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Business intelligence for decision-making in the collection area of a municipality

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ABSTRACT

The large volume of data in systems in the collection area leads to the lack of adequate management of information, as well as dissatisfaction on the part of the user. The purpose of the study is to implement business intelligence (BI) technology to improve the effectiveness of the information and the satisfaction of the attention of the users of a municipality of Lima in the area of collection; therefore, the phases of the Ralph Kimball method with the following phases: project planning; definition of requirements; design of technological architecture; in the dimensional modeling a snowflake scheme was made with 9 dimensions and 1 table made, in the physical design it was implemented in the MySQL management system and in the extract, transform, and load (ETL) development the migration, transformation and cleaning of the data from the online transaction processing (OLTP) database to online analytical processing (OLAP) was executed; obtaining as results that BI managed to increase the level of information efficiency by 53.32%, as well as the level of user satisfaction (LUS) by 1.90%, concluding that BI allows to meet the needs of the user since it maintains a clean, secure and reliable data structure.

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1. INTRODUCTION

The implementation of business intelligence (BI) uses tools for data transformation, helping the efficient development of the company [1], evidenced in the sum of inaccurate data collected in different areas formed in the entity, where 80% of the information provided by companies are not properly managed, making it difficult for managers to make timely decisions [2]. Similarly, in the United States, 70% of municipalities are limited by the absence of easy-to-use models, and that at the same time is detailed and reproduces accounting, which helps to elaborate the income statement data, so they need to opt for the change of appropriate technology that generates knowledge data to final consumers, i.e., implement financial statement systems [3]. Therefore, it is common for the most recent organizations to depend on information technology (IT), these being internal and external drivers of the operations of a business, whose quality of IT operation is affected, and that is where the importance of obtaining solutions based on storage, analysis and processing of complex collected data stands out. To problems that are within the reach of the population [4]. However, many companies do not have this, obtaining inefficient processes and lack of reliability and integrity of the information to make decisions [5]; where it should be noted that the management of collection is considered an important tool in the municipalities, since it facilitates the execution of the procedures collected, allowing to reach the revenues that are projected in a fiscal year [6].

It is that at first it was thought that large companies were those that implemented technologies, but over time more companies that use BI have been adapting, so there are several studies that talk about this technology, such as. in a research in China in 2021, an investigation was carried out, with the aim of studying the effect of BI on the finances of companies, being descriptive, where the structural equation modeling (SEM) methodology was used, working with a sample of 20 people; obtaining as results that the BI helped to improve the innovation index by 0.99%, as well as the financial productivity in the entities by 0.311%. Concluding that BI has effects on finance, this because multidimensional analysis contributed to the performance of companies [7]. Subsequently Fuertes *et al.* [8], conducted a study in order to design a model based on BI that provides proactive services in a computer emergency response team (CSIRT), making use of the stages of the Kimball method and online analytical processing (OLAP) processes; which shows that 85% of the results show early warnings based on the level of criticality and level of sensitivity in vulnerabilities, based on the BI solution.

In Portugal, Lopes *et al.* [9], conducted a study whose purpose was to analyze the role played by adaptive business intelligence (ABI) software in the progress of a health center. Based on the results, it was observed that the BI helped reduce both costs and time in relation to work by 79%, on the other hand, with respect to the performance of different specialties of the hospital, this increased by 95%. Likewise, in Japan in 2021, Bulgaria *et al.* [10] conducted research in which they aimed to create visual tools to improve decision-making procedures, using the systems dynamics methodology (DS), with the result that through the implementation of graphical reports 88% of users were satisfied.

On the other hand, Salazar and Mejía [11] conducted a study with the aim of determining whether by implementing a data mart, it influences the degree of effectiveness in decision-making of the faculty of stomatology of the Universidad Peruana Cayetano Heredia (UPCH), working with a sample of 15 reports of the indicator, using the hephaestus methodology and extract, transform, and load (ETL) processes, an efficiency increase of 24.21% was achieved.

Finally, Cardoso [12], in his study aimed to demonstrate whether the implementation of a software improves the level of effectiveness for decision making, working with a sample of 2 bidding reports to measure the level of efficiency of the data, as well as the rational unified process (RUP) method and it is phases, having as results that with the web application the level of efficiency was improved by 65.76%. For this reason, various solutions have been found for the resolution of the aforementioned problem, through effective processes through visualizing the information, with the purpose of increasing competitiveness by predicting or modeling the result of the activities carried out by the entity, contributing to the appropriate analysis with real data [13]. BI technology is a solution, since when requiring access to a large amount of information, the data is analyzed and structured to be interpreted in statistical tables, which provides a clearer understanding to the user [14]; as it contributes positively to the reduction of costs, to know new opportunities and to maximize profits [15]; leading to the obtaining of competitive advantages over other organizations in the same sector [16]. Even more than in Peru, organizations need to make use of technology for the collection area, as is the case of Marvisur, a transport company that did not have secure information management, which generated ineffective decisions and difficulties in its activities when consulting the system; reason why the entity invested in technological solutions that help in the decision making of executives [17].

The study presented was carried out in a municipality of Lima, where it was observed that there are problems with respect to the effectiveness of the information, because the reporting module they have does not help to deliver clean, safe and real-time information on municipal revenues, also the data are little understandable for the users because they are not presented through graphs or dynamics tables. On the other hand, the dissatisfaction of the users is observed in relation to the attention that is given to them, at the time of obtaining the reports, which begins with the preparation of files (Excel) where the Subgerencia stores its collected data extracted from the system, to then, make an order of the same and thus obtain an analysis and interpretation regarding the income, demanding a lot effort and loss of time. Therefore, this article aims to implement BI technology for the improvement in the decision-making process of a municipality in the area of collection. For this, the present work has been divided as follows: section 2 shows the fundamental concept, section 3 details the method of project development, section 4 presents the results, section 5 presents the discussion and section 6 shows the conclusions of the scope of the study.

