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Environmental Sustainability Evaluation Method in Public Works Audit: Analysis of the Maciço do Morro da Cruz, Florianopolis, SC, Brazil

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Abstract: In Brazil, the public sector is the largest constructor in the country. However, considerations of the impacts of the conventional constructive techniques adopted and green technologies alternatives hardly take place in the public sector. Audit works carried out by the Federal Government's high internal control body cover public projects and works but for compliance measurements mostly. In addition, these audit's works help to improve public policies. Thus, this study is aimed at include environmental sustainability assessment as a subject part of public audit works regarding to urbanization. This research used the case study strategy in a descriptive way in order to apply an analysis model. It lays on a specific thematic clipping: integrated water management under the environmental layer view. The constructed analytical model is based on sustainability indicators. The selected urban fraction is a marginalized area, in an insular city. Public power is carrying out urbanization works in this locality. This research shows the viability to include principles of sustainability assessment in audits works of urbanization. Analyzing the suitability using such principles in public works could enforce best management practices to become an alternative or a complementary part to the conventional public network.

Key words: sustainable urban planning, integrated water management, public works audit, sustainability indicators, clandestine human settlements

1. Introduction

The Brazilian government is gradually seeking modernization. Institutions are trying to conform to the principles of good governance and have been adopting instruments of performance analysis and accountability more frequently. Analysis models, indicators and indexes have been developed in the last decades to become management and result evaluation tools [1]. Similarly, control bodies have been incorporating such tools into auditing works on governance, public policies and government expenditure assessments. Such issues must be monitored to guarantee they conform to both the needs of the State and of the community. In addition, the right to a balanced environment is one of the fundamental needs of the Brazilian citizen [2]. The need to use indicators of environmental sustainability arises within this context. An indicator can assess the estate or point in time of a project regarding a specific goal and contribute to the elaboration of plans for improvements [3].

The Brazilian legislation establishes that goods and services acquired by the public authorities must promote sustainable development [4]. It also requires that public works projects should be technically feasible and have adequate environmental treatment.

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Despite the national legislation requirements, there has been little progress towards achieving sustainable public works [5]. The Brazilian government is concerned to provide basic sanitation but the efforts to use more environmentally sustainable solutions are incipient. In Brazil, the Office of the Comptroller General (CGU henceforth) is the Federal Government's high internal control body responsible for conducting public works audits. However, little is discussed about ecological solutions to basic sanitation. Public works audits commonly refer to the conformity with the bidding process, documentary compliance and compatibility between design and implementation in physical, chronological and financial terms.

This study aimed at proposing an auditing method for urbanization works using environmental sustainability indicators [6] and Best Management Practices [7] to achieve integrated water management (IWM) techniques. The goal of this study also was to support that, with the aid of environmental indicators (i.e., sustainable urban drainage systems, low-impact urban design and development, water-sensitive urban design, green infrastructure), audit reports can be a tool to enforce a governance leap in the formulation of public policies for the execution of urban works.

2. Material and Methods

The case study was selected from a poor community on a hill, called Maciço do Morro da Cruz (MMC henceforth), which is located downtown Florianopolis, a coastal and insular Brazilian city in Santa Catarina State, south of Brazil. Florianopolis has the third highest Municipal Human Development Index (IDHM: 0.847) [8] and one of the highest per capita incomes of Brazil. As such, there are excellent housing options for the portion of citizens who can afford it. However, there are places in the city occupied by poor clandestine land settlements in precarious conditions. These segregated areas are one of the several problems related to accelerated population growth in Florianopolis, which in the last 30 years, has been the result of public policies without proper development strategies and urban planning [9]. Currently, there are 18 irregular settlements in MMC, which is a 283-meter-high granite hill [10, 11]. The local government legally recognized the need to provide urban services to the MMC's inhabitants to reduce social inequality in these precarious settlements [12, 13]. Efforts to consolidate this plan have intensified since 2007 [10, 14], with CGU supervising the urbanization works since 2012 [15, 16].

