

Costs and benefits of SuDS

The following study has been made to help assess the cost-benefit ratio of different storm water solutions. Accurate cost calculations have not been made and the study reveals that many of the benefits are still difficult to assess in monetary terms. However, it is clear that some solutions, such as bioswales and wetlands, have a high potential of providing multiple benefits with low costs.

Why Cost-Benefit Analysis?

Well designed, constructed and maintained stormwater management structures can deliver a wide range of benefits to local communities and places, as well as underpin sustainable economic growth. Apart from managing stormwater, green infrastructure structures have the potential to provide a full range of other ecosystem services, such as energy savings; air quality improvement; mitigation of climate change by reducing greenhouse gases; and provision of habitats and biodiversity. They can also have an impact on urban liveability including aesthetics, recreation and environmental health.

It is not an easy task to identify the key benefits associated with a stormwater management solution, to demonstrate the ways it can add value to a broader developmental project, or to choose between different solutions. A cost-benefit analysis will illuminate the monetary values of different solutions as well as the value of other economic, societal or environmental benefits, where the scientific basis for quantification and/or monetisation is not yet sufficiently robust.

POINT 1
URBAN
RESILIENCE

POINT 2
TECHNICAL
OPTIMI-
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POINT 3
DAY-TO-DAY
VALUES



Contents of the study

This study summarises information that will help tentatively analyse the benefits of a stormwater management solution. Table 1 and Table 2 give additional background knowledge; the **TABLE 1** lists ecosystem services that are related especially to SUDS, and the **TABLE 2** indicates which solution delivers which ecosystem service.

In the following table the solutions are listed in a table that summarises the main benefits, values and considerations related to design, construction and maintenance from the cost point of view.

Descriptions and a short summary of the cost-benefit ratio of each stormwater management solution can be found on the toolsheet “Descriptions of sustainable stormwater management solutions”.

Definition of cost-benefit analysis and related terms

Cost analysis

Cost comparison is a method for assessing the economic impacts of a stormwater management solution. The cost of a sustainable urban drainage system (SUDS) can be considered to be a combination of two components: 1) the capital expenditure to build the solution including potential land take costs, and 2) the on-going operational costs to maintain the solution to ensure continued performance.

Both approaches ignore the value of delivered benefits in the performance of the solution. As a result, they provide an incomplete basis for decision-making. Since SUDS can potentially offer more benefits than conventional stormwater management systems, a mere cost analysis fails to offer decision-makers adequate information for evaluating the alternatives.

Cost-benefit analysis

A cost-benefit analysis (CBA) is more complicated than a cost analysis, but also provides a more complete basis for decision-making. It considers costs

as well as environmental, social, and public health outcomes of alternative management approaches. The result is more complete information on the benefits associated with different stormwater solutions.

Life cycle analysis

A life cycle analysis is a method of assessment that considers all costs arising from planning, designing, constructing, operating, and finally disassembling of a solution. This approach to valuation is particularly suitable for the evaluation of stormwater and combined sewer system design alternatives that have different initial costs, operations and maintenance costs, as well as life spans. The life cycle cost approach is critical in estimating SUDS costs, because often their operations and maintenance costs can be significantly lower than conventional approaches.

A life cycle analysis allows a range of SUDS options to be appropriately compared. Through encouraging a combined monitoring and maintenance, the approach promotes the explicit assessment and management of both short-term and long-term risk.

How is CBA executed?

The usefulness and effectiveness of assessing costs and benefits is greatest when it forms part of an early stage of the design process. Once the main planning and design decisions have been determined for a site, the type of options that can be assessed and compared become more limited.

Both costs and benefits are highly context-specific and will vary significantly (in monetary terms) depending on the site characteristics, the use(s) of the site and the specific composition of the SUDS solution. It is important for any assessment to be robust, transparent and open to scrutiny. This will lead to an increased acceptance from stakeholders as well as more opportunities for shared funding.

