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Environmental improvement to reduce urban vulnerability in irregular settlements

Mejoramiento ambiental para disminuir la vulnerabilidad urbana en asentamientos irregulares

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Abstract

The peripherals illegal settlements in Puebla, have common denominator to born in a situation of urban vulnerability, it means with a lack of infrastructure and basic services and on some occasions on land not suitable for urbanization. This is the case of the Cuitláhuac neighborhood where approximately 400 inhabitants live. The neighborhood only has electricity service, his high urban vulnerability becomes worst in the rainy season with the formation of gullies, flooding sites and soil erosion, affecting the mobility of the inhabitants. Authorities ignore these problems and not always included them in urban development plans. The objective of research is to look for environmental alternatives to reduce urban vulnerability in illegal settlements. The methodology is based on action research and the main techniques were: documentary review, physical and virtual field trips, virtual meetings and semi-directed interviews. A relevant conclusion is that green infrastructure is feasible and can be implemented in the short term and that it arouses much collaborative interest from the inhabitants both for its implementation and for its maintenance.

Ilegal settlements, Urban vulnerability, Green infrastructure

Resumen

Los asentamientos irregulares de la periferia poblana, tienen el común denominador de nacer en situación de vulnerabilidad urbana, es decir, con carencias de infraestructura y servicios básicos y en algunas ocasiones sobre terrenos no aptos para urbanizar. Este es el caso de la colonia Cuitláhuac, donde habitan aproximadamente 400 habitantes. La colonia solo cuenta con el servicio electricidad por lo que su vulnerabilidad urbana es alta y se agudiza en temporada de lluvias con la formación de cárcavas, sitios de anegamiento y erosión del suelo afectando la movilidad de los habitantes. Las autoridades suelen hacer caso omiso de dichas problemáticas y difícilmente son incluidos en los planes de desarrollo urbano. El objetivo de la investigación ha sido buscar alternativas ambientales para disminuir la vulnerabilidad urbana en los asentamientos irregulares. La metodología está basada en la investigación acción y las principales técnicas utilizadas fueron: revisión documental, recorridos de campo físicos y virtuales, reuniones virtuales y entrevistas semidirigidas a actores clave. Una conclusión relevante es que la infraestructura verde es factible y puede implementarse en el corto plazo, y despierta el interés colaborativo de los habitantes tanto para su implementación como para su mantenimiento.

Asentamientos irregulares, Vulnerabilidad urbana, Infraestructura verde

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Introduction

Urban peripheries have become the recipients of the growth of cities, where many times this expansion was carried out without the provision of the necessary infrastructure and services. In the municipality of Puebla, it is estimated that about 65% of the urban sprawl was generated by settlements with some type of irregularity (Flores, 2017).

Several authors (Bazant, 2004, Alguacil, 2013, Flores, 2017) have pointed out how urban peripheries tend to grow in a disorderly and functionally disjointed manner from urban centres, with strong deficiencies in facilities, services and infrastructure. They show that they are conceived from their origins in conditions of institutional, social and urban vulnerability. Vulnerability can be defined as the propensity of a society to suffer harm or to be harmed, and to encounter difficulties in recovering afterwards, so that it does not refer to the existence of an established critical situation, but rather, to the set of conditions of risk, fragility and disadvantage that would make possible the entry of that critical situation of disadvantage (Lavell, 2001).

The above characteristics are identifiable in the irregular settlement of Cuitláhuac, located in the south-west of the city of Puebla. It is situated on a terrain with irregular topography, specifically on the slope of a hill whose slope drains the rainfall through the colony to the lowest levels. Its irregular character places it outside of the institutional development plans, making it invisible to the municipal authorities, which has caused it to be currently only served by electricity. Lacking, among other things, drainage systems that allow for the proper management of rainwater, it is conducive to the formation of waterlogging and flooding sites, a problem that is exacerbated by having only dirt roads, thus affecting the mobility and accessibility of the inhabitants. Studies such as those by Flores (2017) and Patiño (2004) have observed irregular settlements in the Puebla-Tlaxcala metropolitan area, generally from the point of view of marginality, poverty and lack of services and infrastructure, and even when their situation of urban vulnerability has been pointed out, their contributions have focused mainly on reflecting on institutional aspects, on the lack of municipal action and their exclusion in planning frameworks.

