

Wastewater Treatment Project for Palma Soriano, Cuba: Assessment of Cultural and Ecological Conditions

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Abstract

The Palma Soriano's Wastewater Treatment Project is a proposal to use cultural identity as a trigger to reverse ecological degradation. The research methodology draws from environmental, social and urban analyses to unveil the best strategy to address the ecological, river restoration, agricultural, and water treatment challenges in Palma Soriano, southeast Cuba. The primary objectives are to provide a better quality of life and to create new opportunities for the local community to reconnect with natural cycles of water and the cultivation of their own land. The research shows that stopping the processes of desertification combined with forest restoration of the upper of the Cauto River, where Palma Soriano is located, is critical to the achievement of these objectives. The project promotes the strength and capacity of local people to protect their own environment by proposing a community-based master plan for public spaces, cultivation areas, new sanitary and storm water treatment infrastructure, and restored natural landscapes on the Cauto River. The project includes natural wastewater treatment, reforestation, community urban agriculture and a public commons along the river. This project will produce healthy water recycling, provide a potable water source for the city, encourage ecological restoration of the riparian zone, and provide new opportunities for food production. It is derived from and designed to preserve the cultural identity of the local community, and to restore the essential balance between the community's need to sustain itself and the natural environment.

Keywords: *Water Treatment; River Restoration; Community Identity; Local Food Production;*

Introduction

The impetus for this water treatment project is the interest in local communities with strong spiritual ties to their environment – where a close relationship between culture and environment is cultivated and nourished (Heidegger, 1951; Norberg-Schulz, 1980). This article explores some of the dilemmas that arise when the human need for water quality and food overpowers the ability of the natural ecosystem to support the demands.

The research is presented in the context of ecological design – an emerging framework for re-envisioning the built environment in terms that encourage the dynamic, positive, and mutually beneficial interaction between humans and the ecological world (Mozingo, 1997). This paper is a proposal for an ecologically based water treatment project for Palma Soriano in Southeast Cuba: It is also a proposal for re-imagining the complex web of

interactions among people, the built human environment, community identity, urban agriculture, and the supporting natural ecosystem. In order to achieve such a solution, this paper first identifies a potential community and environmental problem. Second, it develops an analysis of the area and recognizes the main problem. Third, it presents an integral solution of the problem. And finally it discusses this specific project in relation with a global context, and evaluates the solution proposed as a solution for other areas that have been affected by similar social and environmental injustices.

The research project also uses a socio-metabolic perspective on the “end of the pipe” issues of water quality and social disadvantage (Martinez-Alier et al., 2010), understanding “social metabolism” as the manner in which human societies organize their

exchanges of materials and energy with the environment (Fischer-Kowalski, 1997; Martinez-Alier, 2009).

Methodology

It has been essential for the research to combine quantitative and qualitative data in order to develop an integrated solution. The fragility of the ecosystem and the necessary participation of the community in this process require a specific methodology that incorporates fieldwork and secondary analysis. The challenge of working with little or no existing data has required extensive data collection by the author, using advanced mapping techniques of GIS (Geographical Information System), field observation, site analysis, and a community survey.



Figure 1 Site Map: Satellite image of Cuba 2012. The Palma Soriano research area is located in Southeastern Cuba, in the Sierra Maestra Mountains, headwaters of the Cauto River (Source: - Google Earth)

The Community

The city of Palma Soriano is located in the foothills of the Sierra Maestra, at the headwaters of the Cauto River (Figure 1-Site Map). Palma Soriano is the biggest city in the Cauto, with approximately 124,000 inhabitants. The upper portion of the 230-mile River, including Palma Soriano, is home to poor and

marginalized communities of Afro-Haitians who began settling here after the abolition of slavery in Haiti in 1868 (Nunez Jimenez, 1998).

The spiritual and artistic centre of the Palma Soriano community is Ennegro. Ennegro is an Afro-Haitian environmental art group that sees a sacred relationship between ecology and

religion, giving spiritual values to the landscape. They believe their ancestors' spirits and gods live in the native forest and that it is therefore extremely important to keep rivers and streams clean and in continuous movement (Thompson, 1983). The spiritual frame of reference extends to the cultivation of their land and the integration of human activities into the natural environment.

