Int. J. Hum. Capital Urban Manage., 6(3): 291-304, Summer 2021

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

CASE STUDY

Development of Eco-Park in flood prone areas using green technologies

C.M. Torres Navas[1,*], J.C. Musa Wasil[1], K. Malave Llamas[2], C. Morales Agrinzoni[3]

[1] *Department of environmental planning, Ana G. Méndez University, Virtual Campus, San Juan, Puerto Rico*

[2] *Department of sciences and technology, Ana G. Méndez University, Carolina Campus, Carolina, Puerto Rico*

[3] *Department of sciences and technology, Ana G. Méndez University, Cupey Campus, San Juan, Puerto Rico*

ARTICLE INFO

Article History:
Received 02 November 2020
Revised 12 February 2021
Accepted 20 February 2021

Keywords:
Cities; Geographic information system (GIS)
Land use
Strengths
Weaknesses
Opportunities and Threats (SWOT)
Urban planning

ABSTRACT

BACKGROUND AND OBJECTIVES: The destruction of urban areas has caused environmental, social and economic problems. One of these areas was identified in the Municipality of Humacao, on the east coast of Puerto Rico. This land is vast and unused, Fulladosa farm, located in the urban area of the Municipality of Humacao. It is suggested to create an eco-park in this place to restore this green space and help improve the environment.

METHODS: The collection of information through public documents offered information related to the study area. Through a physical spatial analysis, the strengths, weaknesses, opportunities and threats of the study area could be obtained. This technique made it possible to identify areas with development potential to create an eco-park. Management strategies were developed for the development of the eco-park. Sustainable aspects were analysed to assess the viability of establishing an eco-park on the Fulladosa farm.

FINDINGS: The Fulladosa farm, located on Almodóvar Final Street in Barrio Cataño, has a high-density residential rating. According to the joint regulation, the use of parks in classified plots as high-density housing is not allowed. Therefore, a location query must be used to submit the project to the Licensing and Approval Office. Finally, it was found that the study area is prone to flooding. Flood insurance is also required, and the municipality must obtain the elevation certification required by the Federal Emergency Management Agency.

CONCLUSION: The creation of this eco-park can provide environmental education, community interaction and recreational spaces. Completion of this project will generally provide environmental, social and economic benefits to the community.

DOI: 10.22034/IJHCUM.2021.03.07

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
38	6	2

*Corresponding Author:
Email: *cieloymar1999@hotmail.com*
Phone: +787-354-0087
Fax: +787-733-1012

Note: Discussion period for this manuscript open until October 1, 2021 on IJHCUM website at the "Show Article.

INTRODUCTION

Currently there are abandoned urban areas causing economic, environmental and social problems. Several examples of these problems are: clandestine landfills, urban sprawl, contamination of natural resources, vandalism, sedimentation of water and vectors. Urban pollution also affects people's health (Bergoglio, 2015). The lack of environmental awareness produces a series of conflicts that can be resolved by identifying territorial and economic strategies. It is necessary to integrate the community in environmental matters to create initiatives in the educational area. The development of eco-parks and urban planning of green areas play a long-term role in cities. Eco-parks are areas of recreation, conservation, environmental education and ecological tourism (Darío *et al*., 2018). They promote social well-being and family integration. According to Paul Davidoff, urban planner, urban development and the social integration of cities are necessary (Luengo, 2015). An eco-park is a place where biodiversity and environmental awareness are preserved. They are green spaces suitable for environmental education and recreation. Knowledge about recycling, plants, conservation of animal species and other aspects associated with nature can be offered. They can be built with recycled materials and are usually found within protected areas (INFOBAE, 2016). The origin of eco-parks is related to the culture they represent. For example, in 1984, the place where the Xcaret eco-park is located in Mexico, was a private property. The architect Miguel Quintana Pali, lover of nature, discovers rivers, lagoons and remains of an ancient Mayan city. This discovery led him to make the decision to convert the place from a private residence to a public place, where it is currently visited by millions of visitors per year (Loco Gringo, 2018). Another example is the Eco-park of Buenos Aires, Argentina, which was originally a zoo. The old zoological garden was used from 1888 to 2016. This zoo was transformed into a modern and innovative eco-park, which contributes to environmental education, recreation and the conservation of biodiversity. This eco-park has a Wild Animal Rescue Center, including marine fauna, amphibians and reptiles (BAT, 2021). On the other hand, many parks are not really green. This is the case with New York's Central Park, which was designed by Fredrick Law Olmsted and built with great expense and effort. It is a place where thousands of trees were replanted, as it was designed to create a natural landscape within the stressful urban life (Refaat, 2014). The International Federation of Parks and Recreation Administration is an organization that represents parks and recreation services. Among the findings of studies carried out through this federation, it was found that urban parks have a number of benefits, among them, biodiversity, health and well-being, cooling of the environment, quality of air and water, tourism and social interaction (Konijnendijk *et al*., 2013). Eco-parks are of great international importance, since thanks to their existence it is possible to control our waste, reduce soil and water pollution. Based on research results, eco-parks have been used to offer a better quality of life to citizens (Refaat, 2014). In addition to being able to participate in its beauty and recreation, eco-parks contribute to solving ecological and urban problems such as traffic noise, pollution air and urban runoff. They also maintain the habitats of flora and fauna, minimize environmental impacts and maintain ecological diversity (Refaat, 2014). The objective of this project is to determine the feasibility of creating an eco-park at Fulladosa farm in the Municipality of Humacao, Puerto Rico in 2019.

MATERIALS AND METHODS

The first step in the methodology was the collection of information through public documents that offered information related to the study area and the performance of a physical-spatial analysis to carry out the SWOT matrix technique (strengths, weaknesses, opportunities and threats). The SWOT matrix made it possible to identify areas with development potential for the creation of the eco-park.