When the costs and benefits are assessed together, this enables the SUDS design to be optimised (i.e. to manage, treat and optimise the use of surface water in order to maximise benefits at a reasonable cost) and should form part of the option-budgeting process.

It is important to ensure that like is being compared with like when alternative SUDS options are being

contrasted, or a SUDS solution is being compared with a below-ground piped drainage system. For example, either the water quantity and water quality performance of each option has to be identical or the benefits that can be attributed to that performance (such as improved water quality or reduced flood risk) need to be estimated separately for each option.

Existing guidance and tools

A large amount of cost-benefit analysis cases, related guidance and scientific papers are available online. For example, EPA, the United States Environmental Protection Agency, has listed a green infrastructure (GI) cost analysis, cost-benefit analysis and tools that help to execute the analysis (<https://www.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources>); Susdrain, the British community of sustainable drainage, has listed guidance that is available to assess benefits and costs (<http://www.susdrain.org/delivering-suds/using-suds/the-costs-and-benefits-of-suds/guidance-on-cost-benefit-analysis.html>). In addition, separate publications exist that provide unit costs and benefits, but these should

be used with caution, because both cost and benefits are always related to specific design solutions.

Furthermore, CBA can be implemented with the help of computer programmes. There are stormwater management modelling tools used by researchers and professionals in order to understand various aspects related to stormwater management, such as run-off volume, run-off rate, and pollutant-loading reduction, due to the implementation of different GI practices. Usually these modelling tools work with GIS or other cartographical applications, and include modules for the analysis of whole life cycle costs of a stormwater solution. There are also a number of simple spreadsheet tools available for an economic analysis of these practices.



The challenge of valuing the benefits

The challenge is that the benefits created by most common solutions, such as green roofs, rain gardens, infiltration and detention are well identified, but the values of more tailored or complex systems are harder to evaluate. In addition, some of the benefits are unrecognised or underestimated, because all the positive impacts are not included in the analysis. Direct environmental and economical impacts are typically easy to recognise, whereas social benefits are disregarded, such as improving aesthetics, habitats, community liveability, human health, and increased land value.

Moreover, the scale of analysis can affect the end result. On the district scale, several SUDS can be combined. In such a case, costs can be reduced because of potential scale benefits, for example, by the labour force or materials. Ecosystem service-related benefits can be simultaneously increased. As the amount of required biological structures, such as swales or ponds, increase and are combined, they tend to deliver multiple-associated ecosystem services, such as habitat provision and stormwater purification. Due to the several existing challenges

related to CBA, it is likely that the available information and approaches to a cost-benefit evaluation of green infrastructure solutions will rapidly develop in the future.

SUDS* (technical solutions)	BENEFITS ** (ECOSYSTEM SERVICES)	VALUES***	DESIGN AND CONSTRUCTION COSTS	OPERATING AND MAINTENANCE COSTS	REMARKS
Green roofs	Water retention Climate regulation Habitats and pollination Aesthetics and inspiration Education and science	Avoided costs of flood prevention € Avoided costs of flood damages € Avoided costs of heating/cooling € Health and social value of favorable climate Value of natural pollination € Value of local gene pool for future use Increased property values € Marketing value of an aesthetic landscape / views Identity value Social and cultural values of environment Value of educational environments and learning	From moderate to high. Some special design expertise needed for custom solutions. Construction costs of a green roof in average 50-60€/m2 (in addition to the cost of roof).	Depend highly on the type of green roof. Green roof can also extend the lifetime of a roof.	The cost of investing on green roofs are relatively lower on areas where the value of land is high. Both the potential benefits and costs increase when a thicker soil layer is installed.
Green facades/walls (above ground growing medium)	Water retention Climate regulation Habitats and pollination Aesthetics and inspiration Education and science Tourism and nature experiences	Avoided costs of flood prevention € Avoided costs of flood damages € Avoided costs of heating/cooling € Health and social value of favorable climate Value of natural pollination € Value of local gene pool for future use Increased property values € Marketing value of an aesthetic landscape / views Identity value Social and cultural values of environment Value of educational environments and learning	High design and construction costs.	High operation and maintenance costs. Maintenance might need special skills and equipment.	Green facade of vines that grow from ground is much cheaper solution to implement. If new solutions are tested there might be a risk of a short lifetime for the solution.
Street trees	Water retention Water filtration Mediation of waste and toxins Erosion prevention Soil fertility and formation Nutrient retention	Avoided costs of flood prevention € Avoided costs of flood damages € Property values and the value of land € Value of clean groundwater € Avoided costs of extensive water cleansing € High quality surface water Avoided maintenance cost €	Construction costs are relatively high for one street tree. For example an average investment cost on a street tree in Helsinki is about 2500 € (HKR 2014).	From moderate to high. Especially young trees require regular maintenance which demands for special expertise. The cost of maintenance of a young	Several studies indicate that investments on street trees have in general high revenue value. Lifetime of a street tree might be very long in good conditions. The value of a tree increases when it matures.

