

METHODOLOGICAL PROPOSAL FOR REDESIGNING INFORMAL COMMUNITIES — CONSTRUCTING RESILIENCE IN HYDROLOGICAL STRESS CONDITIONS¹

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Introduction

In the course of the 20th century an impressive increase in life expectations was registered all over the world. In Brazil the population increased almost tenfold from 17.4 million in 1901, to 169.6 million in the year 2000 (IBGE, 2000). However, population growth was mainly concentrated in urban centers. The 2010 census identified 84% of the population as urban residents (IBGE, 2013). Reserves of natural water, however, are limited and the spatial distribution of water resources is far from uniform.

Furthermore, there were no adequate public housing policies to accompany population growth and that led to the occupation of land that was environmentally fragile either because of its geographic location, such as riparian regions, low lying areas and steep slopes or because of its legal status in terms of undefined rights of ownership (CERQUEIRA E PIMENTEL DA SILVA, 2013). Notably it has been in just such fragile areas with degraded landscapes that the *favelas* (slums) have sprung up from informal occupation and settlement and in them the population growth rate is even higher than in the rest of the city (UN, 2006) and the urban infrastructure is improvised and insufficient.

There have been various policies and programs in Brazil designed to address the housing shortage and the poor living standards in areas of social concern, especially in the big urban centers (BONDUKI, 2004, 2009). In those programs the models proposed for drainage and other urban infrastructure merely reproduced, in an improvised man-

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ner, the conventional ways of implanting infrastructure in the city's formal spaces. That conventional system, in turn, was already being superseded by systems specifically taking into account the question of environmental sustainability.

Although Acts 9433/97 (defining the national water resource management policy and system) and 11.445/07 (establishing the federal policy and guidelines for basic sanitation) have led to considerable progress in the proposal for the articulation of water resource planning and management, basic sanitation and the policy on land use and settlement, in municipal and local spheres, it is still not possible to detect any reversal of the scenario of environmental degradation and poor quality of life in the areas of informal occupation and of social concern.

In the international context, in the 1990s the insufficiency of the classical approach to urban infrastructure projects began to be recognized and new innovative, integrated urban planning initiatives began to emerge with a focus on the conservation of water resources and their rational use. Among them was that of Low Impact Design - LID (COFFMAN, 2002) and LIUDD (Low-impact Urban Design and Development) (VAN ROON, 2005 and 2006). They propose that urban development should be based on the principles of participative management and in them rainwater is attributed environmental value and constitutes the thread of continuity running through urban design projects.

In that sense/direction, Wu and Wu (2013) underscore the importance of developing an ecological resilience associated to urban planning and design and focused on the coming decades of the 21st century.

Brazil, albeit still lagging behind in comparison with other countries, has gradually been consolidating a low impact proposal for urban development (POLETO, 2011; SILVEIRA *et al.*, 2009; MARTÍNEZ and POLETO, 2014).

Added to these considerations are the complex problems of global warming, climate change and the increasing frequency of natural disasters. From 2008 to 2012 floods affected 1,543 Brazilian municipalities (27.7% of the total), displacing or depriving of shelter 1.4 people (IBGE, 2013). In 2014 and 2015, low rainfall levels, especially in the southeast and northeast regions, contributed to the current crisis in public water supply. In that context, the less economically favored population groups inhabiting densely occupied areas at risk are the most vulnerable.

The complex nature (MORIN, 2004) of the problems associated to the study object of the present research calls for an interdisciplinary approach which, according to Ahem (2013) is the inevitable path to take for the conception of the city of the future, and to address the issues involved in the sustainability of very large urban conglomerations.

The present paper sets out to present a framework that describes the stages and sequences of an urban redesigning project for the city's informal spaces that is in alignment with the perspective and measures of low-impact urban development especially for the communities and *favelas* (slums) of low-lying areas on the outskirts that are typically vectors of the expansion of large urban centers. This work is part of the research and extension efforts associated to the State University of Rio de Janeiro's HIDROCIDADES (Hydro-cities) project and involves researchers from different fields of knowledge. The HIDROCIDADES project focuses mainly on issues related to achieving the rational use

and conservation of water by means of innovative actions that simultaneously foster the generation of income and improved living standards (PIMENTEL DA SILVA *et al.*, 2008)¹.

Low-impact Urban Development

Low impact development is a new strategy for urban development in a sustainable perspective. It is part of the evolution of the so-called Best Management Practices or BMPs (POLETO, 2011) which emerged from the recognition of the fact that the classic concepts of drainage proved to be inadequate to face the dynamics of the urban growth that took place in the course of the 20th century. The efforts to supersede the so-called Hygienist systems that seek mainly to obtain a fast rainwater run off downstream led to the recognition of the environmental value of rainwater and to the search for measures, often referred to as compensatory (BAPTISTA *et al.*, 2005), that promote rainwater infiltration and storage thereby contributing towards the conservation and rational use of water (PIMENTEL DA SILVA and MARQUES, 2010; SOUZA *et al.*, 2012).

