Water+: from informal to water-sustainable, from water-sustainable to water-provider

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Abstract

Mexico City is situated on an elevated valley surrounded by a ring of mountains within an endhoreic basin. The urban area continues to steal land from an ancient lake and the surrounding foothills. Two of its most significant environmental issues, are the simultaneous lack and excess of water – the paradox of an increasingly thirsty metropolis, developing within a flood plain.

Major infrastructure has been built over time to extract seasonal rainfall and sewage out of the valley, and even larger infrastructure has been introduced to import water from adjacent basins to complete the insufficient and over-exploited aquifer extraction. However, the city is still unable to satisfy the needs of its over 20 million population.

Rainwater falling on the surrounding hills infiltrates the soil, to refill the aquifers, and runs through streams that go into the sewage system when entering the urban area. Informal-settlements grow on these foothills, occupying former co-opted lands. They have gradually consolidated, progressively achieving basic urban infrastructure and legal ownership of the land, but they still face acute water scarcity and have a negative influence on water running downstream.

This project conducts a study of one of these communities. It analyzes its water balance and its physical and socio-economical conditions in order to produce alternative solutions. First, one where water needs can be provided through rainwater harvesting and water reuse: Water Zero. A second one, where the negative influence on water running out reverts to become a clean water source for downstream communities: Water +.

A non-governmental organization (Isla Urbana) working within the community has developed and installed appropriate rainwater harvesting systems. Through the evaluation of its vision, methods and performance, this

project aims to produce a community action project methodology that can provoke the community's evolution towards water sustainability.

1 Introduction

Mexico City's water infrastructure is not large enough to provide drinking water to its almost 20 million people and it is not up to the task of evacuating the enormous volume of seasonal rainfall.

Mexico City's valley is situated 2240 meters above sea level. Its original lake has been artificially drained to provide growing space to one of the world's largest cities. From Tenochtitlan, the Aztec lake city, to today's megalopolis it has gone through several very different growth phases. In the 1970s, the population increased by a factor 4 times in just ten years. That growth spurt was so severe that the city has been struggling and failing to provide needed infrastructure ever since.

People outside the formal real-estate market have developed informal settlements on any free land they have found: land without basic urban services, often in risky areas or within environmental protection zones. These slums have developed at high speed in Mexico City's periphery and have undergone alternating periods of repression and tolerance from the city's authorities.

Many of these settlements have by now acquired basic services like a water distribution network, paved streets, schools and small clinics through community organizing, but some still lack these most basic features. The installation of water networks does not mean people have running water in their homes. The service is intermittent at best, and weeks can go by without water coming out of their faucets.

District authorities or "Delegaciones" truck water tankers up to these areas and people store water in plastic containers. But not even this municipal supply is enough and neighbours have to organize and privately buy additional water to satisfy their needs, consequently paying the highest price per litre of water in the metropolitan area.

The mountains that surround Mexico City's valley are covered with forests through which springs and rivers run: a precious source of clean fresh water that feeds the lake system. Like other cities around the world, Mexico City grew swallowing its rivers, transforming them into sewage, eventually covering them up for hygienic reasons and to give way to avenues and freeways that ease urban traffic.

The sewage filled pipes that replaced the original rivers are emptied through an opening that exits the water basin. They feed an artificially created irrigation district in the neighbouring state of Hidalgo, from where they flow into the Gulf of Mexico.

Many of the informal settlements have developed on the foothills of the valley's surrounding mountains, colonising forests where rainfall is more abundant. Evidently, this has had a detrimental influence on the environment;

waterproofing precious water infiltration land, accelerating and expanding storm water flow to the central city, polluting the springs and rivers that still run downstream.

Up until the last 30 years, the valleys, foothills and mountains on Mexico City basin's south and north have been the city's main natural reserve zones. These natural areas had been spared by urban settlements' expansion, but they have been gradually occupied for urban use since then. According to Mexico City's Land Management and Environmental Attorney (PAOT), Mexico City's urban sprawl has swallowed one hectare of forest per day through the last 60 years and 76% of the new houses dating from 1980 to 2000 were built on "Conservation lands".

This "Conservation Land" is a protected natural reserve that belongs to the "Corredor Biológico Ajusco-Chichinautzin" one of the world's primary nature conservation regions for it houses 2% of the world's biodiversity and provides almost two thirds of the water used in Mexico City's Metropolitan Area. Ancient Mexicans clearly understood the importance of this forest, naming it "Ajusco" from the Nahuatl word *Axosco* which means "where water springs" or "water forest" [1].

