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Artificial intelligence for the management of water projects and the management of water resources: A bibliographical analysis

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A B S T R A C T

This bibliographical review gives us a clear and summarized analysis of the management tools for a water infrastructure construction project and, a tool that allows the management of water resources through the application of everything analyzed and compiled in scientific articles obtained from the Scopus database and after that it was analyzed using the VOSviewer tool, which has the complexity of analyzing a large amount of data. This analysis was carried out from the appearance of the first related investigations until the year 2023, analysis graphs were obtained from representative levels of the words "artificial intelligence", "project management" of "construction" and "water" resource with greater interest in the analysis. The results obtained allowed us to understand the great variety of technological tools that are available today to be able to manage the construction of a project through artificial intelligence and its components that work together, likewise the application of these tools is carried out by countries as well as the United States. The United States and China are the ones that represent the greatest interest in these investigations, however this contribution is minimal to be able to generate effective solutions since each project presents its particular characteristics that technology has to adapt to. The future of these projects was also analyzed, such as the management of water resources through intelligent technologies that allow the preservation, care and maintenance of water resources, in addition to this, it is emphasized that worldwide there are already problems of droughts, lack of water resources and shortages of water in some countries. This research has the purpose of an overview for decision-making in the execution of the project at the water level and after the management of the water resource, it is important to apply these tools for their different advantages and carry it out to large-scale works in Peru subsidized by the Peruvian state since they are the most responsible for ensuring the care, maintenance and preservation of water resources.

1. Introduction

Worldwide, almost 36% of the population lives with water deficiencies and 52% of the population will have severe problems of lack of water by the year 2050 (Velazkez, 2021), also the World Bank reports that by the year 2030 there will be 700 million inhabitants affected by drought (Milne, 2021), by 2025 it is expected that 50% will live in areas with scarce water resources (Nel et al., 2022), National Geographic also reports that only 3.5% of the water is sweet and 0.025 is made drinkable and the most important thing is that today 2,200 million people do not have drinking water services (Torres, 2021) because of this they live stressed for not having this resource (Nel et al., 2022).

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In the east of the world, the countries that suffer from water supply are due to excessive extraction of the resource, illegal water holes and inefficient supervision, generating deficiency in the supply and depleting water resources (Rahmani et al., 2023), it is Just as drought not only affects these countries but also worldwide, generating economic and social problems since the survival of people depends on it (Amanambu et al., 2022), all this is generated due to the effect of climate change generated by global warming. which decreases the concurrence of rains, generates melting of glaciers and indurations worldwide (Nel et al., 2022). Peru is also affected since 53% of the glaciers are melting, these glaciers represented it as a country rich in water resources, highlighting this, there are still deficiencies in the distribution because the coastal region is the most affected since it houses More than 65.98% of the population in Peru (Care, 2022) and the capital Lima of Peru there are 800,000 people who live without water (El Pais, 2022) generating problems such as diseases, agricultural losses, malnutrition, famine and among others (Care, 2022). One of the objectives of sustainable development is to improve the management and sanitation of water in the population worldwide (Nel et al., 2022; Torres, 2021), for this a system is required that allows us to evaluate the environmental conditions, the physical and chemical parameters, environmental conditions and its volume (Mohammed et al., 2023), as well as having efficient infrastructures that allow efficient distribution of water to the population. (Krishnan et al., 2022), since effective water resource management is a global task, whether in the economic sectors and drinking distribution (Krishnan et al., 2022) to balance access to all (Nel et al., 2022), all this through the help of artificial intelligence in the management of water projects, allowing planning, designing and managing all the problems at the start of construction and in the supply process (Rahmani et al., 2023).

This article aims to demonstrate solutions to be able to manage hydraulic projects that fulfill the function of managing water resources in an efficient way in the future, through artificial intelligence. For this reason, a bibliographic analysis was applied with the help of the VOSviewer tool that allows us to analyze a large number of scientific articles for project management with artificial intelligence, water resource management with artificial intelligence in order to have a level of deep learning. that allows learning, deducing, and acting against water problems.