2. THE FUNDAMENTAL CONCEPT

This section will proceed to describe the important concepts about BI, decision making within companies, efficiency in productivity, methodologies of both management and development of BI, and tools, so the objective is to obtain a more detailed overview of this topic and how it is related to the BI model.

Therefore, this allow conceptualizing, directing, explaining and contextualizing the study. As well as, to have a solid base for its correct application.

2.1. Business intelligence

They are indispensable strategies in decision making that help analyze, interact and directly access data in real time; having an indispensable role in companies; reasons why they feel the pressure to use technology to make strategic and operational decisions correctly [18]. As part of the avant-garde advancement of BI projects, it focuses on ensuring that end users accept the beneficial changes that BI brings and see it as an instrument of daily use in the work environment, which responds correctly to the necessary requirements of bosses, managers or organizational directors and above all that makes it possible to minimize the time in the execution of operational tasks [19]. Therefore, once these components are combined, companies begin to recognize that reports with reliable and truthful information are suitable to direct and control corporate obligations and tasks, as well as enable them to carry out their different organizational processes efficiently [20].

2.2. Decision making with business intelligence

It is the action of an individual when choosing an option, when taking into account provided data, which influences contexts on the behavior of the decision that was made [21], where generally, the justifications around the choice to carry out the implementation of BI part of the organizational point of view based on aspects such as the wear and tear it implies in time and resources [22], at the same time it helps to comply with the efficient development of the company in terms of sales and productivity, by having intelligent reports in real time that give quick response when making decisions through structured and reliable data to obtain a competitive advantage over other companies in the same field [23].

2.3. Business intelligence in companies

The objective of BI for the efficient development of a company is the generation of knowledge, so that people have an active role in the knowledge of information, having the ability to understand that allows them to group information at different levels and use them in different environments. Likewise, the importance of BI is that it manages knowledge with a specific perspective to the organization's environment [24]; regardless of the type of company, size and procedures of the information [25]. So, it can be said that BI reflects above its application a change in the efficient development of its processes and in the doctrine of the organization around decision making, from the management of daily processes to the complicated decisions that must be made, based on evidence provided in information [26].

2.4. Efficiency in business productivity

Currently, new technologies worldwide are the so-called "expert information systems", characterized by providing efficient activities in the development of each area formed in the entity, having the probability of emphasizing that there are still no difficulties in the technology that limit when applying BI trends [15]. More currently, challenges have been incorporated into projects when implementing BI for the efficient development in the productivity of the entity in the emergence of information security regulations and compliance with them, as well as the strategic development of the organization [27]. From the marketing point of view, BI is also a very common topic in market intelligence, since it is oriented towards the creation of knowledge [28].

2.5. Business intelligence development methodologies

2.5.1. Ralph Kimball method

It is a method characterized in the requirement of stored data that help companies in the analysis of them when convenient and that is useful for a correct administration of decision making [29], where it should be noted that, being focused on the management of BI data, it is helpful to achieve the results of the entity, by building a BI solution.

2.5.2. Hefesto method

It is a methodology that is based on other methodologies that already exist about stored data, where Hephaestus helps to build BI solutions in an easy and orderly way, in order to present the advantages and disadvantages of a datawarehouse, which consists of 4 main processes, starting with the analysis of requirements, followed by the analysis of the online transaction processing (OLTP), logical model of the datawarehouse and ending with the data integration phase [30].

2.6. Business intelligence tools

2.6.1. Power business intelligence

It is a set of cloud-based programs that work in groups for the transformation of data that is not connected to each other, into secure and efficient data, which consists of a variety of capabilities such as storing information and discovering dynamic dashboards, while the primary advantage of BI is the ability to load custom visualizations [31].

2.6.2. Tableau

It is a BI tool that is developed in the US entity. UU Tableau software, which helps when using different apps and developing didactic visualizations of data to analyze them, which contains different programs, such as: tableau mobile, desktop, online, and server [32].

3. METHOD

In the research work, the following hypotheses were raised:

- Level of information effectiveness (LIE)
  $H1_0$: the implementation of BI does not significantly improve the level of effectiveness of the information of the decision-making process of the collection area of a municipality of Lima.

  $$H1_0 = NE_a \leq NE_d$$

  $H1_a$: the implementation of BI significantly improves the level of effectiveness of the information of the decision-making process of the collection area of a municipality of Lima.

  $$H1_a = NE_a > NE_d$$

- Level of user satisfaction (LUS) in relation to obtaining reports
  $H2_0$: the implementation of BI does not significantly improve the LUS in relation to obtaining the reports of the decision-making process of the collection area of a municipality of Lima.

  $$H2_0 = NSU_a \leq NSU_d$$

  $H2_a$: the implementation of BI significantly improves the LUS in relation to obtaining the reports of the decision-making process of the collection area of a municipality of Lima.

  $$H2_a = NSU_a > NSU_d$$

Based on the above, in order to demonstrate the hypotheses raised, the BI system was implemented, where the Ralph Kimball method was used as shown in Figure 1 each of it is steps which will be detailed.