The study site selected for this research was a street called Nova Descoberta within Mont Serrat Community, one of the 18 tenements in MMC (Fig. 1). Nova Descoberta Street is in an environmentally vulnerable area, designated as a Limited Use Preservation Area (or APL in Portuguese acronym) by the Brazilian Forest Code.

Fig. 1 Left: Maciço do Morro da Cruz view (red square), in Florianopolis, SC; Right: Monte Serrat community (green square) and Nova Descoberta Street (red polygon).

This research was carried out in a descriptive method based on environmental indicators [17]. Given the complexity and breadth of the subject, the scope of the evaluation was limited to the aspects of integrated water management (IWM) to demonstrate the application of the proposed evaluation criteria. Environmental sustainability principles and indicators were identified based on the approach used by Belo Horizonte, Florianopolis [18] and Andrade and Lemos [19], and separated into five topics: Water Supply; Sewage; Rainwater; Water Source, and Wastewater.

Belo Horizonte [3, 18] created a mathematical model to obtain a final index for a planning unit within the municipal territory. CECA [3, 18] proposed indicators to measure socio-environmental quality in the city of Florianopolis, considering the specificities of the city, such as its island condition, its geomorphological and environmental characteristics. Finally, Andrade and Lemos [19] developed environmental indicators based on principles on the quality of urban morphology and green enterprises certification.

Field data was collected from September to November 2016, followed by the analysis of public documents and literature review. The data were later arranged in dichotomous variables (yes or no). Lastly, specific recommendations found in the literature regarding environmental impacts derived from urbanization were selected to assess the situation of the study case.

3. Results and Discussion

Based on the five sustainability indicators regarding aspects of integrated water management (IWM), Table 1 shows the result of the evaluation of the Nova Descoberta Street.

Table 1 Evaluation of the Nova Descoberta Street with a focus on integrated water management (IWM).

Environmental indicator of sustainability	Performance			
	No	Not Applicable	Yes	Comments
1. Water Supply				
1.1 Treated water supply			X	Interviews revealed a 100% of houses have potable water supply.
1.2 Remote water withdrawal			X	About 30 Km from the study site.
1.3 Self-sufficiency	X			This region needs to import water for its livelihood.
2. Sewage				
2.1 Sewer network availability			X	Interviews revealed a 100% of houses are connected to public sewer network
2.2 Decentralized sewage treatment incentive program	X			The water and sanitation company only recommends residents build a sump or sink.
3. Rainwater				
3.1 Natural systems for rainwater retention	X			Techniques used are traditional, so unfiltered water are drained through pipes directed to the local stream.
3.2 Collection and storage of rainwater in public spaces and buildings	X			There are no natural or artificial systems for rainwater retention. There is not rainwater harvesting and storage in public spaces and buildings.
4. Water Source				
4.1 Respect for the natural condition of perennial and intermittent watercourses and recovery of streams	X			The existing stream in the locality was channeled in order flow under the houses. The drainage system leads the rainwater to this stream.
4.2 Respect to topography and streams like boundaries between neighborhoods	X			The design of roads and blocks does not follow the contour lines. The design is not linked to green infrastructures.
5. Waste Water				
5.1 Ecological treatment of wastewater	X			There is no treatment of wastewater.
5.2 Wastewater reuse for non-potable uses	X			There is no wastewater reuse.

For evaluation purposes, the case study was divided in two sectors (Fig. 2). In the first sector, the road is flat (between the red and blue arrows, 150 to 140 m) and the street was partially paved with permeable material. The site is steep in sector 2 (between the blue and yellow arrows, 140 to 105 m), and public spaces were completely waterproofed.

Nova Descoberta Street today has a network of water supply, sewage and drainage (Table 1, items 1.1). This represents an upgrade in terms of basic sanitation when it comes to precarious settlements.