In various countries the BMPs have evolved into broader proposals that go beyond the mere application of innovative devices in drainage projects and different nomenclatures have arisen around them, according to their ramifications in the different cultures and countries. Fletcher *et al.* (2014) have presented a discussion of the different jargons used in recent times to typify the sustainable urban development initiatives in various countries in a bid to register the recent history and evolution of urban drainage terminologies: *Low Impact Design - LID* (COFFMAN, 2002), *Water Sustainable Urban Design - WSUD* (LLOYD, 2003), *Sustainable Urban Drainage System - SUDS* (CHATFIELD, 2005) and *Low Impact Urban Design and Development - LIUDD* (VAN ROON, 2005 and 2006).

Such approaches broadly embrace many aspects but take the preservation of water as their central concern and the region of the drainage network is adopted as the planning and management unit – not necessarily an entire river basin, but part of one. Participative management processes are encouraged in various spheres. In regard to drainage devices, priority is given to the construction of elements that favor water infiltration and conservation. Among the innovative drainage elements used in low impact development are: infiltration trenches and wells, water tanks and cisterns to store rainwater, green roofs, bio-retention ditches, infiltration and evaporation beds and walkways with permeable paving and the protection and restoration of wetlands in city areas such as marshland, bogs and mangrove swamps (BRACEY *et al.*, 2008; VAN ROON, 2012).

The aim is to get the hydrological patterns back to the condition they were in prior to urbanization. Unlike the concept underlying conventional drainage projects whereby the natural drainage network is altered through earthmoving activities and the introduction of altered hydraulic circuits, low-impact urban development seeks to restore the natural drainage network, preserve riparian vegetation and avoid the settlement of areas immediately bordering water courses. Furthermore, the low impact development proposal goes beyond questions of drainage alone; it involves holistic aspects of the ecosystems and social and cultural issues; it includes policies and structure for the public management of the systems, the creation of income and employment in a new context altogether, and

the decentralization of urban infrastructure services – always seeking a local solution for the such questions. It also seeks to preserve water and mitigate various other aspects of urbanization impacts. Control measures targeting water have a transversal impact on other questions too.

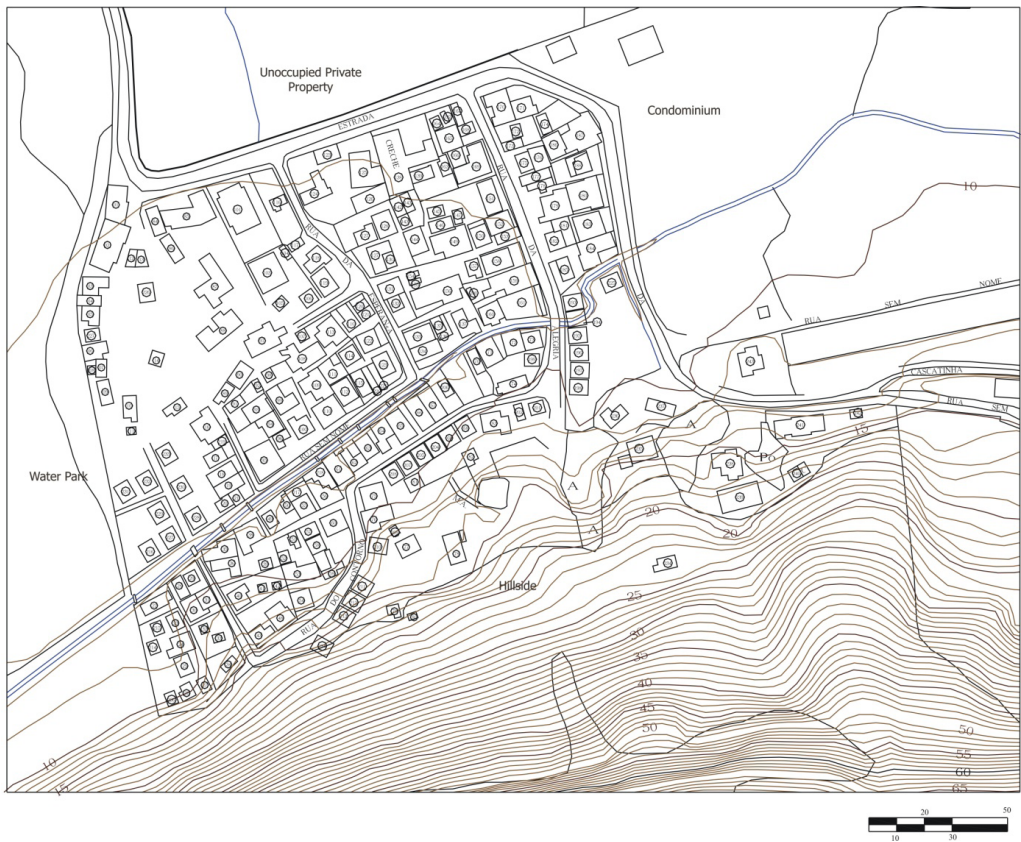
In New Zealand, such concepts have been steadily evolving since the end of the 1990s in a way that has enabled them to address other aspects, in addition to those implicit in the LID approach, such as negative physical-chemical impacts, impacts on biodiversity and natural amenities, socioeconomic effects and the protection of the ecological integrity of the aquatic ecosystems while, at the same time, allowing urban development to take place in differing densities and intensities. LIUDD incorporates ecological principles associated to the so-called green architecture, experiences acquired with eco-towns, integral management of the three waters (supply, use and drainage) of the WSUD, in addition to designing alternative used water management systems. It also incorporates knowledge concerning economics and the environment, regional planning versus urban planning, landscape recuperation, and research in the design, implementation, operation and maintenance of alternative rainwater management devices and systems. LIUDD has been proposed and has served to orientate the urbanization of peripheral areas in New Zealand that have not yet been heavily impacted and many of which are occupied by groups associated to the Maori people. What is noticeable is the focus on respect and preservation for the native people and for biodiversity. There are also clear references to participative processes in decision-making involving policies seeking the dissemination of personal habits that can contribute towards reducing the pressure on water in its aspect as a natural resource (VAN ROON, 2006).