Ten years ago the Cuban Government gave Ennegro a piece of land upstream from the city, at the intersection of two tributaries, which, together, form the Cauto River. The community had worked for years to obtain this land, reflecting their cultural agreement that this land was a sacred and life-giving place. According to Martinez-Alier (Martinez-Alier et al., 2010) "sacred places" for a particular community require just such a cultural agreement. It is on this land Ennegro is planning an agrarian spiritual community, where culture and traditions would combine in the cultivation of their own land.

The community is proposing to build upon a Vatn concept, which proposes to transfer a market economy to non-market domains (Vatn, 2000). The responsibility for care and management of the environment in which they live would become that of the local community, with their own production within the public domain. This opens the possibility of a socially responsible restoration of the Cauto that has been critically damaged by agricultural exploitation in favour of coffee and sugar during the last centuries (Scarpaci & Portela, 2009).

The recent economic and cultural transformation of Cuban society from a centrally controlled socialist economy into a new model of more independent private initiative has not been a smooth transition, particularly for marginalized

communities like Palma Soriano, which lacks access to foreign capital. In addition to deteriorating public health and quality of life, absence of public transportation, limited food variety, and unstable energy support, the city has serious problems with its potable water system. The municipality provides domestic water from the Cauto River in a discontinuous system with erratic deliveries. The water quality is poor with high levels of microorganisms that cause serious health problems in the population despite high levels of added chlorine. Cholera is not unknown in spite of public health efforts such as sanitizing person's hands and feet before entering public buildings.

The proposed wastewater treatment project addresses water pollution and its associated problems by following a holistic integrated-based ecological approach consistent with the cultural identity and values of the local community. There are clear linkages between the poor water quality in Palma Soriano and the ecological balance in the Cauto. The project proposes a natural cycle using the sun, gravity, plant life and fisheries as elements to clean the effluent, thereby taking advantage of the cultural values that Ennegro has been cultivating for years and the spiritual cultural heritage of the local population. The public wastewater treatment project empowers the local community with social environmental responsibility and provides them an opportunity to integrate urban agriculture and natural restoration of the borders of the Cauto by using recycled water for aquaculture, irrigation of fruit trees, and the restoration of the riparian forest of the river. That Palma Soriano is the "Sister City" of Berkeley, California with whom it has an on-going cultural exchange opens the possibility of the citizens of both cities contributing to the project together. In 2012 Berkeley's mayor and

state senator visited Palma Soriano to encourage this cooperation.

The ecological degradation in Palma Soriano is a result of narrowly conceived single purpose “urban development”, which has caused extreme damage to the natural environment and severe harm to the urban community. The Cauto River and Palma Soriano is just one example of this common phenomenon found throughout the world. The agricultural exploitation since the 18th Century has left a profound impact on the local landscape and culture with the loss of nearly 87.5% of island’s forest (Scarpaci & Portela, 2009) and the uncontrolled desertification of the of the Cauto River watershed. Population growth and development have reached a critical point in the community’s relationship with the environment.

As is true in much of the world, “development” has led to cycles of destructive environmental changes in ecological processes, which threaten humanity (United Nations General Assembly, 2000). Water quality, deforestation and the unhealthy extension of urban areas are examples of this damage. As a result, social and economic suffering has increased in developing nations, as exemplified in marginalization and poor living conditions for vast numbers of people (United Nations General Assembly, 2000). This is why the purpose of this project is to provide an example of how a healthy relationship between the city and its water source can be restored by a community work and the cultivation of their own land.

The problem

Raw sewage from Cauto River urban settlements flows directly to the river, contaminating their only water source.

This not only degrades the surrounding ecosystem but also threatens public health. For example after the Hurricane Sandy in 2012, numerous outbreaks of cholera occurred. This problem has led to several damaging consequences not only to the environment but also to the health of the population, as the river is both the source for potable water and simultaneously the sink for wastewater.