2. Materials and methods

Carrying out a bibliographic review allows researchers, professionals and interested parties to understand the application of artificial intelligence for the management of water projects and the management of water resources, for which the scientific tool of Scopus was used, which is reliable. Firstly, the data extracted from Scopus was analyzed, resulting in the bibliometric map, allowing to understand and analyze a database (van Eck & Waltman, 2010), in order to show the words that have the highest incidence and correlation between the documents, the extracted data is in (.csv) format, which was obtained from the beginning of its analyzes until 2022, the search was applied as follows:

a. First, the analysis of the data was carried out with the following research items “Artificial intelligence”, “project management” of “construction”, which found 138 documents from scientific journals, related conferences, analysis books and theories where they were analyzed. documents worldwide with free access.
b. Second, the analysis of the data was carried out with the following research items “Artificial Intelligence”, “resource management” and “water”, which found 331 documents, in scientific journals, related conferences, analysis books and theories where they were analyzed. Free access documents worldwide.

The data in Fig. 1a and Fig. 2 were analyzed using the VOSviewer tool, which gave us bibliometric maps as a result. Figures demonstrate the relationship between the documents. Second, the data was analyzed to understand which are the methodologies with artificial intelligence that are required for the management of hydraulic projects and also to be able to manage the hydraulic resource.

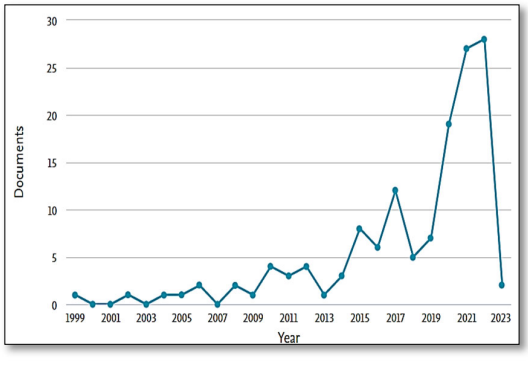

Fig. 1a. The number of documents published referring to each year of the words “Artificial Intelligence”, “project management” of “construction”
Source: Obtained from Scopus.

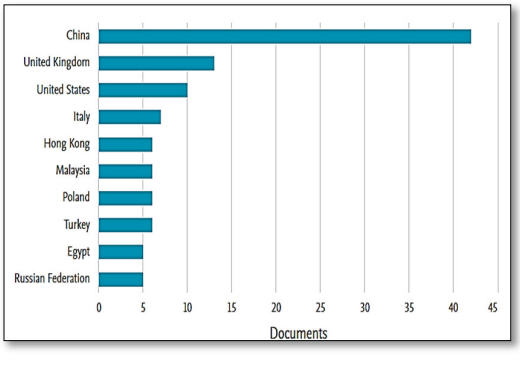

Fig. 1b. Countries that carried out research with the words “Artificial intelligence”, “project management” of “construction”

3. Results

3.1 Bibliometric analysis of artificial intelligence for the management of water projects

For 24 years there has been a database in the scientific journal Scopus related to "Artificial Intelligence", "project management" of "construction", however since 2019 more than 15 articles related to this topic have already been published. Fig. 1a shows the growth from 1999 to 2023, highlighting the historical one in 2022 with more than 25 articles and Fig. 1b shows the countries that publish the most, having the first two world reference states as China and the United Kingdom. The analysis of the map is shown in Fig. 2, it is determined that the data mining obtained from Scopus was analyzed using the VOSviewer tool, the most representative words were "Artificial intelligence" and "Construction projects" among others. The circles determine the interaction between each word leading to the conclusion that the contracted words have greater correlational interest among themselves, and which allows us to form a good reliable database to be analyzed.

