STREAM – WATER EngD PROGRAMME

Machine Intelligence Methods for Optimised Urban Drainage Design

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Background

The vulnerability of drainage systems and the importance of flood risk management have drawn increasing public attention following major flood events around the globe. Sustainable drainage systems (SuDS) have been proposed as better alternatives to conventional pipe-based drainage systems. Compared to traditional pipe and storage networks, SuDS bring additional values such as treatment and biodiversity.

Figure 1 – examples of both conventional and sustainable drainage systems (images courtesy of Micro Drainage).

SuDS in Drainage Models

Several drainage software packages have already included SuDS modelling modules (e.g. WinDes and XPSWMM). This allows users to configure various SuDS components in their drainage models and to run simulations in order to determine the impact of different SuDS techniques on flooding, water quality as well as life cycle cost.

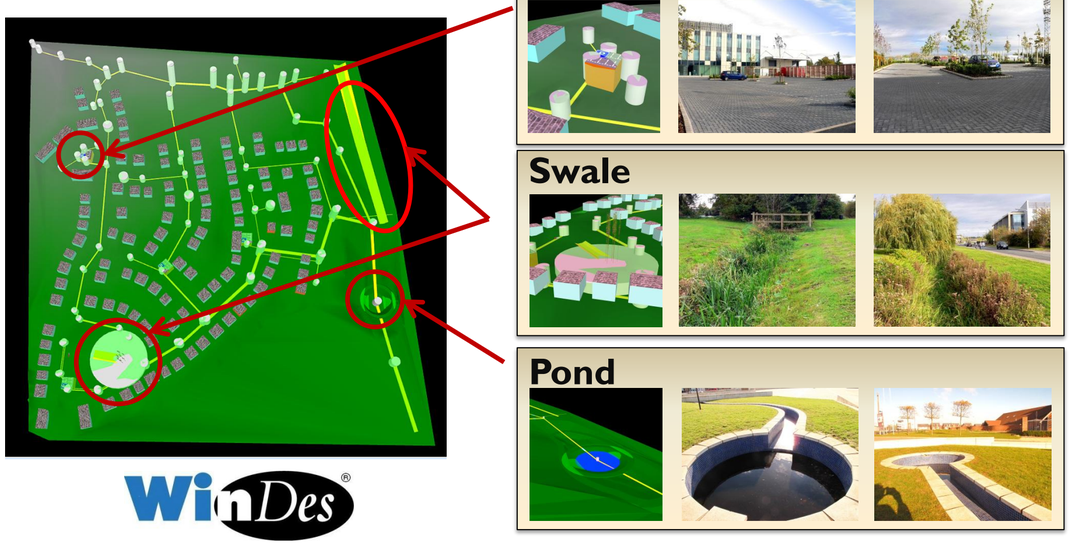

Figure 2 – using Micro Drainage's WinDes to model SuDS for a typical site development drainage design (images courtesy of Micro Drainage).

Towards Sustainability

Yet the existing software modules are not sufficient for sustainable drainage design as they mostly focus on water quantity and quality aspect. There is not enough emphasis on the amenity value and cost-benefit analysis. In order to fill this gap, we decided to develop additional software features that will put more emphasis on social impact and will enable stakeholders to maximise multiple benefits.

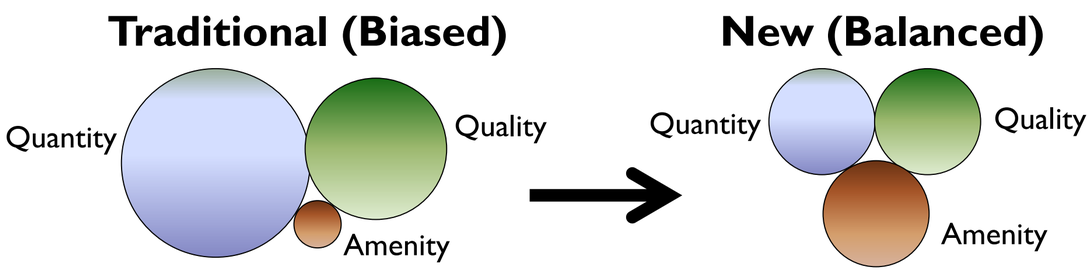

Figure 3 – Comparison of traditional and new approach.

Challenges

Identifying the optimal combination of different SuDS techniques with regard to system performance, social-environmental impact and cost is a complex multi-objective optimisation problem. The number of SuDS combinations can grow into hundreds and thousands depending on site characteristics. The traditional trial and error approach is inefficient and impractical for this problem.

New Decision Support Tools

A prototype decision support framework has been developed to look at changes in hydraulic performance, water quality and costs based on different SuDS combinations. Additional indicators (e.g. social impact, energy, air quality, carbon etc.) will be implemented in the next phase of the project. Multi-objective evolutionary optimisation functionality has been implemented into this prototype using GANetXL. As illustrated in the two-objective example below, users can choose and compare various drainage design options from the Pareto front with trade-off between costs and performance.