Area of Study

The object of the study was the Vila Cascatinha community located in the low-lying area of Jacarepaguá, in the neighborhood of Vargem Grande, a region that is one of the main vectors of city growth in the city of Rio de Janeiro and where the installations for the 2016 Olympic Games have been constructed. In the lowland area of Jacarepaguá, many informal settlements have sprung up. The community selected for the study is in the region that is drained by the basin of the Rio Morto. In its lower stretch the river has had its course straightened to form what is known as the Sernambetiba canal which drains off straight into the ocean at Macumba beach. This stretch of the river is considerably degraded and it often makes use of the beach impossible. Vila Cascatinha is typical of the *favelas* in the low-lying areas of the Vargem Grande and Vargem Pequena neighborhoods in the city of Rio de Janeiro. In it many of the dwellings do not have areas for circulation separating them and the urban layout is fragmented and disarticulated. On the left the area is marked off by the walls of a water park, on the right by a residential condominium of houses, in front by an unoccupied walled-off area of private property and at the back by a steep slope known as the Morro do Bruno. From that point the channel of the Bruno canal begins. It receives the effluents from the neighboring condominium and most of the effluents and waste of the Vila Cascatinha community.

The community sprang up in 1991 as the result of a movement of working class people from the neighborhood to occupy what was originally land subject to flooding and where they are settled to this day. It was not possible to identify the ownership status of the occupied area. The place lies close by the Bandeirantes Highway, the main thoroughfare of Vargem Grande and is about 2 km from the central part of that neighborhood. According to information supplied by Mr. Guimarães, who was president of the Residents Association from 2004 to 2008, at the last count, in 2006, there were 800 people in the community, occupying a total area of 37,946.81 m², of which 24,282.73 m² were occupied by the residential plots, 8,375.81m² by streets and 5,288.27 m² formed a leisure area (the steep slope) (Figure 1). Over half of the residents are descendants of former small farmers in the region who lived there at a time when the area supplied the city of Rio de Janeiro with vegetable products, especially greens (CERQUEIRA et al., 2007).

Figure 1 – Urban layout of Vila Cascatinha, Vargem Grande, Jacarepaguá – Rio de Janeiro. Source: Adapted from the base map of the Pereira Passos Institute – Rio de Janeiro City Hall.



Materials and Methods

This work was carried out using the Action-Research method proposed by Thiollent (2008), which includes the integration of scientific knowledge and traditional knowledge with a view to achieving the collaborative construction of solutions for real problems. It is also in alignment with the precepts of the Social Technology (NEFFA and RITTO, 2009) movement which proposes the identification of the vocations of a given population group as a means to delineating strategies designed to break with the established order and foster environmental education through labor (work). Knowledge exchanges between scientists and social actors are also defended by Silva *et al.* (2013).

The present research chose to adapt the LIUDD, originating from New Zealand, to Brazilian reality. It was observed that the array of directives and impressions that orientate the LIUDD were closely aligned to the complex problems of informal communities in the peripheral areas of big Brazilian cities, especially Rio de Janeiro.

The proposed framework has preserved the principles that underlie and orientate LIUDD, namely: 1) working in consonance with nature by adopting the river basin as the planning unit, maintaining the integrity of the systems and minimizing the ecological footprint; 2) minimizing impacts by selecting adequate spaces, making efficient use of those services that the ecosystem is capable of providing and containing and minimizing the generation of residues; and 3) stimulating development alternatives that restore natural conditions increasing infrastructure efficiency). On a local scale, the aim is to strive to obtain the pre-urbanization conditions in regard to soil, water and the nutrients cycle, by optimizing re-use and or recycling, minimizing demands and external discharges, reducing and containing contaminants, protecting native populations with due sensitivity in regard to cultural and historical values and the value of (aquatic and terrestrial) biodiversity and reducing the need for mobility (of people and materials).