The polluted drinking water has caused the spread of disease and in some cases death within the community. Many people treat the polluted water by boiling it before consumption. Wood is collected from the riparian forest of the Cauto River for fuel. As a result of decades of this process and high agricultural production, the borders of the Cauto River are now severely deforested. The deforestation has led to an increase in sediment input and the degradation of the river’s ecosystem. It is very difficult to control the illegal deforestation and this practice will likely continue if no alternative is provided. The water cycle of Palma Soriano is certainly not helping to this problem (Figure 2 - Palma Soriano’s associated problems). Wastewater coming from industry and housing runs directly into the river where it is retained behind a small dam to be pumped to the city for consumption. Deforestation compounds the problem by instigating soil erosion which get washed into the river, further impairing water quality. Deforestation and the contaminated water lead to unsafe conditions for use of the natural areas around the river normally used for swimming, fishing, and food collection. The local Afro-Haitian community is especially concerned about the degradation of water quality in the Cauto River and they have asked for international support. The local problems provide an opportunity to

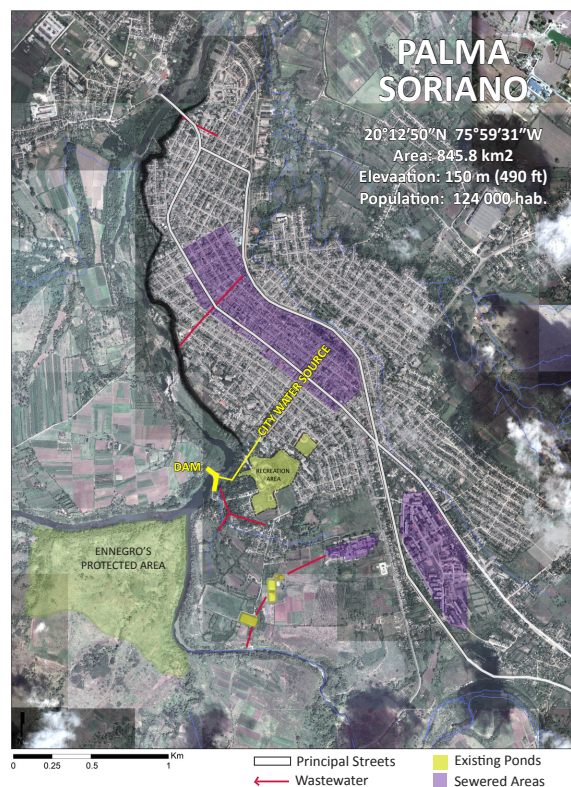


Figure 2 Palma Soriano's associated problems: Contaminated wastewater runs from the street directly to the Cauto River contaminating the sole water source for the city and the main public open space for people (Google Earth Satellite Image 2012 edited by the author)

develop design solutions that integrate social and environmental issues for a community in need of help.

It is important to understand that in Palma Soriano people live under very poor conditions. Several families may live in a two bedroom house, with just one latrine and often without electricity or potable water. Public transport is almost non-existent and people struggle for food and economic opportunities. It is crucial to resolve water quality problems by providing treatment of wastewater before it returns to the river in order for the community to survive at a reasonable level of quality of life.

What is the best solution? Conventional water-treatment facilities are multimillion-dollar highly engineered facilities (Yang 2006). They are designed

with minimal regard to their environmental impact and their dependence upon energy and raw materials. These systems generate by-products and pollutants during treatment (e.g. waste sludge, waste gases, and waste chemicals) and have a high operational cost (Yang 2006). The environmental by-products and cost make it impossible to implement such facilities in Palma Soriano, where the cost and consumption of energy must be held to a minimum. A traditional, engineered treatment facility is not viable for this community due to the economic condition of the city and its poor energy supply. Palma Soriano requires a solution that is inexpensive to maintain and operate and will provide multiple benefits in addition to increased water quality.

Proposed solution

This project proposes to treat the discharge to the river with a natural water treatment facility in order to improve the quality of drinking water for the community and to mitigate the impacts of deforestation of the riparian forest. Additionally, the project proposes to provide opportunities for environmental education and community engagement with the environment in the context of changing the social metabolism. Because on the conflict “at the end-of-the pipe” are enormous amount of opportunities, nutrient and energy that we must to simply tap within agriculture and forestry or by other appropriate technologies (Martinez-Alier et al., 2010).