Once these results were obtained, we proceeded with the second step: the management strategies for the development of the eco-park were established. Finally, in the third step, the sustainable aspects were analysed within the parameters of urban development, to evaluate the viability of creating the eco-park on the Fulladosa farm. Fig. 1 shows the geographic location of the study area.

Public document information

Information was obtained related to the land registry number, owner of the parcel, qualification of the property, permitted uses in the zoning maps,

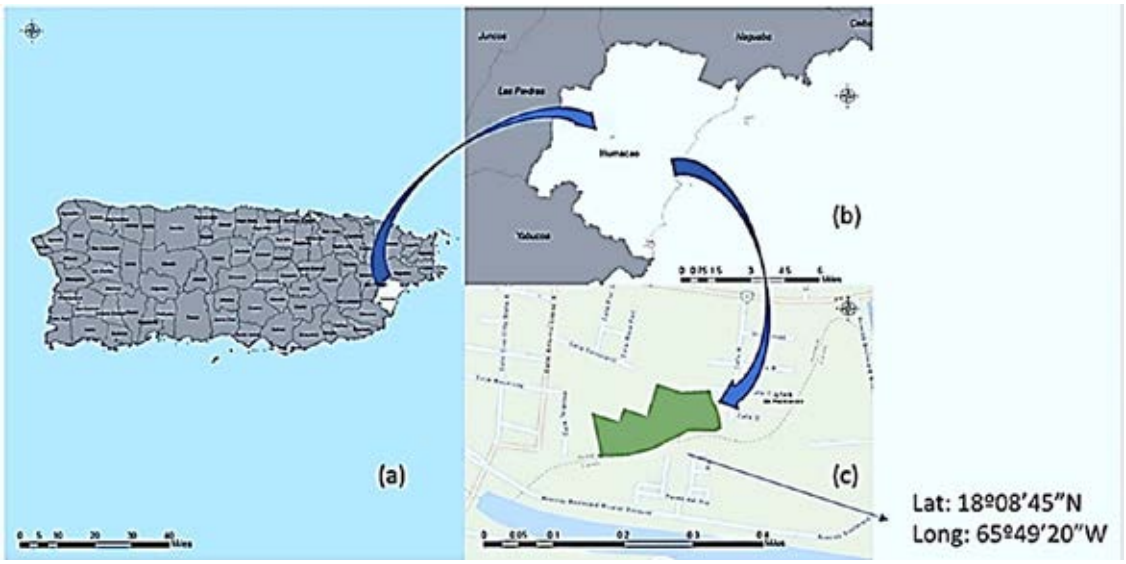

Fig. 1: Geographic location of the study area; (a) Puerto Rico, (b) Humacao city, (c) Fulladosa farm in Humacao, Puerto Rico

biophysical elements of the area and low-impact development practices. Wildlife conservation, location inquiries, permits issued near the area, and permits related to the project were studied. In addition, information related to the minimum requirements to develop management plans was reviewed and the presence of endangered species was verified. The Joint Regulation of Permits for Construction Works and Land Uses was analyzed and the applicable environmental regulations and laws were studied.

Geographic information system

The GIS 10.5 system from 2016 was used to perform a physical-spatial analysis, through which the maps of the land surface of the study area were analyzed from 1996 to 2019. Areas susceptible to flooding were identified through the map of levels of recommended base flooding from FEMA (Federal Emergency Management Agency). Information related to soil properties was studied to define the limitations that affect land uses. Information was also obtained on the geological formation of the study area.

SWOT matrix technique

With this technique the opportunities, threats, strengths and weaknesses that the study area presents were identified. Through the SWOT matrix technique, the internal and external factors that participate in the study area was analyzed (D´Inca *et al*., 2015). A visual inspection of the study area was carried out through several field visits in order to evaluate the structures and lands adjacent to the site. To perform the SWOT matrix technique, the information from the public documents of various aforementioned government entities and the result of the physical-spatial analysis were used.

Management strategy recommendation

These strategies are focused on the protection and conservation of the property. The results obtained in the SWOT matrix were used to identify the areas suitable to make the activities to be carried out in the eco-park.

Analysis of sustainability aspects

This analysis was carried out within the parameters of urban development, to evaluate the viability of creating the eco-park on the Fulladosa farm. Sustainable elements were identified that will be developed through activities for the enjoyment of the general public. It is planned to develop the Fulladosa farm in terms of planning and conservation, applying sustainable elements to the proposal.

