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Development of SIGA-ME: a management tool for evaluating costs, waste, and water footprint in school meals in Presidente Bernardes-SP

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ABSTRACT
For administration, indicators function like a compass in navigation. Based on their availability, quantity, and quality, decision-makers are better assisted in their daily tasks. In public administration, it is no different; however, it is very common for small municipalities, such as Presidente Bernardes-SP, to require managerial support to aid in this task. The aim of the article was to develop a database tool for generating cost and waste indicators in school meals for elementary school students, as well as to calculate and identify the virtual water used in food preparation. Thus, this work was developed through the construction of a system designed in Microsoft Access. The approach employed to achieve this goal was applied research. Consequently, the SIGA-ME system—Applied Management Information System—School Meals was created. The result was the provision of a duly parameterized tool for the municipality. The database includes stock movement entries for twenty days in March 2020. The researcher registered the application with the National Institute of Industrial Property (INPI).

KEY-WORDS: Database. Virtual Water. Cost Indicators.

1 INTRODUCTION

The National School Feeding Program (PNAE), maintained by the Federal Government through the National Fund for Educational Development (FNDE, 2018), is one of the important income distribution actions for the population. According to FNDE (2019), almost 40.2 million students benefited from the program. Specifically regarding elementary school students, under municipal responsibility, 15.1 million students were served. The amount corresponding to transfers in 2019 totaled R$ 3.95 billion, 70% of this amount directly to elementary school students. The funds are sent monthly to the municipalities over a period of 10 months, from February to November, covering 200 school days per year. Additionally, according to FNDE (2020), 109,361 school units were assisted in 2019.

The management of these funds is carried out by the municipality with an obligation to provide accountability, as stated in Article 70 of the Constitution (TCU, 2019). However, even older than our Constitution, Decree-Law 200/67 (Brazil, 1967) already mandated this requirement.

Since 2012, the accountability process has been carried out virtually through the Management System for Accountability (SIGPC) (FNDE, 2012).

According to Law n° 12,527, dated November 18, 2011 (BRASIL, 2011), in its Article 1, which guarantees access to information as provided in the Federal Constitution in Item XXXIII of Article 5, every citizen can verify public expenditures. Transparency is an important instrument of democracy; however, the availability of data related to the revenues and expenses of various government programs can be a real complicating factor. This is one of the problems in monitoring the public administration.

Another issue relates to the way expenditures are presented. The data, derived from the accountability forms provided by FNDE (2017), merely represent receipts and payments made over periods. These numbers could be processed to present information such as the cost of food per student, the cost of one kilogram of processed food, food waste and its rate, the cost of that food waste, and the water footprint (WF) with its associated costs.

Moreover, considering the problem of food security in the world, according to the FAO (2023), more than 828 million people are experiencing hunger globally. In Brazil, the report "The State of Food Security and Nutrition in the World 2023" indicates that approximately 21.1 million people in Brazil were in a situation of severe food insecurity between 2020 and 2022,

corresponding to 9.9% of the national population. This statistic reveals a 5.35-fold increase compared to the previous survey (between 2014 and 2016), during which 1.9% of Brazilian citizens were in this condition. In parallel with the hunger issue, it is noted that 70.3 million Brazilians, approximately 32.8% of the population, face some degree of food insecurity. Furthermore, malnutrition affects a contingent of 10.1 million people, corresponding to 4.7% of the population (FAO, 2021).

According to data from FAO (Food and Agriculture Organization of the United Nations): 17% of all food available for consumption is wasted. Food waste has reached an alarming level: each year, 17% of what is produced globally is lost after harvest or wasted in stores, restaurants, or households. This waste represents approximately USD 1 trillion annually (FAO, 2021). To put this volume into perspective, according to the Brazilian Institute of Geography and Statistics (IBGE, 2022), Brazil's GDP was BRL 9.9 trillion in 2022, meaning that at consumer prices, global food waste represents half of Brazil's GDP.

It is estimated that annually around 931 million tons of food are discarded as waste, representing 8 to 10% of the greenhouse gases generated. Food waste also accounts for 38% of the energy resources used by the global food system to produce food that is not consumed. Additionally, 30% of the planet's agricultural land is used to produce food that ultimately becomes lost or wasted (FAO, 2021).