It is clear that continuing colonisation of forest lands would be disastrous and the Informal City spread needs to stop, but even if it did, future development and growth of existing communities is a fact we need to address as architects and urban planners.

As planners we are looking for opportunities that can trigger alternative ways of development. We want to find ways to help our cities become sustainable. Around the world, the need to develop models that guarantee a satisfactory quality of life for everyone within the natural limits of our planet has inspired the conception of new neighbourhoods. Newly recovered railroad or industrial brown-field lands in different European cities are providing urban opportunities within downtown districts. Many of these opportunities have given way to sustainable urban developments. In the Mexico City Metropolitan Region (ZMCM, for its Spanish initials) communities whose infrastructure problems need an immediate solution, the need for clean fresh water can be the engine for evolution to an alternative sustainable way of using water and can provide this urban opportunity.

Understanding that these communities are fertile soil for sustainable urban development in Mexico City and for all the people living at the margins of the global south's emerging cities, this project aims to find how we can empower a particular community and accompany it towards an alternative sustainable water management. This management incorporates rainwater harvesting and storage, local storm-water management and water treatment; reverting the negative influence on the springs flowing downstream to provide the full community's water needs and to become a fresh water provider through clean down flowing streams: Water Plus.

2 Informal settlements in Mexico City

"A slum is not merely an area of decrepit buildings. It is a social fact" [2].

More than a billion people live in informal cities in today's world; and a billion more are expected to move in [3]. Informal settlements occupy 40% of the total ZMCM's territory and form 52% of its housing zones. They are between 10 and 22 years old (Environment Secretary SME Environmental Protection Program for the Federal District 2002–2006) and 20% of them are estimated to occupy high-risk zones on cliffs or riverbeds. 68% of these irregular settlements are on three Delegations: Tlalpan, Cuajimalpa and Xochimilco [4]. All three delegations are mostly on "Conservation Land"

Different attitudes to the sprawl of Informal Settlements have produced different reactions from the city authorities. They have been considered an urban sickness, leading to "bulldozer" action, but they have also been acknowledged as a complementary counterpart to the formal economy in developing countries. For Abrams (1964, 1966) informal settlements have to be understood as the result of people's struggle for housing, a struggle that should not be ignored; on the contrary it should be capitalized (see [5] for details). This later vision has led to regularization and urban infrastructure introduction programs for illegal settlements. The World Bank and the United Nations have promoted and financed these kinds of policies.

Resilience is the ability of a system to absorb disturbance and still retain its basic function and structure. In a world threatened by economic crisis, depletion of natural resources, diminishing biodiversity and climate change, sustainability depends on resilience [6].

Informal settlement's resilience is based on an enormous capacity of self-construction after disasters. Being deprived of the most basic tenure of their premises, the poor of global slums have hardly any rights, yet they live in an ecosystem where nothing is wasted, nobody is unemployed and things somehow work. Their study and the lessons to be learnt to improve their needs in security, health, energy, food, water, might be essential in determining the resilience of our future urban ecosystems [6].

In Mexico City's foothills, informal settlements on "Conservation Land" affect the entire ZMCM's access to vital resources. There are not many options when trying to find a balance between the needs of all the citizens. Are their alternatives to the informal settlements' repression and eradication if we want to reduce their impact on the natural balance of the forestlands?

In the ZMCM, eight million residents suffer from inadequate water supply, many of them waiting weeks or months for a single drop of water to fall from the faucet [7].

Need drives action, action drives learning, creating community leadership which can affect positive change. Communities within the informal city have developed grassroots initiatives that have been able to obtain official ownership of the land for their residents. After organising and obtaining some basic services they have kept on working to become a place where the next generation can expect a better quality of life.

The rational use of resources is already part of the Informal Settlements' culture. These settlements have understood before others that water resources are limited and have adapted by adopting rational water use habits. In order to be able to become a Water Zero community it is primordial to acknowledge the scarcity and preciousness of clean water. This consciousness is part of the Informal City culture.

Understandably, the detrimental influence of these communities on the basin's water resources is not yet a source of preoccupation for people whose priority is still surviving every day. One way to change this attitude can be to reward them for their positive influence on their urban context. Rewards can take the form of "Environmental Services Payments" or even the creation of jobs related to water harvesting, treatment and reuse. Creating a purification and distribution of bottled drinking water could also become an interesting source of income for them.

