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ANALYSIS OF THE EFFECTS ON THE ENVIRONMENT AND MARITIME ECOSYSTEMS CAUSED BY THE EXTENSION OF THE PANAMA CANAL LOCKS

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Abstract

Since the inauguration of the new locks of the Panama Canal have transited millions of ships loaded with goods and these locks are the connection between the Atlantic Ocean with the Pacific, due to the demand that this has had and its influence on economic growth in Panama it is decided through a referendum the construction of new locks of clear water in Panama, with the intention that they can transit other vessels that have greater capacity such as the Neopanamax, in the year 2007 they begin the expansion to execute this construction, in which they were committed more than 490 hectares of vegetation which leaves an affectation to the flora and fauna, since in this inhabited plants and animals like the snake eye of cat, green iguana, sloth of two and three fingers, howler monkey, titi monkey, among others; the affectations do not finish because the operation of the canal of Panama is executed with fresh water and this has affected the water supply for the citizens.

Keywords

Environment, ecosystems, environmental impacts, locks

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1. Project Formulation

1.1. Title

Analyzing the Effects on the Environment and Maritime Ecosystems caused by the Expansion of the Panama Canal Locks.

1.2. State of the Art

"EVALUATION AND COMPARATION BETWEEN THE PANAMA CANAL AND THE DIQUE CHANNEL FOR OBTAINING HYDRAULIC PARAMETERS IN

CHANNEL DESIGN" Impact of the Panama Canal. Since the construction of the new set of locks for the expansion of the Panama Canal, environmental impact has been more controlled through mitigation established in the Environmental Management Plan (EMP). With the expansion, more than 1800 hectares of the basin were affected, and with the help of WFP twice as many affected areas were reforested. In addition, to prevent the material excavated by the construction of the locks from being deposited in wooded areas, a shooting range belonging to the U.S. state of defense was located where it was cleaned, sanitized, and adapted to deposit the excavated material. (Bello, Vanessa, 2017).

"NUMERICAL MODELATION OF THE THIRD GAME OF PANAMA CANAL SCLUSES FOR THE STUDY OF DESIGN ALTERNATIVES" this research was carried out by Fernando Re in 2010 between the University of Buenos Aires and the National Water Institute of Argentina. And its object of study is to optimize the use of the water that will be used for filling and emptying the locks in Panama. (Re, Fernando; Badano, Nicolas; Mendez, Angel; Sabarots, Martin, 2010).

Dr. Donaldo Sousa talks about the Panama Canal and its environmental impact, he indicates that Panama's environmental authority is violating environmental rights at the time of building the locks, to the point that they have filed several complaints to the Panama Canal because he indicates that the officials only have economic and personal interests in this project, since they are violating internal environmental laws. (Sousa, 2016).

During its construction, 140 million cubic meters of earth, sand, rocks, and other aggregates were extracted and taken elsewhere. 500 km2 of jungle were exterminated, so nature underwent major changes. On the other hand, the main negative impacts of the canal can be summarized in: a great deforestation of the environment, exterminating hundreds of square kilometers of jungle, an important affection to the marine species of the place, as well as a demographic growth that brings with it the elimination of species along the banks of the canal. (Javier Martín, 2018).

According to activist Donaldo Sousa, Panama has a large number of protected areas due to the struggles of ecologists; therefore, he said he did not agree with the construction of projects in these protected areas of Panama. Susana Sarracín of the Alliance for Conservation and Development pointed out the disagreement for permits that are being given to build in protected areas due to the lack of an adequate management plan; however, she says that this type of situation will bring serious environmental consequences that will harm all Panamanians. (Celia douglas, 2017).

6,102 animals lost their homes due to the expansion of the canal, Boas constrictors, ocelots, endangered turtles, and up to 130 species inhabited the tropical forest now occupied by the new project. Besides, the tropical rainforest of Panama is plagued by hundreds of species. Chubby capybaras - the largest rodents in the world - elusive armadillos that had to be searched for underground and constrictor boas of up to two meters make up the bestiary of animals expelled by the expansion of the canal. (Balarezo, 2016).

