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SUDS: New solution for urban flooding

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Abstract. Climate change causing extreme weather events across the world. The excising urban drainage system facing the great stress of managing heavy precipitation events and caused urban flooding. The specialists in the urban designing field are searching for more effective way of managing flooding events. Sustainable Urban Drainage System is kind of drainage system design which simulating nature rainwater managing practices. In this research, the SUDS is analyzed mainly from three aspects: Flood managing ability, economic benefits, and ecological benefits. This research reviews the existing SUDS examples and research basing on the SUDS designing strategies. Research has found that the SUDS is more than capable of managing stormwater but also can generate both monetary and indirect economic benefit. Furthermore, the nature feature of SUDS facilities can provide ecological benefits like providing habitats for animals, improving hydrological feature, and increase comfortability for residents. Thus, SUDS can be an ideal solution for the new urban drainage systems.

Keywords: Sustainable Urban Drainage System; Flooding Risk; Hydrolysis; Urban Design.

1. Introduction

Climate change is attracting attention globally. Dramatic climate change brings unusual extreme climate events like heavy precipitation, hailstorm, etc., and leading to increasing stress to the existing urban drainage system. The traditional urban drainage system is struggling with fragments stacking, high volume of runoff, and ground water contaminations. Those extreme events caused increasing flooding cases across the world. It is urgent to improve or replace existing urban drainage system. Sustainable urban drainage system (SUDS) is considered as a combination of open space with engineered vegetation covering space. It can manage surface runoff and mitigate peek volume of storm water. SUDS are supposed to be designed based on nature ecosystem principal and benefit urban system [1]. Some common SUDS facilities including green roof, rain garden, permeable pavement, etc. SUDS has been applied in many cities, but the terminology used to describe it are dynamic because the different combination or principle in the system. The well-known names such as Low Impact Development (LID), Blue-green system, Sponge city, or nature-based solution [2].

However, since there are still plenty of choice for the climate changing period's urban design, whether SUDS is the optimal one or not need to be discussed. Public still have concerning about weather SUDS could be the optimum solution or not. Before making any further decisions, the ongoing SUDS projects need to be summarized and conclude for better understanding of the SUDS system. The existing case example will be reviewed in this project and analysis will be made mainly based on three aspects:

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Flooding risk managing ability, economic benefits, ecological benefits. The goal for this research is to find theoretical evidence for supporting SUDS design and convincing public or urban system designers. Providing more detail information about SUDS could have significant impact on the decision-making level. Once the theoretical fundament is made, it will be easier to promote SUDS system to more cities.

2. Flood risk control

The existing urban drainage system composed with too much impermeable pavement which caused higher volume of surface runoff and higher peak. Thus, when considering SUDS, it shall have more nature-like method to slow down catchment response and reduce peak outflow. According to what being mentioned above, the SUDS has included multiple facilities. Coventry University ran a research focus on finding the flood controlling effect from some specific SUD facility. In this research, they used MicroDrainage to build 4 model which separately implemented Dentation basin, green roof, pours pavement, and swales into a study area. Figure 1 to 3 show the flood controlling abilities of those 4 facilities from 3 different aspects [3]. As the result showing, the volume of the outflow has shown a significant decrease when the SUDS being used. Among those 4 facilities, the swale reduced effective effect on managing stormwater. And porous pavement is the second most effective facility which can also have side effect like mitigate urban heat island effect. As for green roof, it did not work well in the high intense precipitation event. However, the when the intensity decrease, the green roof show a great ability to storing rainwater. While other facilities controlling outflow by retain runoff, the swale is transferring those runoffs on the edge of the road and reduce the peak volume [3]. This research proved the SUDS is more than capable of managing flood risk, but also benefit urban systems.

