Architecture Image Studies

Vol.6, Issue 4, pp.1470-1476, 2025
DOI: https://doi.org/10.62754/ais.v6i4.773

https://journals.ap2.pt/index.php/ais/index

Operational Management For The Desilting Of The Poechos Dam: An Applied Study In The Chira-Piura Project

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Abstract

This article explores an operational management model for desilting the Poechos Dam in Chira-Piura, considering the sedimentation rate, which is decreasing by 1% annually, significantly impacting water availability for irrigation, drinking, and hydroelectric power generation in northern Peru. The research was basic, descriptive, cross-sectional, and non-experimental. Two questionnaires, validated by five experts, were used as instruments, each with 23 items for the two variables and a Likert scale. The main findings include frequency tables that reveal a lack of information and uncertainty regarding desilting procedures. This is corroborated in the results discussion by studies conducted in the Moquegua region, such as Romero's 2022 work, and at the Gallito Ciego Dam, by Matute-Velásquez, also in 2022. The discussion incorporates ideas from the Integrated Water Resources Management Model Theory and the adoption of Lean practices, suggesting an organized approach to achieving transparency and sustainability. The proposed model aligns with SDGs 6 and 9, contributing to the 2030 Agenda through reservoir restoration and climate resilience. The conclusions highlight perception neutrality as an opportunity for training, positioning the work as a benchmark for water management in Latin America.

Keywords: *operational management, desilting, dam, sedimentation, reservoirs.*

Introduction

To begin this work, it should be noted that the Pechos Dam, located in Sullana and managed by the Chira-Piura Special Project (PECHP), is an important part of the infrastructure for water management and agricultural development in northern Peru. However, the slow accumulation of sediment is jeopardizing its storage capacity, which in turn threatens access to water for irrigation, domestic use, and electricity generation in the area. This text presents a new management plan to address this situation through a practical and constructive approach.

The fact that there has been a large accumulation of sediment in reservoirs is a global problem that reduces total water storage capacity by between 0.5% and 1% each year (Scott et al., 2023). According to the World Bank, this phenomenon requires the construction of approximately 300 large dams annually just to cover the losses, highlighting the urgent need for efficient ways to remove such accumulation (World Bank, 2020). Therefore, in areas with high erosion, such as active river basins, the sediment carried by floodwaters exacerbates the damage to hydraulic infrastructure.

In Latin America, deforestation and poor water management accelerate sedimentation, making it difficult to access water and generate energy, as is happening in Venezuela with its constant accumulation of sediment in its water reservoirs. The Economic Commission for Latin America and the Caribbean (ECLAC, 2019) points out that these problems require comprehensive action to reduce damage to the region's environment and resources. For example, in Peru, reservoirs like Gallito Ciego lose almost 1 percent of their total capacity each year due to sedimentation, which reduces water use and hinders access to water for the various uses so vital to the area.

Similarly, the Poechos dam suffers a 1% annual loss of its usable capacity because the Chira River, with a flow rate of approximately 120 cubic meters per second, carries 7,488 tons of total solids (Meza et al., 2022). This large accumulation reduces the dam's operational capacity and creates dangers due to water scarcity during droughts, harming the population that needs water for irrigation and electricity generation. Bathymetric surveys show that the problem is exacerbated by the El Niño phenomenon, which periodically affects Peru and other countries in the Americas. Furthermore, if this

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problem is not addressed, the dam could become unusable within a few years (National Civil Service Authority, 2022).

The low level of usable water in the Poechos Dam directly affects the supply of drinking water, agriculture, and hydroelectric power generation. Surveys of PECHP workers reveal neutral opinions regarding current preventative measures. This raises concerns about the dam's management and its impact on the Peruvian economy, with potential costs exceeding 70% of the construction price for similar dams. Furthermore, in Piura, the increased risks associated with the climate cause the reservoir to face significant challenges, exacerbating economic hardship. The question then becomes: What is the most effective approach to addressing the issue of removing debris from the Poechos Dam within the Chira-Piura project? Furthermore, specific questions arise regarding the level of waste generated, the excavation and earthmoving work at the dam, and the theoretical basis of the proposed operational management model for the Poechos desilting project within the Chira Piura Project. These questions guide the study toward useful and lasting solutions.