	Climate regulation Air quality regulation Aesthetics and source of inspiration Education and science	Health benefits Avoided costs of heating/cooling € Health and social value of favorable climate Market value of arts and other cultural products inspired by nature € Marketing value of aesthetic landscape Identity value Social and cultural values of environment		tree might be multiple times the investment costs (HKR 2014).	
Stormwater planter	Water retention Water filtration Mediation of waste and toxins Habitats and pollination Aesthetics and source of inspiration Education and science	Avoided costs of flood prevention € Avoided costs of flood damages € Property values € Value of clean groundwater and surface water € Avoided costs of extensive water cleansing € Avoided health risks Value of natural pollination € Value of gene pool for future use Marketing value of aesthetic landscape Identity value Social and cultural values of environment Value of educational environments and learning	Moderate. Requires some expertise to design and construct. Requires some space in densely built areas.	Moderate. Requires regular maintenance to keep the system functioning.	Little experience of the functionality of the systems in winter conditions.
Rainwater cistern	Water retention	Avoided costs of flood prevention € Avoided costs of flood damages € Property values and the value of land €	Specific design solutions are needed in order to integrate the system with buildings or other structures.	Moderate. Regular simple maintenance tasks needed. Electricity might be required for pumping and for preventing freeze-up.	Above ground tanks can be unsightly. Below ground tanks might take space from trees and vegetation.
Infiltration pit	Water retention	Avoided costs of flood prevention € Avoided costs of flood damages € Property values and the value of land €	Simple and low cost solution.	Easy to maintain.	
Pervious surfaces (porous and permeable)	Water retention Water filtration	Avoided costs of flood prevention € Avoided costs of flood damages € Property values and the value of land € Value of clean groundwater and surface water €	Moderate, similar to normal pavement. Though stone pavements cost more than asphalt to build.	Moderate. Regular maintenance is needed to prevent long-term clogging and weed growth.	The ability of the paved area to retain and infiltrate water depends on the permeability and the quality of the below soil layers. Multifunctional areas don't require additional space No need for deep excavations for drainage, which can have significant cost benefits.

Canals and rills	Some potential for water retention, erosion prevention and water purification (depending on the solution and maintenance)	Visual value Identity value	Easy to construct but some special design solutions might be needed. Costs highly dependent on the material.	Routine maintenance of urban areas, removal of litter/debris.	Vegetation can be added to the structure to deliver additional ecosystem services.
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SUDS (biological solutions)	BENEFITS** (ECOSYSTEM SERVICES)	VALUES***	DESIGN AND CONSTRUCTION COSTS	OPERATING AND MAINTENANCE COSTS	REMARKS
(Bio)swale	Water retention Mediation of waste and toxins Air quality regulation Habitats and pollination Aesthetics and source of inspiration Education and science	Avoided costs of flood prevention € Avoided costs of flood damages € Property values and the value of land € Value of clean groundwater and surface water € Avoided costs of extensive water cleansing € Health and social value of clean air Value of natural pollination € Marketing value of aesthetic landscape Identity value Social and cultural values of environment Market value of innovations € Value of educational environments and learning Social, economic, intrinsic and health value of innovations and knowledge	Low cost investment.	In addition to general landscape management costs litter/debris removal needed. . Pollution and blockages are visible and easy to dealt with. Costs depend on the quality of water and the type of vegetation.	Requires some space.
Ditch (oja)	Habitats, genetic diversity and pollination Some potential for water retention, filtration and mediation of waste and toxins (depending f.e. on the gradient, maintenance and the type of soil)	Intrinsic value of species reproducing in their natural nursery habitats Value of natural pollination € Value of gene pool for future use	Low cost investment.	General landscape management costs.	Risk of erosion. Ditches might in some cases function as small-scale ecological corridors.

