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RESEARCH ARTICLE

MODEL OF THE ELECTORAL REGISTRATION INFORMATION SYSTEM IN MOZAMBIQUE

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Abstract

Electoral Registration (ER) is essential for the legitimacy of elections in Mozambique, and it is crucial to ensure that all citizens have access to the political process. The objective of this article is to propose an efficient model for the Electoral Registration Information System in Mozambique, which integrates modern technologies to optimize the registration process, improve data accuracy and increase citizen participation. The research used a mixed approach, using a combination of data collection methods, including direct observations, document analysis, literature review, questionnaires and interviews with relevant stakeholders. The results indicate that the excessive use of paper materials in the years 2018, 2019, 2023 and 2024 had a negative impact on both the efficiency of the system and its environmental impacts. The research revealed that eliminating these redundant materials could significantly improve the effectiveness of the Electoral Registration Information System (ERIS).

Introduction:-

The Electoral Register (ER) is highly relevant to the conduct of voting processes. It is through this process that citizens of active voting age, and those who will reach that age by the day of a given election, are registered in the electoral rolls. Furthermore, they acquire voter cards in order to vote. Beyond voter cards and electoral rolls, the information resulting from the ER is particularly relevant for quantifying all the electoral equipment necessary for conducting the voting processes, as well as for planning electoral logistics. That is, the ER provides essential data for making decisions about the total number of polling stations, the allocation of voters to polling stations, the quantity of voting equipment needed, the number of vehicles needed for the distribution and collection of voting equipment, and for the supervision of the process, the total number of Polling Station Members (PMMs) to be hired, and the planning of the budget necessary for carrying out the process.

Problem Definition:

According to Malhotra, Ebster, and Garaus (2013), the ability to reduce costs and avoid waste is a strategic factor for organizations in today's market, in order to maximize efficiency. Issues involving environmental problems, such as the depletion of non-renewable natural resources and economic growth disconnected from sustainable

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development, have become a major global concern in recent years (Lunardi and Frio, 2012). Given that the ERIS (Integrated Electoral Registration System) is mixed, i.e., simultaneously digitized and analog, this scientific study is justified in order to assess the relevance of using paper-based electoral materials, especially for the Government of Mozambique, the National Elections Commission (CNE), the Technical Secretariat for Electoral Administration (STAE), and stakeholders, and consequently evaluate the system's efficiency.

The partial digitization process of the Electoral Registration in 2018, 2019, 2023, and 2024 was costly, mainly due to the financial resources used to acquire redundant paper-based electoral materials and other supplies. Furthermore, the manufacturing and incineration processes of these materials generated a proliferation of greenhouse gases. It is obvious that the negative environmental impacts of the production, processing, consumption, and incineration of materials are profound and increasing. The scientific research problem identified in this article concerns the redundant use of paper-based electoral materials at all stages of this electoral process. These materials, from their manufacture, acquisition, and consumption, cause negative economic and environmental impacts. In the environmental domain, the proliferation of greenhouse gas emissions was observed in the raw material, manufacturing, and incineration processes of these materials after their 5-year shelf life expired.

Objective:

The objective of this study is to propose an efficient model for the Electoral Registration Information System in Mozambique, which integrates modern technologies to optimize the registration process, improve data accuracy, and increase citizen participation. This study aims to contribute in practice, science, and theory. The practical contribution can be: i) operational efficiency: the implementation of the proposed model can optimize the Electoral registration process, reducing queues and improving citizen participation when registering to vote; ii) access to information: the proposed system model can facilitate access to updated electoral data, allowing for more effective management of information about voters and their registrations; and iii) transparency and trust: by improving data accuracy and security, the model can increase public trust in electoral administration and management institutions, promoting greater civic participation.