Food waste is a serious global problem, and its effects are not limited to social dysfunctions, such as the issue of hunger. It is also important to consider the environmental disruptions, as producing food, whether in adequate or excessive quantities, impacts the environment through the use of water and other ecosystem resources.

Water is one of the most critical resources for all spheres of society, and meeting multiple uses and clients requires coordinated planning. It is impossible to consider food security without addressing water security, as a significant amount of water is needed to produce food. According to the National Water and Basic Sanitation Agency (ANA, 2019), agricultural production uses about 70% of the freshwater consumption in Brazil, making it the largest user and waster. According to a report by IBGE/ANA (2018), the total water consumption in 2017 amounted to 329.8 trillion cubic meters.

Considering the estimated one-third food waste by the UN and applying it to 70% of the total 329.8 trillion cubic meters consumed (230.8 trillion cubic meters), it amounts to nearly 77 trillion liters of water wasted in one year.

Therefore, considering the issues involving improvements in public resource management, food security, food waste, and the use of virtual water, the aim of this study was to develop a database tool that could, more efficiently and effectively, generate indicators based on the stock movement of school meals provided to elementary school students in the municipality of Presidente Bernardes-SP. These indicators would support decision-making and present the figures related to school meals in a managerial format, while also considering the water footprint and its cost as a means to generate impact and awareness, thereby contributing to eliminating food waste in school meals.

The actors in this study were strategically chosen. The municipality of Presidente Bernardes is part of the Brazilian cities with fewer than 30,000 inhabitants, which represent almost eighty percent of the municipalities, according to IBGE data (2022). These cities do not

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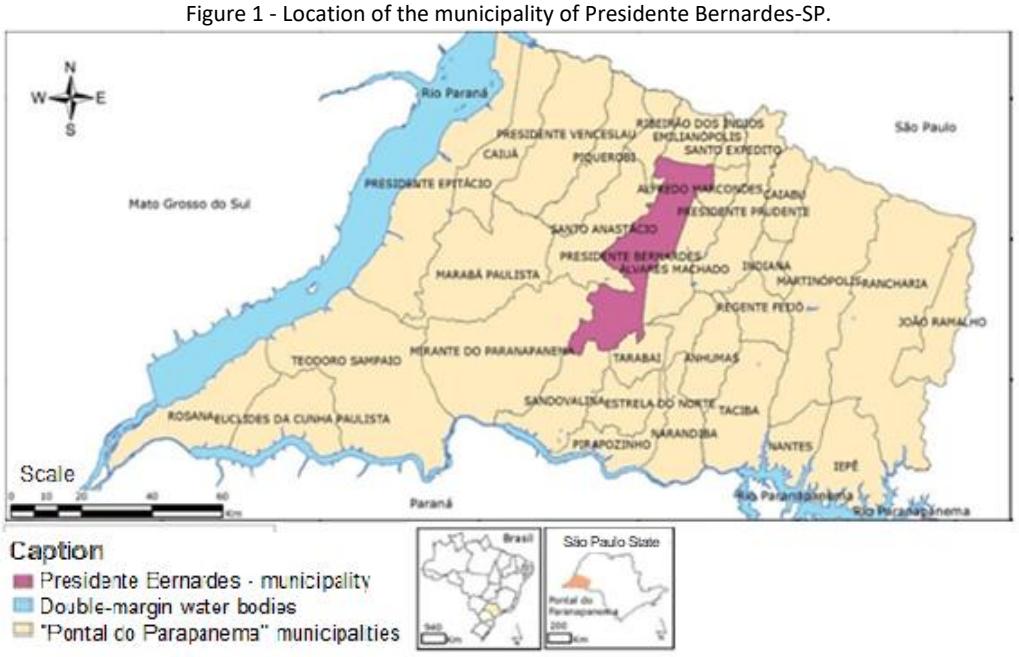
have their own income and are substantially dependent on federal resources (FIRJAN, 2019).

2 CONTEXTUALIZATION OF THE TOPIC

The municipality of Presidente Bernardes, located in the western region of the state of São Paulo, was elevated to the category of municipality on January 23, 1935. According to IBGE (2022), the city has an estimated population of 14,490 inhabitants in 2020, with the average monthly salary of formal workers being 2.2 minimum wages, and 22% of the population being economically active (Figure 1).