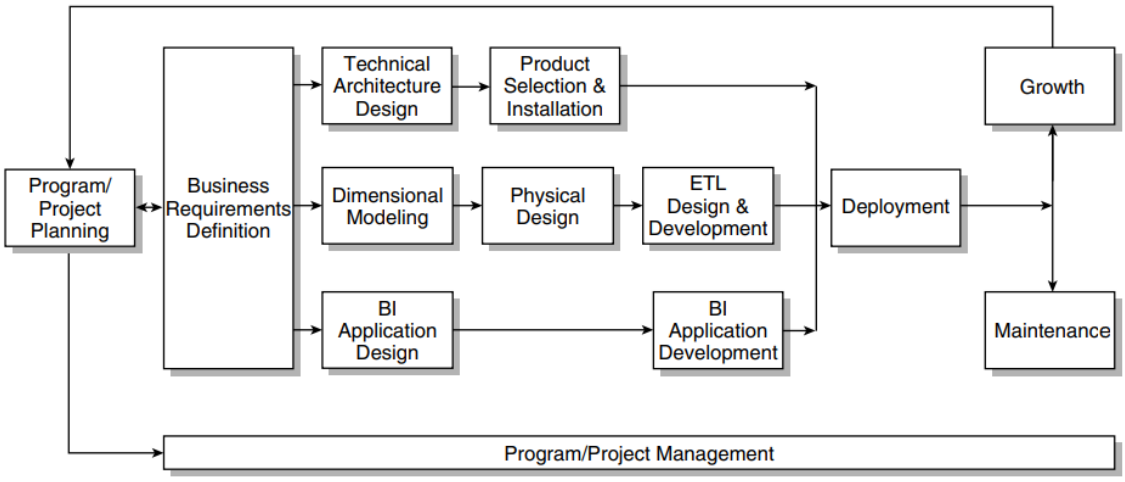

Figure 1. Phases of the Ralph Kimball method [33], [34]

3.1. Proyect planning

In this first phase of the Kimball method, we proceeded to define the project, as well as the requirements, in this case a BI system was required to improve the decision-making procedure of the collection area, later the preparation for the project was carried out, with the support of the staff and deputy manager; continuing with the scope where the data of the new datamart were identified, which was elaborated the OLAP cube and the dashboards were generated; where the roles were assigned and finally the administration of the project was carried out with the goal of the final presentation of the system.

3.2. Definition of requirements

In this section, the analytical needs were established and the requirements were determined. In this process, the information was gathered through an interview with the assistant manager and user surveys, which were based on the functional requiremenst, who are the ones that interact with the dashboards and/or reports for the analysis of strategic information. On the other hand, the current database containing the analyzed information was also observed. Among the functional requirements are the following: FR01: visualize the growth of revenue collection by budget item of the last 4 years; FR02: visualize the growth of the collection of the collection area of the last 4 years; FR03: visualize the growth of collection by daily budget item; FR04: visualize the best cashier you collect on the day; and FR05: visualize the total number of attentions that were carried out on the day, as shown in Table 1.

Table 1. Functional requirements

Functional requirements
FR01: visualize the growth of revenue collection by budget item of the last 4 years.
FR02: visualize the growth of the collection of the collection area of the last 4 years.
FR03: visualize the growth of collection by daily budget item.
FR04: visualize the best cashier you collect on the day.
FR05: visualize the total number of attentions that were carried out on the day.

3.3. Design of technological architecture

Within this phase, the procedures for the application of the BI were covered, which was based on 3 layers; being the first, the analysis and extraction of the data, stored in Microsoft SQL Server 2008, which were part of the datamart; subsequently, the back room was carried out, where the data were obtained through the ETL process; and finally the front room, in which the settlement of the datamart for the construction of the OLAP Cube was carried out, which allowed obtaining information and increasing user satisfaction. Figure 2 shows the design of the BI architecture.

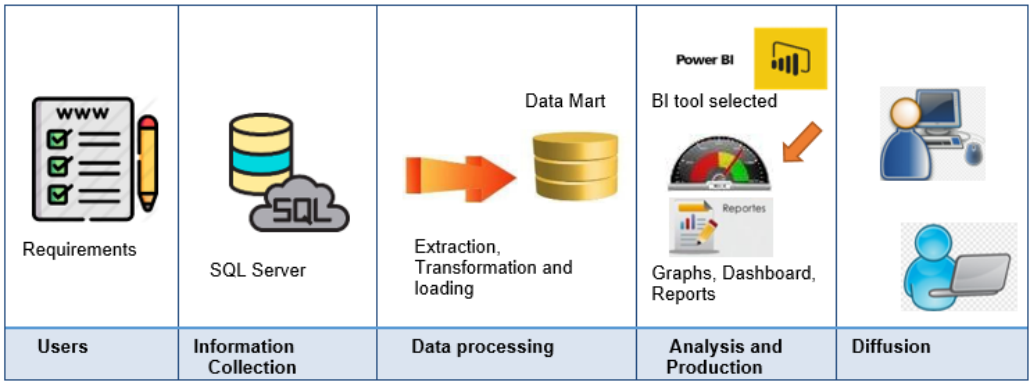

Figure 2. BI technical architecture

3.4. Product selection

To extract information, certain considerations were taken into account and to develop the BI system, sql server 2008, SQL server data tools for visual studio 2012 and power BI tools were used.

3.5. Dimensional model

In this phase, the dimensions for the creation of the datamart were identified, being taxpayer, fiscal year, type of payment, population center, type of population center, procedure, budget item, state, and time.

In addition to the presentation of the factual table. As shown in Figure 3, the Snowflake scheme was used since the dimensions contain dependencies that are necessary for the grouping of data, as well as the level of granularity of the identification of the fact table.