Types of Research:

Type of Research Regarding Approach:

This scientific work used a mixed-methods approach. Creswell and Creswell (2021), state that this method is characterized by the fact that the researcher first conducts quantitative research; then, proceeds to analyze the results, explained without further detail through qualitative research. According to Creswell (2010), the mixed-methods approach combines or blends both quantitative and qualitative methods. Just as it advocates obtaining precise data, it also advocates a thorough understanding of this data. Not taking them as an absolute answer, but understanding that the data are part of a whole that needs to be understood as such.

Research Type Regarding Nature:

From the point of view of its nature, applied research was considered for this work, since, according to Silva and Menezes (2005), it “aims to generate knowledge for practical application and is directed towards solving specific problems.”

Methodological Procedures:

The methodological procedures used in this research are: bibliographic research, exploratory research, documentary research, and observation. However, these approaches were chosen because, in fact, according to the problem under study, they are the ones that provide the right alignment to the results of the research.

Bibliographic Research:

Gil (1999) explains that bibliographic research is developed using already elaborated material, mainly books and scientific articles.

Exploratory Research:

In order to provide greater familiarity with the research problem, with a view to making it more explicit or building hypotheses, the exploratory research methodology was also used. Exploratory research provides greater familiarity with the topic, seeking to make it more explicit and clear (Silva and Meneses, 2001). According to Churchill (1999), exploratory research is indicated in situations where information about the problem in question is limited. Therefore, this technique was necessary because, due to the nature of the organization under study, the information is sensitive.

Documentary Research:
According to Silva and Grigolo (2002), documentary research uses materials that have not yet undergone any in-depth analysis. This type of research aims, therefore, to select, process, and interpret raw information, seeking to extract meaning from it and introduce value to it, thus contributing to the scientific community so that others may play the same role in the future. Within the scope of documentary research, documents from the institution that had not undergone any type of scientific analysis were consulted, such as official reports, communications, and some documents containing formal rules such as electoral legislation and the Constitutions of the Republic of Mozambique.

Observation:
According to Marconi and Lakatos (2003), observation is a data collection technique used to obtain information and utilizes the senses to obtain certain aspects of reality. It consists not only of seeing and hearing, but also of examining facts or phenomena that one wishes to study. Through this technique, the researcher observed ER processes that took place in 2018, 2019, 2023, and 2024, during supervisions conducted at 70 ER stations and 3 STAE warehouses where ER ballots and other paper-based electoral materials are stored.

Field Research:
In the field research, primary data collection was carried out using methods such as interviews, questionnaires, and direct observations. Direct observations were made at 70 ER stations and 3 warehouses where all paper-based electoral materials and their respective supplies are stored, during the periods under analysis.

Sampling:
The sample consists of 62 participants, of which 10 are CNE members, 7 are heads of the Department of Electoral Organization and Operations (DOOE), 15 are DOOE technicians, 10 are ER Brigade members, and 20 are citizen voters. The criteria used for selecting the participants, namely the CNE members, DOOE heads, DOOE technicians, and RE Brigade members, were based on the areas they are involved in, areas that are aligned with the RE and suffrage, experience, and length of work in these areas, while for citizen voters, the criterion used was experience in participating in the ERs held during the periods under analysis.

Data Collection Instruments:
In this research, data collection instruments included questionnaires with closed-ended questions on a 5-point Likert scale, individual interviews with selected employees, and direct observation, primarily to acquire sufficient information to conduct scientific research on the efficiency analysis of the SIRE (Integrated System for Receiving and Registering Voters). This data collection technique was chosen to extract relevant information to characterize the ERIS currently used for voter registration in Mozambique.

Data Analysis:
According to Bastos (2024), data analysis is the process of applying statistical and logical techniques to evaluate information obtained from certain processes. The main objective of the practice is to extract useful information from the data. Data analysis was carried out in the following terms: first, the research objective was determined and the problem identified; then, a literature review, document analysis, and the development of research questionnaires based on questions from a 5-point Likert scale were conducted. Following this, qualitative and quantitative data were collected using the research instruments employed; in the next phase, the data were cleaned to find suitable and reliable data; and finally, the data were analyzed.