In the research INEQUALITY AND GREAT PUBLIC WORKS: THE ENLARGEMENT OF THE PANAMA CHANNEL developed by Mr. Antonio Aledo Tur, mentions the socio-environmental impacts caused by major public works that produce negative consequences on the environment as they generate evictions, decrease of fauna and flora destroying ecosystems. (Aledo Tur, Antonio, 2007).

1.3. Problem Statement

From 2009 to 2016, there was talk of expanding the Panama Canal so that other types of vessels that until now could not navigate the Panama Canal like the Neopanamax could

transit, so that this would be possible, the construction of a new lane (Cocolí and Aguas Claras locks) was begun, which allowed the improvement of maritime transport in Panama.

But behind this come not only economic changes but also positive and negative environmental changes, according to the Panama Canal Authority this project contributes positively to the environment as it improves water savings and reduces CO2 by lowering transit time and improving vessel capacity. But this is only one part of the effect, since international maritime transport has different effects on the environment, such as: discharge of bilge water, which is the mixture of all the substances used inside the ship (hydrocarbons, additives, greases, detergents, solvents, among others).

Ballast water: which is taking water from an ecosystem to give stability to the ship and pour it into another ecosystem, and these effects are notorious in the biodiversity of the oceans as it generates an exchange of species (animals, microorganisms, bacteria) that can generate diseases in the new habitat to which they arrive, also for this project to be possible had to make an artificial lake in which it was necessary to excavate and extract 6.1 million cubic meters of material. (Panama Canal Authority, 2009) In which different species (fauna and flora) inhabited, the aim is to know what have been the environmental effects in the natural Panamanian ecosystems due to the expansion of the locks of the Panama Canal?

1.4. Objectives

1.4.1. General Objective.

Analyze the effects on the environment and maritime ecosystems caused by the expansion of the Panama Canal locks.

1.4.2. Specific Objectives

- To study the historical background and the environmental impact generated by the construction of the Panama Canal.
- To identify the negative and positive impacts that the construction of the Panama Canal has had on the environment and maritime ecosystems.
- Propose possible improvements to help mitigate the environmental damage caused by the construction of the Panama Canal.

1.5. Justification

1.5.1. Theoretical justification

The Panamanian economy is largely supported in the provision of services, having as main service the canal, where they were transported in 2018 and after its expansion according to the administration of the canal, about 13795 vessels. The Panama Canal allows the connection between the Pacific Ocean and the Atlantic Ocean in the Panamanian territory, which provides world trade with savings in distance, time, and cost in maritime transport. The expansion of the canal increased the flow of trade in Panama and therefore the income of the country, which has improved its economic development. However, the construction of the canal has also caused damage to the Panamanian environment. With the expansion of the Panama Canal, at least 490 hectares of vegetation were affected, in addition to the living beings that inhabited them. Affectations aggravated today by the contamination of the fresh water of the Gatun and Miraflores lakes as a result of the use of this for the operation of the third set of locks of the canal that allows the connection of the Pacific and Atlantic oceans. It should be noted that the fresh water contained in these lakes is essential to meet the drinking water needs of a large part of the population living in the Panamanian territory.

Each time the Panama Canal enters into operation, salt water is mixed with fresh water and 40% of the water entering the locks is lost, which represents a threat in the future to the environment and especially to the fresh water of the territory of Panama.

1.6. Referential Framework

1.6.1. Theoretical framework

Today it is normal to talk about the importance for humanity to take measures to conserve and improve the environment, since changes suffered by this in recent decades put at risk the existence of the human species. Changes that are no more than the result of human mismanagement of natural resources that are disproportionately exploited, are such a threat to the stability of the planet's ecosystems that nowadays a wide variety of living beings are at risk. A clear example of this is the affectation suffered in the natural ecosystems that once formed part of Lake Gatun in Panama, a place where today there is only an artificial

ecosystem inhabited only by boats driven by the development of capitalism or in other words where only the third set of locks of the Panama Canal is found.