However, no work was found that focused on analysing aspects related to urban improvement through environmental alternatives, particularly green infrastructure as an innovative element that contributes to the substitution of grey infrastructure for rainwater runoff management.

The work was developed under the hypothesis that, with the collaborative work of the population, aware and informed about the importance of the environmental services that nature provides, green infrastructure techniques can be designed and implemented to reduce their vulnerability. The objective is to show the main results on urban vulnerability in Cuitláhuac as well as the work carried out with the inhabitants to develop a green infrastructure project and start the work for its implementation.

The paper is composed of four sections. The first develops theoretical approaches to urban vulnerability in irregular settlements and the importance of green infrastructure with social participation to reduce it. The second section analyses and diagnoses the conditions of urban vulnerability in the Cuitláhuac colony. The third section identifies viable green infrastructure to improve urban conditions in the face of risk, as well as the participatory process for its initial implementation. In the fourth section, the discussion leads to the conclusions.

Methodology

The methodology is qualitative, based on action research, which consists of developing mutual learning processes between the different actors involved in the problems in order to analyse and mitigate them through collective learning (Flores, 2018).

Three physical field visits were carried out to diagnose urban vulnerability and risk situation. To complement the above, Geographic Information Systems were used for the spatial analysis of terrain topography and runoff dynamics using mainly available vector datasets. Two virtual meetings were also held with the board of directors and some inhabitants (due to the COVID-19 pandemic) to inform, elaborate the project and make agreements to carry out revegetation actions.

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Semi-directed interviews were conducted with key actors to understand their organisational situation, their relationship with public institutions and the conditions for carrying out environmental actions. A documentary review was also carried out on vulnerability in peripheral areas, green infrastructure and social participation, as well as local official instruments on irregular settlements and risk.

Vulnerability in irregular settlements, a long term constant

Urban vulnerability, according to Ochoa and Guzmán (2020), refers to three basic aspects: the environmental risk conditions (due to poor topographical conditions or conditions prone to natural disasters or located in risk areas for human activity) in which some sectors of the population are settled, which makes them insecure; poor habitability conditions, i.e. a degraded urban-architectural environment; and deficiency in the coverage of basic services and infrastructure and equipment. These differentiated characteristics of society or subsets of society predispose human settlements to suffer damage when faced with the impact of an external physical event, making their subsequent recovery difficult (Alguacil, 2013).

Irregular settlements (IA), when established spontaneously, outside of urban planning, are vulnerable because they do not have the urban conditions to settle and are often located on land that is not suitable for urbanisation. In addition, transactions are private between seller and buyer without being recorded in the land registry, which prevents them from being taxed or provided with basic services (Bazant, 2004). The criteria established by the regulatory framework for the regularisation and incorporation of this type of settlement into urban development has excluded them from the right to urbanisation, leaving them behind for an indefinite period of time (Silverio, 2020) and invisible to state institutions.

In the search for solutions to their housing needs and the provision of basic services (water, electricity, drainage and sewage), they form leaderships or form relationships with organisations that help them to manage these needs. Some political organisations take advantage of the solidarity and need of the inhabitants, turning them into objects of manipulation (Silverio, 2020) in exchange for the introduction of basic services. This condition leads to a lack of autonomy in decision-making, which recreates a form of social vulnerability which, according to Sánchez (2011), corresponds to the set of characteristics that a person or group has, which determine their capacity to anticipate, resist and recover from the impact of unforeseen events.

Green infrastructure as an environmental alternative to reduce urban vulnerability

Accelerated urbanisation processes reduce open spaces in urban centres, which leads to a series of problems such as minimal groundwater recharge, reduced infiltration and increased runoff, causing flooding, decreased biodiversity, urban heat island effect, and in general a reduction of environmental services (Peñúñuri & Hinojosa. 2017). In irregular settlements, conventional urbanisation patterns are commonly followed, giving priority to the implementation of impermeable elements such as the use of asphalt and hydraulic concrete, which reduces the infiltration capacity of rainwater and increases the risk of flooding.

Faced with this problem, the use of green infrastructure has become a viable alternative to move towards sustainable forms of city-making and address urban vulnerability. According to Benedict & McMahon (2006) it is defined as an interconnected network of natural areas and open spaces within cities that preserve the functional characteristics of natural spaces and provide a wide range of benefits to people and wildlife, within the ecological framework for environmental, social and economic health. Green infrastructure has an impact on the increase of green areas and open spaces in cities and therefore of catchment and infiltration areas, reducing stormwater runoff, preventing the overflow of grey drainage systems, flooding and the saturation of urban watercourses.