RESULTS AND DISCUSSION

Public document information

The land registry number of the Fulladosa farm is 304-029-161-08-000 (PRPB, 2021). It is located at latitude 18◦08'45'' North and longitude 65◦49'20'' West. This farm is located on Almodóvar Final Street, Barrio Cataño. It was acquired by the Municipality of Humacao on the date of July 1, 2000. Its area is 32,379.73 m². Under the land registry number of the farm there is no location query. Nor is there any kind of project through the Puerto Rico Planning Board (PRPB) and the Office of Management of Permits and Endorsements. The study area does not require a management plan to carry out the project. It was determined that the farm has a Residential qualification four (R-4) and is classified as Urban Land. The R-4 Zoning District belongs to a high density residential (R-A) rating. According to the Joint Regulations, the use of parks is not allowed on plots which are classified as high density residential areas. A location query is necessary to present the project (PRPB, 2010a). The eco-park parking lots will be carried out in accordance with the provisions of Chapter 24 of the Joint Regulation of November 29, 2010 (PRPB, 2010a). Thus, the Planning Board evaluates and establishes the process in the Office of Management of Permits and Endorsements digital system. This process requires several stages of evaluation, so it can take approximately one year, until the proposal for an eco-park can be approved. The process will include the preliminary development stages, urbanization works, construction of the structures, required utilities and the regulatory use permit. The Autonomous Municipality of Humacao must pay the expenses to recruit a professional with a degree in architecture or engineering to represent the case. The process involves associated expenses for the preparation of an environmental document, Determination of Environmental Assessment and the regulatory phases of the Environmental Recommendation Letter since the project cannot be analyzed under Resolution R-11-17, List of Categorical Exclusions (EQB, 2011). Since the study area is susceptible to flooding, the Municipality must establish the Elevation Certification required by the Federal Agency for Emergency Management (FEMA, 2015). In addition, Regulation Number 13 on Special Flood Risk Areas of the Planning Board should be used to delineate the plans of the buildings that can be established (PRPB, 2010b). This Regulation establishes the following commands and laws: Organic Law of the Administration of Regulations and Permits, Law of Uniform Administrative Procedure of the Commonwealth of Puerto Rico and Organic Law of the Puerto Rico Planning Board. Regulations of the National Flood Insurance Program of the Federal Agency on Emergency Management, part 44 CFR, section 60.3 and Law for the control of buildings in areas susceptible to flooding (PRPB, 2010b) are also estabilished. These floods, caused by surface runoff water, cause soils to become saturated. The calculator for rain catchment is a method of determining the amount of runoff water. This system, presented by the Office of Research and Development of the Environmental Protection Agency, suggests that low impact development practices (Low Impact Development) be used to encourage the natural movement of water. These practices are also known as efficient management of green infrastructure (US EPA, 2018).

Geographic information system

The following information was collected from the physical-spatial analysis using GIS

10.5, 2016 System. Through this system, data related to the property was analyzed. The following maps and photos show the increase in urban development over time. Figs. 2 and 4 presents the maps of the land surface of the study area from 1996 to 2019 provided by the Planning Board of Puerto Rico. These maps show how, over the years, the increase in the construction of infrastructures has been affecting the Fulladosa farm, reducing its green areas.

The increase in urban development pressure is due to the excessive construction of roads, houses and buildings. Besides, it was determined that the study area is zone A, an area susceptible to flooding. Fig. 5 presents this area.

SWOT matrix technique

The field visits helped to identify the access areas to the Fulladosa farm and the conditions in which it is located. Through these visits it was possible to evaluate the ecotourism potential, the natural attractions and the infrastructures in the surroundings. All this information was used to determine the activities that will be carried out in the eco-park. After performing

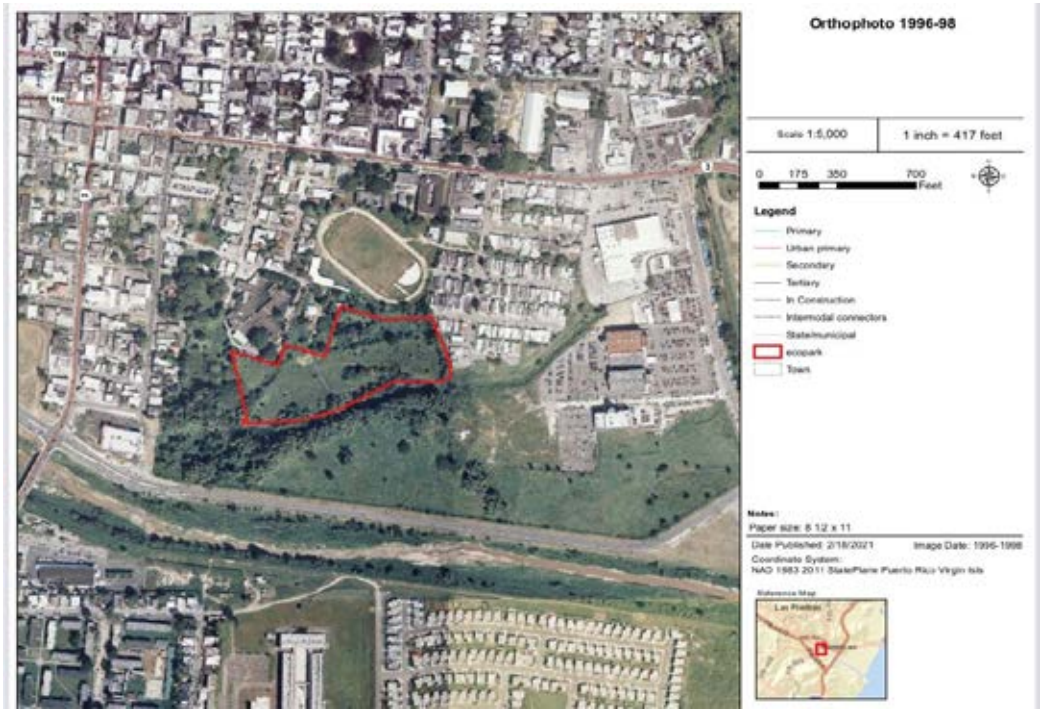

Fig. 2: Map of Fulladosa farm in the Municipality of Humacao, Puerto Rico in 1996 (Rodríguez, 2019)

Fig. 3: Map of Fulladosa farm in the Municipality of Humacao, Puerto Rico in 2006 (Rodríguez, 2019)

Fig. 4: Map of Fulladosa farm in the Municipality of Humacao, Puerto Rico in 2019 (Rodríguez, 2019)

the SWOT matrix, the information shown in Table 1 was obtained, which presents the opportunities, strengths, threats and weaknesses in the study area.

Strengths

Environmental and physical strengths

Being close to the Humacao River, the property has a biodiversity of both aquatic and terrestrial species.

Social and economic strengths

Possibility of promoting the local economy through social activities. Recreation, educational development, and landscape appreciation are examples of these activities.

Institutional and legal strengths.