According to the administrative authority of the Panama Canal, during the construction and currently with the operation of the third set of locks, measures have been taken aimed at caring for the environment and protecting its environment; this complemented with policies that seek to improve environmental standards, which have promoted energy saving programs, water resource management, maintenance of freshwater quality, reforestation, and environmental education.

The engineering project to expand the canal began in 2007, with the objective of building a third set of locks to improve the transit capacity of vessels with greater capacity (Neopanamax) through the canal. For the construction of the navigation channels it was necessary to use dredging and excavation techniques, which consisted in the removal of solid materials from the surface, such as the bottom of the sea and the Gatun and Miraflores lakes. During the development of this mega project, around 9.1 million cubic meters of solid material were dredged from the Pacific Ocean and approximately 7 kilometers of land with a width equivalent to 218 meters was removed. On the Atlantic side, approximately 7.5 million cubic meters of solid material were dredged and approximately 2.4 kilometers of land were removed. (Panama Canal Authority, 2017).

In order to protect the environment, during the construction of the third set of locks of the Panama Canal, most of the fauna and flora species that were part of the ecosystems affected by the execution of the project were relocated, rescuing and relocating monkeys, sloths, anteaters, titi monkeys, reptiles among other animals, achieving between 2006 and 2010 the rescue and relocation of approximately 1500 animals, according to the APPC. (Association Panamericana para la Conservation, 2005). As a consequence of the construction of the project, it is estimated that at least 6,102 animals lost their natural habitat, most of which were relocated to different protected natural areas. It should be noted that Panama has never in its history carried out a relocation of species of this magnitude, so that this was possible required a large amount of both human and logistical resources. However, it was inevitable that some species such as the sloths would be affected, as their location on the project grounds was difficult since their slowness and camouflage made their visualization more complex.

The relocation of these species was carried out by the Pan American Conservation Association (APPC), headed by biologist Néstor Correa. (BALAREZO, 2016).

Panama has implemented a policy of conservation of ecological parks, with the intention of mitigating the damage caused by deforestation and other works that have endangered the Panamanian environment, a clear example of this are the projects of protected areas as an alliance for the million that aims at reforestation and the development of sustainable work to improve the quality of the environment and its reconstruction. Among the protected places are altos de campanax , nargana village, san san-pond sak named as international importance, island bastimentos, damani guariviara, volcano barú, fortuna, santa fe, hill hoya, palo seco, general of division Omar Torrijos herrera and la amistad. In order to achieve these objectives, four fundamental strategies have been developed by the Panamanian government; the first is the sustainable management of protected areas, in charge of promoting alliances with private entities for financial sustainability. The second is biodiversity and sustainable production landscapes, which are responsible for implementing sustainable and environmentally friendly production systems, such as organic fertilizer, living fences, agroforestry, and renewable energy. The third strategy is knowledge management, training, and communication, which aims to raise public awareness of environmental protection aimed at sustainable consumption. The fourth and last strategy is the project management which is responsible for coordinating, supervising, monitoring, and evaluating the functioning of environmental conservation policies. (Ministered of Ambient de Panamá, 2019).

Among them we find the UN ENVIRONMENT, in charge of developing environmental, friendly, economic, and social policies that allow to reduce the pollution levels of the planet, which contributes to the global warming reduction. Warming that for Panama represents a threat for its population and the good functioning of the locks of its canal, due to the fact that this is the first cause by which the water flows available in the country's water basins are reduced. In order to develop new strategies, the UN and the PANAMA CANAL signed a cooperation agreement on July 26, 2019, to fight and jointly develop strategies to face climate change, which has allowed the training of officials in charge of the operation of the channel. This has allowed to enrich the knowledge on the care of the environment between both entities, and to a greater extent for the administration of the channel, since it has been able to

take advantage of the great knowledge of the UN Environment on this subject, as it is an organization that works in the care of the environment since 1972. (UN Environment Programme, 2019).