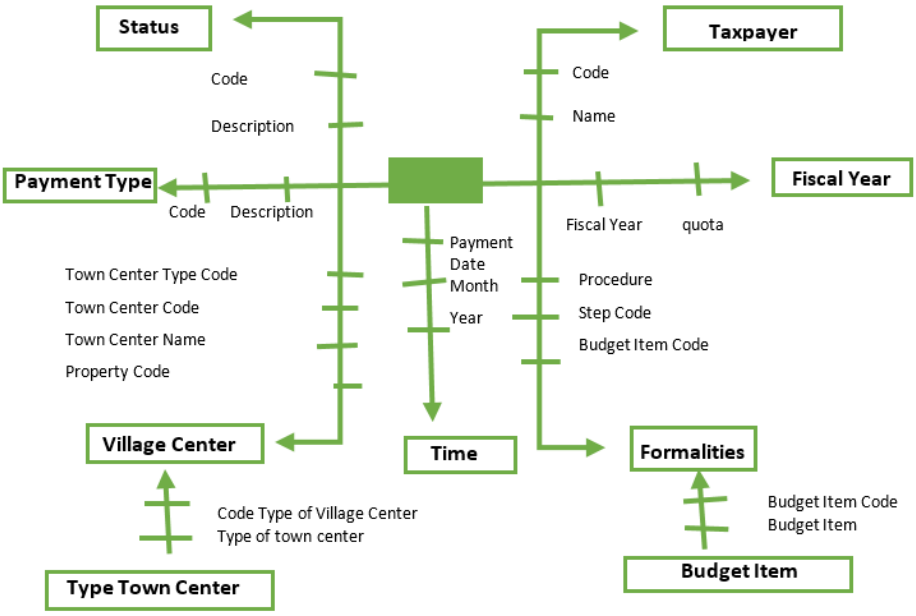

Figure 3. Determination of granularity level-snowflake design

3.6. Physical design

In this phase it is composed of the structures of physical tables which allows the support of the dimensional schema, divided into the following components: data source and analysis structure. The star model shown in Figure 4 illustrates all the dimensions in the fact table and the flow of the process, and then proceeds to the ETL process using the power BI tool, where the data was processed and loaded into a data mart, so we proceeded to store the data sources in a MYSQL database manager.

3.7. Extract, transform, and load-extraction, transformation and loading design

Likewise, the development of the BI was carried out, so the involvement of this tool allowed the communication of the data directly with the datamart and the construction of the OLAP cube. Figure 5 shows the presentation of the data, which was done through dashboards in the power BI desktop tool, which allowed access to the data necessary for the creation of dynamic visual environments and for their analysis as needed.

3.8. Business intelligence application specification

At this stage, the information was provided to users, which were presented through analytical reports, such as: collection report by budget-historical item, collection report by budget item-daily, collection report by cash-daily and report of attentions by cash-daily.

3.9. Business intelligence application development

After uploading the information to power BI, the dashboards were dynamically developed for a better understanding of consumers. As shown in Figure 6 is presented, the collection report by budget-historical item, which helped to show the statistical data and collection by the consumer, encompassing budget items of the last 4 years, containing different filters in interacting in searches made by final consumers. Figure 7 presents, the collection report by area-historical, which helped in the knowledge of total and detailed collection of the areas of the last 4 years, as well as processes that generate income. It also contained various types of filters to interact in the search carried out by the individual.