Natural Water Treatment, as an alternative to the traditional highly engineered approach, uses the same quantity of energy as conventional systems. However, the energy is provided from natural sources such as solar energy and gravity flow, which keeps the water in movement and promotes the natural biologic process of purification and decomposition (Marrero 2008). There are different systems of natural water treatment such as aerated lagoon, bio filters and constructed wetlands. A complete process of wastewater treatment should integrate primary, secondary and tertiary treatment units (Drechsel, Scott, Raschid-Sally, Redwood & Bahri, 2010).

A primary treatment unit would remove suspended matter. Where wastewater has a high number of pathogens, primary treatment can remove a substantial number of pathogens (Drechsel, Scott, Raschid-Sally, Redwood & Bahri, 2010). Secondary treatment systems, which follow primary treatment, are biological treatment

processes coupled with solid/ liquid separation. Tertiary treatment refers to treatment processes downstream of secondary treatment, which filter and disinfect the water. Filtration is also an effective additional step for removing pathogens (Drechsel, Scott, Raschid-Sally, Redwood & Bahri, 2010). Recent studies of biogeochemical cycles indicate the important role of wetlands in natural cycles of organic and inorganic matters (Marrero 2008). Because wetlands have a higher rate of biological activity than most ecosystems, they can transform many common pollutants that occur in conventional wastewater into harmless by-products or essential nutrients that can be used for additional biological production.

Understanding the biological processes behind water treatment provides an opportunity to think about human integration in this process of decomposition. It opens up the possibility of thinking about the relationship between production and waste in order to rethink and redesign the cycle of human consumption. For example, the rich quantity of nutrients that are a by-product of the treated wastewater could be used to nourish soils and plants. Using these nutrients could improve food production and return essential nutrients to the environment. It is from this perspective the Palma Soriano Wastewater Treatment plan was born. By establishing a new water cycle, where the organic materials of the wastewater could be integrated into and benefit the environment and the treated wastewater used for irrigation, a treatment facility could promote food production in the area, restore the highly-eroded soils at the borders of the Cauto River and support reforestation in the riparian zone of the river.

Key to accomplishing this is the

conscience and environmental education of the local population. Applying the principles of local economic development based on solidarity, support and sustainability, the proposed project has been developed to help the local community restore the essential ties that link their lives with the world we inhabit. Moreover, this project aims to improve people's diet and increase the opportunities for urban food production. Public space and open areas should integrate the sense of belonging, respect and oneness with the land in order to create new generations who will care for the environment and appreciate the consequence to their own health and well-being if they fail to do so. Food production should be the result of that this relationship between humans and their environment. As Carlo Petrini expresses in the Manifesto of Future Food "They are important and strategic factors in human nutrition, in the delicate balance between nature and culture that underpins our very existence. Food communities are the expression of human labour: in the sector of agriculture, animal breeding, fishing, herding and food processing. They are also the expression of the earliest human interaction with nature: cooking" (Shiva, 2007).

Establishing a sense of community and growing things are essential characteristics for a sense of well-being. Restoring a water cycle that integrates human activity and natural processes is the basis for the construction of a better future.