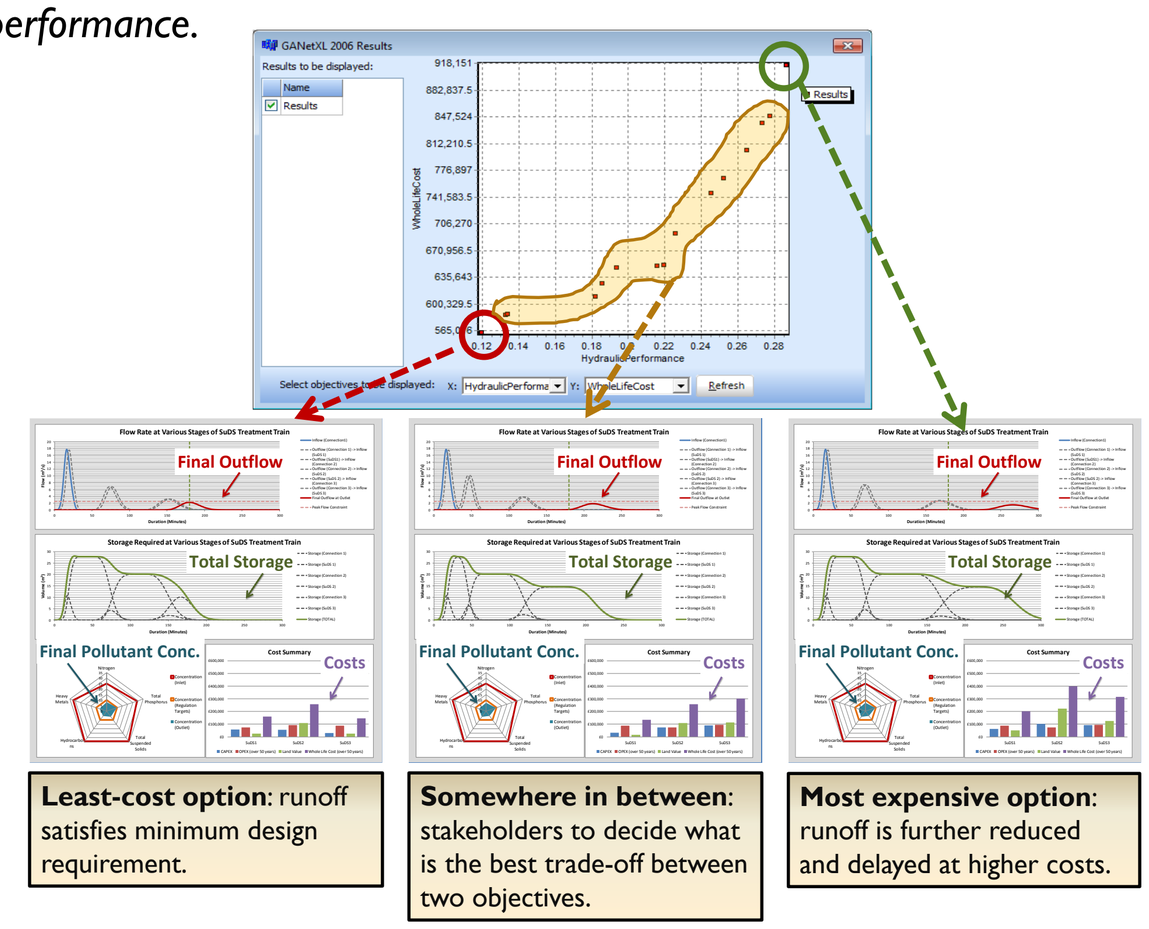

Figure 4 – exploring and comparing different design options from optimisation Pareto front .

Summary

The existing software tools are not sufficient for sustainable drainage design as they lack the emphasis on social impact and cost-benefit. We are developing new software tools that will allow drainage designers and engineers to determine optimal combinations of SuDS efficiently and will enable stakeholders to compare and evaluate best trade-off between water quantity, quality, whole life costs and various benefits.

The work presented here is part of author's 4-year EngD project under the STREAM research initiative. For more information, please contact the author (jo-fai.chow@microdrainage.co.uk or uk.linkedin.com/in/jofaichow).

Further Reading

Chow, J., Savić, D.A., Fortune, D., Kapelan, Z. (2012). Developing a New Decision Support System for Sustainable Drainage Design and Flood Risk Management, Proceedings of 10th International Conference on Hydroinformatics, Hamburg, Germany, 2012.

Chow, J., Savić, D.A., Fortune, D., Mebrate, N., Kapelan, Z. (2012). Developing a New Decision Support Framework for Sustainable Drainage Design, Proceedings of 9th International Conference on Urban Drainage Modelling, Belgrade, Serbia, 2012.