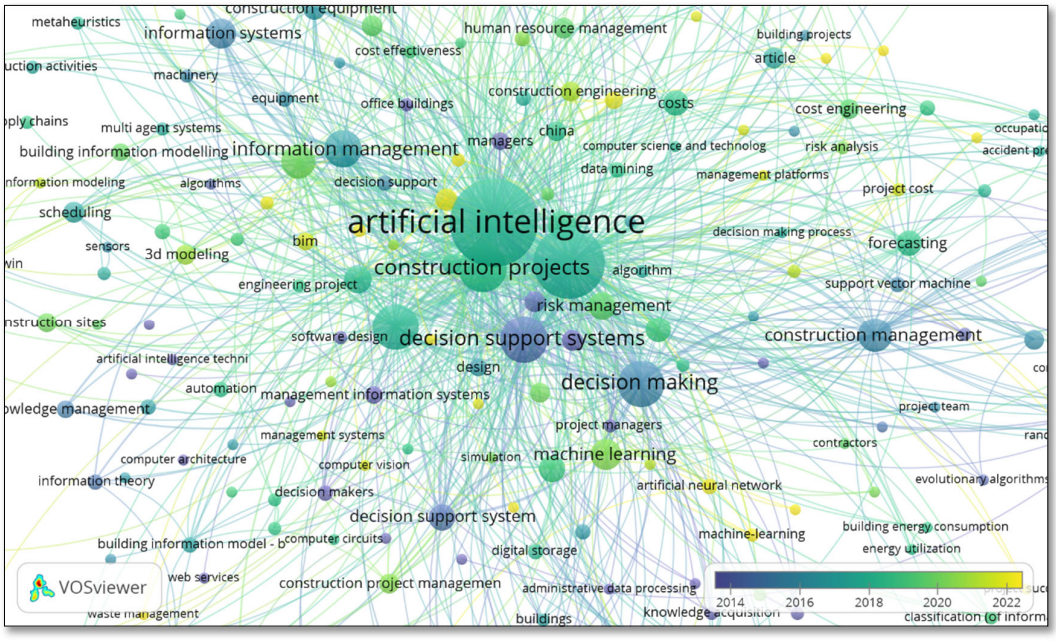

Fig. 2. Bibliometric map of the analysis of the words "Artificial Intelligence", "project management" of "construction", with greater interaction Source: Obtained from the VOSviewer analysis.

For 35 years the database has been found in the scientific journal Scopus related to "intelligence", "artificial", for "management", "resource" and "Water", however since 2017 more than 30 have already been published related articles on this topic. Fig. 3a shows the growth from 1987 to the year 2023, highlighting the historical one in the year 2022 and Fig. 3b shows the countries that publish the most, having the first two world references as the United States and China.

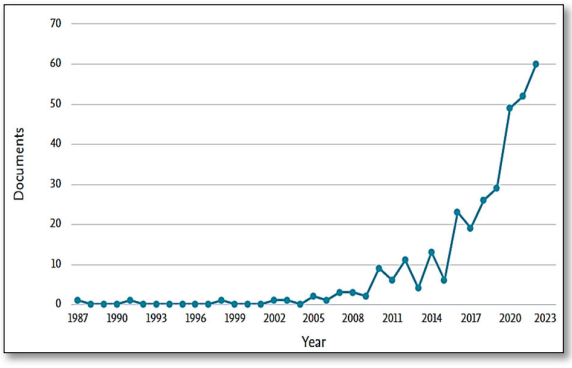

Fig. 3a. The number of documents published referring to each year of the words intelligence", "artificial", for "management", "resource" and "Hydric"
Source: Obtained from Scopus.