With the help from state and federal organizations, these green spaces can be developed in urban areas.

Threats

Environmental and physical threats

Poor government management: The Municipality has not maintained the property for conservation purposes. On the contrary, there was a proposal to make a parking lot in this place.

Extensive urban development: The lots adjacent to the property cause development pressure that does not favor the conservation of natural resources or the protection of the Humacao River. These lots include residences, businesses, and the Jacinto Hernández Park.

Pollution and sedimentation: The pressure of urban development increases pollution and sedimentation towards the Humacao River. This includes motor vehicle oils and solid waste that affects this body of water through runoff.

Inappropriate use of space: The Fulladosa farm is an open space that can be used improperly, becoming a public nuisance or a clandestine landfill, producing vectors that affect public health.

Social and economic threats

Tourism costs: The tourism development in the areas adjacent to the property makes it easier for consumers to pay a little more in these nearby businesses to obtain more innovative benefits and enjoy greater comfort.

Gentrification: In order to increase the value of properties adjacent to Fulladosa farm, residents may be displaced. This increase is aimed at tourism development in the area.

Impact on the economy: The development of the property implies certain costs that in the long term are cost-beneficial. However, Puerto Rico is experiencing

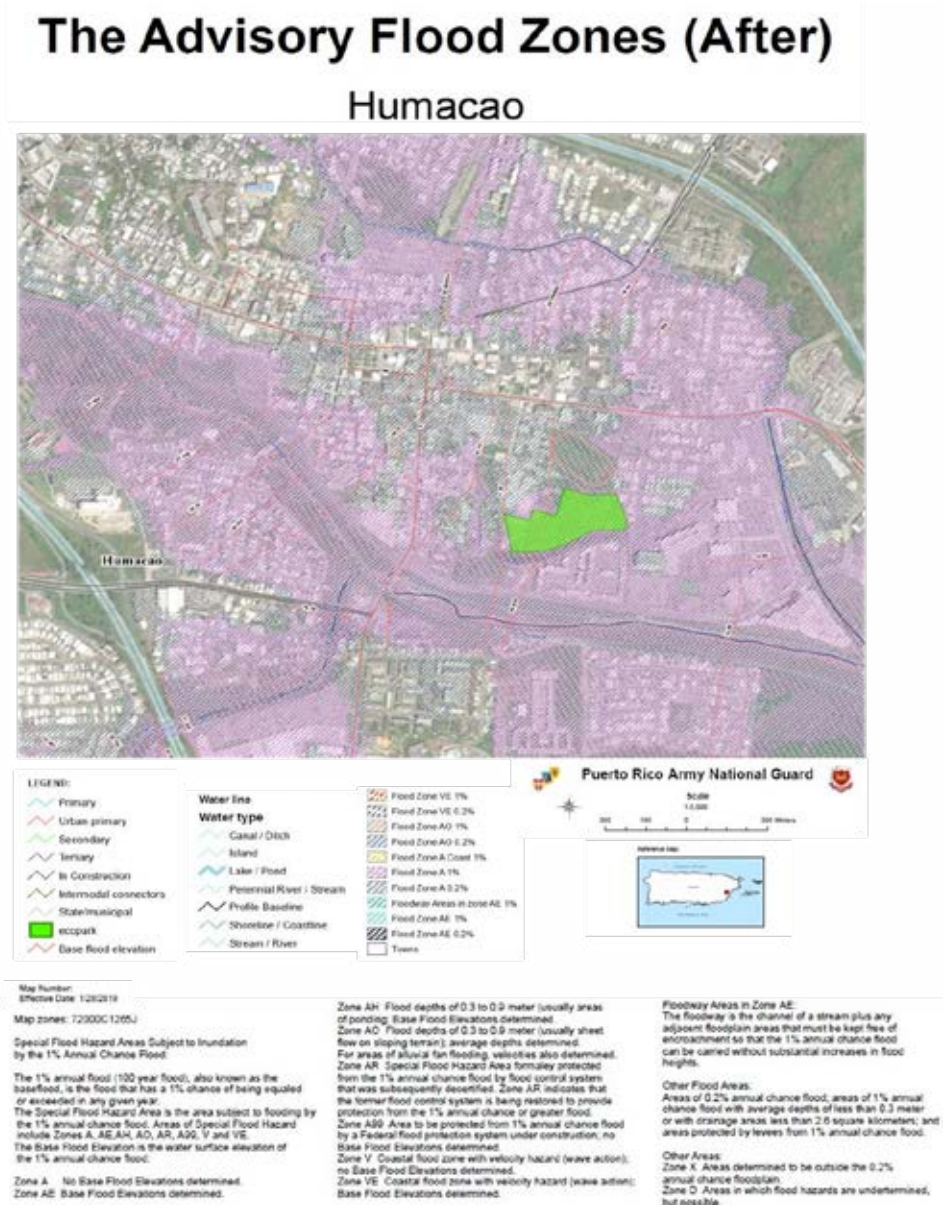

Fig. 5: Map of recommended base flood levels, zone A in Fulladosa farm in the Municipality of Humacao, Puerto Rico in 2019 (Rodríguez, 2019)

an economic crisis, which is incorporated into the situation associated with the high investment due to the destruction of the passage of Hurricane María (Mazzei and Williams, 2018).

Institutional and legal threats

Investment and development vision: The property was considered to make a parking lot for the Jacinto Hernández Park. Since the Municipality of Humacao owns the farm, this implies a limiting development vision.

