Using Green Stormwater Infrastructure Retrofitting a Low Income Community into a Climate Resilient Neighborhood

Utilisation d'une infrastructure verte de gestion des eaux pluviales pour la modernisation d'une communauté à faible revenu vers un quartier climatiquement résilient

Nian She*, Hui Chen** and Xiaolin Zhong**

* Guangzhou University, 230 Wai Huan Xi Road, Guangzhou Higher Education Mega Center, Guangzhou, PR China 510006. nianshe@gzhu.edu.cn

** China Machinery Technology Design Institute International Engineering Co. Ltd. No. 18 Mid. Shaoshan Rd., Changsha, PR China 410000. irenechan@126.com

RÉSUMÉ

Les inondations causées par l'urbanisation rapide et le changement climatique sont devenues une menace majeure dans de nombreuses villes à travers le monde. En particulier dans ces zones urbaines à faible revenu, en raison du manque d'infrastructures appropriées et de justice sociale. Nous présentons une étude de cas sur l'utilisation d'infrastructures vertes pour la gestion des eaux pluviales (Green Stormwater Infrastructures) pour moderniser une communauté à faible revenu de la ville de Zhenjiang en Chine en un quartier résilient au changement climatique. Cette communauté construite avant les années 1970 avait subi des inondations annuelles, la détérioration des infrastructures vieillissantes, l'absence de conditions sanitaires adéquates et de stationnement. Pour résoudre ces problèmes, l'approche GSI a été utilisée pour atteindre de multiples objectifs, dont le contrôle des inondations pour des évènements pluvieux jusqu'à une période de retour de 30 ans, la conservation de l'énergie, la séparation des réseaux d'assainissement et l'amélioration du paysage. Dans le processus de conception, des modèles hydrologiques ont été utilisés pour guider l'architecte paysagiste dans la conception d'infrastructures vertes pour la gestion des eaux pluviales non seulement résistantes aux conditions météorologiques extrêmes, mais aussi esthétiquement remarquables. Après l'achèvement de la modernisation, la communauté est devenue un endroit idéal pour les interactions sociales des résidents, un lieu convivial pour les retraités et les enfants qui jouent ensemble, et un beau quartier où les résidents peuvent se détendre, ce qui réduit les symptômes de dépression et d'anxiété. Les résultats des trois années de suivi montrent que le ruissellement a été réduit de 95% et que les lieux qui étaient historiquement inondés ont été éliminés.

ABSTRACT

The floods caused by rapid urbanization and climate change have had becoming a major threat in many cities around the world. Especially in these low-income urban areas because of lack of appropriate infrastructure and social justice. In this study we present a case study of using green stormwater infrastructure (GSI) to retrofit a low-income community in Zhenjiang City of China into a climate resilient neighborhood. This community built before the 1970s had endured annual flooding, deterioration of aging infrastructure, lack of appropriate sanitary conditions and parking lot. To solve these problems GSI approach was used to achieve multiple goals including flood control up to 30-year storm event, energy conservation, sanitary sewer separation and landscape upgrade. In the design process hydrologic models were used to guide the landscape architect to design GSI not only resilient to extreme weather conditions but also shinning in aesthetics. After the completion of the retrofit the community has become an ideal place for social interactions of the residents, a happy place for retirees and children to play together, and a beautiful neighborhood for residents to relax reducing symptoms of depression and anxiety. Three-year monitoring results showed that the runoff was reduced by 95% and historical flood spots was eliminated.

KEYWORDS

Climate Change, Flood Control, Green Stormwater Infrastructure, Resilient

1. INTRODUCTION

Flooding, sewage surcharge and lack of appropriate sanitary conditions in old neighborhoods are common problems in China. In 2015, the Chinese government implemented the “Sponge City Initiative Pilot Program” aimed to solve these problems. Among the first 16 cities of the pilot program, the Zhenjiang City is the only one that its pilot area (22 square kilometer) is all in highly developed urban area. Hundreds of old neighborhoods in the heart of the city are combined sewer system with poor sanitary condition. Some of them frequently suffer flooding and sewage surcharges. According the city’s master plan these problems need to be solved by year 2020. About 200 neighborhood retrofit projects were prioritized for designs and constructions. All retrofit projects need to meet ‘Sponge City Initiative” requirements.