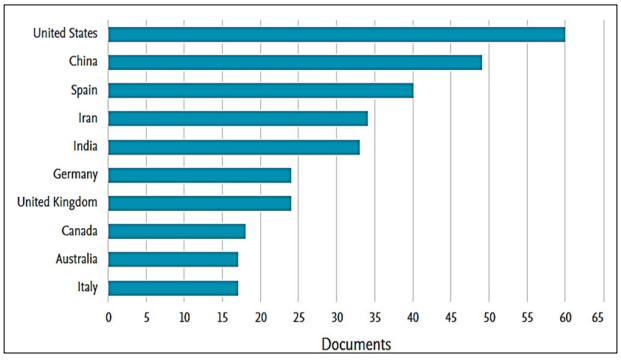

Fig. 3b. Countries that carried out research with the words intelligence", "artificial", for "management", "resource" and "Hydric"

The analysis of the map is shown in Fig. 4, it is determined that the data mining obtained from Scopus was analyzed using the VOSviewer tool, the most representative words were “Artificial intelligence”, “decision support systems” and “water management” among others. The circles determine the interaction between each word leading to the conclusion that the contracted words have greater correlational interest among themselves, and which allows us to form a good reliable database to be analyzed.

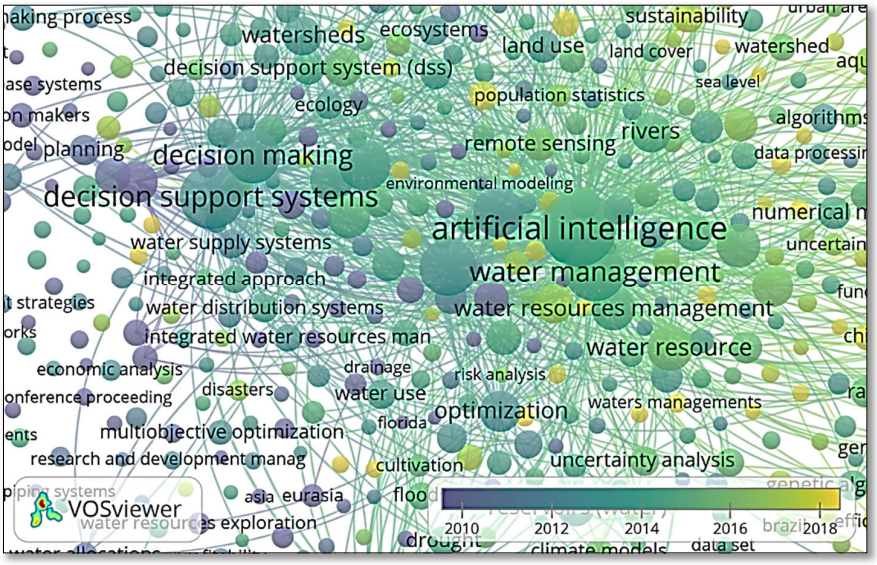

Fig. 4. Bibliometric map of the analysis of the words “intelligence”, “artificial”, for “management”, “resource” and “Water” with the greatest interaction

Source: Obtained from the VOSviewer analysis.

3.2 Artificial intelligence for construction project management

Technology in project management impacts from the organizational, personal level to obtaining the results, for this reason, the need for these tools is born that allows decision-making at the informational level (Mesa et al., 2022) for the success of the project (Ruperto & Strappini, 2021). Also, the success is quantified through compliance with the budget, duration of execution with compliance with the project specifications (Ali et al., 2022) thanks to the fact that it can be control, planning and monitoring of planned activities (Ruperto & Strappini, 2021). Some of the most important factors are as follows,

- Data prediction towards project construction costs (Ali et al., 2022),
- Safety management for workers improving occupational health within and outside their reach (Ruperto & Strappini, 2021),
- Improving the execution time of the project (Ruperto & Strappini, 2021),
- Waste prevention, material use prediction, waste recycling and logistics activities (Oluleye et al., 2023), and
- Improving uncertainty when starting a project to improve complexity and issues aligned to execution (Ali et al., 2022).