Field work was carried out in 2006 not only to identify the general characteristics of the local population, but also the features of areas around the community, as well as the morphology and internal features of the dwellings, and to acquire census information and the residents' perceptions of their main problems. The results of the survey were reported by Cerqueira *et al.*, 2007. According to residents' perceptions, their most outstanding problems were: the proliferation of rats and the quality of the water they consumed (either drawn clandestinely from a nearby adductor or taken from shallow wells), the water in the canal from the Morro do Bruno which runs right through the community carrying the discharge of effluents and solid waste and the repeated flooding especially in the summer months [rainy season]. After contacts with residents had been intensified and consolidated by means of meetings and the organization of events to mobilize the community around the question of water, the survey was expanded.

The second survey of residents' perceptions aimed to make a more specific investigation of the Cascatinha Community residents' perceptions in regard to: the environmental impacts in the spaces of their settlement and its surroundings, their willingness to get involved in participative processes designed to find solutions to their problems, and in regard to: water supply alternatives, waste disposal, their interest in engaging in new activities

that might bring in some income in alignment with low impact development principles (such as a plant for the re-use/recycling of solid waste, a compost-making installation, agricultural activities, water quality control), and finally in regard to their knowledge and impressions of the innovative drainage devices that are part of the LIUDD proposal for conservation and rational use of water (including rainwater storage tanks and cisterns, green roofs, infiltration trenches and wells and permeable paving). In the HIDROCIDA-DES project, in addition to the articulation with the Vila Cascatinha residents and other residents of the Vagem Grande neighborhood by means of the Vagem Grande Residents Association (AMA Vagem Grande), the Teófilo Moreira da Costa Municipal School was established as the venue for the Project's actions. Mobilization events and workshops involving students' parents (many of them Vila Cascatinha residents) were held in the school and there demonstration units of rainwater capture, a composting plant and a green roof for the practice of urban agriculture. Against that background, the questions were administered to the community residents by the students in lower secondary education coordinated by the geography and science lecturers. That strategy was intended to make the residents feel more at ease when answering because during the meetings it had been observed that the residents seemed somewhat intimidated and worried about their image in the eyes of the university lecturers and researchers.

So in that way the framework that will be presented below was gradually constructed and optimized in a way that made it feasible to repeat the procedures adopted within the principles of the LIUDD adapted to local reality and to that of other communities. As will be seen from the description that follows, in its final stages the framework embraces the proposal of a new urban design adapted to the real context. In addition to the methodological procedures consolidated in the framework proposal, the results presented below constitute a demonstration of the proposed new urban design applied to the space occupied by the Vila Cascatinha community. In spite of being innovative, the sustainable urban design is entirely in alignment with the international methodologies for addressing urban spaces (VAN ROON, 2012).

Framework for implanting Low-impact Urban Development in Informal Communities

Figure 2 displays the proposed framework for the urban redesigning of informal settlements according to LIUDD principles. The framework contemplates three main groups of stages: initial, diagnostic and the project.

The Initial Stages involve establishing bonds and greater proximity between the researchers and the members of the community and that can be done by means of the local Residents Association or similar entities. Those associations are considered to be appropriate environments for articulations. Then follows a presentation of the plan or project, identification of local leaders that can contribute towards making it widely known and the localization of any necessary (cartographic or demographic census) information concerning the settlement. Free softwares such as Google Earth can be used as an auxiliary resource to update such information, making it possible to delineate the basic map which,

together with the diagnostic stages that follow, will contribute to the formulation of the new urban design that takes place in the Project Stages. Meetings are held to disseminate information and they should take place “on neutral ground”. That is because in such communities there are often sub-groups associated to religious conviction, predominant families and other features. Drawing closer to one such group to the detriment of another can lead to an undesirable fragmentation of the participative processes. It is important that everyone should feel themselves to be included.

The Diagnostic Stages follow in which relations with community leaders and other residents are intensified to reconstruct the history of settlement, identify ownership information and conduct the inventorying and mapping of the existing infrastructure. During these stages the information should be collected in a structured manner and if necessary by means of interviews. At the same time contact should be made the public authorities who can designate their representatives to take part in the meetings and supply any registration information that may be available. If the entity fostering actions for the new urban design happens to be the public authority itself, then such relations will have been established in the initial stages and the said information, in that case, will have been the starting point. Thematic mapping is also done during these second stages. The interviews should be directed at obtaining the main features of the local population (census information), its knowledge, skills and desires as well as typifying the internal conditions of the dwellings, clarifying health issues (not only of the target community but also in the river basin area in which it is located) as well as residents’ environmental perceptions and their adherence to the physical devices envisaged for the management of the “three waters” contemplated by LIUDD. A matrix of environmental impacts is generated (the “causal chain” tool may be used here for analysis (CERQUEIRA, 2006). Based on the results obtained from the interviews and the analysis of any previous plans (successes and failures), the community’s demands and expectations are delineated with a view to elaborating proposals which should be consolidated in a participative manner.