Weaknesses

Environmental and physical weaknesses

Flood zone: All construction that is carried out on the property will be according to the Regulation on

Table 1: SWOT analysis framework

Indicators	Strengths	Opportunities	Weaknesses	Threats
Environmental-physical	1. Biodiversity	1. Green technologies 2. Possibility of low investment 3. Improves public health	1. Flood zone 2. Flood rate 3. Soil type 4. Soil qualification	1. Extensive urban development 2. Sedimentation
Social-economic	1. Recreational potential	1. Job creation 2. Intervention of groups of interest 3. Biological Corridors	1. Absence of academic programs 2. Absence of collective transport 3. Little commercial activity 4. Unemployment	1. Gentrification 2. Impact on the economy
Institutional-legal	1. Incentives for the development of green spaces	1. Aid programs from some agencies	1. Lack of government support	1. Investment and vision of development

Special Areas of Flood Risk (PRPB, 2010b) since said place is a flood zone.

Poor soil management: The soils that surround the bodies of water near the property must be protected, since they have been affected due to urban sprawl.

Low water quality: The Environmental Quality Board (EQB) carried out an evaluation in which it was pointed out that the water quality standards are not in compliance, due to turbidity and coliforms generated by sedimentation (EQB, 2013).

Flood rate: The study area is prone to flooding. This involves purchasing flood insurance (FEMA, 2011).

Soil type: It contains alluviums, which carry sediments to the Humacao River. These materials easily infiltrate contaminants (US GS, 2016).

Qualification: The use of parks is not allowed in lots classified as high density residential. The project would be presented through a location query (PRPB, 2010a).

Social and economic weaknesses

Absence of academic programs: In the Municipality of Humacao, no programs have been developed aimed at conserving natural resources. However, the Carmen Pilar Santos School (elementary level) and The Palmas Academy (preschool to higher level) are under the Maria Montessori system. This system is aimed at the appreciation of natural and environmental resources. The existence of eco-parks would be adequate for the personnel trained in this system.

Absence of collective transportation system: Since the property does not have enough space for parking, trolley-type transport can be implemented to take visitors from the Jacinto Hernández Park to the eco-park.

Little commercial activity: There is little commercial activity in the urban center of the Municipality, so the creation of the eco-park contributes to the development of local businesses, such as pharmacies, ice cream parlors and restaurants.

Unemployment: Corresponding estimates reflect a decrease in employment for all areas of the labor market (DLHR, 2019). The eco-park will provide jobs to the Municipality of Humacao.

Institutional and legal weaknesses

In the Municipality there are no projects dedicated to environmental education due to the lack of support from government companies and the private sector.

Opportunities

Environmental and physical opportunities.

Restoration of natural systems: To solve the sedimentation problem in the Humacao River, a retention pond can be created, which retains runoff water for long periods. This pond can also be used as a recreational area, by renting boats.

Green technologies: The Solid Waste Authority (SWA) incentive program offers financial aid through various entities when green technology is used (SWA, 2019). The eco-park in the Fulladosa farm presents the opportunity for the use of this technology, including permeable paths, recycled rubber, plastic wood, among others.

Low investment possibility: Among the buildings to be lift up in the eco-park are: the visitor center (where educational talks will be held for students), bathrooms and an area for the sale of snacks and refreshments. Consequently, a high investment will not be required.

Tourist interest area: The Fulladosa farm is located in an area of great tourist interest. We can mention the residential and hotel complex of Palmas Del Mar, the Natural Reserve of Santa Teresa and Mandry lagoons, the Forests of Pterocarpus and the Beach of Punta Santiago.

Improves public health: The creation of the eco-park improves public health in several aspects: it prevents the place from becoming a clandestine landfill or public nuisance, increases the quality of life of people and promotes the safety of nearby residents.

Social and economic opportunities

Generation of funds and jobs: It encourages the increase of jobs for the development and conservation of the area, as well as to increase the local economy.

Intervention of interest groups: There are several groups interested in conserving natural and environmental resources, including: the Planning Board, the Department of Natural and Environmental Resources and the Forest Service of the United States Department of Agriculture.

Educational, recreational and environmental benefits: The development of the eco-park will promote the good management of natural resources, recreational and environmentally educational activities.

Biological corridor: The development of a biological corridor contributes to the learning and exploration of visitors through routes designated by the Municipality. The areas of tourist interest are: the children's water park and the camping areas at Punta Santiago Beach, the Mandry and Santa Teresa Lagoons Natural Reserve, the fishing village of Palmas Del Mar, the Pterocarpus forest, the boardwalk of the Municipality of Naguabo and the museums of Humacao.

Community improvement and the surrounding areas: Outdoor activities such as exercises, walking groups, workshops for agricultural gardens, the biological corridor, and rental for boats and bicycles, among others, are aimed at promoting community improvement and environmental education.

Multisectoral alliances: There are several multi-sector alliances that can promote social, economic and educational development in the eco-park project. Among them is the Community Delivery and Service Education Program, aimed at promoting environmental education (Oriental, 2018). The Conservation Trust has also managed to protect a large amount of land on the Island of Puerto Rico (Para la Naturaleza, 2019). These alliances, together with the Department of Natural and Environmental Resources, can strengthen the development of the eco-park in terms of the conservation of its lands and the Humacao River.

Benefits: The creation of the eco-park will result in economic, social and educational benefits for the Municipality of Humacao. In addition, the conservation of natural resources will be promoted.

Real estate: The Municipality could increase its tourism development and consequently, the residences and buildings surrounding the eco-park would increase their value.

Institutional and legal opportunities

Previous proposals: Among the proposals carried out by the Municipality are to make a parking lot in this place. To carry out this project the property does not require a management plan.

Compendium and applicable incentives: The Solid Waste Authority promotes a tax exemption in its recycling project, in which the eco-park proposal can participate.