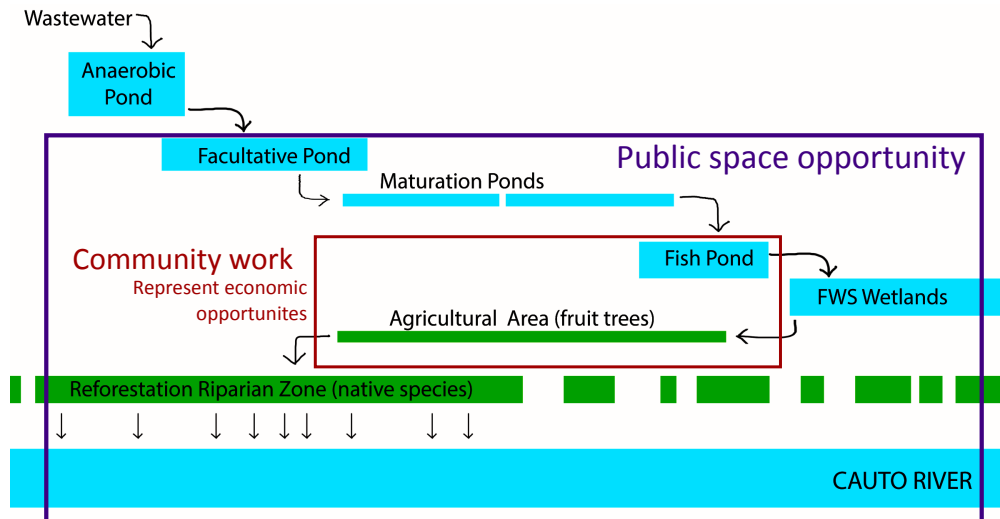
However, the solution cannot come from the outsider but from the hands of the local community. That is why I am proposing a natural treatment system which will integrate the local community with their surrounding environment through their participation in the construction of a new, natural way

to solve their problem (Figure 3 - Concept diagram of the Master Plan Idea). As an added bonus, this will include opportunities for the cultivation of their own land, improvement of the soil, and the restoration of the native forest in a strategic eco-park which will encourage people to have a profound spiritual identity with in the natural landscape and food production consistent with their traditional belief system.

The proposed wastewater treatment system has multiple benefits. A pond system and a constructed wetland will be used to treat the city's wastewater and storm water. After the wastewater has been treated, water will be directed into a pool that can be used for aquaculture. The community will be in charge of maintaining this system and can use the aquaculture as a source of food for their pigs, the main source of livestock consumed in the community.

Additionally, the wastewater treatment design incorporates a reforestation component. As part of the tertiary system, the treated water will be used to irrigate riparian vegetation and fruit trees. The riparian vegetation will provide habitat for wildlife and improve the ecology of the watershed. The fruit trees will provide additional habitat for wildlife as well as provide a source of food for the community.

It is critical to keep the community engaged with the project to ensure its long-term success and the sustainability. The ponds must be maintained and cleaned from time to time. To ensure the community's engagement, the community will be involved in refining the final design, constructing the project and managing the system. The fruit orchard and aquiculture system will



Figures 3 Concept diagram of the Master Plan Idea (Image created by the author)

provide additional incentives for the community to become involved in maintaining the system. If successful, communities both in Cuba and elsewhere can employ the project's low cost, yet effective methods. Any environmental protection and ecological design solution necessitates a healthy relationship between humankind and nature, and will foster environmental education and preserve cultural identity, which are the essential values for sustainable development.

The Master Plan Design

The master plan proposal (Figure 4 - Master Plan Proposal & Site Location) integrates all the proposed solutions into one overall project. The master plan provides a macro scale solution for the city of Palma Soriano. Although each individual component of the master plan could be seen as an independent project, the overall success and function of individual components truly depend on implementation of the entire master plan. This includes a new source of up-stream water and a new sewer system

that permits drainage of wastewater to an area that will provide natural wastewater treatment. Fortunately, the municipality of Palma Soriano has already proposed plans to implement a new source of up-stream water and a new sewer system are part of a proposal entitled, "Saneamiento y Sanitización para Palma Soriano".

This project addresses the need for a natural wastewater treatment facility and reforestation proposed in the master plan. The New Wastewater Treatment Project (Figure 5- Schematic Design Project and Programming Location), includes a (a) Wastewater Treatment Ponds, (b) a Fish Pond, (c) a Wetland, and an irrigation zone of (d) Fruit Orchard and (e) Reforestation of the Riparian Zone. The area of natural wastewater treatment is divided into three stages of treatment: primary (a sedimentation and facultative pond), secondary (maturation ponds) and tertiary (a fish pond and constructed wetland). Treated water will be used for irrigation of a community fruit orchard