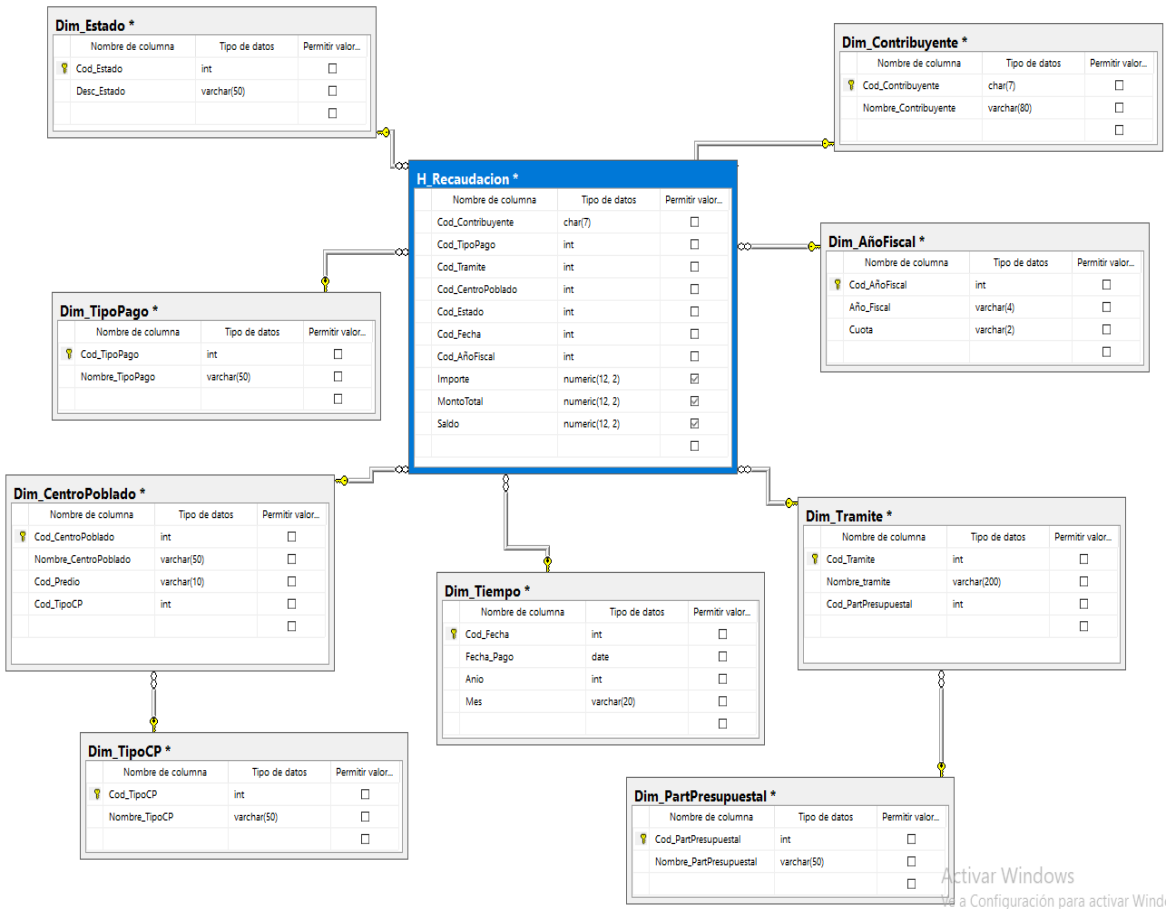

Figure 4. Datamart physical model

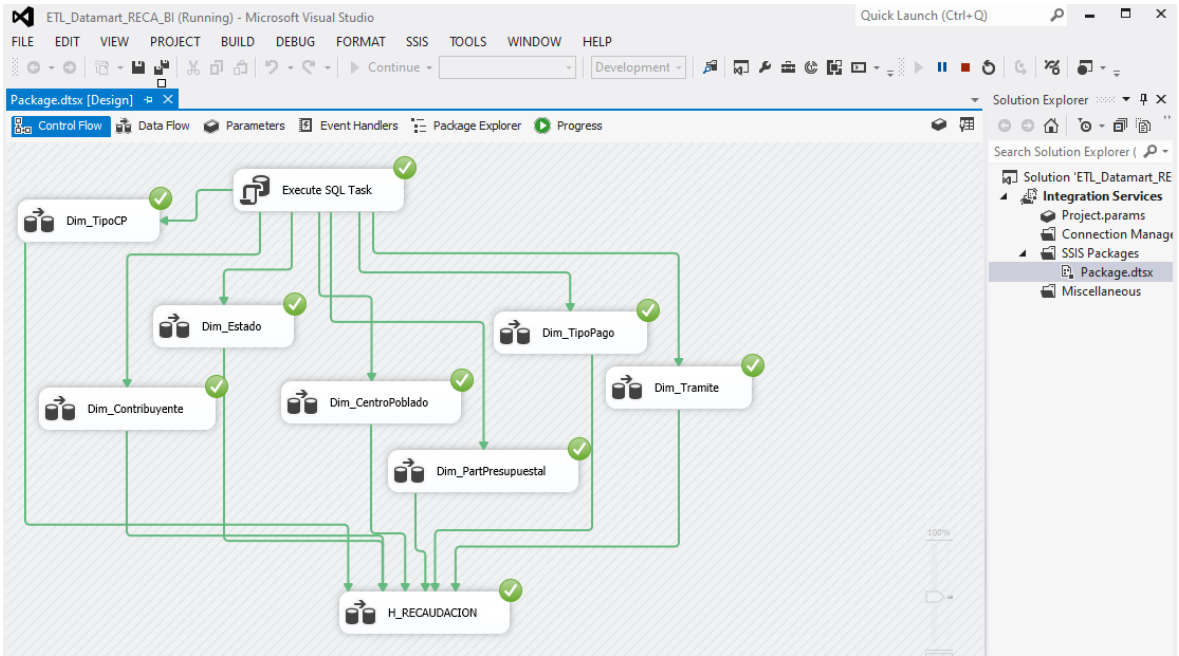

Figure 5. ETL process-execution of the complete ETL process

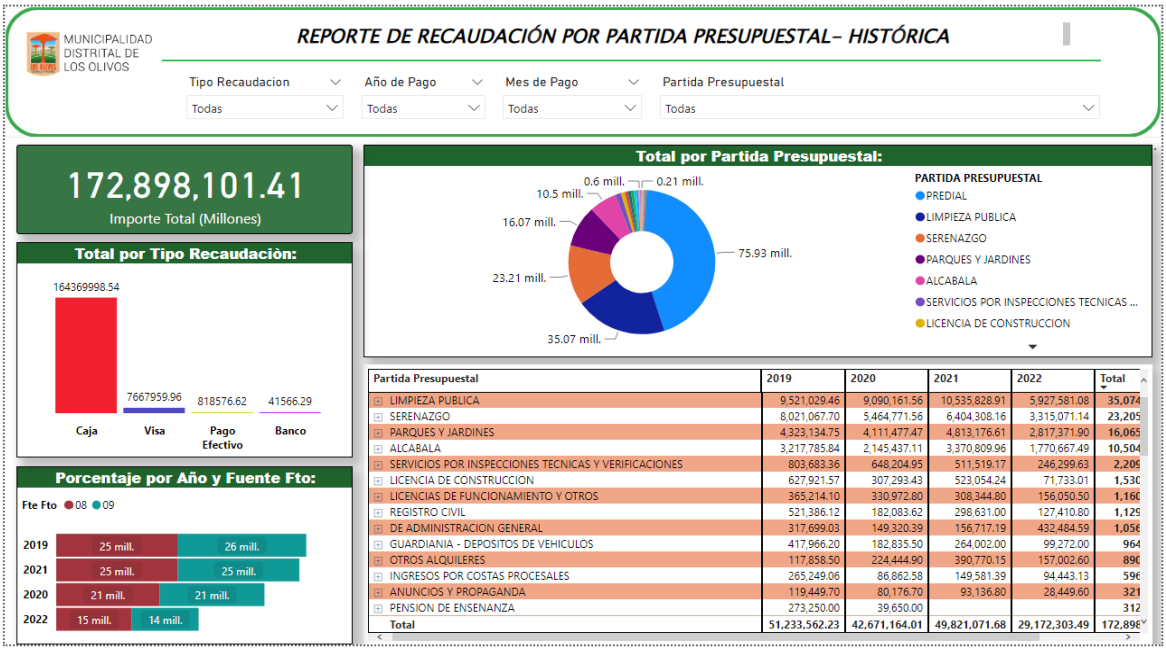

Figure 6. Collection report by budget item-historical

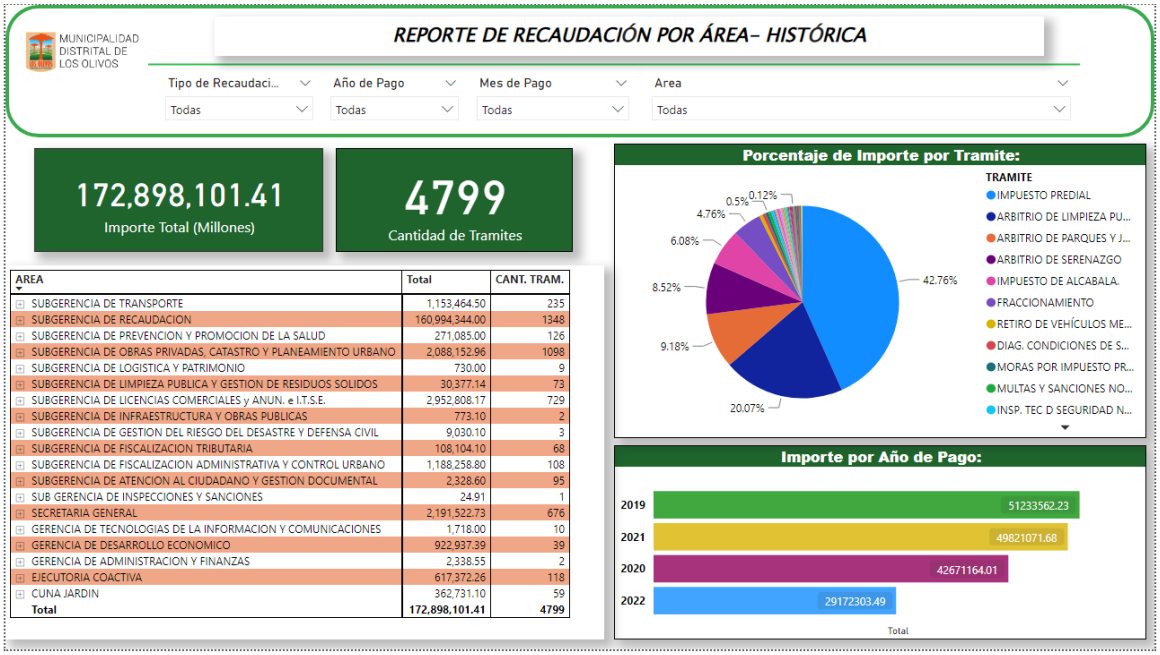

Figure 7. Collection report by area-historical

Figure 8 presents, the report of collection by budget item-daily: this report allowed to know the collection by budget item on a monthly and daily basis of this year. It also contained various types of filters that helped in the search interaction made by the end user. Figure 9 presents, the collection report by cash-daily, this allowed to know the total amount of the boxes of the area, both before and after the budget closing. It also contained different types of filters that helped when interacting with the search.

Figure 10 presents, the report of attentions by cash-daily: this report allowed to know the amount of attentions that each of the cashiers made within the present year. It also contained various types of filters that helped in the search interaction made by the end user. The results obtained from the implementation provided

great benefits to the entity through the construction of 5 reports that measure the most important KPIs for the study area, which allow it to currently have an increase in favor of the collection.