We can learn from informal settlements, from this non-official unplanned processes or "Emergent Urbanism". Emergent urbanism contrasts, or at least complements conventional urban planning. The "emergent" surges mostly in a self-organized way and as a consequence of interaction and collaboration of diverse human groups. Citizen participation is an engine of the whole process, starting as debate and deliberation and more importantly turning into direct action to build the city [8].

3   Water zero and water plus communities

The concepts of "Water Zero" and "Water Plus" are analogies of "Zero Energy" and "Positive Energy Building" ones. The Zero Energy concept refers to buildings that use zero fossil energy, or only renewable energy, in order to fulfil their comfort demands throughout the year. Positive Energy buildings are Zero Fossil Energy buildings that are able to produce more renewable energy than needed. These buildings can provide that excess energy to other users. In temperate climate developed countries high energy needs in buildings have been addressed by initiatives that promote these concepts.

Communities throughout the world are using more than their renewable water resources; they are consuming their *fossil water resources*. Many of these communities in the developing world are still not being able to supply potable water to their entire population.

Our cities' water systems were conceived in a different historical moment, in an era where resources seemed unlimited. Deep changes are taking part today. Our collective vision of the world is different from the one our predecessors had when designing the urban systems we live in. Further changes are expected with climate change: rising global temperatures are expected to deepen water scarcity problems that already exist throughout the globe.

Today's urban metabolisms have increasing resource needs and produce more and more excreta. We need to radically change the way we conceive our urban systems in order to keep our urban ecosystem resource needs within renewable source limits.

Water Zero and Water + communities' water management paradigm starts with the acknowledgement of the scarcity of potable water: Rainwater is no longer overlooked as a primary water source. All the water that can be caught on clean surfaces is harvested and stored. Water falling on streets and other impermeable surfaces does not run-off downstream to join other communities' storm-water in the city's sewage system. Run-off water stays in appropriate spaces where it can infiltrate naturally into the aquifers before it gets polluted while travelling through miles of streets down to the sewage. The community understands the environmental service it can give to the entire water basin by stopping this rainwater from flowing into the sewage and by letting it refill the underground water sources because it gets remunerated for it.

By being conscious of the big benefits rainwater can bring to the community, the way used-water is looked upon changes as well. Treating and re-using water has a very important freshwater saving potential. Awareness of the real value of clean water makes people realise they don't want it for activities where treated water is perfectly efficient. High demand water uses like garden irrigation or toilet flushing can be perfectly covered with appropriately treated water.

Within Water Zero and Water + communities, resource needs are reduced and fulfilled using renewable sources. Excreta are reduced to zero through treatment and re-use.

4 Working within the community

Architects must be advocates for users, agents of change. This change must be accomplished thoughtfully and carefully, one step at a time, so as to be viable and sustainable [9]. Design and technologies for sustainable development have to be effectively appropriated whilst responding to the social needs and the realities of the beneficiaries [10]. Being an "agent" of change and not an isolated "product creator" is crucial to the product's future acceptance and appropriation by its final user. Complex urban strategies cannot be created in-vitro in a laboratory without the direct participation of the future users.

"Emergent Urbanism" can be more than informal urbanism. In informal urbanism the social and urban organization processes happen without planning ahead. The "Design Thinking" methodology can be a good tool to create the conditions where this kind of organic processes can flourish [8].

"Design Thinking" is an emerging model that approaches the most different realms, from business models to services or conflict resolution models. In this model, design appears as a meta-discipline, as a strategy to approach and solve problems. Designers within this approach can be understood as "integrators" or "agents" of different disciplines and people. This role becomes especially useful when solving complex problems that require creative and interdisciplinary solutions.

The "Design thinking" methodological model has these basic characteristics: it is collaborative; it is based on successive divergence and convergence cycles; it is experimental; it is integrative.

There are three basic processes in "Design Thinking":

1. User experience.
We need to understand the city from the citizen's point of view, from his/her daily life situation (and from all points of view coming from diverse citizens). We need observation and representation methods that can picture this reality. We need to go beyond the information we can find on surveys or demographical data to get to know the citizens more "personally".

2. Prototyping
Design prototypes should be developed and then tested, modified and made better continuously. Small scale projects can be developed and then replicated virally.

3. Storytelling
In order to provoke active participation in a project and its viral spread, it has to be communicated to other citizens. In this communication, visual language is of capital importance. The story has to be told in an attractive, convincing and simple way.