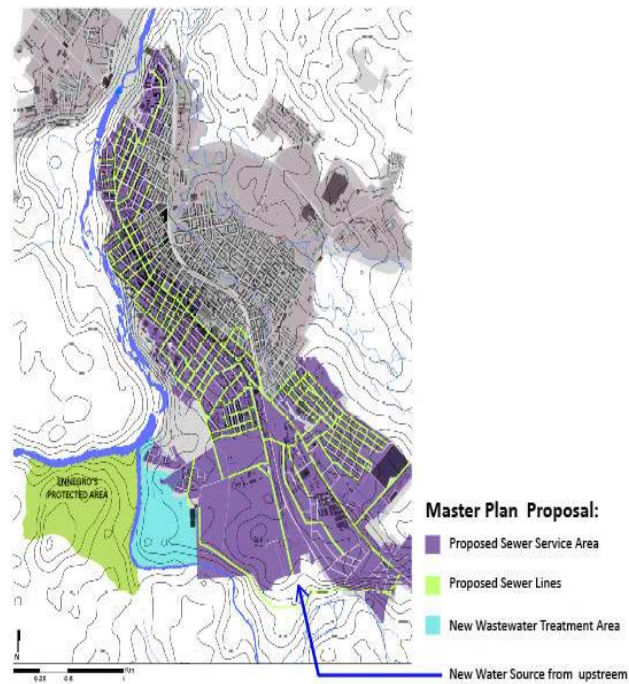


Figure 4 Master Plan Proposal & Site Location: Map developed by the author using a DEM (Digital Elevation Model) to build topographic data of the area. Image shows the 5 meter contour lines constructed. DEM source: Jet Propulsion Laboratory of the NASA (<http://www2.jpl.nasa.gov>)

and in the proposed reforestation area. Finally, the master plan locates and designs a pedestrian path that integrates the project into the surrounding area and provides an element of human experience.

Project parts

New Source of Water Upstream

The city of Palma Soriano needs to access an upstream source of water. The primary objectives of this new water source will be to provide to the city with fresh water and a continuous flow to replace its current polluted source from a stagnant pond formed by a dam which will be removed to allow the free flow of water.

New Sewer System

The city of Palma Soriano needs to update their old sewer infrastructure, and extend sewer service areas to the entire urban area. This expansion will

control excess wastewater draining into the river and streams. The alignment of the pipe system is based on the natural slope-drainage and provides sewer services without requiring complex engineering solutions and thus the project includes a design of a new sewer system for the city.

Natural Waste water Treatment:

From the base of the sewer system and the water coming in from serviced areas, it is possible to design a natural treatment system that digests organic matter through the biological process of degradation. The first two ponds function to encourage sedimentation of solid sediment and start the process of organic composition that is the function of the next two maturation ponds. A shallow depth of the pond will allow more sun light penetration to the water and facilitate photosynthesis from the algae.



Figure 5 Schematic Design Project and Programming Location (Author's drawing)

Fish Pond

After the sequence of maturation ponds, a fishpond would generate an aquaculture. Aquaculture techniques are used to feed populations without taxing natural fish populations. By integrating a fish pond that can be managed by the local community giving them products from water treatment; and integrating economic opportunity for the community and an essential food source.

Constructed Wetland

The final element of the proposed master plan involves the construction of a wetland area. Wetlands are beds of aquatic life that grow in soils or, more commonly, sand or gravel. They provide wildlife habitat and have a strong capacity to support nesting and feeding of birds. The principal species proposed are based on native, non-invasive species in Cuba. Finally the design and

area of the wetland should integrate not only wildlife and hydraulic functions, but also include an interesting design that permits interaction of people with the place and engagement of people with the wastewater system.

Community Fruit Orchard

An additional element was added in order to construct a space for the community and to direct effluent water from the treatment system towards locally supported agriculture. This designated area will be a community fruit orchard. This Treated wastewater has high levels of nutrients and is therefore appropriate for irrigation of agricultural fields. Community involvement in this project will allow locals to understand how their food needs and waste disposal practices can be intricately linked to the surrounding ecosystem.

Reforestation Area

The plan proposes to irrigate an area of low dense forest and deforested patches in order to restore the Cauto River's native riparian forest. This area is located on the border of the river and the reserve area of Ennegro. The native riparian forest restoration project will restore the native ecosystem of the river, create a barrier between the urban area and the protected area and provide open space to the local community.