The last stages are **the Project Stages**. The starting point is the current design of the settlement. What is usually observed in such informal settlement is a great concentration of people and the installation of buildings without there having been any prior establishment of layout or blocks. The stages should begin by designing the desired layout, redefining the residential blocks and the street plan. Concomitantly spaces for any eventual re-management (which should be avoided) should be guaranteed and the leisure areas defined. That is followed by the elaboration of the infrastructure networks projects and the three waters management plan bearing in mind the local scale and prioritizing non structural measuresⁱⁱ as proposed by Bienenstein *et al.* (2011), making use of the natural drainage features available and that are part of the LIUDD and taking advantage of the relief of the land thereby minimizing interventions and costs and guaranteeing the efficiency of both devices and services.

A demonstration of an urban design project based the application of the framework is provided by the case study of the Vila Cascatinha and serves as a kind of validation for this innovative proposal. The current design displayed in Figure 1 was the starting point. The development of the new design is demonstrated by means of some intermediate key-

-designs illustrating the process with the intention of facilitating community participationⁱⁱⁱ right through to the final design proposal.

The meetings, workshops and mobilizations and the results of the two surveys administered interviewing the Vila Cascatinha residents made it possible to obtain a highly consistent vision of the residents, their culture and their demands. Among the latter was the residents' ambition to have the same kind of "urbanization" as the other parts of the city, namely asphalted streets, a sewage drainage system without any concern as to where the sewage might be destined, and the disconnection of the ditch that runs through the community from the river constructed there. In a similar way, there was a notable lack of perception of each subject's own participation in the environmental impacts. The residents' vocations were duly appropriated and it also proved possible to enhance their sensitivity in regard to the low impact development principles. All the impressions were re-worked in the second survey with interviews in the field. Those interviews served to foster an exchange of knowledge and led to various mobilizations/workshops in both the local school and with the Vila Cascatinha Residents Association in the community spaces. University experts participated in those events as well as representatives of government agencies involved with water resource issues (the Rio de Janeiro State Environmental Institute, Rio Águas and the Pedra Branca State Park), students of the municipal school, their parents and lecturers and local residents in general (from Vila Cascatinha and from the surrounding neighborhood). On those occasions, by means of oral presentations, university experts gradually introduced the perspectives implicit in low impact development and government representatives presented the perspectives of water resource planning and management (Act 9433/97), participative water resource management, the associated policies, their management systems and associated institutions, how to participate in the respective forum, and the City Hall's current and future projects for the locality. The participants' impressions of those oral expositions were duly registered. Some were even recorded on video and those recordings are available at the State University of Rio de Janeiro^{iv}. Finally, the new design proposal for Vila Cascatinha was elaborated; one that could be positively appropriated by the residents, influence income generation and the transformation of the local reality and at the same time represent a more sustainable alternative than that offered by the conventional patterns of urbanization in force.

Figure 2 – Framework for the application of LIUDD to the urban re-designing of informal settlements of social interest.

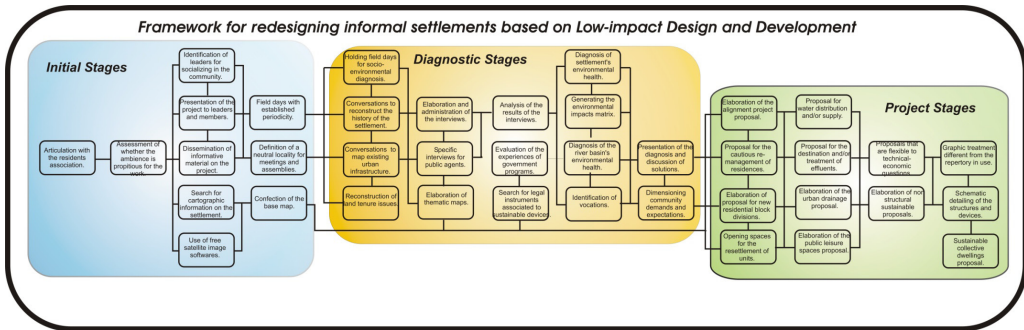
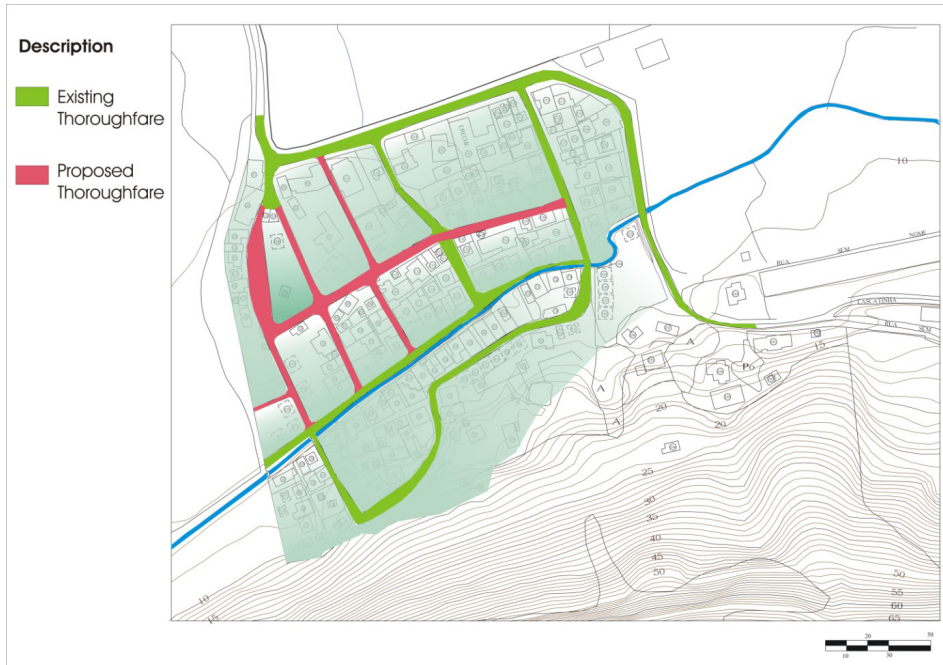