According to the Seade Foundation (2020), in 2018, the São Paulo Social Responsibility Index (IRPS), in its Wealth dimension, showed the locality with an indicator of 30, compared to 35 for the Administrative Region it belongs to and 44 for the entire state. In the Education dimension of the IRPS, in 2016, the city scored 44, the Administrative Region 55, and the state of São Paulo 51 (Figure 1).

Figure 1 - Location of the municipality of Presidente Bernardes-SP.



Source: Quaglio e Arana (2020).

According to the IBGE report, the per capita GDP of Presidente Bernardes is R$ 28,001.53 (IBGE, 2022). In 2018, the municipality ranked 363rd among the 645 municipalities that make up the state of São Paulo (IBGE, 2020). The local activity that stands out is commerce and services (IEGM/TCESP – Presidente Bernardes, 2023). The Federation of Industries of Rio de Janeiro (FIRJAN, 2020) reveals, through its Firjan Index of Fiscal Management (IFGF), that the municipality of Presidente Bernardes-SP ranks 4,080th among the 5,570 Brazilian municipalities. The local Firjan index is 0.2915. FIRJAN (2019) warns that 1,856 Brazilian municipalities are not self-sustaining, as the locally generated revenue does not surpass the expenditures on the City Council and the administrative structure of the municipal government.

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3 METHODOLOGY

For practical reasons, aiming at the construction of an information system designed in a database using Microsoft Access software, the method used to achieve the objective is applied research. This type of research is used when "motivated by practical reasons. It aims at practical applications, with the objective of meeting the demands of modern life. In this case, the goal is to contribute to practical purposes, seeking solutions to concrete problems" (ANDRADE, 2017).

The operational structure of the Department of Education was constructed using StarUML software, a software engineering tool that assists in modeling the purpose of a system. Additionally, a proposal for a new structure was made.

Given this, a database application was developed using Microsoft Access software to manage the stocks of school meals directed at elementary school students and to generate management indicators. The research proposal focused on indicators that could provide decision-makers with a broader range of metrics, such as quantities per school unit, quantities per student, cost per kilogram of processed food, meal costs, waste costs, and water footprint costs.

To support information about the procedures adopted in inventory control at the study site and to better understand them, in loco visits were conducted. Through unstructured observation, it was possible to verify the control practices adopted. Observation is known as naturalistic or ethnographic study, where the researcher visits the places where the phenomena occur naturally (FIORENTINI and LORENZATO, 2006).

4 RESULTS AND DISCUSSION

4.1 Public Management

The public sector has the responsibility to meet an extensive and ever-growing variety of social needs, thus requiring strict and disciplined management of limited public resources to fulfill its duties to society. The reality of insufficient and scarce public resources, the population's demand for a higher quality of life, as well as the concerning social, economic, environmental, and financial crises, are some of the variables causing intense inequalities in social and economic structures, the issue of the reduced trust of society in public sector institutions and their leaders, to name a few among many issues related to the topic. These occurrences demonstrate that there is no room for hesitation regarding the immense necessity of incorporating concepts, extensively used in the private sector, of economy, efficacy, and efficiency in the operations performed by public sector agents, in order to stimulate the State apparatus, enhancing the supply-demand relationship of goods and services for society (BRESSER-PEREIRA, 1998).

The crisis of the State implies the need to reform and reconstruct it (BRESSER-PEREIRA, 1998). According to Saravia (2010), under the influence of international organizations (World Bank, Inter-American Development Bank, UNDP, OECD), a new way of thinking about public administration spread rapidly around the world. In general, the reforms were considered experiences of the new concept called New Public Management, characterized by the belief that public administration should improve by adopting techniques and behaviors typical of business administration.

A public administration described as democratic and open has slower mobility compared to that of companies, whose administrators can make decisions quickly and behind closed doors.

Osborne and Gaebler (1992) point out that one of the major differences between public and private administration is motivation. In the public sector, reelection is a significant factor for leaders, while in the private sector, the ultimate goal is profit. Government resources come from taxpayers, whereas private sector resources come from customer purchases. Government decisions are made democratically, while business decisions are made by the entrepreneur alone—or at most, with the company's shareholders. "The fundamental mission of government is 'to do good,' while that of a company is 'to make money'" (Osborne and Gaebler, 1992, p. 22).