In "Design Thinking" the designer goes from being responsible for the creation of products or contents for the final user to the one who generates processes and/ or structures where final users can participate in the development of the products or contents. In order to obtain the best results via the creation of innovative and resilient organizations we should design the contexts within which social interactions, individual and collective work can thrive [8].

Isla Urbana is a Non-Profit Organization that works within the informal settlements on the Ajusco's foothills in Mexico City. Isla Urbana's team has developed a low cost, easy-to-install rainwater harvesting system which is installed on individual households. These RWH systems provide a family with about 50% of their annual water need. They are developing a method of widespread implementation of rainwater harvesting in Mexico City. This implementation method includes training local plumbers, using only local materials, and working closely with the beneficiaries to train them on the maintenance and use of their system. Isla Urbana's RWH systems are low-cost, are installed in about one day, are easy to maintain, and provide clean water for all household uses.

The non-profit organisation is a multidisciplinary team of designers, engineers, urbanists, and sociologists who work closely with the community, local businesses, non-profits, non-governmental organisations, and the Mexico City government to facilitate the widespread adoption of rainwater harvesting as a viable solution to the water crisis [7].

Through Isla Urbana's presence and methods "Water Zero" and "Water Plus" strategies will be developed using "Design Thinking" processes. Opportunities will be deeply documented in-situ in order to co-develop prototypes that will be validated and corrected with the beneficiaries. This working methodology itself will be tuned and validated throughout the project.

5   Opportunities

The strategic key to sustainable development resides on a culture of environmental resource value within the citizens, and not on some supplementary technical prostheses [11]. We believe that only citizen participation and understanding will permit sustainable water management in informal communities. The technologies we introduce are mere tools that will need to continue their evolution and redesign to continue adapting to new water management paradigms that arise over time.

A preliminary water-balance analysis of a small community within the informal settlements on "Conservation Land" of the Ajusco foothills indicates that the entire water needs of the population can be provided through rainwater harvesting alone from June to November. If we additionally include re-use of treated water for toilet flushing, exterior cleaning and yard irrigation, rainwater alone can cover the community's full water needs all year round. (Data used for the preliminary analysis: water needs are 120lt/person/day, Tlalpan's yearly average rainfall is 944mm – the local rainfall should be higher. Water use is supposed based on studies done by WWF in Belgium: 35% for showers, 35% for toilet flushing, 14% for clothes washing, 7% for dishwashing, 2.5% for drinking and cooking, 6.5% for other uses: cleaning, watering. Urban surfaces were calculated using information found in public GIS and Ortofotos made available by INEGI. Demographic information comes from the same source. These data has to be validated in-situ to produce the water-balance to use for design purposes.)

This preliminary balance has to be validated with more precise data obtained through fieldwork but it already suggests interesting opportunities. Hypotheses drawn from this study have to be proved to provide the basis for the first prototypes. These prototypes will become the starting block for community workshops where they will be once again validated and corrected and become the departure point for this *sustainable water use revolution* or *blue revolution* as Isla Urbana calls it. In these workshops stakeholders from the community, environmental protection institutions, City Authority representatives and other organisations can sit together with the designers to define the appropriate strategies.

6   Conclusion

"Territory is a work of art. Maybe the most noble and the most collective work of art humanity has ever made…Territory is the product of a dialog between living entities, humankind and nature through history" [11].

This paper notes that the presence of informal settlements in the Ajusco foothills creates significant resource problems that need to be addressed to arrive at a sustainable solution, and that such a solution will only come about through a holistic approach that involves the inhabitants themselves and their power to influence their own urban environment.

Reciprocal learning takes place, we learn from the settlement's resilience, organisation and self-building capacity and the community enhances its awareness on its influence on the natural and urban contexts within which it exists.

Houses in Mexico City's informal settlements are not built to comply with building codes and without getting any sort of building permit, and yet, the basic building module, a 4m by 4m, 3m high room is put together with the proper columns and beams for adequate earthquake resistance. We assume such earthquake building know-how is passed by word of mouth by the many construction workers that inhabit and self-build the settlements. This knowledge is now part of the informal settlement's culture and houses will continue to be built this way without any need of external intervention.

And this is exactly the goal of the approach we're proposing, to work holistically with the community to get to a point, a day when without knowing who, how or when these "ways of using water" were introduced, they will reproduce themselves sustainably and durably, adapting to new times and uses.

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