Recommendation of management strategies

Recommendation of management strategies for

Table 2: Management strategies focused on conservation and protection

Strategy	Examples	Results
Installation of technologies	Porous pavements Cisterns Pocket wetlands Vegetated swales Rain gardens Green roofs Mangrove conservation Protection of riparian buffers Educational signs	Protection and conservation of natural resources
Trained personnel for eco-park maintenance	Water analysis and maintenance of the areas	Security for visitors
Planning of activities to be carried out in the eco-park	Activities: Outside the eco-park In the visitors center Outdoors In the Amphitheater	Community integration

the development of the eco-park in the study area focused on conservation and protection. Table 2 presents these strategies.

These strategies promote environmental education, community integration, conservation of natural resources and visitor safety. Green technologies and their maintenance preserve the operation of the project in the long term (D'Inca *et al*., 2015). The first strategy consists of the installation of technologies, also known as green infrastructure or low-impact development, with the purpose of conserving and protecting natural resources. Said technologies are the following: ditches with vegetative cover, retention pond, permeable pavements, rainwater cistern and green roofs. Mangrove conservation will be promoted, since they contribute to flood mitigation. Arrangements will also be made to protect riparian buffers and rain gardens will be installed as bio retention systems. The second strategy is based on hiring trained personnel for the maintenance of the eco-park. To meet federal and state standards, these staff will conduct a periodic analysis of recyclable materials, technologies, and water quality. Among the water quality standards are: pH, coliforms, dissolved oxygen, turbidity, enterococci, color, substances that cause odor or taste, sulfates, total nitrogen and total phosphorus (EQB, 2019). Measurements of Total organic carbon (TOC), Biochemical oxygen demand (BOD) and Chemical oxygen demand (COD) determine the amount of organic matter and the impact of wastewater (Raffo and Ruiz, 2014). To prevent deterioration, a periodic inspection of the green infrastructure will be carried out, including playgrounds, solar panels, educational signs, restrooms and vegetation. This periodic maintenance will ensure that the project is maintained in the long term (US EPA, 2017). The third strategy consists of planning the activities to be carried out in the eco-park. These activities will be the following: Activities at the visitor center. Educational workshops, recycling activities, projection of videos related to fauna and flora and sale of snacks will be offered. Activities on the platform or amphitheater. Children's performances, music, troubadours, yoga, folk dances, among others. Activities outside the eco-park. The biological corridor will be carried out, in which visitors will have the opportunity to appreciate and enjoy cultural and tourist places near the eco-park. Outdoor activities within the eco-park. Hikes, bicycle and boat tours, excursions and appreciation of the landscape.

Analysis of sustainability aspects

Sustainable aspects were analyzed. These aspects include: biodiversity conservation, recreation, environmental education, photographic adventure, recycling activities, educational workshops, and technological knowledge and guided tours for groups (CSA, 2016). All these elements can be incorporated into the Fulladosa farm eco-park. The eco-park in the Fulladosa farm will have Observation towers for birds, similar to the Tortuguero Lagoon (Vásquez *et al*., 2011). In the visitor center there will be a small store similar to La Marquesa Park in the Municipality

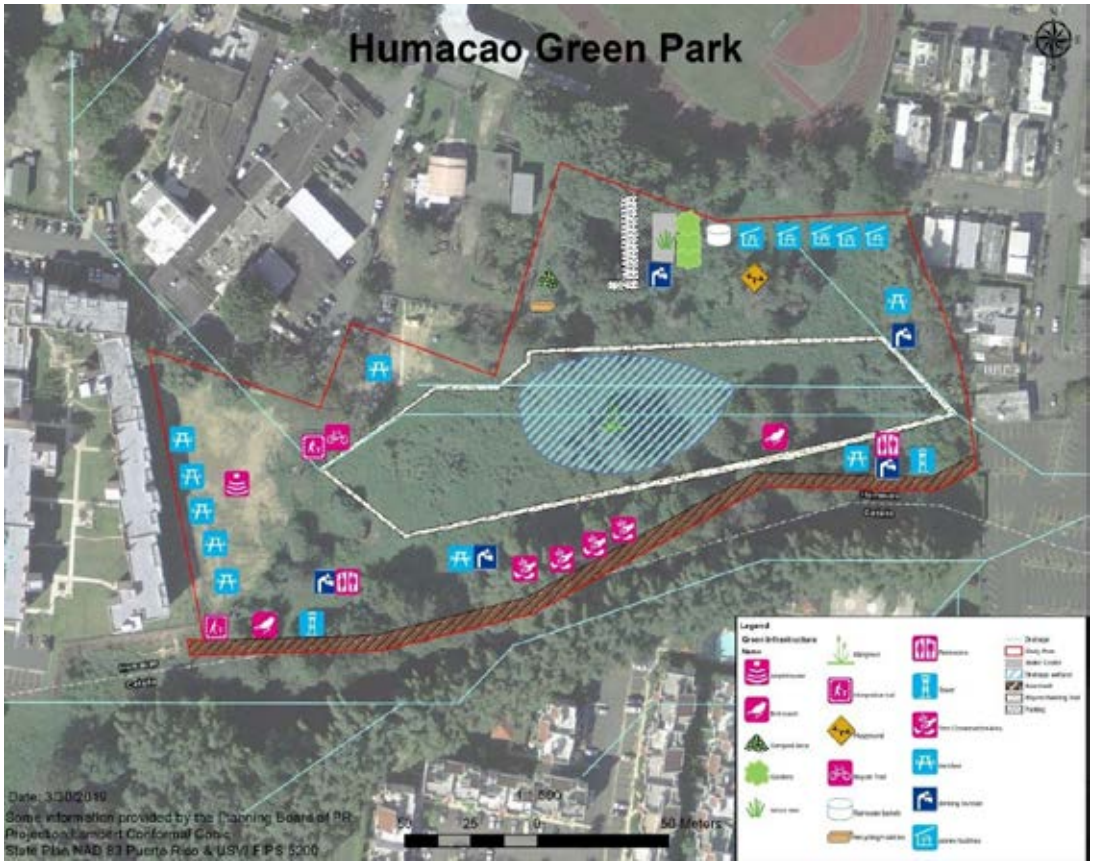

Fig. 6: Map of the future eco-park in the Fulladosa farm in the Municipality of Humacao, Puerto Rico