Given the above, it is necessary and urgent to transform public management, shifting from bureaucratic and patrimonial to managerial, with the objective of presenting the use of resources in a transparent and effective manner, as stated by Bresser-Pereira (1998).

4.2 Water Crisis and the Water Footprint

One in three people worldwide does not have access to safe drinking water, according to the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) in their report "Progress on Drinking Water, Sanitation and Hygiene: 2000-2017: Special Focus on Inequalities" (UNICEF, 2018). The so-called "water crisis" is not only about scarcity but is the result of a combination of intensified environmental problems along with other issues related to the economy and social development, as well as the lack of water management by the population (GLEICK, 2000). The worsening and complexity of the water crisis stem from factual disturbances such as availability and increased demand, and from management techniques that have so far been territorial and reactive, without preventive measures and systemic procedures (SOMLYODY and VARIS, 2006).

Water resources are considered a global concern, as the supply and use of drinking water have been decreasing worldwide, severely impacting the survival of species. In light of this, water is considered an international right, and numerous international decrees and treaties address this issue.

Despite the fact that Brazil holds about 12% of the world's available surface freshwater, according to the OECD (Organization for Economic Co-operation and Development) report (OECD, 2016), water has become a restrictive variable for the country's economic development.

Environmental issues thus impose on contemporary society the need to devise new ways to reverse the ecological unsustainability crisis by coordinating tangible actions that seek balanced measures to preserve nature while simultaneously benefiting from it.

The concept of Virtual Water was introduced by John Anthony Allan in 1993, defined as the water embedded in the production of commodities. In other words, it is the water involved in the production process of any industrial or agricultural good (ALLAN, 2012). In 2002, Arjen Hoekstra, at the international expert meeting on virtual water trade held in Delft, Netherlands, introduced the concept of Water Footprint (WF). The WF of nations was quantitatively measured by Hoekstra and Huang (2002) and later more comprehensively by

Hoekstra and Chapagain (2007).

The WF was incorporated to illustrate the little-known relationships between human consumption and water use, as well as between global trade and water resource management. According to Hoekstra (2003), the impetus for his research stemmed from the concern that water resource management is typically viewed as a regional issue or, at most, as a problem occurring within a watershed environment.

The term WF was chosen by Hoekstra analogous to the ecological footprint; however, the concepts related to footprints have different origins, as the ecological footprint is explained in hectares and the WF in the volume of freshwater consumed (SILVA et al., 2013).

In essence, this concept pertains to the indirect trade of water embedded in certain products and involves understanding that human water consumption is not limited to the direct use of water in daily activities, but also includes the water contained in the products consumed, as well as the water used for their production, manufacturing, and transportation, which must be accounted for and evaluated (HOEKSTRA and CHAPAGAIN, 2007; CARMO et al., 2007).

4.3 Losses in Food Production and Waste in Consumption vs. Food Security and Sustainability

Often used as synonyms, the terms food losses and food waste have distinct differences in their definitions. According to Parfitt et al. (2010), waste is more easily defined at the retail and consumer stages, where products from the agricultural system are clearly food intended for human consumption. However, food loss refers to the decrease in the quantity or quality of food, making it unfit for human consumption; this occurs throughout the supply chain, from harvest to processing and distribution.

By reducing food losses and waste, more food could be made available for consumption without the need for increased agricultural production (BABAR and MIRGANI, 2014).

As established by FAO (FAO, 2014), food loss refers to the reduction in volume or nutritional value (quality) of food produced for human consumption, while food waste encompasses the discarding of food. Even recognizing that both should be avoided, it is possible to perceive in these definitions a certain critique of the term waste, presented as a harmful and even unethical action. According to FAO (FAO, 2021), nearly 1 billion tons of food are wasted annually, a volume that, in addition to causing significant economic losses, also compromises the natural resources essential for humanity to continue producing food.