During a visit to Panama to learn more about the construction and operation of the third set of canal locks, Miraflores visitor center officials in charge of explaining the history, progress, and operation of the canal give a detailed description of each of the processes that are executed in the canal, especially the processes that require the use of fresh water for their operation. Thus, in order for ships to transit through the canal, it is necessary to fill the storage tubs of the canal with fresh water, a process that causes the contamination of more than 40% of the fresh water stored in its locks.

1.6.2 Conceptual Framework

Ecosystems: the author Ana Jesús Hernández defines them as entities formed by many plants and many animals, of the same or different species, that act and react with each other, within a physical environment, (Hernandez).

Environment: The United Nations Conference on Environment in Stockholm (1972) defines it as: "Environment is the set of physical, chemical, biological, and social components capable of causing direct or indirect effects, in a short or long term, on living beings and human activities." (MinAmbient, 2012)

1.7. Methodological Framework

1.7.1. Method of investigation

The proposed research will address the construction of the Panama Canal, its start, progress, and operation. With the purpose of knowing what have been the effects on the environment as a result of the construction of the third set of locks of the Panama Canal. In order to develop the present research, information was sought using the inductive method, starting with the most general research, such as the history of the Panama Canal, and finally arriving at the most specific thing for this work is to be able to offer a possible solution that allows for a reduction in the environmental effects caused by the construction and operation of the third set of locks in the Panama Canal.

1.7.2. Research Focus.

In order to specify the formulation in which this project will be developed, a qualitative methodological approach will be carried out, with secondary sources consisting of documentary tracking (Books, Repositories, Google Academic and case study occurred in the country of Panama, official pages of the same).

1.7.3. Type of Study

This research work was based on a descriptive study, since, for its development, the environmental effects produced by the expansion of the Panama Canal from 2007 to the present day were analyzed. In order to address the issue in its entirety, it will be structured in different stages: 1st research on the history of Panama and environmental impacts, 2nd positive and negative impacts that has had the construction of the third set of locks of the Panama Canal on the environment and marine ecosystems, 3rd finally seeks to identify possible solutions to help mitigate the environmental damage suffered by natural ecosystems in Panama due to the construction of the Panama Canal.

1.7.4. Research methodology

- **Information gathering techniques and tools.**

The techniques and instruments used during the development of this research work are: documentary analysis carried out through consultations of secondary sources, such as official pages, degree theses, magazines, websites, and official pages of Panama, historians, internship works, university repositories, academic google, and books. In addition to observation techniques and unstructured interviews.

- **Information Selection and Analysis.**

Documentary analysis: in order to obtain reliable information, some key words are searched that give a starting point to the research, after having these words and the clarity of the subject that you want to investigate in that country; allowing with this a better filtering of the information which will be searched in reliable sources such as the official pages of the country to investigate and bibliographical references, this leads to obtain precise information

and give a direction to the investigation, also the information of the teacher must be taken into account since it is the guide for the development of the project.

- Bias Control.

In order to obtain reliable and verifiable information that is secure at the time it is included in the research, it is validated in other sources, in order to compare whether the information obtained previously is reliable and true, on the other hand, the sources are kept so that other interested people can access this information.

1.8. Scope

This research project seeks to analyze the effects on the environment and marine ecosystems caused by the expansion of the locks of the Panama Canal.

2. Development of research

2.1 Development of the First Specific Objective

HISTORICAL BACKGROUND AND THE ENVIRONMENTAL IMPACT GENERATED BY THE CONSTRUCTION OF THE PANAMA CANAL.

History of the construction of the Panama Canal.

Since the time of the Panamanian conquest it has enjoyed a privileged geographical position for having in its territory the narrowest strip of the American continent between the Pacific Ocean and the Atlantic Ocean. This has historically made Panama considered essential for the exchange and transit of various goods.

For this reason, in 1881, the Frenchman Ferdinand de Lesseps began work on the construction of an inter-oceanic canal to connect the waters of the Atlantic and Pacific oceans in the Isthmus of Panama, but in 1889, after facing a variety of difficulties such as the epidemics of yellow fever and malaria suffered by those who worked in the construction of the canal and the waste of money, the company in charge of the works went bankrupt, forcing Lesseps to suspend them.