Historical records showed that 48 locations in the pilot area were flooded in recent years. Among them Riverside New Village is one of the most troubled community that was flooded every year (Figure 1.1). This is because the area is located at the lowest point of the drainage basin, and the drainage system was only designed to convey one-year storm event. In addition, leakage of water supply lines, illicit connections, lack of parking spaces, landscape deterioration, and illegal garbage dumping, were the problems (Figure 1.2). During the large storm events sewer surcharge became a threat to residents’ health. For these reasons, most young people escaped from the community although it is within prime of Zhenjiang. Most residents in the community were elderly and children. There was no suitable space for leisure, recreation and social interactions among the residents in the community.

The selection of Riverside New Village Community as a pilot retrofit project is because its problems are common citywide, and the project will serve as a model for about 200 identified neighborhood retrofit projects citywide. Since this is the first green stormwater infrastructure (GSI) implementation, it will be an opportunity changing people's perspective to GSI. Many people today still think that GSI works only for light rains, and the aesthetics of GSI is unacceptable. Therefore, the significance of this project is to demonstrate that GSI works for large storms and can be beautiful. It also provides additional economic and social benefits to the community.

2. DESIGN PROCESS

2.1 Multi-Objective Approach

This Riverside New Village Community Sponge City Retrofit Project provides a unique landscape-civil engineering integrated approach transforming this low income 1.9 ha neighborhood to a healthy climate resilient place to live in. Instead of employing traditional engineering solutions, this project envisions a new way to solve these problems using a multi-objective approach named GSI + N elements, which include landscape improvement, energy conservation, utilities upgrades, installation of parking lot and preservation of urban farming. The project serves as a model for about 200 identified neighborhood renovation projects citywide.

2.2 Hydrologic Modeling

US EPA SWMM model was used to design GSI which guided the landscape design to make these neighborhoods not only resilient to extreme weather conditions but also shinning in aesthetics. The model was built to simulate the runoff prior to the retrofit first using 30yr - 24 hr design storm event first. The flooding locations, flood depth and durations were identified. Then GSI layout based on the site visiting and investigation was added into the model. The simulations were performed using the same design storm event. This is an iterative process. The layout changes until the simulation result shows that the flood depth and duration in all locations are less than 15 cm and 30 minutes, respectively. The final simulation result showed that using GSI the runoff volumes are reduced by 48%, the runoff coefficient are changed from 0.87 to 0.46, and the flooding locations are reduced from 24 to 7 when 30yr – 24hr design storm event is used.

2.3 Resilient Landscape Design

The challenges of using resilient landscape for flood mitigation in this case requires multi-disciplinary approaches to bridge the gaps between planners, landscape architects, civil engineers, government officers and citizens. The most challenge part is to change people's stereotypes perception that GSI only works for small storms and doesn't look pretty. This is especially challenging in bioretention design because the growing media in bioretention can not be nutrient rich and requires good infiltration rate. Since several studies showed that compost based growing media export nutrients and heavy metals (Hinmen, C. 2009; Chahal MK, Shi Z and Flury M. 2016; Sally D. L. 2017; Stephanie H., Paliza S. and Amanda C. 2017), an alternative media contains clean sand, coconut coir and silt (d > 25 μm) were mixed together. The short-term infiltration rate of the media is 150mm/hr, and the long-term infiltration rate is 80mm/hr. More than 30 plants were tested growing in the media in a pilot lot to see their health. There are about 20 plants grow well in the media.