The physician, geographer, and anthropologist Josué de Castro, as early as 1946, wrote that hunger was the number one ecological problem (CASTRO, 2001), at a time when environmental issues were not yet on the agenda. His advanced line of thought already linked hunger and sustainability, and in his text, he asserted that:

> No development plan is valid if it does not lead, within a reasonable time, to the improvement of the people's food conditions, so that, free from the crushing burden of hunger, the people can produce at levels that lead to true balanced economic development. Hence the importance of the goal "Food for the people," or "the liberation from hunger" (CASTRO, 2001, p. 270 - our translation).

The concept of food security encompasses various aspects, such as the quality and

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safety of the food produced, the variety that meets dietary habits and culture, as well as the sustainability of the food system. Considering the definition of food security, it is essential to ensure the availability and access to food in the present without compromising the future production capacity. This aligns precisely with the concept of sustainable development as defined in the 1987 UN report, titled "Our Common Future" (UN, 1987).

Although democracy concerning environmental issues has advanced in recent times, there is still a portion of society marginalized from participation in decision-making processes on the subject. There seems to be a perception among the public that the responsibility for addressing this issue lies exclusively with the Government at its various levels. However, governance for environmental matters should be centered on cooperation between the State and organized civil society, in a space of alliances and understanding that the negligence of one affects all.

Addressing environmental issues from a governance perspective assumes, according to Leal Ivo (2004, p. 78), that:

> [...] the mobilization of society expanded the public space, creating new rules of coexistence and public arenas through which society channeled its demands, established legal principles that laid the foundations for a new civilizational, institutional, and democratic matrix in the new Constitutions of the 1980s (LEAL IVO, 2004, p. 78 - our translation).

The actions needed to mitigate environmental disruptions are specific, like meticulous work, even if they may be considered "a drop in the ocean." However, each participating actor has an important role, and each action taken represents a gain.

According to the UN (2021), the harmonious coexistence of humans with the environment depends on their understanding that nature does not have infinite resources, and a radical change in their habits will be necessary, as established at the United Nations Conference on Environment and Development, Rio92, where the three pillars of sustainability were born: Reduce, Reuse, and Recycle, and later the fourth pillar: Rethink.

In this regard, Ramos (2010, p. 83) states:

> Be that as it may, the current view of nature, amplified by technology, has inherited the project of domination based on the dualism of man and nature, in which the latter is instrumentalized for the benefit of the former. In other words, the stance of transforming the knowledge of nature into an instrument of its own domination has become universalized and turned into a dogma (RAMOS, 2010, p. 83 - our translation).

Sustainability, in its course, must be planned and established in the long term, as it is evident that for sustainable development to occur, it is necessary to have a way to achieve development with sustainability. In other words, development must take place while considering the full development of humans, animals, plants, and the entire planet Earth.

According to Leff (2001, p. 31):

> The principle of sustainability emerges as a response to the fracture of modernizing reason and as a condition for building a new productive rationality, founded on ecological potential and new meanings of civilization derived from the cultural diversity of humankind. It is about the reappropriation of nature and the invention of the world; not just a world in which many worlds fit, but a world shaped by a diversity

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> of worlds, breaking the siege of the globalized economic-ecological order (LEFF, 2001, p. 31 - our translation).

This transition from one system to another will only be possible through environmental education, which can provide the theoretical foundations to achieve sustainability.

4.4 Proposal for a Database and Inventory Control Tool for Municipal Schools

Appropriately, Uhlmann (2002, p. 15) proposes:

> Systems thinking is contextual, meaning the opposite of analytical thinking. It requires that to understand something, it is necessary to understand it as such and in a larger context, that is, as a component of a larger system, which is also called its environment (UHLMANN, 2002, p. 15 - our translation).

Given the statement by the author mentioned above, it is necessary, before understanding the management of school meals in the municipality of Presidente Bernardes-SP, to understand the concept of a system as being: "A set of interacting and interdependent parts that together form a unitary whole with a specific objective and perform a specific function" (OLIVEIRA, 2009, p. 6). In the author's description, the terms "interacting and interdependent" stand out as an important aid to understanding the topic.

The operation of the Department of Education of the Municipality of Presidente Bernardes-SP, concerning the administration of school meals, was structured as shown in Figure 2.