Figure 3 represents the new layout for the residential blocks designed to achieve an improvement in the permeability of the urban layout and to guarantee access to services such as furniture removal, transit for people with mobility difficulties, shopping in the supermarket and also to safeguard health aspects. To that end an effort was made to eliminate as many bottlenecks as possible from the street system, that is, to avoid situations in which the width of the street is less than the recommended or desirable dimension and restricts the possibilities of implanting infrastructure.

Figure 3 – New Layout and Division of Residential Blocks for Vila Cascatinha. Source: CERQUEIRA (2012).



The treatment of the public areas of urban infrastructure was focused on the question of conserving rainwater. That was due to the fact that the problems that were narrated by the residents during the interviews are intimately linked to that theme. Examples are the cases of flooding, the proliferation of insects and other vectors, the reflux of sewage and other situations. Another factor that justifies this particular approach is the fact that the settlement is located in a low-lying area and for that very reason the question of rainwater management is considerably more complex than it would otherwise be because high tides lead to the flooding of urban areas.

The sustainable urbanization methodologies that were the references for the new urban design in question are far more sensitive to the question of the conservation of water – a resource that can, and should be made use of. For the question of drainage of the settlement area, the proposal was to make use of the structures contemplated by LIUDD (Figure 4). To be more specific, in the present project, the solutions adopted included permeable paving, retaining and detaining basins, infiltration gardens, leisure areas equipped with mechanisms for the detention and infiltration of rainwater and infiltration trenches. The expansion of green urban area offers multiple benefits. The incidence of such areas to the detriment of gray areas [in satellite images] is considered to be an indicator of environmental quality as pointed out by Moreno *et al.* (2007). There now follows a more detailed account of the situations and contexts in which each one of those structures was proposed.

Infiltration trenches were implanted along the courses of the settlement's internal streets so that they could perform as rainwater channels but at the same time allow the infiltration of rainwater in the soil.

It was proposed that there should be two rainwater retention reservoirs on the edge of the settlement dedicated to absorbing the water coming down from the slopes above and to reducing the quantities and the mechanical force with which such rainwater hits the lower-lying parts of the settlement. Given that they are always full of water, the reservoirs could be used for ornamentation. The infiltration gardens were distributed along the main road of Vila Cascatinha, because, apart from being the main access route to the community, it is wide enough to allow for investment in solutions that are capable of simultaneously contributing towards drainage, to ornamentation and to the creation of spaces in which community bonds and connections can be reinforced and expanded.

In one of the initially proposed blocks of the settlement it was suggested that a leisure area should be implanted with sporting equipment installed but which could, at the same time serve as a detention reservoir. In that way it could be used for leisure purposes in the dry season and in rainy times it could help to retard the rainwater.

Permeable paving was proposed for the settlement's internal streets as a way to contributing to recharging the aquifers. That solution was not extended to the Vila Cascatinha Road however because of the heavy traffic it carries.

Figure 4 – The treatment for public areas Source: CERQUEIRA (2012).



For the street layout the retrofit concept delineated by Ashley *et. al.* (2011) was used. It consists of an urban remodeling intervention in already consolidated public thoroughfares (such as the Cascatinha Road for example) and the implantation of devices that contribute towards increasing green areas, increasing the areas of permeable ground and improving the urban ambience. It must be stressed that the structures recommended for treating the public areas differ considerably from those of conventional solutions.