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At the same time it fulfils multiple functions, brings a wide range of socio-environmental benefits, and also according to Peñúñuri & Hinojosa (2017) these alternatives are often more economical compared to conventional measures.

The need for social participation

Peñúñuri & Hinojosa (2017), indicate that it is necessary to include citizen participation in the realisation of the different stages of design and implementation of green infrastructure, taking into account its ease of construction and implementation. Furthermore, integrating the community in such processes promotes a sense of ownership of the space, and the likelihood of perpetuating its maintenance and operation.

Considering that irregular settlements are generally organised for the demand of their basic needs and services, it highlights the possibility of taking advantage of these pre-established organisational networks to implement this type of measures. At this point, the collaborative action of universities and governmental institutions play a fundamental role in transforming thinking and putting environmental alternatives into practice, allowing progress to be made towards empowerment to solve problems. Likewise, acting on a small scale is a more apprehensible opportunity to get closer to the inhabitants, for the understanding and resolution of territorial problems through participatory action (Flores, Guevara, & Milán, 2018).

The Cuitláhuac colony

This study focused on the colonia Cuitláhuac (Figure 1), an irregular settlement established in 2010, located southwest of the city of Puebla, at a distance of 17 km from the historic centre, within the municipality and state of the same name, in Mexico. It currently has approximately 400 inhabitants (Silverio, 2020) and a surface area of approximately 17 hectares.

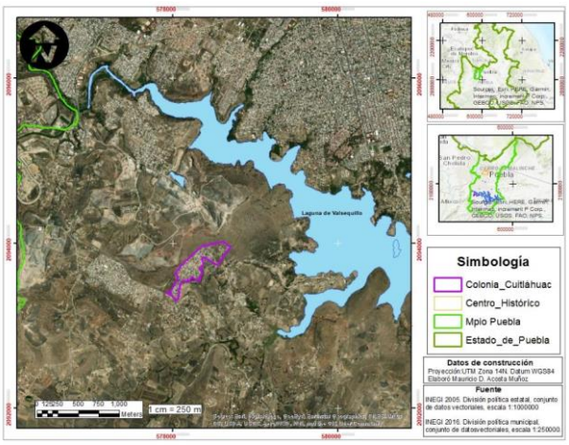

Figure 1 Location map of the colony Cuitláhuac
Source: Own elaboration based on the State and Municipal Political Division of INEGI (2010.)

In the colony Cuitláhuac, according to Silverio (2020), the economically active population amounts to 53% of the colonos, of which 36% have an average monthly income of 250 USD, 26% have an income of 150 USD, another 26% have an average income of 350 USD, while 13% have an income of less than 100 USD per month. Only 3% of the inhabitants earn 450 USD per month. Given these conditions, the inhabitants found it viable to buy cheap lots in the periphery, which had its origins in the sale of ejido land in San Andrés Azumiatla, Puebla, to the organisation Antorcha Campesina (AC), which then lotified and sold the land. It also assumed control over decision-making and actions in Cuitláhuac, where the president is appointed directly by this organisation. AC also manages the infrastructure and services for the improvement of the settlement before the local governments, violating the autonomy of the colony.

The institutional inability (and convenience) to incorporate irregular settlements into urban development programmes excludes Cuitláhuac from the provision of basic services. This situation is worsened by the limited equipment and personnel available to state institutions, which is reflected in a deficient coverage of their functions over the territory, leaving the Cuitláhuac colony outside the scope of institutional programmes.

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Currently, only 60% of the colony has electricity service, and eight years ago an attempt was made to implement a drainage system, with 50% progress, but this was not achieved. In 2014, the drilling of a well to provide drinking water to the community began; however, this work only left the registration of the deposit, without giving continuity to the phases of the establishment of a supply network, so the water service is supplied through the purchase of pipes. The streets are unpaved, and get worse during the rainy season, have a poor mobile phone signal, lack of cleaning services and no street furniture.

In Cuitláhuac, urban vulnerability due to environmental risk is also observed because it is located on the slope of a hill near the watershed that delimits the micro-watershed, where the slope of the land has a northwest-southeast direction, with rainwater coming from the upper part of the micro-watershed, which crosses Cuitláhuac and incorporates its channels into the ravines near the settlement, whose immediate destination is the Valsequillo dam.