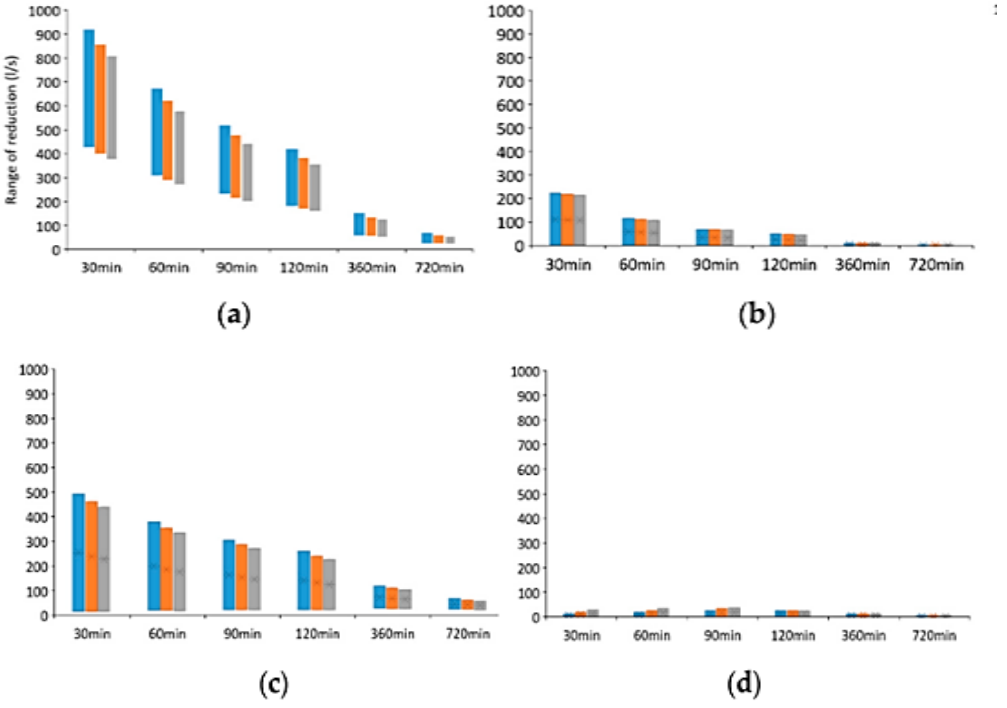

Figure 1. The range of possible reduction of runoff; (a) Detention basins, (b) green roofs, (c) porous pavement (d) swales. Each color represents a different WRAP scenario. Blue 0.5, Orange 0.3 and Grey 0.15 [3].

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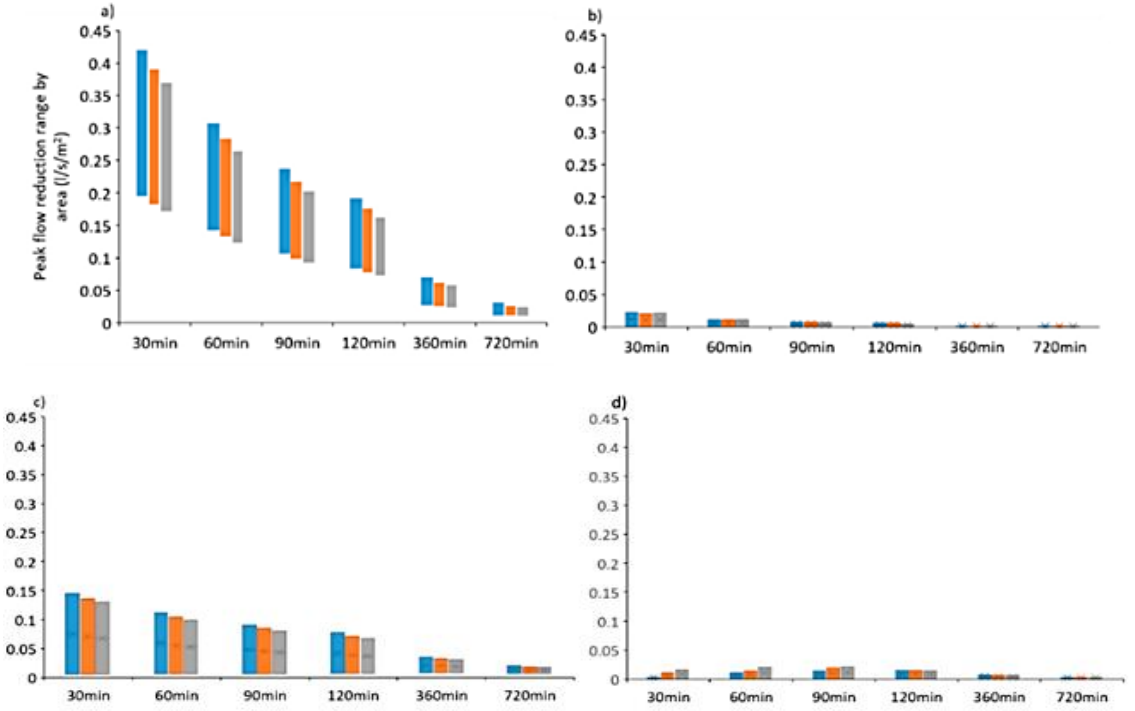

Figure 2. The range of peak flow reduction by area [3].