In the case of a mixed approach, the analysis and systematization of qualitative data focused on data obtained through observations and document analysis, while the analysis of quantitative data obtained through questionnaires was carried out through statistical analyses in SPSS. This process began with the insertion of research questions and the coding of responses on a scale of 1 to 5 (where points 1 and 2 are negatively associated, point 3 is neutral, and points 4 and 5 are positively associated). Finally, the analysis included the percentage of processed cases (valid, excluded, and total), the reliability of questionnaire responses using Cronbach's alpha, and the correlation between questions.

Data Analysis Methods:
The methods used for data analysis are: defining questionnaire questions and interview guides, data collection, data cleaning, and descriptive data analysis.

Tools Used for Data AnalysisL:
The tool used to analyze the quantitative data was the Statistical Package for the Social Sciences (SPSS) software, using a 5-point Likert scale, while for the qualitative data, there was no need to use a tool and the analysis was based on information obtained through bibliographic review, document review, and observations.

Ethical Considerations:
This scientific research was conducted ethically. However, in its execution, the protection of the rights of all participants was guaranteed, such as: transparency with the participants about the research, the accuracy of the results, informed consent, the confidentiality of the participants, anonymity, and above all, the protection of privacy. Accuracy in the research and data collection was also ensured, crucial aspects to help in making fact-based decisions. The ethical integrity of the research, and intellectual property rights were also guaranteed. However, all authors of the documents consulted are listed in this dissertation through bibliographic references. Furthermore, before beginning data collection, participants received prior information regarding the protection of their rights.

Presentation of Results:
Description of ERIS and Presentation of the Proposed Model:
ERIS allows for the collection, processing, and storage of information in the context of Electoral Registration. Electoral registration processes can be manual, computerized, or mixed. The first electoral registration in Mozambique was carried out in 1994, the second in 1999, and the third in 2004. These three electoral registration processes were characterized by being completely manual. During this period, information was stored only in physical format, at the Electoral Registration Posts, especially during the periods when the registrations were carried out, and in the STAE warehouses, specifically after these electoral processes were completed.

In 2007, due to the limitations presented by the manual ERIS, and on the other hand, due to the advancement of modern digital technology, the biometric ERIS was introduced for the first time in the context of electoral administration in Mozambique. In parallel with computerized registration,themanual registration was also carried out in some stages of ERIS, such as electoral registers and electoral registration forms. In the current approach, the ERIS is digitized, consisting of the collection of biographical and biometric data (photographs and fingerprints) of voting citizens of active electoral age, typing, processing and printing of electoral documents such as voter cards, voter registration forms, weekly and monthly reports, electoral registers, and storage of information pertaining to voter registrations in a digital database, through the Mobile Identity Document (ID).

Table 1: Comparison of ERIS models used in other countries (Adapted from Siqueira 2012).

Electoral Registraion Technology		
Country	**Type**	**Model**
Mozambique.	Biometric/Active.	Decentralized System. Data consolidation is done regionally.
Cape Verde.	Biometric/Active.	Integrated and online system. Data between RE stations is updated daily.
Guinea-Bissau.	Manual/Active:	Manual data capture via forms. Data entry into the system uses double-blind data entry.
São Tomé and Príncipe.	Biometric.	Decentralized. Data consolidation is centralized.
Timor-Leste.	Biometric/Active.	Decentralized. Data consolidation is centralized. The system captures biometric data (photo and fingerprints) but the Automated Fingerprint Identification System (AFIS) and Facial Recognition System (FRS) are not implemented.
Netherlands	Biometric/Passive	Voting system citizens are automatically registered to vote once the legal requirements are met. To this end, electoral registers are produced using integration and interoperability between the Civil Registry and Electoral Bodies Information Systems. There is no need to produce voter cards; citizen's vote using their Identity Card (ID).