of Guaynabo, for the sale of toys and educational items (GPR, 2019). In this store, a method will be carried out in which envelopes with vegetable seeds will be delivered in the absence of coins (Rodríguez, 2019). A demonstration garden of vegetables and fruits can be considered in a section of the property, avoiding the use of pesticides and inorganic fertilizers. This can be achieved with the collaboration of the Department of Agriculture of Puerto Rico, Agricultural Extension Service of the University of Puerto Rico. The Green Contact Program was carried out on October 14, 2015 so that students from the educational system can complete contact hours per semester carrying out activities related to nature (GPR, 2015). In the Fulladosa farm eco-park, students can comply with these hours by participating in the planting of vegetables and fruits in the orchards, thus also allowing the communities to integrate. Various community members have made efforts in the last decade to ensure that projects are carried out outside the classrooms (López and Bastida, 2018). The Fulladosa farm can offer this type of project, since education is a great development opportunity in this place. Both the Gurabo Recreational Park and the Luis Muñoz Marín Park have been built in flooded areas. Despite this, they have multiple attractions, among them: a pavilion for activities, a walking track, a playground, artificial lakes, areas for recycling and gazebos (López, 2016). These sustainable aspects can be applied to the eco-park in the Fulladosa farm as this is also a flood zone. The Humacao Natural Reserve and the Hacienda Esperanza in Manatí have resources that are used for the appreciation of the landscape through walks and excursions. These places are: interpretive trails, mangroves, wetlands and forests (Rodríguez, 2019). The Fulladosa farm, as it also has these ecological resources, can be considered for the application of these sustainable aspects.

Scheme of the future eco-park

Fig. 6 shows a summary of the future eco-park on the Fulladosa farm, which would include various green technologies or efficient management practices. Among the efficient management practices are: areas for the conservation of trees and mangroves, the green roof in the visitor center, collection of rainwater through cisterns, gardens and the retention pond, which helps to capture the runoff waters. To avoid power lines, the amphitheater will have solar panels. Educational activities will be carried out in the visitor center, such as the projection of videos related to the environment, endangered species and the different habitats that exist. Restrooms will be found in the visitor center, as well as a small educational supply store. The visitor center will have facilities for the consumption of nutritious vegetarian food. The eco-park will have picnic facilities, fountains to drink water, boardwalk near the river, benches, playgrounds, two composting toilets for educational purposes, interpretive paths for cyclists and an amphitheater or platform for activities. It will also have two towers for bird watching, a ranger station, composting areas, and recycling facilities, 10 parking spaces for cars and 2 parking spaces for public buses. The installation of photovoltaic luminaires, a security booth at the entrance and a warehouse for the maintenance team can be considered. The parking lots for the eco-park will be implemented in accordance with Chapter 24 of the Joint Regulation of November 29, 2010 (PRPB, 2010a). Any construction carried out in the area of the property will be carried out according to the Regulation on Special Flood Risk Areas (PRPB, 2010b).

CONCLUSION

The study area is located in an area susceptible to flooding, causing limitation for the development of buildings. In addition, there is urban sprawl around it, which causes sedimentation towards the Humacao River, which is close to the lot. The support of government entities is recommended to avoid public health problems on the property, as it can become a clandestine landfill or public nuisance. However, this characteristic of flooding is an opportunity to conserve the property for recreational uses and as an educational element. Being in a wetland area, the creation of this eco-park can mitigate the problem of flooding because green technologies are designed to protect floodplains and reduce stormwater runoff. During times of constant rain, wetlands absorb large amounts of water. Green infrastructure absorbs rainfall, preventing water from accumulating in the streets. The terrain should not be disturbed with pavements, as this would also decrease the populations of flora and fauna species. It is recommended to carry out a study of fauna and flora in the farm to recognize the existing biological diversity. Development opportunities in the study area can diminish many of the threats and weaknesses that arise. Through the recommended strategies, strengths and opportunities will be reinforced, while weaknesses and threats will be reduced. These strategies will also help protect and conserve the future eco-park. The installation of green technologies and their maintenance is recommended, as they contribute to mitigating flood areas, which would be of great benefit to the development of the eco-park. The periodic monitoring of green technologies contributes to the reduction of environmental pollution and sedimentation. Despite the limitations that arise in the study area, the creation of this eco-park can provide spaces for recreation, community interaction and environmental education. The activities that will be carried out will help integrate the community and promote environmental education and awareness and conserve natural resources. Therefore, this project will be useful for the Municipality of Humacao, in a social, environmental and economic way.

AUTHOR CONTRIBUTIONS

C. Torres carried out the research, analyzed the results and prepared the manuscript. J.C. Musa, C. Morales and K. Malavé helped in editing, reviewing the literature, and analyzing the data.

ACKNOWLEDGMENT

The author is very grateful to M. Miranda and V. Suazo for their collaboration with the SWOT matrix. In addition, to R. Rodríguez for having collaborated with the maps of the study area.

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this manuscript. The ethical issues, including misconduct, plagiarism, fabrication or falsification of data, informed consent, redundancy and double publication or submission, have been completely witnessed by the authors.