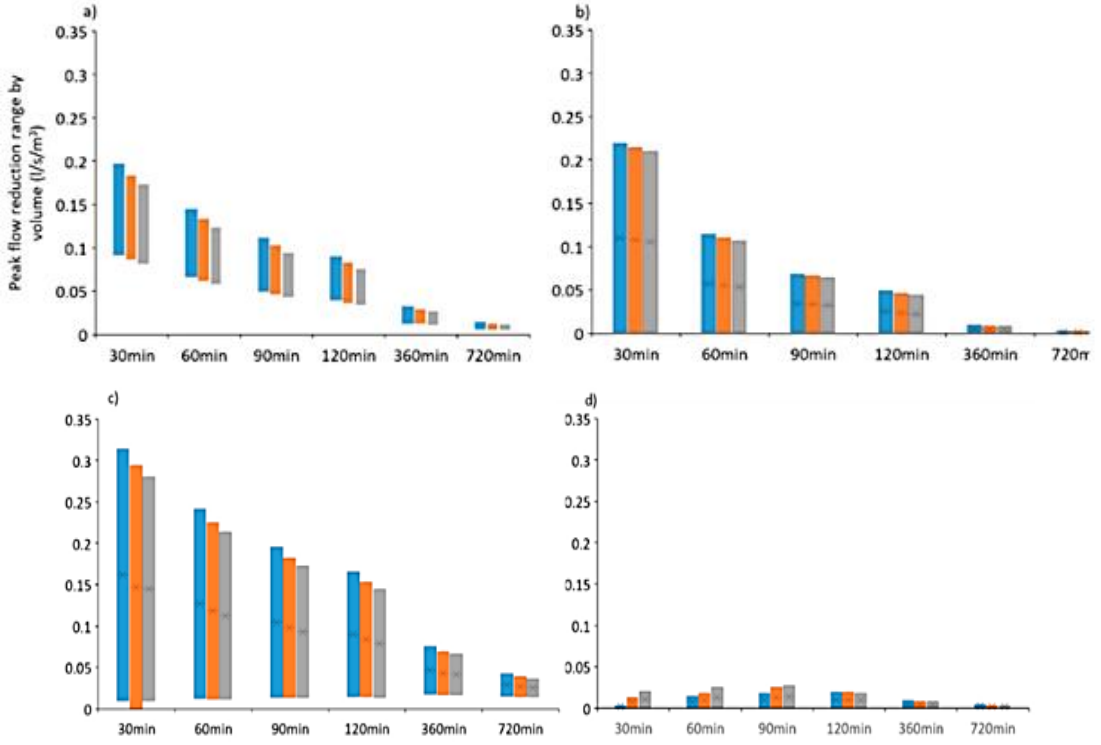

Figure 3. The range of peak flow reduction by volume [3].

It is clearly shown that SUDS's facilities as isolated parts have ability of managing flooding risk. Furthermore, they can have greater potential when designing them as a coordinate system. When

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designing SUDS on site, it is important to put local environmental condition into considerations. Local climate, temperature, geographical features will alter designing SUDS. For example, China has applied sponge city design in multiply cities to deal with the flooding risk caused by the rapid urbanization [4]. With enormous population and great climate difference, it is being difficult to place new drainage system over the country. However, the sponge city design and attach to the existing urban drainage systems. By use Baicheng city as a case, sponge city design eliminates the waterlogging point in the city, reduce the high flooding risk area and increase the drainage capacity of existing pipeline network [5]. But for British, they choose nature-based solution which can managing the high volume of surface runoff. Also improve water qualities, amenity, aesthetics, and biodiversity [4]. This is also an advantage of SUDS: optimized the ability of flooding risk control by choosing the most suitable combination of SUDS facilities.