The construction sector is a large contributor to the economy and to the consumption of resources, generates waste, impacts the lives of workers and negatively impacts the environment (Bang & Bjorn, 2021), therefore greater importance must be taken in the investment and application of artificial intelligence in projects from zero level to the completion of the project. However, there are barriers in the application for project management, this is due to the currently accessible database, since it depends on it to train and validate the data in order to predict, model, simulate this data (Oluleye et al., 2023) also professionals are not yet related to artificial intelligence (AI) for the execution of projects (Kumar et al., 2022), however we can analyze the current systems that exist for project management through artificial intelligence which are:

- The Microsoft share Point program allows the sharing of information supported and authorized by the owner in website formats (Ruperto & Strappini, 2021),
- Artificial intelligence is associated with Microsoft Power BI that transforms the data in a visual and interactive way, the BIM AND CAD platform that shapes the elements (Ruperto & Strappini, 2021),
- The artificial neural network ANN, which works like the brain, serves to handle multivariate data, allowing trial and error to learn (Uddin et al., 2022),
- Fuzzy logic (FL), artificial neural networks (ANN) and support vector machines (SVM) to be able to estimate the cost of a project (Ali et al., 2022), and

- Deep neural network (DNN), random forest (RF), artificial neural network ANN, support vector machine (SVM) and DT decision tree (Oluleye et al., 2023).

Everything mentioned is for different areas for the management of projects with artificial intelligence, for this we support the use of cell phones with the internet of things that allows improving the management of materials, construction data and thus predict data to improve the decision decisions (Igwe et al., 2022). However, the existing construction software is currently specific for the design and modeling of the project, which also allows to analysis in environments through virtual reality, and replicate them for other projects (Uddin et al., 2022). An advantage at the design and visual level is the fact that 58% of the professionals related to the construction branch use technologies that allow them to improve the quality of analysis, management and control of the project through cell phones (Igwe et al., 2022).

3.3 Artificial intelligence for water resources management

The management of water resources becomes a concern worldwide and with it the waste generated by construction is due to the bad procedures carried out that negatively impact the environment (Bang & Bjorn, 2022; Ahmed et al., 2022), there are places in the world that need to manage water resources at this time such as Teeran-karaj that are in danger of having water for only 20 years (Rahmani et al., 2023) developed countries suffer from water scarcity (Nel et al., 2022) and the solutions are storage plants treatment, extraction of rainwater and graywater for reuse, likewise currently the artificial recharge of aquifers (Rahmani et al., 2023) for this requires an infrastructure planned and designed exclusively for water conservation.

The authorities are responsible for taking into consideration the best solution to implement technologies that allow the effective management of water and drinking water (Krishnan et al., 2022), the water supply must meet several assignments such as optimization in government objectives, criteria of evaluation, decision support, economic benefit and allocation based on needs (Nel et al., 2022), generating the benefit at the global level of the entire water supply chain (Krishnan et al., 2022) maintaining the sustainability of the water resources since it is a paramount and basic need (Rahmani et al., 2023).

The engineers involved in the construction sector propose project proposals for the management of water resources, for this they need to know parameters such as river flow, water levels according to the seasons, precipitation parameters, this in a historical data (Mohammed et al., 2023), they also need to apply strategies that are aligned to the water supply flows (Krishnan et al., 2022) and that these meet the parameters to monitor water such as color, odor, conductivity, solids, alkalinity, hardness, nutrients, metals and others (Alamanos, 2022), an additional to this is that they can be prevented from droughts, so it is important that they know the parameters of the climate, geology, vegetation, anthropogenic activities and the already mentioned Amanambu et al., 2022).