However, the project was not conducted in a sustainable manner concerning the hydrological cycle. Serious issues regarding the Florianopolis' water supply system were detected: insufficiency in water supply, the inexistence of a permanent program to protect underground and surface water sources; lack of grants for water abstraction from springs and of an environmental license for the operation of the station;

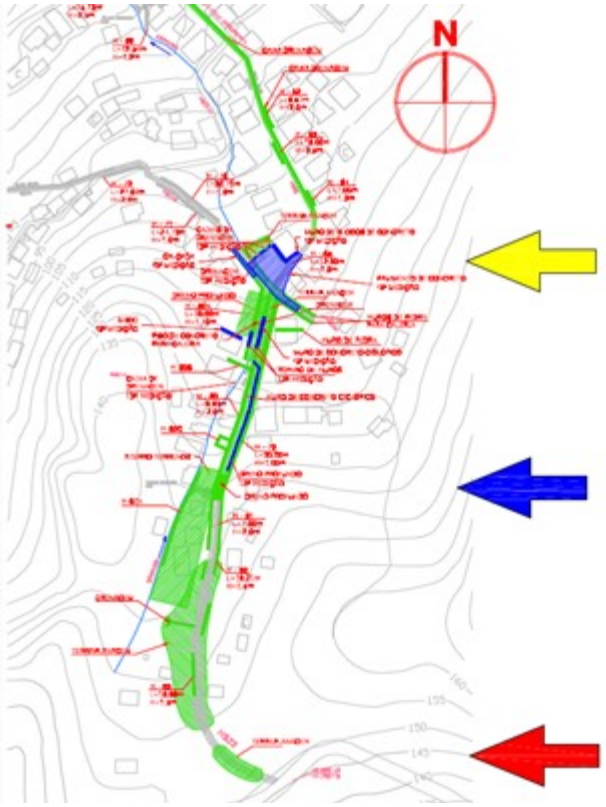

Fig. 2 Topographic map of Nova Descoberta Street (between the blue and red arrows, sectors 01 and 02).

lack of water resource plans for the regional watersheds; inadequate water treatment system; absence of a sanitary permit for the treatment laboratory operation; inaccurate available water volume data; water wastage during transportation or due to clandestine connections (43.31%); inadequate system maintenance; old equipment and water wastage by consumers [20].

For Rueda [21], a model of sustainable water management needs the following principles: the reduction of the extraction of natural resources; the reduction of the pollutant load discharged on the basin; actions for the water economy; reuse of treated water; the use of rainwater; and the reduction of pollutants produced by the discharge of physical, chemical and biological agents into the aquatic environment.

According to Ellis [6], hydrology must be considered before planning a space intervention so that any settlement can be self-sufficient in water supply (Table 1, items 1.2 and 1.3). This author defends that the Low Impact Development (LID) project is more adequate and cheaper than the conventional urbanization found in Nova Descoberta Street. The LID approach helps to maintain and strengthen the hydrological system of river basins, minimizing the waterproofed surface area, preserving natural vegetation, and reducing the pollutant effluents with local water treatment.

The city's undersized drainage infrastructure was built in the 1970s without a complete urban drainage plan, with shallow runoff and no catchment wells in some parts [22]. Nova Descoberta's rainwater drainage network was finished recently and was partially done through concrete pipes, or retaining stony walls. Both mechanisms lead the storm water directly to a local stream. There are no public or private reservoirs for storm water retention, filtration and harvesting (Table 1, items 3.1 and 3.2), despite the existence of a municipal norm that requires that recent buildings must have rainwater reservoirs.

In Florianopolis, some watercourses were straightened, channelled and silted due to lack of

proper maintenance [22]. In Nova Descoberta, retaining stony walls were built along the local stream and the houses remained close to its border it. Rainwater washes off the street directly into the stream due to the inexistence of Green Infrastructure or other mechanism to retain and filter rainwater before it reaches the watercourse (Table 1, items 3.1). The local stream could have been protected from the impacts of washed-off toxics and pollutants that flow directly in to the stream with the unfiltered rainwater if the public sector had used the LID approach in the area.