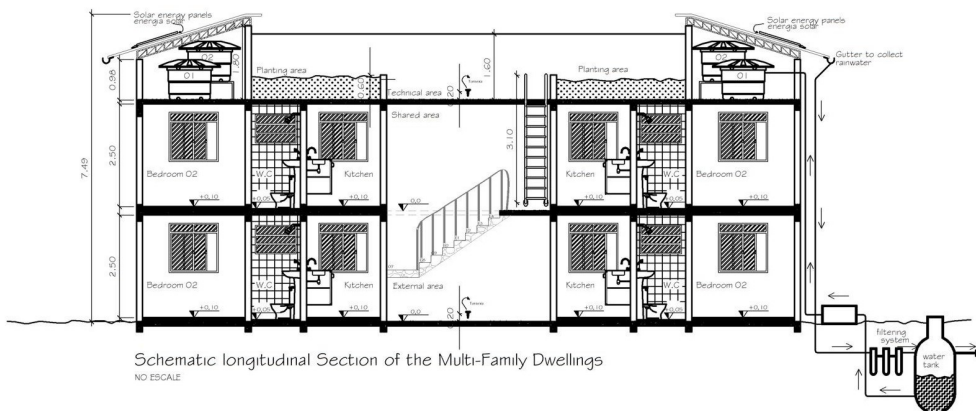
Tucci (2002) identified the huge gap separating the stage of development of sustainable methodologies in developed countries from that of the developing countries. There is also an outstanding need for research into urban treatment techniques that result in a greater number of the hydrological features prior to urbanization and densification being maintained (SOUZA *et. al.*, 2012). In that light, and given the importance of the process unfolded in the Vila Cascatinha and the impediments to be overcome, such as the current form of urban infrastructure management, a consolidation of the stages involved in elaborating a Plan of Action was prepared with detailed comments and notes associated to each stage of the process. The underlying intention is to contribute towards the performance of other professionals and/or researchers conducting similar processes.

The alteration of local reality with a view to improving the quality of life there should also involve environmentally sustainable income generation. Thus the architectural solution found for the new housing there was to adopt buildings with a set of four

apartments but that did not clash with the patterns and typology of those already existing in the settlement. The buildings support a green roof in deference to the perceptions of residents' agricultural knowledge gleaned and appropriated in the meetings and from the interviews. Other mechanisms to capture solar energy and to capture and re-use rainwater were very well received by the residents. It must be underscored that the rainwater reservoirs help to enhance resilience to the hydrological extremes, namely, floods and water shortages. The proposed solutions are set out schematically in Figure 5.

The green roofs are destined for the production of food plants that can be sold in the local markets. One of the positive consequences expected from the adoption of this solution is an increase in income stemming the use of the roofs as spaces for cultivating plants thereby helping to minimize vertical expansion and community densification. Other aspects worth mentioning are the improvement in the population's nutritional standards, a reduction of the temperature inside the residences in the light of the local climatic conditions, the stimulation of sustainable productive activities within the settlement area and improvements in the relations with the middle class residents living in the surrounding areas. The quest for greater sustainability of the urbanization through the practice of family agriculture has been addressed by Dos Santos *et al.* (2014). The positive consequences of adopting green roofs can be examined in greater detail in the literature of Mary *et al.* (2008) in which there are descriptions of the results of experiments with green roofs carried out in the Teófilo Moreira da Costa Municipal School located near the settlement and which was also the site of actions of the HIDROCIDADES project.

Figure 5- Schematic longitudinal section of the multi-family dwellings.



The project stages have been set out in the form of an action flow chart (Figure 2) with particular importance placed on the consolidation of information about the population under study which can orientate the process in more dynamic manner (LEITÃO, 2007). It is believed that this flow can be reproduced entirely or partially in the light of Poletto and Merton's (2007) observation of the similarity that exists among the peripheral areas of the big Brazilian cities where there are large settlements with a high degree of socio-environmental vulnerability.

Conclusions

The insufficiency of the classical approach to urban infrastructure projects in the light of population growth dynamics and the expansion of urban areas that took place in the 20th century has been widely acknowledged. The question of climate change and the increasing frequency of natural disasters and extreme hydrological situations (floods and water shortages) have served to aggravate the problems. The most vulnerable population segments in the developing countries are those living in communities of informal settlements especially in the peripheral areas of big cities where infrastructure is naturally more precarious, and others living in coastal areas subject to the effects of the rising sea level. Since the 1990s, there has been an expansion of the proposals of Best Management Practices in the form of new models for urban development generally referred to as Low-impact Urban Development which aims to improve rainwater management processes by means of participative processes and due recognition of the environmental value of rainwater and of its infiltration and conservation. One of the initiatives under that heading is LIUDD which originated in New Zealand. This paper presents a methodological contribution in the form of a framework for applying LIUDD adapted to local realities of communities of social concern, especially in the coastal region known as the Baixada de Jacarepaguá into which the city of Rio de Janeiro is expanding. To consolidate the proposal, its application has been demonstrated by means of a case study targeting the Community of Vila Cascatinha in the Vargem Grande neighborhood and lying in the basin of the Morto river. The new urban design presented showed that it was possible to adopt low environmental impact urban development measures in *favelas* and informal settlements. The innovative nature of the work is underscored but, nevertheless, it does not offend the fundamental principles of classic urban design and implantation of water supply and basic sanitation infrastructure.

