme aimed to find alternatives that would lead to the prioritization of resources and information available in an organization producing cartographic information, resulted in the selection of 46 (forty-six) articles, after the use of inclusion and exclusion criteria, defined in accordance with the provisions of the pu selection process, resulted in the selection of 46 (forty-six) articles, after the use of inclusion and exclusion criteria, defined in accordance with the provisions of the pu selection process, resulted in the selection of 46 (forty-six) articles, after the use of inclusion and exclusion criteria, defined in accordance with the provisions of the pu selection process, resulted in the selection of 46 (forty-six) articles, after the use of inclusion and exclusion criteria, defined in accordance with the provisions of the pu selection process, resulted in the selection of 46 (forty-six) articles, after the use of inclusion and exclusion criteria, defined in accordance with the provisions of the pu selection process, resulted in the selection of 46 (forty-six) articles, after the use of inclusion and exclusion criteria, for the present systematic review work.

In the selected studies, it is observed that the majority comes from Brazil, in case 19 (nineteen), then we have Switzerland with 13 (thirteen) publications, Germany with 05 (five) publications, the Netherlands with 04 (four) publications and Argentina with 02 (two) publications. Finally, it was observed 01 (one) publication for the United States, 01 (one) publication for France and 01 (one) publication for Colombia.

In terms of authors,183 (one hundred and eighty-three) researchers committed to the execution of the 46 (forty-six) studies were computed. We also observed 93 (ninety-three) citations from educational institutions, located in 24 (twenty-four) different and scattered countriesand with 04 (four) continents. The papers were published between 2007 and 2022 and, regarding keywords, the number of 216 (two hundred and sixteen) different keywords was observed in the articles.

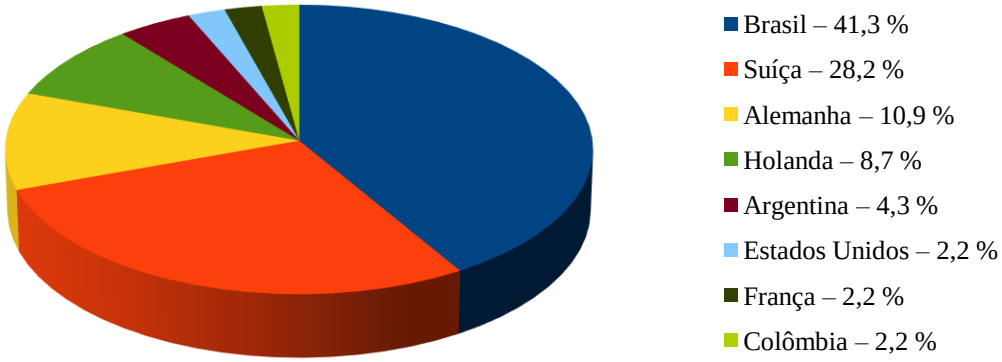
At the time of the detailed verification of the content of each of the 46 (forty-six) articles selected in the research, it was possible to group by similar themes. However, it is emphasized that the employability, objectives and results of publications are different from each other.

Graph 01 - Publications found by Database.



Source: The authors.

Graph 02 - Number of Publications by Journal Source.



Source: The authors.

Table 06 shows the publications according to the authors, within the relevance for the proposed research, and the observed themes condensed.

Table 06 - Groupings according to the themes.

Item	Article	Thematic
01	ARAUJO, W.C. *et al.*	Multicriteria AHP
02	BORTOLUZZI, S.C. *et al.*	
03	BIG BOYS, R.L. *et al.*	
04	GOMES, C. F. S. *et al.*	
05	HÄMMERLING, M. *et al.*	
06	LONGARAY, A. A. *et al.*	
07	LUCENA, A. F. E. *et al.*	
08	OUMA, Y.O. *et al.*	
09	PETROUTSATOU, K. *et al.*	
10	SANTOS, D. F. *et al.*	
11	SIMÃO, A. S. *et al.*	
12	SOLANA-GONZÁLEZ, P. *et al.*	
13	VALDÉS, R. M. A. *et al.*	
14	BORTOLUZZI, S.C. *et al.*	Multicriteria MCDA-C
15	ENSSLIN, L. *et al.*	
16	ENSSLIN, S. R. *et al.*	
17	GIFFHORN, E. *et al.*	
18	LONGARAY, A. A. *et al.*	
19	RAMOS, P. R. *et al.*	
20	STEFANO, N. M. *et al.*	
21	VEGINI, D. *et al.*	
22	CAMPOS, V. R. *et al.*	Multicriteria .com Miscellaneous Methods
23	FARGNOLI, M. *et al.*	
24	GUTIÉRREZ, L. E. *et al.*	
25	HERNÁNDEZ, L. *et al.*	