Design the Path: Access to the River and Public Spaces

The design of access and public spaces for people to interact with the restored area will encourage community participation with the treatment system and surrounding ecosystem.

Conclusions

Creating equilibrium between societies and the environment is very challenging and water management is an essential factor in sustainable development (Yang, 2006). A natural water treatment system improves not only the quality of the water discharged, but also the quality of life for the surrounding community. In this specific case, local communities will directly benefit from the project as owners of the production are within the public domain and the public space proposed on the border of the Cauto River. The public project is located next to the protected sacred place of the Ennegro Community and it is designed for the local people of Palma Soriano. While the entire local community may not necessarily integrate Afro-Haitian beliefs into their daily lives, they have a strong Afro-Haitian heritage in their culture which welcomes and supports restoration of the natural water cycle in Palma Soriano. The cultural perception of nature in the local community has

certainly influenced the environmental conflict (Martinez-Alier et al., 2010) and the final design solution. Community engagement and local support are both key factors to the success of the project.

Reforestation plans integrated with agricultural systems have great support from this local community. This integral approach and holistic perspective of the problem will help move the project forward. It is essential to think of solutions that integrate people's interest and provide them new opportunities to improve their quality of life. Public spaces are essential spaces in cities and should integrate natural environmental conditions as well as human necessities. The sense of belonging, respect, and domain of the land, which cultivation activities produce, is highly important (Heidegger, 1951); and urban agriculture and community reforestation processes are a successful ways to provide them.

The master plan proposed provides essential elements to help initiate this project. With the participation of international NGO's, the Green City Fund, and the strong interest of the community this project is moving to the next stage of development. Community education and community motivation on the development of the project are key factors. This project is an example of a sustainable solution for Palma Soriano and I believe the community of Palma Soriano and the local group, Ennegro, have the capacity, motivation, and power to make this happen. Urban agriculture and aquaculture are the main incentives of locals to participate and integrate into the project. These activities provide economic and subsistence opportunities. Moreover the restoration of the natural ecosystem of the river will return to the city the opportunity to use the Cauto River as its main open space. Furthermore the project will provide a healthy

recreational space for adults and children to enjoy and learn about their environment. It will stimulate environmental education and enhance the Afro-Haitian spiritual values and respect for the place they inhabit.

Community gardens and participatory reforestation are the most successful ways by which the local community of Palma Soriano can be empowered by the project. The Palma Project should serve as an example of an approach that can be used to solve similar environmental and social problems elsewhere and provide a methodology for problem solving that could be replicated in other areas of the world. As Vandana Shiva states (2007): “...*drinking water is already scarce in many regions of the world, and we must make sustainable freshwater management a priority*”. A sustainable water-management plan must also stop the ongoing soil erosion to preserve the basis of agricultural production and must phase out the alarming input of toxic substances into vital ecosystem as well as the human food chain” (Shiva, 2007). Moreover Shiva points out that agriculture and traditional food production systems are an integral aspect of cultural identity and all human communities have the right to preserve and further develop their diverse cultural identities (Shiva, 2007).

The case of Palma Soriano and the important Afro-Haitian Community is just one microcosm exhibiting the relationship that could be constructed between culture, environment, and food production. If this project is successful, these methods could be used to improve water supply and sanitation in other disadvantaged and impoverished communities, where cultural identity needs to be recognized and validated in order to approach a sustainable solution for the community and their habitat.

This affirmation will raise the question of the problem-solution for the conflict at the “end of the pipe” in multicultural and globalized cities. Cities where local solutions and local opportunities blur in a huge economic system. It is a solution that can take over essential and humanistic ways of connection between humans and their environment. In this way, water management, and specifically wastewater treatment, would be a solution to bringing together communities in a common territory, reclaiming a clean environment, and promoting a respectful and conscience social metabolism of exchanges with the environment (Fischer-Kowalski, 1997; Martinez-Alier, 2009).

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Related Links

- Video: “Palma: The Story of a People”: <https://vimeo.com/60928823>
- Palma Soriano Project: <http://dcorvillon.com/environmental/palma.html>