Only until 1904 with the acquisition of the property rights of the Company Nueva del Canal de Panamá by the United States, the excavation work of the Panama Canal was restarted, which was officially inaugurated on August 15, 1914, but its commercial operation was only given until 1920. (Celestino & Pizzurno, 2003).

During the time it took to build the Panama Canal, the main difficulty that limited its execution was nature, but with the passing of time the engineers and project workers learned enough to understand that they had to understand everything that was happening around them to carry out one of the most representative works of civil engineering worldwide.

2.2 Development of the Second Specific Objective

POSITIVE AND NEGATIVE IMPACTS THAT THE CONSTRUCTION OF THE THIRD SET OF PANAMA CANAL LOCKS HAS HAD ON THE ENVIRONMENT AND MARINE ECOSYSTEMS.

The Panama Canal from a socioeconomic, environmental, and political perspective.

Since Panama separated from Colombia with the help of the U.S. government, it has faced a major transformation in its political cosmogony, from a Colombian province to a Republic.

In spite of it, Panama continued depending on another State in this case of the North American country, that for that time wielded the economic power and would be in charge of the construction of the interoceanic canal in Panamanian territory, with which a socioeconomic transformation was given in the country, since this work became the preferred maritime route for the transport of goods from and towards all parts of the world, since this route represented an increase in the productivity for the businessmen by saving times and costs of the transport. But at the same time the construction of this canal represented a great negative impact on the environment as a result of the large extensions of native jungle territory that was intervened to give way to this great work and the affectations suffered by a great variety of animal species of which many had to look towards another habitat and others that simply disappeared due to their inability to adapt.

Expansion of the canal and its environmental impact.

The construction of the third set of locks on the Panama Canal caused a serious impact on some of the natural ecosystems surrounding the project's construction area, such as the decrease in the population of the sloths, which, due to the difficulties of the terrain, were not able to capture and relocate this species in its entirety, since most of them are virgin jungle lands.

On the other hand, the destruction and intervention of the natural ecosystems that are part of the canal always produce diverse losses of flora and fauna, which simultaneously cause the reduction of the biological habitat. In addition, it cannot be ignored that the relocation of species to non-forest areas of which they are not native also produces significant changes in these new ecosystems.

In the same vein, it should be borne in mind that the sediments and solid materials resulting from the construction of the project, which are mixed with water and especially the waste resulting from the transit of ships through the canal pollute the waters affecting their

transparency, which reduces the visibility of aquatic species and therefore their ability to feed.

Thus, with the construction of the third set of locks in the Panama Canal, not only the terrestrial species have been affected, but also the species of the aquatic niche, whose ability to obtain food has been reduced due to the great contamination of sediments.

It is clear that the dimension and size of this engineering work makes maritime transport through the canal more efficient, since it allows, in addition to a reduction in costs, the passage of ships with the capacity to transport up to fifteen thousand containers per transit, ships that before 2016 were not able to circulate through the canal. But it is also evident that this mega work deteriorates every day more the quality of the fresh water contained in the lakes that make possible the navigation of the canal, salinizing an essential water for the Panamanian population and for the species that inhabit the surrounding natural ecosystems and that are part of the Panama Canal.

The salinization of the freshwater lakes of Gatun and Miraflores as a result of the operation of the third set of canal locks and the operation of the old locks, has become a challenge for the administration of the canal and the Panamanian government. For these it is essential to maintain the quality of fresh water contained in lakes, necessary for many species that inhabit these ecosystems to survive.

Although the new locks pollute and waste freshwater to a lesser extent, in recent years these lakes have suffered a decrease in freshwater levels due to the lack of rainfall as a result of global warming, putting at risk the functioning of the canal and the supply of freshwater to the Panamanian population. During 2019, measures have been taken aimed at saving water by both the canal and the population.

2.3 Development of the Third Specific Objective

POSSIBLE IMPROVEMENTS TO HELP MITIGATE THE ENVIRONMENTAL DAMAGE CAUSED BY THE CONSTRUCTION OF THE PANAMA CANAL.