26	MENDONÇA, G. C. *et al.*	
27	OLIVEIRA, S. R. M. *et al.*	
28	PARRA, X. *et al.*	
29	PEÑA, A. *et al.*	
30	QUESADA-GARCÍA, S.	
31	SANTOS, M. R. *et al.*	
32	SAUVÉ, P. *et al.*	
33	TOVAR-PERILLA, N.J. *et al.*	
34	ABDI, A. *et al.*	Other Varied Themes from Interest
35	ABOURRAJA, M. N. *et al.*	
36	BOUILLASS, G.	
37	CASAL-GUISANDE, M. *et al.*	
38	CASAL-GUISANDE, M. *et al.*	
39	CASAL-GUISANDE, M. *et al.*	
40	GARCÍA, A. B. *et al.*	
41	McKENNA, R. *et al.*	
42	RONQUILLO-CANA, C. J. *et al.*	
43	SALVADORI, T. S. *et al.*	
44	SAUVÉ, P. *et al.*	
45	TRZASKALIK, T.	
46	YU, V.F. *et al.*	

Source: The authors.

The analysis of the results of the clusters, according to the themes, showed a higher number of articles using methods of multicriteria support to decision-making based on the AHP (*Analytic Hierarchy Process*) method with about 28% of the total.

As the second largest grouping, we have the articles employing methods of multicriteria support to decision-making based on the MCDA-C method (Multicriteria Method of Constructivist Decision Support) with about 18% of the total.

It was also observed the useof d and several other multicriteria methods, which together make up about 26 % of the total number of articles seen.

It was also observed the use of varied methods and themes, correlated to theresearch-directed question, and grouped in the approximate amount of 28% of the total number of articles viewed.

In the 46 (forty-six) articles selected, the following 04 (four) thematic groupings were glimpsed: 1) Multicriterion AHP, 2) Multimcda-c criterion, 3) Multicriteria with Miscellaneous Methods and 4) Other Varied Themes of Interest.

5 FINAL CONSIDERATIONS

This research aimed to investigate scientific papers, with emphasis on the characterization of those whose scientific production focused on hierarchy, prioritization and multicriteria methods, through the

investigation and analysis of contributions from various countries, journals, authors, research themes and the use of bibliometric indicators.

Despite a significant number of publications found and analyzed, there was an absence of specificity for the theme addressing research on the prioritization of resources in the execution of cartographic works with emphasis on Multicriter analysis. This finding suggests the need for further research in scientific studies that address the aforementioned area of interest.

During the development of the investigations, it was observed that most publications originate from Brazil and Brazil, having the same, respectively, 19 and 13 publications, followed by Germany and the Netherlands with, respectively, 05 and 04 publications.

In terms of limitations, the research conducted could have expanded the temporal interval of investigation,partic ularmente in relation to the second group of bases, however the restriction in the availability of the time factor, in the achievement of the studies, did not allow further verifications and observations about the aforementioned aspect.

Withfuture work, we can suggest the applicationof variations in the construction and elaboration of the "*string*" of research employed, as well as the application of the methodology used in different databases, with a view to the expansion of analyses and conclusions and for a better dissemination of the resultssettled.

Finally, inthe detailed weighting of the 46 (forty-six) publications, it was observed that they collaborate with relevant subsidies to obtain answers correlated to the proposed question, as well as a significant preponderance of the AHP method, with about 28% of the total number of selected publications, and the MCDA-C method, with about 18% of the total publications selected.

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