This is how the need to apply artificial intelligence in the management of water resources to manage non-linear and complicated hydrological data is born, intelligent solutions serve to take advantage and manage disasters and floods, to be able to forecast droughts, rains and flood analysis, to improve water quality and reduce consumption. The current tools are:

- The GWL method that supports managing water resources based on statistics, maps and that provides valuable data such as the prediction of dry and wet years in a short time considering that the cost to execute it is acceptable (Mohammed et else, 2022).
- The VENSIM DSS software to be able to use it with dynamic loops (Rahmani et al., 2023).
- The short- and long-term memory (LSTM) proved to be a superior neural network, which transforms data to predict (Amanambu et al., 2022) and can analyze large amounts of data, in a period of 90 to 120 days to determine values in the forecasts.
- GIS systems of geographic information and EPANET environmental protection agency network (Hangan et al., 2022).
- WSN are wireless sensor networks to monitor water and intelligence of things (IoT) for real monitoring at an affordable cost (Hangan et al., 2022), in addition these sensors allow to analyze turbidity, temperature and monitor quality control of water (Krishnan et al., 2022) and also obtain data on consumption and leakage at an economic level (Velayudhan et else, 2022).
- The GMDH, ELM, ORELM methods to determine parameters (Amanambu et al., 2022).
- The artificial neural network (ANN) that forecasts future values such as precipitation, runoff, floods, and flows. (Rahmani et al., 2023), it has an effectiveness of 85% to 90%, it can also predict metals in water such as chromium, lead, mercury and others, thus providing better solutions to decontaminate or extract these metals from water (Krishnan et al.; 2022).
- MADRL prepredation that optimizes LCA in treatment plants and application of Auto DL to measure water quality (Krishnan et al., 2022).

Technological advances such as robotics, artificial intelligence (AI), big data automates flows, the block chain adds security to the system (Hangan et al., 2022), the Internet of Things (IoT), augmented reality, drones and sensors are the future to be

able to manage the water resource, anywhere and at any time, they will allow us to obtain information which will allow us to make decisions based on data (Pandey et al., 2022). water management that allows you to see the entire process that is required to have the four results: verification of water quality, analysis of water contaminants, water monitoring and verification if there are leaks, odors and among others.

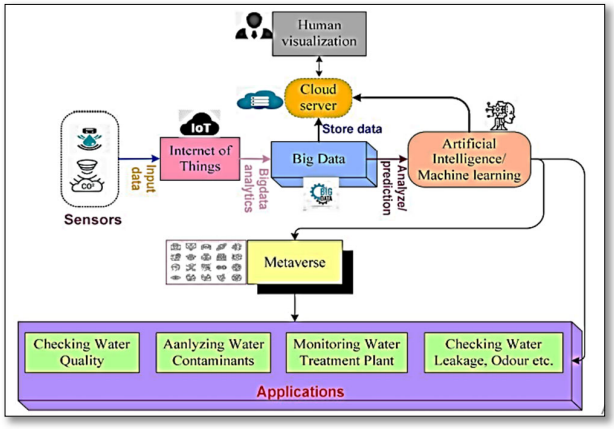

Fig. 5. The water management system. Source: Pandey et al., 2022

The future of our civilization depends on the management of water resources and it is also essential for the construction of infrastructures in urban environments (Hangan et al., 2022) since the consumption of water is increasing, this is how water is becoming more and more importance and becomes a scarce resource (Hangan et al., 2022) for this reason the critical points within the distribution of water must be identified, to detect leaks and assess risks and apply measures to obtain easily accessible available water resources. The union with intelligent technologies allows us to improve and manage water with reliable, effective and efficient decisions in the face of problems, however, to choose the technology, location, distance, cost of communication, government restrictions and other parameters must be taken into account. urban (Velayudhan et al., 2022).

4. Discussion

These types of analysis allow us to know artificial intelligence tools to manage water projects and manage contribution water in scientific bibliographic review analyzed in depth and taking the best references to be applied. This analysis carried out using the VOSviewer and Scopus tool has repercussions in countries such as the United States, the United Kingdom, China and among others, however, no Latin American country is found, giving an understanding of the disadvantages and lack of interest on the part of professionals in preserving and conserve water resources.