The table 1 above illustrates some ER models used in some countries. In this context, the best practice that could be adapted to the Mozambican context is the Dutch model. This practice is economically viable because it does not

require investments in the acquisition of computer equipment for ER, nor does it require the hiring of Electoral Agents to operate the ER Brigades. Therefore, investments for this model are allocated to the technological infrastructure of the Data Processing Centers (DPCs) and the hiring of Electoral Agents to operate in the DPCs.
Nevertheless, implementing this model in Mozambique presents a significant challenge for Electoral Offices, Civil Identification Agencies, and Internet Service Providers. Furthermore, there is a need to make the Electoral Office Information Systems and Civil Identification Information Systems more robust and resilient; in addition, Civil Identification Information Systems and internet services must be robust, resilient, and comprehensive, reaching all remote areas. On the other hand, there is a need to make the national Cybersecurity system in Mozambique more robust and secure.

The series selected for the analysis of the ERIS model were: 2018, 2019, 2023 and 2024. According to international standards, the efficiency score should be restricted to the range of 0 to 1, that is, between 0 and 100%. Advances in electronics have led organizations to invest in Information and Communication Technologies (ICTs), mainly with the objective of increasing efficiency and productivity, and in the context of this scientific study, the domain of mitigating greenhouse gases can also be included. It should be noted that, in the series under analysis, many electoral materials were used on paper and other inputs, and there was also some contribution towards the increase in greenhouse gases. The results of this research showed that eliminating the use of paper-based electoral materials in Mozambique, within the current ERIS model, and migrating to a fully digital model will positively influence the maximization of ERIS's efficiency and the mitigation of environmental impacts. Therefore, there is a need to completely eliminate the use of paper-based electoral materials and their associated inputs, especially in electoral processes, while maintaining all processes and documents in digital format.

Analysis of Questionnaire Responses:
The questionnaires and interviews focused on the following actors: CNE members, DOOE heads, DOOE technicians, ER Brigade members, and citizen voters. Analysis of all questionnaire and interview responses: the questionnaires focused on a sample composed of CNE members, DOOE heads with more than 15 years in this leadership position, DOOE technicians with more than 20 years of experience in the STAE, ER Brigade members who have participated in more than four ERs, and citizen voters who have registered more than four times. It should be noted that the frequency of use of RE ballots and other paper materials in this format, especially in the four series under study, was very high.

Analyzing all the responses received, it became clear that the use of a mixed model, digitized and combined with the simultaneous use of paper-based electoral materials and their respective inputs, creates scenarios of unnecessary redundancies in the electoral processes, makes the electoral system costly in Mozambique, and contributes to the proliferation of greenhouse gases. It was also evident that what is driving this phenomenon is the resistance to change and the lack of sufficient confidence in a fully computerized ERIS-based model on the part of some stakeholders in the electoral processes, especially political parties with parliamentary seats, and the limitations of current electoral legislation. However, according to evidence from various scientific approaches found in the literature review, the redundancy in the use of paper-based electoral materials and their respective inputs in this model is not relevant; therefore, these materials make the model costly, slow down the procedural speed, have negative environmental impacts, and are less secure with regard to the storage of electoral information.

However, models based on computerized ERIS are, by themselves, sufficient, more efficient, secure, robust, easier to manage, and do not emit greenhouse gases. Through literature review, it was also proven that there is no need to print electoral materials on paper when registering voters in Mozambique. All processes related to the use of paper electoral materials should be discontinued, especially in the Mozambican electoral system model, and full confidence should be placed in fully digitized models. From the perspective of the author of this scientific study, eliminating paper electoral materials and their respective inputs in the current model in Mozambique will increase the current efficiency score of the ERIS. The use of a fully digitized ERIS will significantly streamline the performance of tasks related to electoral registration and decision-making. It will reduce the financial burden on the Government of Mozambique and the emission of greenhouse gases. In fact, in this model, paper-based election materials increase the vulnerability of the system and election material warehouses with regard to fire risks.