In the diagram of Figure 2, what is prescribed as a system, according to Oliveira (2009), interdependence and interaction, does not occur at the study site concerning the administration of school meals to elementary school students in the municipality. It is clearly understood that there is no integration of the process actors. Therefore, it is confirmed that there is a lack of synergy in the sector's activities, one of the requirements for efficient and effective management. Thus, compliance with the law does not indicate that indicators, metrics, and monitoring measures are being generated. This is only possible through collaborative and integrated processes.

Thus, the intervention to propose a standardized method that fosters the integration, insertion, and unification of the sector's activities is of utmost importance. In this way, it aligns with the expectation of the transformation proposed here. The proposal for a new management system for school meals in the municipality of Presidente Bernardes-SP can be observed in Figure 3.

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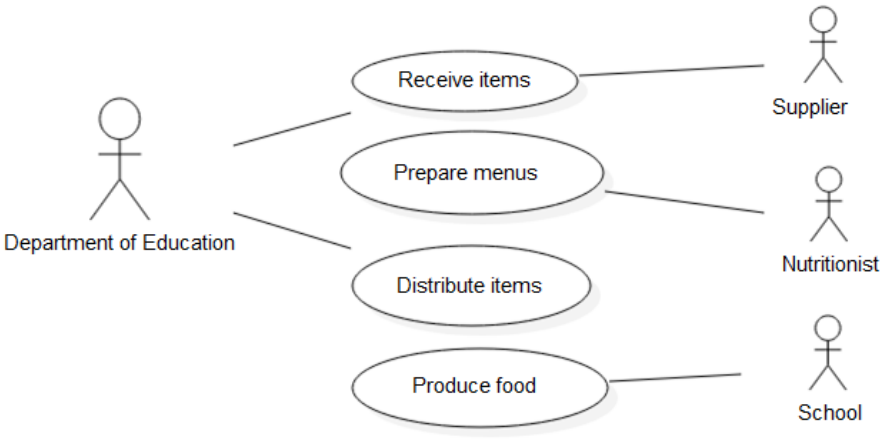
Figure 2 - Current situation of school meal management in Presidente Bernardes-SP.



Source: Prepared by the author.

Observing both Figures 2 and 3, the first point that stands out is the fact that there is a rectangle drawn only in Figure 3. In software engineering structure notation, this means that for a system to exist, integration is a mandatory component, and the drawing of a rectangle symbolizes this (SOMMERVILLE, 2011).

Another item to be noted is the set of integrated and integrative activities in Figure 3, such as: Registration of schools; Registration of stock items; Forms for reporting food waste; Registration of school menus; Stock movement in the central inventory; Food production and stock movement in schools.

Finally, regarding the comparison between the current situation and the proposal made by the author, as shown in Figures 2 and 3, the directional and integration arrows demonstrate the cohesion that should occur between routines and participants to achieve the desired interconnection and interdependence (VALENTE, 2020).

Based on the observations made, the SIGA-ME system (Applied Management Information System – School Meals) was proposed.

The proposal of the SIGA-ME system is that, in an integrated manner, the activities of receiving items, registering products with cost and water footprint, registering suppliers, registering schools, kitchen staff, central stock entry and exit movement, school entry movement, daily food production, waste reporting (if any), among other routines, can generate the necessary metrics for management.

Based on the SIGA-ME proposal, the application was developed over five months, from March to July 2020. In July 2020, the program was duly registered with the National Institute of Industrial Property (INPI) under the number BR5120200001392-9.

In August 2020, the system was implemented and training was provided to the involved users. It was necessary to create a SIGA-ME system manual, including flowcharts of all the main activities. The author prepared video tutorials to accompany the system manual. The initial access screen of the SIGA-ME Tool is shown in Figure 4.