The main objective of this research is to create a working model for cleaning the Poechos Dam, according to the goals of the Chira-Piura Special Project (PEC-HP). This method aims to restore the dam's storage capacity and improve the necessary actions to strengthen its management and ensure its long-term sustainability. An additional objective of this work is to identify the level of waste generated during cleaning operations at the dam. Furthermore, it is necessary to determine the level of excavation and earthmoving required at the Poechos Dam to carry out these tasks. An operational management model for desilting the dam is also proposed. Finally, the rationale for the proposed model will be tested through a professional review process, ensuring its strength and relevance.

This article adopts the definition of administrative management proposed by Riquelme (2022), who defines it as the set of plans to improve how a company functions internally, taking into account planning, execution, monitoring, and evaluation. Furthermore, this work is supported by theories such as Fayol's (1916) Classical Theory of Administration, which indicates that organizational structure is crucial for efficient work management, and Imai's (1992) Theory of Continuous Improvement based on Kaizen, which encourages constant change to benefit people.

For his part, Bonnin (1834) applies these ideas to the public sector, emphasizing clarity and knowing what to do in administration. Therefore, planning has clear goals and seeks the efficient use of government resources; likewise, implementation involves putting plans into action, and monitoring refers to carefully observing how tasks are carried out, as well as verifying the results. Finally, Wright and Mechling (2002) define operational management as the set of strategies, plans, and actions implemented to ensure that an organization functions optimally.

In other respects, Annarelli and Nonino (2016) emphasize that management includes not only managing resources such as raw materials, technologies, and machinery, but also the human factor, in order to improve the performance of an organization's internal processes. Meanwhile, Bueno-Tacuri and Jácome-Ortega (2021) propose that operations management is essential for the success or failure of organizations or companies. This encompasses operational actions such as planning, product design, production processes, quality control, location, materials handling, technological capabilities, and the human resources necessary to achieve organizational objectives. This definition is more comprehensive because it integrates the ideas of the other authors; therefore, it is the one adopted in this work.

However, the definitions of management by Ivanov et al. (2021) should be considered, as they describe a structure for decision-making. Krajewski and Malhotra (2022) define it as a tool for correcting errors and achieving user satisfaction. Similarly, Benjaafar and Hu (2020) present it through a description and analysis of the dynamic model, which clarifies the tasks of the collaborators. All these elements indicated in the presented definitions—planning, as a deliberate process of setting sound objectives; execution, as a cultural application; monitoring of results; and evaluation, as a fair review—form the basis for the framework of this work's proposal for the Poechos Dam.

In another sense, sediment removal helps clean and restore the river channel or dam, as Avilés and Mendoza (2023) state, preventing blockages in these areas. Gleick (1998) proposes it for water source management, highlighting ecological and social sustainability. Furthermore, important aspects include the waste generated and excavation with earthmoving. Cepeda et al. (2024) in Colombia suggest plans to reduce environmental damage with the help of community members for river containment work. Similarly, Palacios (2022) explores ways to remove sediment from full reservoirs, suggesting raising intakes as a temporary measure.

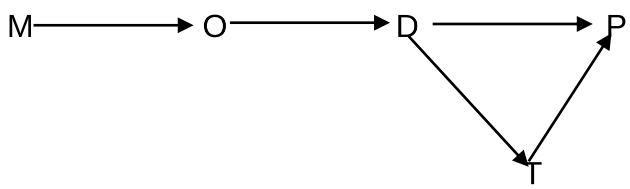
It should be emphasized that, in Moquegua, Romero (2022) counts the sediments in Pasto Grande, showing places where water emerges and places to plant trees of the forest type. Matute and Velásquez (2022) in Cajamarca indicate that 111.61 million cubic meters were lost in the Gallito Ciego dam due to sediments. Ramos (2021) in Lima uses Value Stream Mapping to reduce river cleaning times. In this way, it is shown that the proposed model helps SDGs 6 (clean water) and 9 (good infrastructure), because it proposes caring for nature and ensuring that everyone has access to clean water to guarantee social justice. This aligns with the United Nations Development Programme's Agenda 2030, highlighting the Sustainable Development Goals (UNDP, 2022) and adapting to the changing climate in Piura. From a social perspective, it improves quality of life through access to clean water, theoretically linking concepts of public management and water resources, and practically providing a ready-made model for government institutions. Methodologically, it uses reliable surveys administered to 70 people from the PECHP (Special Project for the Conservation of the Piura River Basin) to achieve the necessary scientific rigor.