Analysis of Questionnaires Using the Likert Scale:
In this scientific research, the reliability of the questionnaire responses was evaluated using SPSS software based on the 5-point Likert scale. Measurement is one of the means by which data are accessed and described to understand facts and phenomena of interest. In this context, the handling of data from this scientific research generated

information and knowledge that can be directed towards both academic and professional objectives and for the benefit of society. Therefore, the Likert scale is the most widely used model among researchers. The Likert verification scale consists of taking a construct and developing a set of statements related to its definition, to which respondents will express their degree of agreement, perception, or satisfaction. This allows for the collection of opinions, impressions, and approaches in a clear and objective way. Table 2 shows an example of the 5-point Likert scale for measuring satisfaction with a service.

Table 2: Example of a Likert scale (Likert 1932).

I totally disagree	Discordo parcialmente	I neither agree nor disagree	I partially agree	I totally agree
1	2	3	4	5

According to Costa (2011), on this scale, respondents position themselves according to a measure of agreement assigned to the item, and, according to this statement, the constructor's measure is inferred.

Analysis of the Cronbach's Alpha Reliability Coefficient of the Questionnaires Using SPSS:
SPSS is a statistical package with different modules, developed by International Business Machines (IBM) for use by professionals in the humanities and exact sciences. It is an easy-to-use and very comprehensive tool, therefore, it allows for statistical and graphical analyses with a wide range of data. The analysis of the data collected through the questionnaires and the reliability of Cronbach's Alpha were performed using SPSS software. Reliability analysis is a measure that aims to define the degree to which measurements are free from errors and, therefore, produce consistent results and measure the reliability of instruments and constructions. According to Campoy (2016), from 0 to 0.4 - is considered very low reliability, from 0.4 to 0.65 - is considered low reliability, from 0.65 to 0.75 - is considered acceptable reliability, from 0.75 to 0.85, is considered high reliability, and from 0.85 to 1, is considered very high reliability.

Cronbach's Alpha:
Cronbach's alpha measures the correlation between responses in a questionnaire by analyzing the profile of the answers given by respondents. It is an average correlation between questions. Given that all items in a questionnaire use the same measurement scale, the alpha coefficient is calculated from the variance of the individual items and the variance of the sum of the items for each evaluator using the following equation:

$$\alpha = \left(\frac{k}{k-1}\right) \times \left(1 - \frac{\sum_{i=1}^{k} s_i^2}{s_t^2}\right)$$

Where:
k - Corresponds to the number of items in the questionnaire;
s^2i - Corresponds to the variance of each item; and
s^2t - corresponds to the total variance of the questionnaire, determined as the sum of all variances.
Cronbach's Alpha values range from 0 to 1; the closer to 1, the greater the reliability between the indicators. However, to calculate Cronbach's alpha coefficient, all responses must be transformed into scores.

Table 3: Validation of questionnaire items for CNE Vowels.

		N	%
Cases	Valid	16	100.0
	Excluded	0	.0
	Total	16	100.0

N - represents the number of questions for the questionnaire intended for CNE members; in this context, there were 16 questions.

Table 4: Cronbach's Alpha for CNE Members.

Cronbach'sAlpha	N ofItems
.988	10

In total, questionnaires were sent to 10 CNE members; therefore, for the reliability of the questionnaires sent to the CNE members, Cronbach's alpha is 0.99, which is considered very high reliability.

Table 5: Validation of questionnaire items for heads of DOOEs.

		N	%
Cases	Valid	7	100.0
	Excluded	0	.0
	Total	7	100.0

Table 6: Cronbach's alpha for heads of DOOEs.

Cronbach'sAlpha	N ofItems
.877	13

The Cronbach's alpha of the questionnaires sent to the 7 heads of the DOOE is 0.88, which is considered very high reliability. Therefore, for these, the questionnaires had 13 questions each.

Table 7: Validation of questionnaire items for DOOE technicians.

		N	%
Cases	Valid	15	100.0
	Excluded	0	.0
	Total	15	100.0

Table 8: Cronbach's alpha for DOOE technicians.