In sector 2, land parcelling does not follow the natural (topographic) contours of the site (Table 1, items 4.1 and 4.2), sidewalks are absent, and public spaces were waterproofed with concrete [15, 16]. Waterproofing urban soil changes the hydrological cycle, reduces infiltration and groundwater recharge, and increases runoff from rainfall, floods, and pollutant and sediment wash off [6, 7]. The Treatment Train [6] would minimize the impacts on the water resources in the community. This technique combines Best Management Practices (BMP) and Green Infrastructure by adding different aspects of storm water treatment using vegetation and high drainage covers to intercept, infiltrate and store rainwater [6, 7, 23].

In Florianopolis, the sewage network covers around 40% of its districts [22]. Individuals or communities try to supply the deficit by building their own septic tanks, infiltration valves or direct launch [24]. Due to the recent urban improvements mentioned in this study, Nova Descoberta's sewage network is now connected to a central station, located in the insular part of the city. However, some of the houses in the community are not connected to the public sewage network yet because the responsibility for houses connections belongs to the owners (Table 1, items 5.1 and 5.2). In addition, the operational capacity of this station was considered outdated in 2012 [26].

Farr [25] defends the concept of Living Machines as an alternative to sewage treatment. This author states that these devices are ecologically based equipment, built inside greenhouses. Living Machines, in addition to filtering water, do not use chemicals and allow the reuse of water from the local sewer. Its design also permits the creation of green areas of multiple use, in which it is possible to grow plants, flowers, raise fish, make water sets and extract nutrients for specific purposes.

According to Niemczynowicz [7], pollution control for water treatment directly on the polluting source facilitates the adaptation of the system to the type of effluent. Therefore, technologies that involve natural biological systems would be suitable for local water treatment in the community [6, 7], and temporary water storage could be achieved through swells [7]. Such devices, as observed by Le Costumer et al. [23], are more cost-effective and durable than traditional filters in removing pollutants and improving water quality and would integrate easily with the urban landscape.

4. Conclusion

Several authors state the necessity of urban planning combined with hydrology, rainwater management through biofilters, wastewater treatment at the site of the pollutant source, green infrastructures, the combination of traditional water treatment infrastructures with BMPs, rainwater storage and wastewater reuse, as well as the reduction of impermeable areas. However, the construction of the Nova Descoberta Street was carried out without the adequate low-impact environmental design and the government's urban works design completely disregard the environmental vulnerability of the area. Additionally, other problems are worth mentioning: waterproofed public spaces, the lack of sidewalks, disregard for the natural topography of the area in the design of roads and lots, the inexistence of green infrastructures to allow rainwater detention, retention and infiltration, the absence of a local water treatment system and wastewater reuse system, absence of measures to preserve the local stream, and the

inadequate hydrological support capacity to sustain the local population.

From an audit's point of view, the recommendation would be to review the suitability of the land-use criteria defined for Nova Descoberta Street and the urban works carried out in the area. It would also be necessary to identify soil disturbance limits, to review land parceling to minimize earthmoving and waterproofed areas surfaces, to use greater drainage capacity coating materials on paved places, to recover and protect the surrounding vegetation and local stream, to include multifunctional and ecological devices to retain, filter and store rainwater, to install wastewater local bio filters and encourage its reuse, and to control erosion and sedimentation. Such measures would mitigate impacts on the hydrological cycle, reduce pollution and urbanization costs [6, 7, 23].

The aforementioned methods should not be merely alternative. According to Falkenmark [27], people need to review water management solutions, and governance strategies should include a more holistic approach. It is important to make stakeholders aware that urban development must combine environmental protection to maintain ecosystem services and sustainable habitability. Public works audits are a useful vehicle for disseminating such ideas as long as they also show the need to implement or reformulate public policies.

However, the results of this research showed that Brazilian public urbanization policy has much to improve regarding sustainable water management. Therefore, more research should be done to improve audits procedures that combine legal, technical and financial compliance analyzes with environmental sustainability assessment. This study also showed that the use of environmental indicators in audit plans is a flexible method that can be applied to any country, where environmental indicators can be selected according to the specific needs of the site, the projects and works that will be analyzed.

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