In the landscape design process "Design Minus Principle" is applied minimizing the landscape intervention because this neighborhood has about 40 years of history. Residents spent most of their life in the neighborhood. Keep their memory is an important factor in the design work. After the retrofit it is desirable to minimize the maintenance cost, and encourage the residents to maintain their vegetable gardens and fruit trees. Figure 2.1 shows some design concepts.

3. RESULT

The project was completed in September of 2015. Before and during the construction many community meetings and discussions were held to response to residents' concerns and requests and the conflicts between designers and residents such as removal of illegal constructions that occupied the public green space for decade and disconnection of illicit connections. As a result, the community has become a climate resilient neighborhood supported by the monitoring data. The monitoring data show that more than 95% of rainfall was detained onsite (Figure 3.1). The pollutant load (TSS, TP, COD, NH_4-N) have been reduced by more than 95%.

In 2016 and 2017 the city was hit twice by 138 mm and 125 mm 24-hour storms consecutively, but this neighborhood is not flooded at all. Figure 3.2 shows the photos taken 1 hour after a heavy storm on July 4, 2016. The rainfall depth is 138mm/24hr.

Other environmental benefits are also observed such as mosquitos in the neighborhood have reduced dramatically because no standing water was present. The neighborhood is now a livable and enjoyable place to live (Figure 3.3). Residents can finally enjoy open space for recreation and socialization, for example play poker and chess under the shadow of trees. Children are enjoying their new playground as well (Figure 3.4 and 3.5). Newly created parking lots now allows young people to visit their parents often.

This project has demonstrated the "GSI + N" strategies works well for old neighborhood renovation in China. This innovative solution now is being applied to about 200 neighborhoods renovation projects in the city whenever it is feasible.

BIBLIOGRAPHIE / LIST OF REFERENCES

Chahal, M.K., Shi, Z. and Flury, M. (2016). *Nutrient leaching and copper speciation in compost-amended bioretention systems.* Sci Total Environ. 556(15), 302-309.

Stephanie, H., Paliza, S. and Amanda, C. (2017). *Nutrient Leaching from Compost: Implications for Bioretention and Other Green Stormwater Infrastructure*. J. Sustainable Water Built Environ. 3(3), 04017006-1 – 04017006-8.

Hinman, C. (2009). *Bioretention soil mix review and recommendations for western Washington.* ⟨http://www.ecy.wa.gov/programs/wq/stormwater/bsmresultsguidelines.pdf⟩ (Jul. 26, 2016)

Sally, D. L. (2017). *Nutrient Leaching When Soil Is Part of Plant Growth Media*. Water. 9, 501-508.

Figure 1.1 Floods in 2015 before the retrofit

Figure 1.2 The problems of the community

Figure 2.1 Integrated design of GSI & resilient landscape

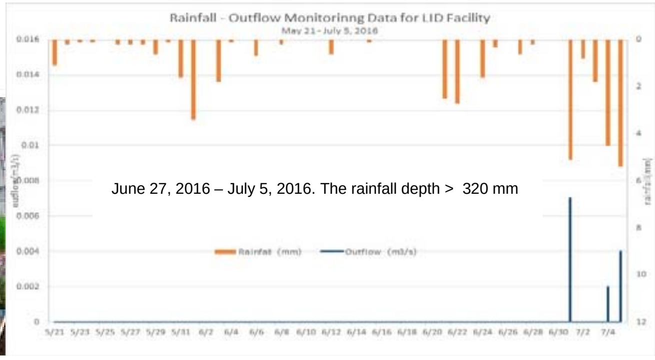

Figure 3.1 Monitoring data from May 21 to July 5 of 2016

Figure 3.2 The neighborhood 1 hour after a 138mm/hr heavy storm event in 2016

Figure 3.3 Aerial photo of the completion of the retrofit

Figure 3.4 An Ideal Place for Social Interactions

Figure 3.5 Happiness: Yong people bring their children back