Cronbach'sAlpha	N ofItems
.927	7

While the Cronbach's alpha of the questionnaire for the 15 DOOE technicians is 0.93, it is considered very high reliability. Therefore, the questionnaire consisted of a total of 7 questions.

Table 9: Validation of questionnaire items for ER Brigades.

		N	%
Cases	Valid	10	100.0
	Excluded	0	.0
	Total	10	100.0

Table 10: Cronbach's Alpha for ER Brigade**.**

Cronbach'sAlpha[a]	N ofItems
.817	5

The questionnaire sent to the 10 ER Brigade members consisted of 5 questions; therefore, the Cronbach's alpha obtained is 0.82, which is considered high reliability.

Table 11: Validation of questionnaire items for citizen voters.

		N	%
Cases	Valid	20	100.0
	Excluded	0	.0
	Total	20	100.0

Table 12: Cronbach's Alpha for Voting Citizens.

Cronbach'sAlpha[a]	N ofItems
.995	2

For voting citizens, 20 questionnaires consisting of two questions were sent; however, the Cronbach's alpha obtained is 0.99, which is considered very high reliability.

For CNE members, DOOE heads, DOOE technicians, and voting citizens, the Cronbach's alpha reliability obtained was very high, while for ER Brigade members, the Cronbach's alpha reliability obtained was also high. The five questionnaires used for data collection also demonstrated a good correlation between the items. Therefore, the validity of internal consistency through Cronbach's alpha demonstrated that the application of such a coefficient allows us to assess the consistency between the items, as well as their responses, providing an estimate of the true reliability of an instrument for the given measurements.

The Cronbach's alpha values obtained are: for the CNE members, the Cronbach's alpha was 0.99 - very high reliability; for the DOOE chiefs, the Cronbach's alpha was 0.88 - very high reliability; for the DOOE technicians, the Cronbach's alpha was 0.93 - very high reliability; for the RE Brigade members, the Cronbach's alpha was 0.82 - high reliability; and for the voting citizens, the Cronbach's alpha was 0.99 - very high reliability. Note that among the Cronbach's alpha values obtained, the minimum was 0.82 and the maximum was 0.99. The average reliability of the five questionnaires was 0.92 - very high reliability. However, the values obtained through Cronbach's alpha coefficient in this scientific study demonstrate the existence of excellent reliability between questions and their answers in the 5-point Likert scale format; there is a positive association between the items and their respective answers.

According to the evidence found in the questionnaires, in order to improve the efficiency of the ERIS model used by STAE in Mozambique, it is recommended to fully digitize and eliminate the use of all paper-based RE materials and their respective inputs at all stages of the ER process. In this scientific research, analyses of the ERs carried out in the years 2018, 2019, 2023 and 2024 were performed, and in the context of data collection and analysis, studies that used a mixed-methods approach were sought.

Conclusions:-

This work sought to contribute to scientific studies for the analysis of the efficiency of the ERIS model in use in Mozambique, mainly with regard to the use of paper-based RE materials and their respective inputs. Considering that the general objective of this scientific article was to "Propose an efficient ERIS model in Mozambique, which integrates modern technologies to optimize the census process, improve data accuracy and increase citizen participation", the results indicate that the excessive use of redundant paper materials in the years 2018, 2019, 2023 and 2024 negatively impacted both the efficiency of the system and its environmental impacts. The research revealed that the elimination of these redundant materials could significantly improve the effectiveness of ERIS. The proposed model for ERIS proves to be effective in mitigating the problems identified during the implementation of ER.

Recommendations:-

It is recommended to promote the use of fully digitized Information Sistem models, without redundant paper materials, especially in the ER and voting processes. Regarding the technological offering for the full digitization of the ERIS model proposed in this research, although proprietary solutions are the most complete, the implementation of open-source technologies is recommended. The implementation of the integration and interoperability of the Mobile IDs of the ER Stations to the DPCs is recommended. The implementation of redundant, robust, and resilient electoral DPCsinfrastructures at the Central STAE, Provincial STAEs, and Districtal STAEs levels is also recommended.

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