3. Economic benefits

It could be costly to implement new system to urban area. While the SUDS could be design in flexibly that its economic benefits are difficult to measure. By implementing SUDS to the urban drainage system, it is being expected to bring both private benefit and social benefits. A research study about economic benefits of SUDS based on the SUDS system in Berlin defined Private benefit as those direct monetary benefit like rainwater fee saved and social benefits as those budges saved for controlling stormwater managements [1]. They conclude that even though the economic benefits from SUDS are complicated, the economical feasible SUDS are achievable. They recommend further use of facilities like vegetative swales and pond which have higher stormwater reduction to footprint ratio. As they state the green roofs and rain garden can provide ancillary benefits like reducing urban heat island effect, but not being considered as best choice be from economical aspect and should be avoid [1]. Another study targeting SUDS in Bogotá has also conclude the economic benefit from placing SUDS in the city. The result from the study shows by using SUDS, the city could reduce their reliance on the traditional drainage system. Thus, saving the unnecessary construction and maintenance fee. The collected rainwater can be reused for irrigation and residential use [3]. Furthermore, the construction of SUDS could be a way to build up cities image. A city with an eco-friendly and sustainable developing image could attract numbers of green infrastructure construction company to the city. It can be the first step for additional green construction in the future [3]. Not to mention those job opportunities and the GDP provide by construction activities. Conclusively, the SUDS can directly generate monetary benefit, also having great potential of further economic benefit.

4. Ecological benefits

Another kind of benefits SUDS can provide is the ecological benefit. One of the principles for SUDS is nature based, it will sustain the nature process and preserving nature features. Thus, the first benefit would be enriched biodiversity. SUDS could provide habitats for animals and connecting those isolated species. Like what be mentioned above, several type of SUDS facilities including vegetative elements. That vegetation is potentially providing habitats for animals. A research run in British has stated that pond in SUDS benefits preserving amphibian. Most of the amphibian are picky about their living environment and pollutant will cause deficient or death to most of the amphibian. It also being considered as the indicator for the environment quality [6]. Also, adding stone or gravel could benefit invertebrate communities and increase the preservability of stormwater. Facilities which having both hydrological and vegetative elements like vegetative swale and rain garden are considered as having most potential to influence biodiversity [6, 7].

On the other hands, with the flood controlling function, SUDS can increase the water qualities and preserve the hydrological function. The permeable pavements can increase water qualities by infiltration. Pond, swale, and green roof could break down pollution settlement through biological process [8]. An experiment ran in Brazil found that implanting SUDS could significantly improve water quality of the lake. The result showing after implemented SUDS to the lake, the amount of suspended solid had decreased over 50% and both COD and nutrient decease almost 50% [9]. The improvement on the water

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qualities can provide better condition not only for human beings but also for vegetations in the SUDS which make the system dynamic and interactive.

SUDS can also increase the comfortability of the city. Research has found that happiness level of citizen will raise with greater green covering area around living environment. The vegetation and water body could be component for the urban landscape design. It improved the living environment of the neighbourhoods. Also, when placing SUDS on the building's external walls, they would have impact on adjusting indoor temperature [1]. Additionally, SUDS could effectively decrease temperature of urban area. The vegetation surface reduces the temperature by shading and evapotranspiration effect. The practice in Malaysia has proved that the surface runoff controlling, and vegetation component of SUDS could have mitigated urban heat island effect [10].

5. Conclusion

While Sustainable Urban Drainage System (SUDS) attracting more attention in the urban designing field. This research has found that the SUDS has shown great potential to manage flooding risk. There are studies not only states the effeteness of flood managing ability of isolated SUDS facilities, but also conclude that by designing them as the corresponding system could have made it stronger and fit in more situations. Besides, it can also generate both direct and indirect economic benefit by saving cost and providing advancing opportunities. It can provide ecological benefit by play roles of habitat for species, improve hydrological condition, and increasing comfortability for the city. Basing on the outcome of the research, the SUDS could be an ideal urban flooding managing strategies in the future. And the research is expected to provide solid evidence for supporting utilization of SUDS. However, there still need further understating of the SUDS to be known by the public. And due to the complexity and flexibility of the SUDS, the cost and side benefits of specific SUDS is difficult to be statistically calculated. Each SUDS facilities have their own merits and demerits. The combination of using which SUDS's facilities need to be decide based on the local conditions. The future research could focus more on the more specific designing situation and analysing specific SUDS. There are multiple decision-making systems in the field but what being expected is a more general and scientific ways of designing SUDS. Finding new materials can the potential solution for the cost problem. Also, SUDS could being cooperate with other drainage system to improve its effectiveness and diverse its function. But the most important is that the decision maker from the government or organizations and public having the better understanding of the SUDS and wisely take advantage of utilizing.

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