Methodology And Materials

The research adopted a practical approach, focused on creating useful solutions validated through real-world testing and contributions to the literature to address unique problems in water system management (Gaspar-Santo et al., 2024). A quantitative design was applied, centered on obtaining and processing measurable numerical data with statistical techniques that help to accurately and unbiasedly count variables (Hernández and Mendoza, 2020). Furthermore, a descriptive level was employed, allowing for a clear description of the phenomenon, highlighting operational shortcomings and providing improvement proposals supported by systematically collected real-world data. Additionally, a non-experimental approach was used, observing the phenomenon in situ without direct manipulation, facilitating rapid observation and the collection of accurate data to promote efficient work.

One of the methods for conducting the research was shown in Figure 1, which displays the diagram proposed by Bernardo et al. (2019), where: M represents the Sample, D the Desilting, P the Operational Management or Proposed Model, T the Analysis and Foundation of Theories to Understand the Phenomenon, and P the Proposed Solution to the Problem, expressed in a plan. Consequently, the "management" aspect of the activity was understood as a pattern made up of steps that improve how activities are controlled through tasks such as "organizing, executing, monitoring, and evaluating," adjusted to real-world situations in society. On the other hand, desilting was considered a technical aid to make the area where the water is deposited larger, reduce friction and prevent floods that harm people or their crops, always monitoring the excess material that comes out and digging with earthmoving.

Figure 1 Design diagram



Source: Prepared by the author

The population consisted of 132 workers from the Chira-Piura Project at the Poechos Dam, including operational and administrative staff, excluding those working for a short period and those who declined to participate, in accordance with strict ethical research guidelines. A non-probability convenience sample of 70 individuals was selected, representing the main characteristics of the general population, to gather information on their perceptions of their work. The primary data collection technique involved surveying workers using Likert-scale questionnaires (ranging from strongly disagree to strongly agree). These instruments were validated by five experts for clarity, relevance, and sufficiency, achieving a reliability of 0.818 for work management and 0.901 for cleaning the dam.

The stages included approval of the structure, use of data collection instruments that would guarantee anonymity, such as informed consent forms, percentage frequency counts, and a study organized based on the objectives set at the beginning of the study, concluding with the discussion of results and the proposal. The ethical code RCUN°470-2022-UCV was followed, placing great importance on not causing harm, respecting freedom of expression, helping others, being fair and upright, in addition to confidentiality and APA 7th edition guidelines for transparency. This control ensures credibility and repeatability in the evaluation of sediment cleaning systems in dams.

Results and discussion

The findings reveal mixed opinions among the seventy employees interviewed from the Chira-Piura Program regarding the excavation and earthmoving activities at the Poechos Dam. The majority remained neutral on issues such as recent excavations (54%), work that impedes vegetation (50%), and upstream sediment control (60%), with little agreement on methods for cleaning sediment (34%) and ways to prevent pollution (38%). These data suggest uncertainty in the implementation process, with only 7-9% expressing full support for major actions, while 3-25% disagreed, implying gaps in communication and execution.

Table 1 Results of questionnaire applied to workers.

Item	Totally disagree	Disagree	Neutral	In agree	Totally agree
1. Vessel excavations (2 years)	3%	22%	54%	14%	7%
2. Vegetation removal from riverbed	4%	18%	50%	21%	7%
3. Upstream sedimentation control	3%	14%	60%	16%	7%
4. Sediment reduction floods	4%	25%	46%	16%	9%
5. Sediment measurement controls	1%	13%	47%	33%	6%
6. Unclogging strategies	3%	16%	41%	34%	6%
7. Water pollution control mechanisms	4%	14%	40%	38%	4%

Source: Prepared by the author based on the results of the questionnaire applied to workers.