Environmental Education: Environmental Education should be a permanent process aimed at developing individuals concerned about the environment and interested in protecting the environment and the problems that affect it, thus people develop knowledge,

attitudes, motivations, commitments, and skills to work individually and collectively to provide solutions to current environmental problems and promote the prevention of those that might come and thus there is a real protection and sustainable environment in time, where human beings and other species can live without any inconvenience.

In the case of Panama, legal dispositions have been dictated with respect to the environmental education is as well as the Law N°41, General Law of the Environment of July 1, 1998, contemplates like instrument to the Environmental Education inside its environmental management and its implementation is instituted like a duty of State, for that reason the Law n° 10 of July 1, 1992 "By which the environmental education is adopted as a national strategy to conserve and to develop the natural resources and to preserve the environment, and other dispositions are dictated."

Prevent the salinization of fresh water.

Freshwater bodies are indispensable for agriculture, human survival and most of the species that inhabit the planet. For this reason, its protection and care is of great importance. The salinization of the Gatun and Miraflores lakes in Panama, which increases every day as a result of the operation of the canal locks, are putting at risk these freshwater tributaries and therefore the survival of the species that inhabit these ecosystems, and especially for the Panamanian population, because these lakes are essential to meet much of the freshwater needs of this population.

In order to prevent the salinization produced by the operation of the Panama Canal and thus be able to care for and conserve the fresh water contained in the Gatun and Miraflores lakes of Panama, different solutions have been proposed to reduce the pollution of these lakes. As a first measure, a staggered washing of the canal is proposed, which is based on allowing the controlled passage of fresh water from the Gatun and Miraflores lakes through the cells of the Panama Canal, which will allow a third of the salinity to be reduced in the canal locks. Although this procedure also brings disadvantages such as the use of a greater amount of fresh water.

The second measure is the cleaning of the tanks bordering respectively the freshwater lake and the sea. This system gives better results than the previous solution, but just as this one also requires an additional excessive use of fresh water.

The third measure is the storage of the salt water that enters the lower lock of the canal, in a tank that must be connected to the post-chamber system of the same, which will allow the extraction to the sea of salt water more efficiently. This solution allows the channel to be in constant operation and decreases freshwater waste by a high percentage. But it represents an increase in the manufacturing and maintenance costs of the Panama Canal.

As an additional measure to the above, the Panamanian State must develop and adopt policies aimed at the preservation and protection of freshwater and the environment in general, which must allow the education of the population, in order to encourage environmentally friendly behaviors, such as the proper use of water and reforestation. It is the government's duty to ensure its conservation. If Panamanian society does not become aware of the importance of protecting the environment and especially the protection of freshwater tributaries, it is inevitable that in a short time they will have to face a problem of freshwater shortages.

3. Conclusions and Recommendations

3.1 Conclusion

The environmental effects suffered by the natural ecosystems in Panama, due to the expansion and operation of the canal, are not limited to the loss of ecosystems, but also extend to the expense and contamination of the fresh water contained in lakes Miraflores and Gatún, as a result of the operation of the canal. To this must be added the reports made by the administration of the Panama Canal, which indicate that 2019 has suffered one of the worst droughts in the last 70 years, as the average level of water contained in the lakes has decreased by 35%. Reason why they have had to take different measures such as the suspension of power generation in the Gatun hydroelectric since October 2018, this to prevent the passage of water through the turbines, also invited the consumption of water between the two lanes of the locks panamax during transits, to reduce their discharge to the sea, the rationing of water has been extended to the cities that are supplied from these lakes. This shows that in the not too distant future, the way in which the canal operates will have to be changed, otherwise the canal will be affected in its operation and to a greater extent the Panamanian population that depends on these lakes to cover their needs for drinking water will be affected.

3.2 recommendations.

The administration of the Panama Canal must design serious policies that allow it to monitor the changes suffered in the environment, due to the construction of the third set of locks of the Canal and its operation.

It is clear that the Panama Canal must seek alternatives that allow it to optimize the use of the fresh water contained in Lake Gatun and Miraflores, in order to ensure its operation over time.

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