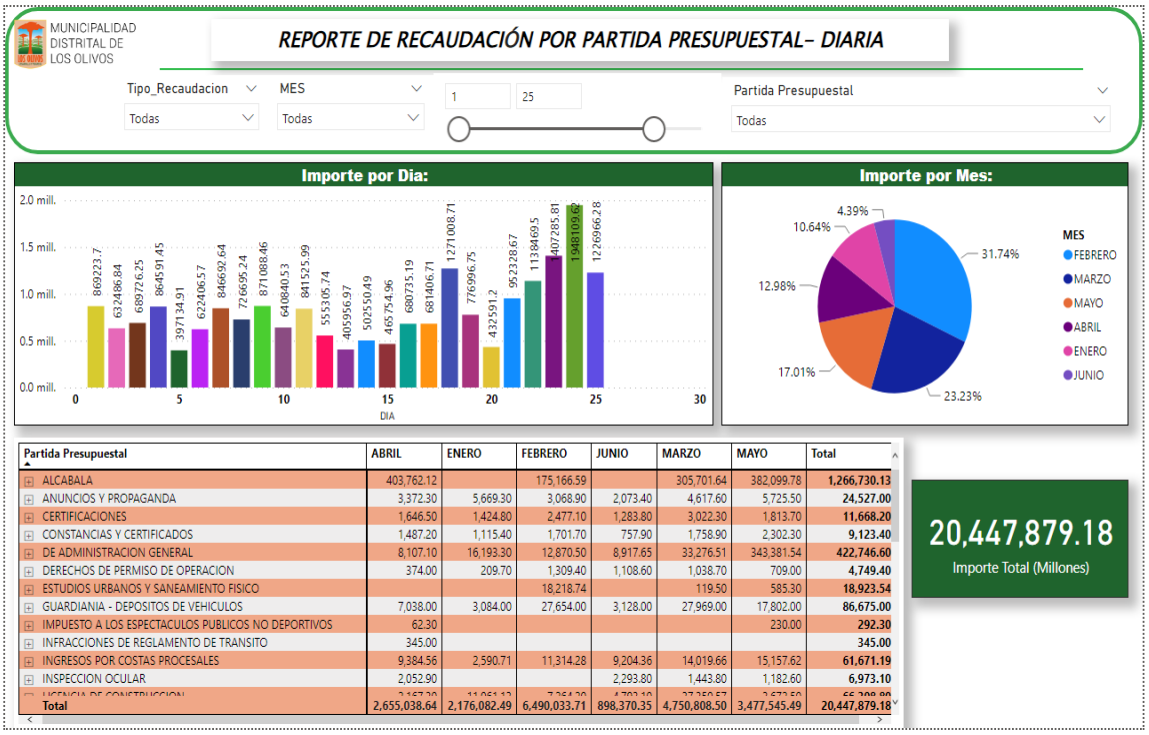

Figure 8. Collection report by budget item-daily

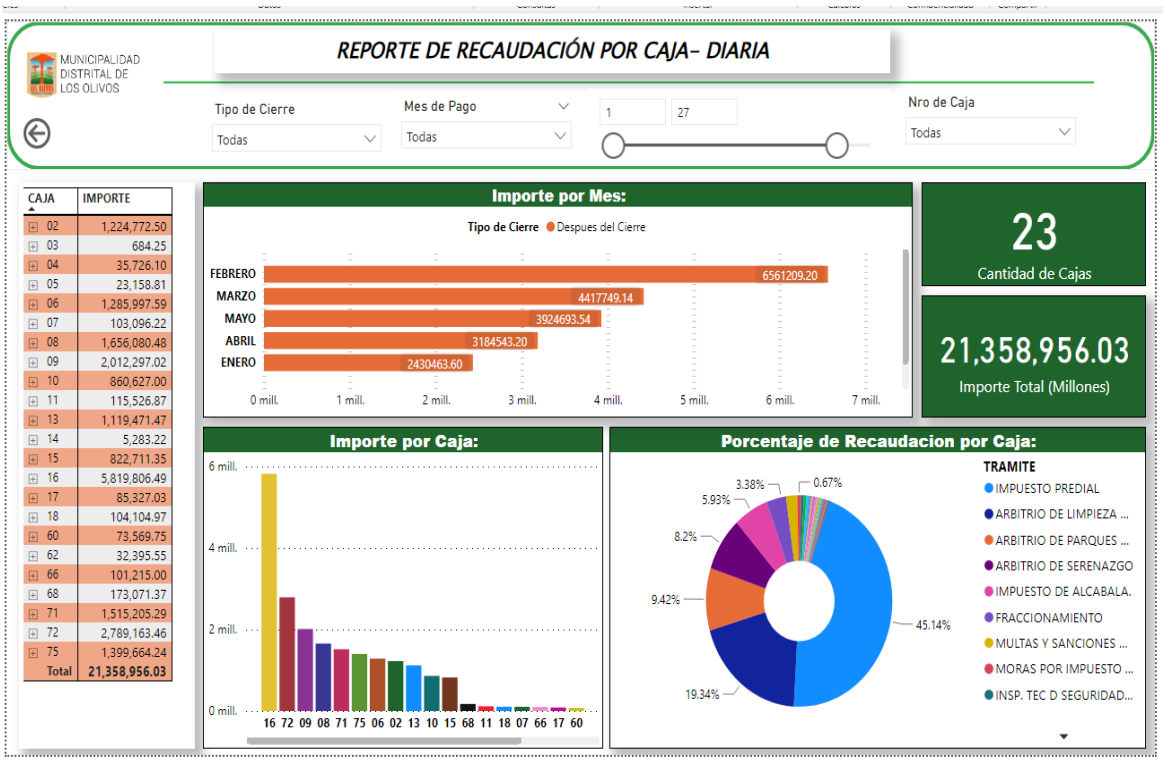

Figure 9. Collection report by cash-daily

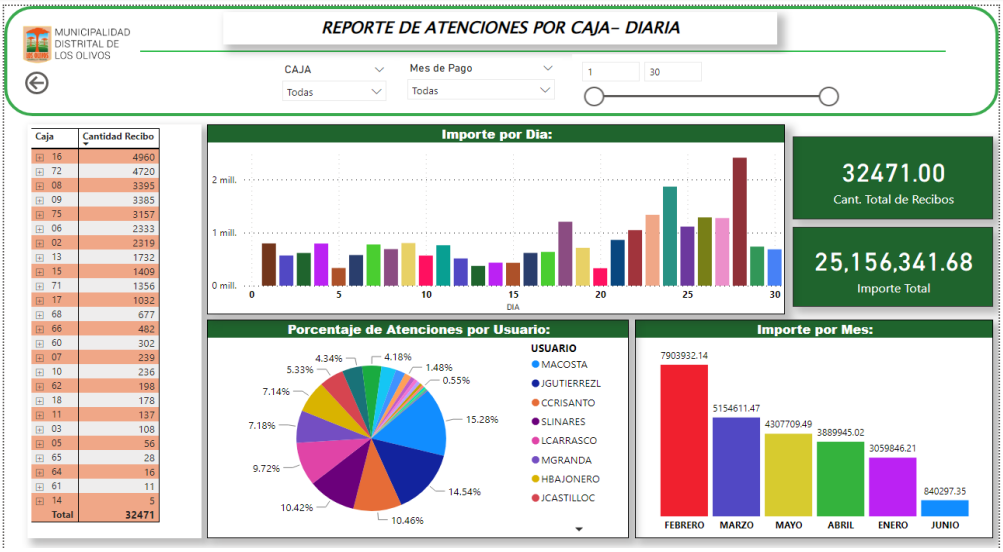

Figure 10. Report of attentions by cash-daily

4. RESULTS AND DISCUSSION

The purpose of the study was to implement BI technology to improve the decision-making procedure of a company; for this purpose, the results obtained are presented in a descriptive way measuring the indicators: LIE information and LUS related to obtaining reports in 2 time slots (pre-test and post-test).