For the second objective, items 9 through 11 were considered. The results showed a high degree of neutrality (53%) regarding the amount of waste generated, particularly concerning water extraction, with 23% agreeing and 18% strongly disagreeing. Preventive mechanisms for treating sediments garnered 43% neutral opinions, 28% support, and 20% opposition. The impact of usable water loss, affecting drinking water, irrigation, and energy, garnered broad consensus (63% support/total support). This clearly demonstrates that people are aware of the socioeconomic risks despite some doubts about current measures.

Tabla 2 Results of questionnaire applied to workers.

Item	Totally disagree	Disagree	Neutral	In agree	Totally agree
9. Desilting by water discharge	3%	15%	53%	23%	6%
10. Preventive mechanisms for sediments	4%	16%	43%	28%	9%

11. Impact of usable water loss	1%	3%	33%	34%	29%

Source: Prepared by the author based on the results of the questionnaire applied to workers.

The removal and movement of earth, which is important for removing sediments that block the river section, requires the removal of vegetation and preventive inspections by experts. Table 2 shows that most respondents were neutral (40-60%), with few in agreement (14-38%), indicating distrust in the results of preventive work carried out in the reservoir, channel, and water passage. This difference suggests a lack of clear information, since neutrality can be a sign of deception and disagreements reflect concerns about poor implementation. Therefore, strengthening collective transparency is essential to align perceptions with operational realities.

The proposal outlines a comprehensive management method for cleaning the Poechos Dam, divided into four key phases: planning, action, observation, and evaluation. The planning phase establishes clear goals aligned with the objectives of the Chira-Piura Project. It also calculates the amount of soil to be removed (based on underwater maps indicating a 1% annual loss), the resulting waste (7,488 tons of solids from the Chira River), and improved costs using Lean methods such as Value Stream Mapping. The action phase combines mud removal by carefully draining water, excavating with specialized dredges, clearing vegetation from the access roads in advance, and installing barriers to prevent river flooding. This approach prioritizes workplace safety and minimizes negative environmental impact, adhering to Peruvian regulations. This path seeks the participation of the 132 employees of PECHP, teaching them correct ways to raise their understanding of the current range of opinions between 14-38%.

Constant monitoring uses bathymetric measurements every six months, real-time sludge sensors, and monthly reports on debris, while the review examines indicators such as volume filling (target: more than 20% of usable capacity in 5 years), reduced socioeconomic impacts (clean water/irrigation/energy), and environmental return. This approach will include a clear budget (around 33 million soles initially), a 24-month plan with gradual goals, and review by five experts, all aligned with Sustainable Development Goals 6 and 9 for environmental protection. Developed by the PECHP (Peruvian Hydroelectric Project), it strengthens resilience against climate change during El Niño, making Poechos an efficient model to replicate in other Peruvian reservoirs like Gallito Ciego.

The analysis of the results shows that the lack of agreement on methods for removing sand from water reflects doubts about their practicality in the area, stemming from a lack of trust or knowledge. Therefore, the methods should be implemented collaboratively, adapted to the local context, and carefully monitored to ensure their long-term effectiveness. This aligns with Romero's findings (2022), who, after observing that 5% of a water feature in Pasto Grande was filled with sand, suggested methods for removing the sediment, constructing dikes alongside the water, and planting trees to systematically remove sand and improve water quality. These measures also improve usable space and curb the proliferation of small insects.

The results of this research align with those found by Matute and Velásquez (2022) in Gallito Ciego, where sediment accumulation reduces the lifespan of dams because they shrink, and the cost of energy resources decreases, potentially leading to losses. Furthermore, Gleick's (1998) Theory of Water Resource Management emphasizes the need to eliminate sedimentation to ensure a long-term water supply, which requires aligning natural processes with regional human needs. It is also crucial to respect the environment and social needs such as food production, energy, and healthcare. This makes the proposed management and operational model for Poechos efficient and viable.