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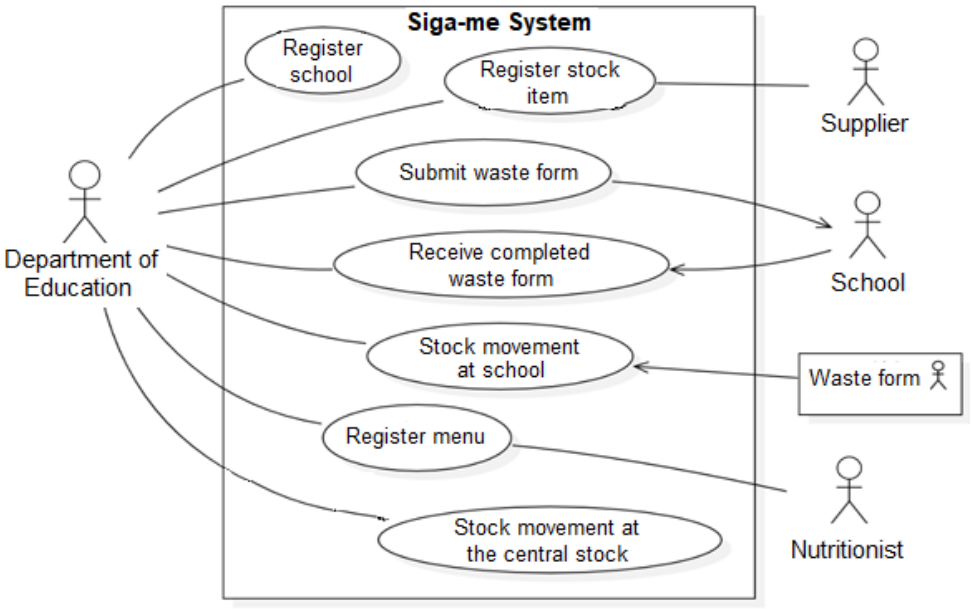
Figure 3 - Proposed operational diagram of the new system.



Source: Prepared by the author.

Figure 4 - Initial screen of the database developed in the research.

Source: Prepared by the author.

Entries of items and food production were recorded in the database for the period between March 1 and 20, with the respective acquisition costs. There was no further movement after this date due to the COVID-19 pandemic.

With the recorded data, it was possible to generate the first metrics through reports and the history of the 20 days of March 2020. Some indicators available from the correct data entry into the tool's database are: Monthly number of meals served; Monthly number of meals served per school; Daily number of meals served per school; Total monthly cost of meals served;

Monthly cost of meals served per school; Monthly cost of meals served per student; Daily cost of meals served; Daily cost of meals served per school; Daily cost of meals served per student; Monthly water footprint of the food served; Monthly water footprint per school; Monthly water footprint per student; Daily water footprint of the food served; Daily water footprint per school; Daily water footprint per student; Overall water footprint cost; Water footprint cost per school; Water footprint cost per student; Overall food waste; Food waste per school; Food waste per student; Cost of food waste; Cost of waste per school; Cost of waste per student.

The indicators can be used for planning future periods, making comparisons with previous periods, verifying the fulfillment of planned objectives, and monitoring and controlling operations. In addition to the mentioned metrics, the tool also includes reports for managing purchases by supplier, quantities in stock, stock values, and routines for stock losses and transfers.

The SIGA-ME tool, being part of the Microsoft Office Suite, interfaces seamlessly with Microsoft Excel spreadsheets. This allows managers to export the database and create as many management views as needed, according to their requirements.

5 CONCLUSIONS

This study addressed crucial issues related to public management, the water crisis, food security, sustainability, and the efficient management of school meals. Each of these areas plays a fundamental role in the pursuit of a more equitable, sustainable, and effective world.

We highlighted the importance of applying private management principles in public administration to optimize resources and provide quality services to society. The global water crisis was presented as a challenge that requires more responsible and conscious management of water resources.

Regarding food security and sustainability, the need to reduce food losses and waste was emphasized, ensuring that agricultural production is efficient and sustainable. Additionally, the connection between hunger and sustainability was underscored, highlighting that the pursuit of sustainable development must include universal access to safe and nutritious food.

Finally, an innovative proposal for a Database and Inventory Control Tool for municipal schools, called SIGA-ME, was presented with the aim of integrating and improving the management of school meals. This tool exemplifies how technology can be applied to enhance efficiency and transparency in public management.

This work seeks to reinforce the importance of addressing complex and interconnected issues in an integrated and strategic manner. The search for effective solutions requires a joint effort from governments, civil society, and the private sector, as well as the adoption of innovative and technological approaches. Efficient and sustainable public and environmental management is essential to ensure a better future for the coming generations.

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