Comprehensive Performance Evaluation of LID Practices: Case Study in Tianjin, China

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In recent years, the rapid development of the city has brought about changes in the underlying surface of the town, which has led to a series of problems such as frequent urban floods, deteriorating urban water environment and a shortage of urban water resources. The sharp deterioration of urban water problems directly restricts people's lives and the development of cities. Along with the rapid development of China's urbanization process, the urban population has risen rapidly, the downtown area has been expanding outward, and the use of land has been continually changing (Ying et al., 2007).

Under the background of current ecological civilization construction, the sponge city projects proposed to effectively alleviate urban floods, improve urban water quality and utilize rainwater resources. Sponge city project is an important part of urban stormwater management and aims to achieve harmonious coexistence between human and nature. The practice of low impact development (LID) as an important part of sponge city is gaining its place in stormwater management and urban planning. The LID practice is an integrated watershed management strategy which provides natural retention, treatment and source protection capabilities.

Research on LID facilities such as bio-retention, porous pavement and grass swales has increased and documented promising findings in recent years. Optimal selection of LID plan is of great importance in the construction of the urban area. There are many factors affecting the decision to choose the appropriate LID practice plan, such as runoff quantity and quality control, economic factor and additional benefits. A formal decision-making framework for LID is a pressing need. Since that, the central question of this research is "How can we get the better combination of different kinds of LID devices based on the simulation above and build a more robust framework for the LID design?".

The study area is the Tianjin Airport Economic Area, located in the Binhai New Area in Tianjin, north China. The average annual precipitation is nearly 550 mm. Due to monsoon climate, the rainfall is unevenly distributed within a year. About 78.5% of the annual precipitation falls in the summer from June to August, while about 58.6% of the total annual rainfall occurs in only one month, from the second half of July to the first half of August. This has substantially caused high risk of flooding dangers. The study area, one of experimental sites for sponge city constructions in Tianjin, is a typical urbanized watershed with multi-functional land uses including industrial (55% of total), commercial (10%), residential (16%) and others. The total area is 22.78 km^2. In this study, Storm Water Management Model 5 (SWMM5) was used to simulate urban hydrological processes with and without LIDs.

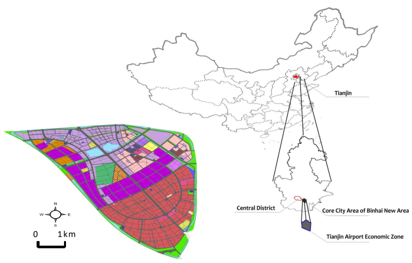

Figure 1 The study area and land use types at Tianjin Airport Economic Area in Tianjin, north China

The Analytic Hierarchy Process (AHP) provides a flexible and easily understood way of analyzing complicated problems. AHP has been widely used in GIS-based landslide susceptibility mapping, flood risk analysis and selecting wastewater facilities at prefecture level. In this study, the hierarchical structure model of LID was built in terms of local conditions and requirements. And three main criteria including runoff quantity control, runoff quality control and additional benefits, and 9 indexes were selected to evaluate the performance of 7 LID design plans (shown in Figure 2).

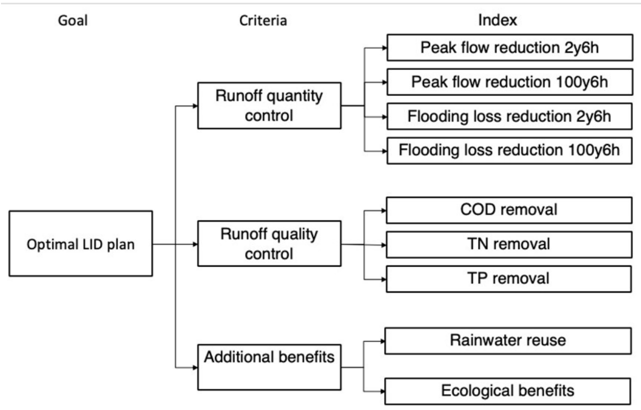

Figure 2 The hierarchical structure model of LID for determining the index weight

Table 1 The LID efficiency rank

	Runoff quantity control	Runoff quality control	Additional benefits	Overall
bio	0.040	0.026	0.093	0.045
gs	0.022	0.025	0.030	0.025
pp	0.256	0.132	0.030	0.160
bio+gs	0.048	0.049	0.171	0.073
bio+pp	0.154	0.228	0.276	0.209
gs+pp	0.141	0.216	0.067	0.157
bio+gs+pp	0.339	0.324	0.332	0.332

As shown in Table 1, the permeable pavements was the most appropriate choice for single LID, followed by bio-retention and grass swale. The prefer order of LID based on the water quality control was permeable pavements > grass swale > bio-retention and the prefer order of LID considering additional benefits was bio-retention > permeable pavements > grass swale. Considering all the indexes, the most preferred single LID type is permeable pavements, followed by two single LID types closely competing with each other. It also reflected several trends that the combination with permeable pavements performs better than the combination without permeable pavements in term of runoff quantity and quality control and the combination of three types of LID is the most preferred choice.

References

Ying, X., Zeng, G. M., Chen, G. Q., Tang, L., Wang, K. L., & Huang, D. Y. (2007). Combining AHP with GIS in synthetic evaluation of eco-environment quality—a case study of Hunan Province, China. Ecological modelling, 209(2-4), 97-109.