For his part, Ramos (2021) supports the use of Value Stream Mapping (VSM) to desilt rivers throughout Lima, an effective method for removing waste, implementing Lean principles, and reducing costs and time by identifying material losses. Table 2 shows a neutral opinion (43-53 percent) regarding discharge techniques and preventive controls for the resulting waste. Furthermore, there is agreement on the impact of water loss (63%), demonstrating that people are aware of the dangers but lack the conviction to implement preventive measures. Consequently, waste management must separate, reduce, and handle waste according to international standards, thus contributing to environmental protection.

On the other hand, Hooper's (2010) theories of total water management in watersheds enhance these findings by making water management a social interaction among people, fostering shared responsibility and creative solutions for equitable distribution. In Poechos, the high level of neutrality (40-60%) highlights the need to find ways to re-engage people by involving employees in designing plans, building trust, and improving the effectiveness of strategies against pollution and sedimentation. This approach supports the implementation aspect of the proposed plan by promoting local discussions to adapt aid to the changes in the Chira-Piura basin.

Asimismo, Fayol (1916) habló sobre la estructura de una empresa como base para funcionar bien, haciendo hincapié en un liderazgo bueno y siempre mejorar en la administración pública. Por lo que, los resultados evidencian problemas (14-25%) como falta en reglas claras para la realización de excavaciones y controles, sugiriendo cambiar funciones que mejoren acuerdos en planos para quitar el sedimento desde la descolmatación presente 34-38%. Esta capacidad de adaptarse organizacionalmente asegura una competencia de larga duración integrando ajustes al clima para temporales malos como el paso de la corriente de El Niño que son recurrentes en la zona.

Meanwhile, the concept of making small, continuous improvements called Kaizen (Imai, 1992) demonstrates gradual changes with the help of the people, standardizing the steps after each improvement so they can be easily replicated and taught. In contrast to doing nothing about removing plants and measuring soil (47-54%), it highlights small, inexpensive daily changes to prevent disruptions, increasing the overall number of agreements through a culture that eliminates errors. At the Poechos dam, this means having clear goals for waste removal and excavation, ensuring positive long-term effects without a large initial investment.

Furthermore, achieving the Sustainable Development Goals (SDGs) 6 (clean water) and 9 (durable infrastructure) positions the plan as an important part of the 2030 Agenda, using funds to improve the environment and provide clean water to people (United Nations, 2016). This agenda aligns with the finding that 63% of respondents are aware of the effects of reduced usable water volume and highlights the critical need to restore the capacity of the Poechos Dam, strengthening its resilience to climate change in Piura. Internationally, it follows the examples of sediment removal in China (1.7% loss annually in Sanmenxia) and South Africa (5% in Welbedacht, adapting local methods for global sustainability).

Conclusión

Regarding the first special objective, which determined the amount of excavation and earthmoving at the Poechos Dam, the data indicate a clear lack of agreement among the workers interviewed (40-60% on key points), with only 14-38% agreeing with actions such as removing vegetation and implementing sedimentation controls. This suggests potential gaps in workplace perception, where small differences (13-25%) point to past practices, although one group sees protective measures in the riverbed and against rainfall. These results highlight the importance of improving communication within the company to align opinions and enhance future actions

Regarding the second specific goal, related to garbage and the method of cleaning the riverbed, there was indifference (43-53%) regarding methods such as dumping wastewater and checking beforehand, with little help (23-28%) and isolated incidents (15-20%). However, there was notable agreement (63%) regarding the significant water loss in drinking water supply, field irrigation, and electricity production, demonstrating an understanding of the social and economic risks despite technical doubts. This difference points to real opportunities for training people and clarifying plans, increasing confidence in ideas to combat water pollution.

Finally, the implementation of the operational management plan created to clean the Poechos Dam in the Chira-Piura Project represents a significant step forward for Sustainable Development Goals 6 (clean water and sanitation) and 9 (industry, innovation, and infrastructure), thereby improving storage capacity and streamlining procedures. This intervention greatly benefits Piura by reducing water scarcity and vulnerabilities to climate events such as El Niño. It also contributes to the global 2030 Agenda by promoting equitable access to water and protecting aquatic ecosystems. For these reasons, the PECHP (Chira-Piura Special Project) serves as a model for sound water resource management in Latin America.

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