Water storage systems such as hydrographic basins are important at an economic, ecological and hydrological level since they are in charge of receiving water from rain and snowmelt (Mircea et al., 2017) and these need to be managed effectively. One of the SDG sustainable development goals is to have access to safe water for all people by 2030 (Hangan et al., 2022), however, there are countries where the scope of drinking water for all is not prioritized. This also involves professionals who must consider water management as a primary objective to emphasize the construction of sanitation works, water networks and others (Nel et al., 2022) since it is affected by excessive population growth. and from pollutants such as agriculture, excessive use by industries and mines.

In order to make good management of water resources and the management of water projects a reality, technological tools with artificial intelligence (AI) were used, since in the construction sector the application of AI at the execution level is still traditional (Bang & Bjorn, 2021) and this is reflected in the cost of the projects, AI is a great advance for implementation in the construction sector, taking into account that there are technologies in the construction sector but they focus on the design or profitability of the structures but not on the execution of the project or how to take into consideration the use of technology in the projects and these are found in mobile applications that play a role in satisfying various needs within the reach of the cell phone (Igwe et al., 2022), this is how the AI that allows automatic learning to solve problems in the execution and analysis of construction projects (Uddin et al., 2022), however, the workforce continues to fulfill the essential role for the project to be successful (Kumar et al., 2022). For all these reasons it is necessary to consider investing in technological tools that allow the preservation of water resources from the execution of the project to the continuous use of the hydraulic infrastructure.

The clear examples of success such as the Head Quarters Viale Regina Margherita (HQVRM) project that implemented cloud computing, AI, machine learning, Big data, becoming tools as a strategic asset that together provide efficiency, effectiveness, profitability with a vision of medium and long-term impacting on the economic, social and ethical aspect of the construction project (Ruperto & Strappini, 2021), also in China the application of WDNetXL a network that solves technical problems facilitating the distribution work of technicians with the aim of reducing losses of water and with the purpose of preserving the water resource for the other generations (Berardi et al., 2014), considering that the waste of water is managed by those responsible for public services that deal with drinking problems on a day-to-day basis. , but with the installation of devices such as telemetry and sensors, it is possible to track consumption, with only this, data can be collected specific and in real time for decision making (Kulkarni & Farnham; 2016).

However, it also has disadvantages such as the application to companies that are not prepared to use these technologies, that there is no current historical data to carry out the data coding, it will be necessary to train professionals in technological management (Berardi et al., 2014), however, even with these disadvantages, the application of artificial technology in the management of these water projects and for the operation of the infrastructure must be taken into account, since everything invested will be necessary to preserve the most valuable resource in all the times.

5. Conclusion

Construction management is increasingly becoming an entry barrier since it depends on many factors such as human factors, technology, resources and society that does not allow it to meet the planned deadline when starting the project, for this reason this document is It emphasizes managing technological tools that allow managing these projects effectively and is based on the construction of water infrastructure and that leads to the management of these water resources with the application of artificial intelligence. The highlight of this analysis is that it allows us to understand that at the Latin American level there are no scientific contributions related to the subject and that secondly there is a great variety of technological tools for the execution of water projects without, however, there are barriers such as professionals who are not trained to use them. With these tools, the same system in charge does not prefer to invest in technologies for execution, according to the management of water resources, there are tools accessible in the market and capable of modifying, however, it also presents barriers such as data to be able to develop the technology apparent to the reality and the difficulty of workers to be able to manage it.

The application of technology in Artificial Intelligence and its fellow allies show multiple advantages from predictions of natural disasters to the effectiveness of managing soluble water for the entire population, reducing diseases caused by contaminated water. We conclude that these methodologies can be applied in Peru and that it is the responsibility of professionals to work hand in hand with artificial intelligence, big data, the internet of things and among others to be able to execute larger projects that require analysis and historical bases. feasible, which is recommended to familiarize yourself with these tools to improve the quality of management in construction projects in water works and present greater interest in the impact of the infrastructure that in this case would be the preservation of water and its optimal management.

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