The lack of a sewage and drainage system, and of paved streets (Figure 2), cause rainwater to form gullies, soil erosion, waterlogging affecting some houses, as some infiltrations can be observed in the walls, and difficulties in the mobility of the inhabitants due to the formation of muddy areas (Figure 2).

Figure 2 Urban conditions in Cuitláhuac
Source: Author, 2021

The vegetation in the area before the establishment of the colony corresponded to induced pastures, alternating with annual rainfed agriculture (INEGI, 2016), however, with the establishment of the colony, the use of the land was changed to constitute a human settlement, removing the already poor vegetation. This increased soil degradation problems, affecting soil functions by decreasing the availability of nutrients and organic matter, reducing the rooting depth of plants, and thus decreasing the infiltration rate and water retention capacity.

Reducing risk with green infrastructure and social participation

A project was carried out with soil restoration measures and green infrastructure to limit water erosion, favour the infiltration of the tributaries, improve the characteristics of the soil and thereby reduce the problems caused by sudden floods caused by intermittent runoff. This is based on the establishment of living barriers and revegetation of the margins where rainwater runoff crosses the colony.

The living barriers consist of plantings of species in rows, arranged in such a way that they do not allow the free passage of runoff and sediments (CONAFORT, 2018), allowing the retention of silt and water infiltration, with the aim of collecting, spreading and reducing the speed and energy of the affluent, as well as its expenditure. This favours water infiltration and the development of native vegetation, favouring the restoration of degraded areas in semi-arid zones, on shallow, stony or compacted soils, characteristic of Cuitláhuac.

The revegetation of the runoff margins consisted of the establishment of plant species, preferably native and low maintenance, in order to establish an interconnected network of green areas, in order to restore the composition of the soil and thereby preserve the functional characteristics of natural spaces, providing benefits to people and wildlife.

The proposal was developed so that the inhabitants could implement it without depending on the authorities and was presented for improvement and strategies for its implementation. It was enthusiastically accepted and approved.

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In order to implement the living barriers and revegetation, we took advantage of the internal organisation of the colony, which carries out Sunday work to improve its streets, generally promoted by the organisation Antorcha Campesina. The first stage of the work consisted of placing live barriers between the streets Valle de Anáhuac and Av. Mexica, as this is one of the places where one of the rainwater runoffs crosses the colony. The actions consisted of planting 18 plants of the maguey espadín species (*Agave angustifolia*) and 10 of the maguey lechuguilla species (*Agave maximiliana*) (Figure 3).

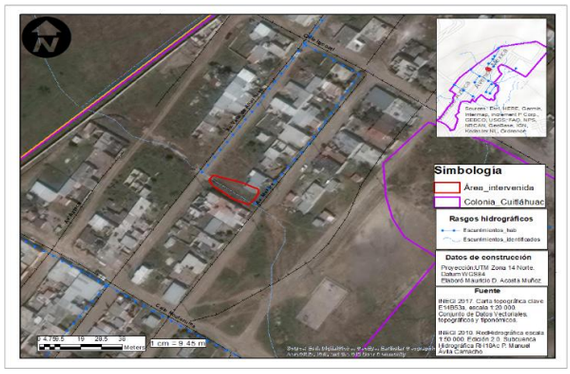

Figure 3 Area intervened for the implementation of living barriers
Source: Own elaboration based on topographic chart and hydrographic network RH18Ac from INEGI (2017 and 2010.)

The planting day was attended by around 35 people, with similar proportions of men and women, ranging in age from 20 to 59 years, but some children also attended. They brought their own tools such as shovels, picks and machetes (Figure 4).

Figure 4 Inhabitants of Cuitláhuac participating in the implementation of living barriers
Source: Author, 2021

The plants were arranged in such a way that they were perpendicular to the direction in which the river normally flows, taking advantage of the fact that, during the planting day, the runoff was dry, given its intermittent nature.

During the planting day, the active and enthusiastic participation of the settlers was observed. These actions aroused interest in addressing the lack of drainage infrastructure through the implementation of nature-based alternatives that they themselves can implement, such as green infrastructure, as a measure to help reduce the problems observed in the formation of waterlogging and mudflats within the colony. A second day was held to revegetate the banks of the same runoff as the first day, but on this occasion, 50 m upstream. Eighty blue agave plants (Tequiliana Webes var. azul) between 20 and 40 cm in height were planted.