If due respect is paid to specificities, then it is believed that the proposed framework can be applied to other areas of informal settlement reducing the vulnerability and enhancing the resilience of such populations in the face of hydrological extremes – floods and water shortage, with a view to achieving fairer and more sustainable urban development.

Notes

- i Since 2012, the project has received financing from the FINEP [Studies and Projects Financer] by means of the BRUM [Mixed Use Basins Research Network] administered by the FUNCAMP. In 2010 it received funding from the FAPERJ, in 2010 and 2011 from the CNPq and from 2007 to 2009 again from the CNPq.
- ii The non structural solutions referred to are those that consider the patrimony constructed in the city's informal spaces as something that can and should recuperated and made good use of.
- iii The importance of valuing the level of information of the locality to be worked in was stressed by Souza et al. (2012).
- iv The question of developing more in-depth field work and research with a view to promoting the integration of scientific knowledge and traditional knowledge as part of an effort to alter local reality was addressed in detail in Neffa et al. (2011).

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METHODOLOGICAL PROPOSAL FOR REDESIGNING INFORMAL COMMUNITIES — CONSTRUCTING RESILIENCE IN HYDROLOGICAL STRESS CONDITIONS

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Abstract: The paper presents a methodological proposal in the form of a framework for redesigning informal settlements based on Low-impact Design and Development methodology. It involves the management of rainwater through the implementation of urban infrastructure on local scale in a decentralized and collaborative manner. It served as an object of study the region of Baixada de Jacarepagua, a vector of expansion of the city of Rio de Janeiro. The proposed framework adopts Action-Research methodology. The stages envisaged in the framework are: (i) initial, which involves approaching the community, establishing bonds and setting up a management group, (ii) diagnosis, and (iii) project. The application of the framework is demonstrated by means of a case study of the community, which typifies the slums in areas of marshland and the peripheral urban landscape. It is believed that this framework can guide the urban redesign of other communities within the perspective of sustainable development.

Keywords: Urban design, informal settlements, the management of rainwater, Low Impact Urban Design

Resumo: Apresenta-se proposta metodológica na forma de um *framework* para redesenho de assentamentos informais baseado na metodologia de Desenvolvimento Urbano de Baixo Impacto Ambiental. Envolve a gestão das águas pluviais por meio da implantação de infraestrutura urbana em escala local, de forma descentralizada e participativa. Serviu como objeto de estudo a Baixada de Jacarepaguá, Rio de Janeiro, região caracterizada como vetor de expansão da cidade. O *framework* proposto segue a metodologia da pesquisa-ação. Entre as etapas principais previstas no *framework* destacam-se: (i) inicial, que se caracteriza pela aproximação da comunidade local, formação de vínculos e do grupo gestor, (ii) diagnóstico, (iii) Projeto. Demonstra-se a aplicação do “*framework*” a partir do estudo de caso da Comunidade Vila Cascatinha, que tipifica os assentamentos informais de regiões de baixada e de paisagem peri-urbana. Guardadas as devidas especificidades acredita-se que

este *framework* poderá orientar o redesenho de outras comunidades dentro das perspectivas do desenvolvimento sustentável.

Palavras-chave: Redesenho urbano, Assentamentos informais, Gestão das águas pluviais, Desenvolvimento urbano de baixo impacto.

Resumen: Se presenta propuesta metodológica, como un framework para rediseño de asentamientos informales basados en la metodología Desarrollo Urbano de Bajo Impacto Ambiental. Trata de la gestión del aguas pluviales a través de la implementación de la infraestructura urbana en la forma local, descentralizado y participativo. Sirvió como objeto de estudio la Baixada de Jacarepaguá, Río de Janeiro, una región caracterizada como vector de expansión urbano. El framework propuesto sigue la metodología Pesquisa-Ação. Las principales medidas previstas son: (i) inicial, se caracteriza por el enfoque de la comunidad local, los bonos conformación y el grupo de gestión, (ii) diagnóstico, (iii) Proyecto. Se demuestra la aplicación del “framework” en el estudio de la comunidad Vila Cascatinha, que tipifica barrios pobres de la región y el paisaje periurbano. Teniendo en cuenta las especificidades se cree que este marco puede guiar el rediseño urbano de otras comunidades dentro de la perspectiva del desarrollo sostenible.

Palabras clave: diseño urbano, asentamientos informales, gestión de las aguas de lluvia, diseño urbano de bajo impacto.