4.1. Level of effectiveness

As shown in Figure 11 and Table 2, the result obtained in the pre-test was 42.12%, while in the post-test it was 95.44%, which can be said to show a significant improvement of 53.36% in the LIE indicator. Likewise, as can be seen in Table 3, with respect to the level of significance in the pre-test, a value of 0.329 was obtained (greater than 0.05), while for the post test it was 0.114 (greater than 0.05), so $NE_a > NE_d$, so the alternative hypothesis is accepted, that is, the implementation of BI significantly improves the level of effectiveness of the information of the process of taking decisions of the area collection a municipality of Lima; having a positive impact.

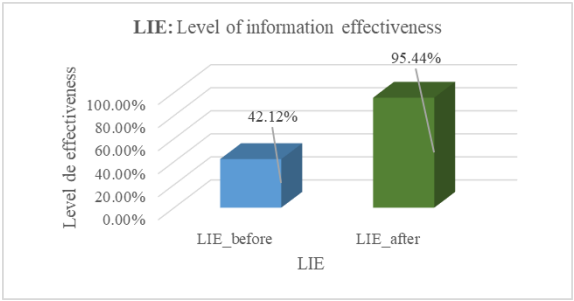

Figure 11. Comparative graph of LIE in pre test and post test

Table 2. Comparative table of LIE in pre test and post test

Indicator	Pre-test	Post-test
LIE	42.1200%	95.4440%

Table 3. LIE normality test in pre-test and post-test

	Shapiro-Wilks		
	Statistical	gl	Sig.
LIE_before	0.884	5	0.329
LIE_after	0.819	5	0.114

Through this research work it was possible to analyze a comparison in the efficiency and satisfaction in the implementation with BI which contributes favorably in the development of a company, since it allows the extraction, storage and processing of data, also thanks to these optimizations strategies can be planned in order to mitigate future inconveniences or delays in the delivery of products, coinciding with the study of Kumar *et al.* [16] who obtained an LIE of 27.22% after having incorporated datamart structures in the information processes in companies, affirming what was supported by the research of Cabrera *et al.* [17] in their study in which when implementing a web system the LIE improves in 65.76%.

4.2. Level of user satisfaction

As shown in Figure 12 and Table 4, the result obtained in the pre-test was 1.63%, while in the post-test it was 3.53%, which can be said to show a significant improvement of 1.90% in the LUS indicator. Also, as can be seen in Table 5, with respect to the level of significance in the pre-test, a value of 0.000 (less than 0.05) was obtained, while for the post-test it was 0.000 (less than 0.05), so que $NE_a > NE_d$, so it is observed that they pursue a non-normal distribution, accepts the alternative hypothesis, that is, the implementation of BI significantly improves the level of effectiveness of the information of the decision-making process of the collection area of a municipality of Lima; having a positive impact.

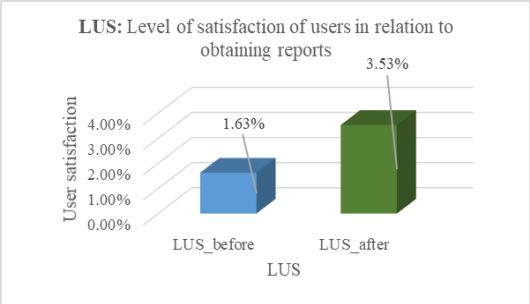

Figure 12. Comparative graph of LUS in pre test and post test

Table 4. Comparative table of LUS in pre test and post test

Indicator	Pre-test	Post-test
LUS	1.6333%	3.5283%

Table 5. LUS normality test in pre test and post test

	Shapiro-Wilks		
	Statistical	gl	Sig.
LUS_before	0.643	12	0.000
LUS_after	0.516	12	0.000

Then, it can be discerned that the results keep analogy, where it reflects an improvement in the level of efficiency of the information when implementing bi, adapted to public or private sector companies and meet the needs of users as supported by Ghasemaghaei *et al.* [14] that obtained an improvement of the LUS of 1.38%, as in Vásquez's research, where when implementing bi, the LUS increased, showing an improvement of 1.59%. In addition to this, Bulgaria *et al.* [10] indicate that the implementation of dynamic tools also favors the improvement of LUS to 88%.

5. CONCLUSION

It is concluded that by implementing the BI it is possible to improve the effectiveness of the information and the satisfaction in the attention of the users of a municipality of Lima in the area of collection. The Ralph Kimball method was used following the phases: in project planning, the objective and scope were determined; in the definition of requirements, the analytical needs of the organization were obtained; in the design of technological architecture, where the technological components used for this solution are described; in the dimensional modeling a star scheme was made with 9 dimensions and 1 table made, in the physical design it was implemented in the MySQL management system and in the ETL development the power BI tool was used, which allowed the migration, transformation and cleaning of the information from the OLTP database to the OLAP database, that allowed to build the solution in the right

way. On the other hand, it is concluded regarding indicator 1: LIE (NSE) when implementing the BI contributes favorably in the efficient development of a company, since before the test a value of 42.1200% was obtained, however, after the test it reached a value of 95.4440%, that is, it improved by 53.32%. Likewise, with respect to LUS, it is concluded that when implementing the BI allowed the extraction, storage and processing of the data, observed that before performing the pre-test a value of 1.6333% was achieved, and then a value of 3.5283%, noting a change of 1.90%. Finally, it can be said that the designed interface presented a set of reports with filters and dashboards that served as support to the needs of users in the interaction with the data, understanding and clear interpretation of them, having a clean, secure and reliable data structure.

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