About 35 people attended this day, approximately 20 women and 10 men and about 5 children. Prior to the planting of the agaves, a brief technical explanation was given on the benefits of the vegetation and how to plant it. The planting was carried out on the margins parallel to the site where the runoff flows, starting from the perimeter fence of the colony to favour infiltration, reduce the mass flow through the site and prevent the plants from being carried away by the current (Figure 5).

Figure 5 Conditions of the intervention site, where the runoff margins were cleaned and revegetated
Source: Author, 2022

The work days awakened interest in the care and maintenance of the intervened space, as they became aware of the benefits that this action will have on the management, infiltration and reduction of rainwater.

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In subsequent days, organised and directed by the settlers themselves, a growing interest in the care and maintenance of the plants was observed. In addition, they planted more plants in the area, in order to give continuity to the work of revegetation of the runoff margins.

Some of the inhabitants commented that they were pleased to participate in this type of activity, as it is an alternative to reduce their vulnerability due to the lack of infrastructure. Likewise, being part of these actions encourages the appropriation of their spaces.

Discussion

Most of the irregular settlements in metropolitan areas such as Puebla have only electricity and water services and it can take up to 20 or 30 years to have other basic services; however, they do not consider the provision of public space, sanitation systems and much less, infrastructure and services that help mitigate the different natural risks that may exist (Flores, 2017). The lack of basic urban infrastructure in the colonia Cuitláhuac is evidence of how these types of settlements are, from their origins, subject to different conditions of urban vulnerability, which is exacerbated by their social vulnerability and their illegal land ownership. Cuitláhuac has only had electricity for twelve years and the rest of the services have not been provided to date.

In addition to the above, it is environmentally vulnerable, and the irregular topography on which it is located plays a central role, as it makes urbanisation difficult and gives way to problems related to flooding and inundation, with adverse effects on the population in their daily lives. In terms of flooding, we cannot forget that climate change becomes a threat that exacerbates this vulnerability since, according to (Conde et al. 2021), climate change scenarios for the city of Puebla for the middle and end of this century point to an increase in temperatures and extreme precipitation patterns.

In this situation, the development of strategies that enable communities to manage their vulnerability and risk is fundamental. Da Cunha and Thomas (2017) point to the need to make them more syntropic in order to move from a state of vulnerability to one of adaptation to the environment.

In this sense, the use of green infrastructure and collective action are fundamental allies to provide solutions that are easy to implement and less costly than traditional grey infrastructure. Furthermore, according to (Vázquez, 2015) it has significant contributions to both mitigation and adaptation to climate change.

The process of revegetation and implementation of living barriers initiated in the Cuitláhuac demonstrates that actions can, according to Peñúñuri & Hinojosa (2017) start with small and simple applications, with multifunctional effects, taking into account that this type of infrastructure brings a wide range of social, environmental and economic benefits. On a small scale, the use of this type of engineering increases the capacity of spaces to offer basic services, without forgetting the improvement of the natural landscape. In addition, the participation of the inhabitants is paramount, as integrating the community promotes a sense of ownership of the space, guaranteeing the functioning of this infrastructure in the long term.

The technical university work and the participation of the inhabitants of the irregular settlements contribute to the community becoming active and taking ownership of the space, contributing to the sustainability of the green infrastructure. As Borja (2019) says, active citizenship is the hope, from the neighbourhoods and from the cities, through, among other things, popular initiatives based on a dialogue between professionals and citizens that makes it possible to advance in the possibility of building a practical ethics.

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Conclusions

Given the vulnerabilities found in Cuitláhuac, the use of green infrastructure proved to be an important ally in reducing urban vulnerability, as it can be implemented in the short term and at a lower cost. This type of infrastructure could be implemented without government intervention, using the pre-established organisational structures in the colonia.

The university plays a fundamental role in the dissemination of knowledge and application techniques, as it is a trustworthy institution and facilitates links with the inhabitants, who are open and available for collaborative work. From the initial accompaniment of the university with the inhabitants, environmental actions were continued in an autonomous manner by the settlers, that is to say, collective work to reduce risk was perpetuated. This was based on an incipient awareness of their situation of vulnerability and risk.

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