ABBREVIATIONS

BAT	Buenos Aires travel
BOD	Biochemical oxygen demand
CFR	Code of federal regulations
COD	Chemical oxygen demand
DLHR	Department of Labor and Human Resources
EQB	Environmental Quality Board
et al.	"and others" in latin
FEMA	Federal Emergency Management Agency
Fig.	Figure
Figs.	Figures
GIS	Geographic information system
GPR	Government of Puerto Rico
IFPRA	International federation of parks and recreation administration
INFOBAE	Information of Buenos Aires economy
PRPB	Puerto Rico Planning Board
R-A	High density residential rating
R-4	Residential qualification four
R-11-17	List of categorical exclusions
SWA	Solid Waste Authority
SWOT	Strengths, weaknesses, opportunities and threats
TOC	Total organic carbon
US EPA	United States Environmental Protection Agency
US GS	United States Geological Survey
Zone A	Susceptible to flooding area

REFERENCES

BAT, (2021). Eco-park. Buenos Aires City.

Bergoglio, J., (2015). Laudato sí. Palabra Editions.

CSA, (2016). International ideas competition: Interactive eco-park, Argentina. Central Society of Architects.

Darío, I.; Escobar, D.; Mejía, M., (2018). Success factors and lessons learned from the management of
a Public-Private Partnership (PPP) in a protected area in Manizales, Colombia. Contemp. Eng. Sci.,
11(20): 959-972 **(14 Pages).**

D´Inca, V.; Bastias, L.; Rodríguez, J., (2015). Recovery strategies of urban areas in the framework of
Sustainability. Architecture, urbanism and design.

DLHR, (2019). Unemployment statistics by municipalities. Department of Labor and Human Resources.

EQB, (2011). Amendment to list of categorical exclusions (R-11-17). Environmental Quality Board.

EQB, (2013). Integrated report 305 (b) / 303 (d). Environmental Quality Board.

EQB, (2019). Puerto Rico water quality standards regulation. Environmental Quality Board.

FEMA, (2011). Answers to questions about the National Flood Insurance Program. Federal
Emergency Management Agency.

FEMA, (2015). Elevation certificate and Instructions. Federal Emergency Management Agency.

GPR, (2015). Promotion of green contact in the country's schools. Government of Puerto Rico.

GPR, (2019). La Marquesa in Guaynabo City: hidden treasure. Government of Puerto Rico.

INFOBAE, (2016). What is an eco-park and which are the best in the world. INFOBAE News Website.

Konijnendijk, C.C.; Annerstedt, M.; Nielsen, A. B.; Maruthaveeran, S., (2013). Benefits of Urban Parks. IFPRA.

Loco Gringo, (2018). History lesson, the story of xcaret eco-park. Loco Gringo News Website.

López, B., (2016). The Luis Muñoz Marín Park comes back to lifestyle. El Nuevo Día.

López, R.; Bastida, D., (2018). The importance of non-formal environmental education in rural areas:
the case of Palo Alto, Jalisco. Dialogues on education.

Luengo, A., (2015). The right to the city and its juridical-urban nature. Complutense
University of Madrid, Spain.

Mazzei, P.; Williams, M., (2018). The crisis in Puerto Rico continues: it will not be able to pay its debt
until 2022. The New York Times.

Oriental, (2018). The Community Education Program of Delivery and Service celebrates the first anniversary of its Community Sustainability Center in Humacao, Puerto Rico. Oriental News Website.

Para la Naturaleza, (2019). The Puerto Rico Conservation Trust was born 43 years ago. Conservation Trust Website.

PRPB, (2010a). The Joint Regulation of Permits for Construction and Land Use (JP-RP-31). Puerto Rico
Planning Board.

PRPB, (2010b). Regulation 13 on special flood risk areas. Puerto Rico Planning Board.

PRPB, (2021). Geolocator. Puerto Rico Planning Board.

Raffo, E.; Ruiz, E., (2014). Characterization of wastewater and biochemical oxygen demand. J. Fac.
Ind. Eng., 17(1):71-80 **(10 pages).**

Refaat, M. H., (2014). Sustainable landscapes; the use of eco-parks as a tool for sustaining the living landscape. Int. J. Educ. Res. 2(7): 571-586 **(16 pages).**

Rodríguez, F., (2019). Ecovuelto, a growing trend in Mendoza. Sitio Andino Digital Diary.

Rodríguez, N., (2018). A local guide's insights about kayaking on Humacao Nature Reserve's
lagoons. Ecotreasures.

Rodríguez, R., (2019). Map of Fulladosa farm in the Municipality of Humacao, Puerto Rico in 1996 [online map]. 1:5,000.

Rodríguez, R., (2019). Map of Fulladosa farm in the Municipality of

Humacao, Puerto Rico in 2006 [online map]. 1:5,000.
Rodríguez, R., (2019). Map of Fulladosa farm in the Municipality of Humacao, Puerto Rico in 2019 [online map]. 1:5,000.
Rodríguez, R., (2019). Map of recommended base flood levels, zone A in Fulladosa farm in the Municipality of Humacao, Puerto Rico in 2019 [online map]. 1:5,000.
SWA, (2019). Economic incentives. Solid Waste Authority.
US EPA, (2017). Green Infrastructure in parks. United States Environmental Protection Agency.
US EPA, (2018). National stormwater calculator user's guide. United States Environmental Protection
Agency.
US GS, (2016). Puerto Rico geology. United States Geological Survey.
Vásquez, R.; Adrover, G.; Carrero, C.; Ortiz, E., (2011). Critical issues to the management of the
Laguna Tortuguero National Reserve. Department of Natural and Environmental Resources.

HOW TO CITE THIS ARTICLE

Torres, C.M.; Musa Wasil, J.C.; Malave Llamas, K.; Morales Agrinzoni, C., (2021). Development of Eco-Park in flood prone areas using green technologies. Int. J. Hum. Capital Urban Manage., 6(3): 291-304.

DOI: 10.22034/IJHCUM.2021.03.07

url: http://