Raingarden	Water retention Water filtration Erosion prevention Soil fertility and formation Nutrient retention / Nitrogen fixation Habitats, genetic diversity and pollination Recreation and mental and physical health Aesthetics and source of inspiration Education and science	Avoided costs of flood prevention € Avoided costs of flood damages € Avoided costs of extensive water cleansing € Avoided cost of fertilizer use € Avoided damage on infrastructure € Avoided cost of soil improvement € Avoided maintenance cost € Avoided cost of fertilizer use € Water protection € Value of natural pollination € High quality surface water Improved growth Health Recreational value of watching nature Value of gene pool for future use Avoided costs of health care € Increased property values € Outdoor activities € Employment € Quality of life Health and social value Increased property values € Market value of arts and other cultural products inspired by nature € Marketing value of aesthetic landscape Identity value Social and cultural values of environment Value of educational environments and learning Social, economic, intrinsic and health value of innovations and knowledge	Typical garden construction cost. Special vegetation and biotope design requires expertise.	Typical garden type vegetation management cost. Requires regular management.	Design solutions such as selection of vegetation affect operating and maintenance costs considerably.
Detention basin	Water retention Habitats, genetic diversity and pollination	Avoided costs of flood prevention € Avoided costs of flood damages € Avoided health risks Feeling of safety Value of natural pollination €	Low cost solution. Simple to design and construct.	Typical landscape and vegetation management. Occasional sediment monitoring and removal might be needed.	
Infiltration basin	Water filtration Mediation of waste and toxins Fresh water	Value of clean groundwater and surface water € Avoided costs of extensive water cleansing € Avoided health risks Value of groundwater resources €	Low construction costs. Comprehensive geotechnical preinvestigations needed.	Requires regular maintenance to keep up the filtration process	Infiltration typically requires larger areas of land than mere storage of water in detention structures.

Rainwater pond	Water retention Habitats, genetic diversity and pollination Recreation and mental and physical health Aesthetics and source of inspiration Tourism and nature experiences Education and science	Avoided costs of flood prevention € Avoided costs of flood damages € Property values and the value of land € Recreational value of fishing and bird watching Value of gene pool for future use Avoided costs of health care € Increased property values € Outdoor activities € Quality of life Health and social value Increased property values € Market value of arts and other cultural products inspired by nature € Marketing value of aesthetic landscape Identity value Social and cultural values of environment Tourism incomes € Employment € Value of educational environments and learning	Relatively low cost solutions.	Typical landscape and vegetation management. Occasional sediment monitoring and removal might be needed.	Requires some space.
Wetland	Water retention Water filtration Mediation of waste and toxins Erosion prevention Soil fertility and formation Nutrient retention Climate regulation Air quality regulation Carbon sequestration and storage Biological control Habitats, genetic diversity and pollination Aesthetics and source of inspiration Education and science Tourism and nature experiences	Avoided costs of flood prevention € Avoided costs of flood damages € Existence of intact natural areas (though flooding might have also positive effect on ecosystems) Value of clean groundwater and surface water € Avoided costs of extensive water cleansing € High quality surface water Existence of intact natural areas Water protection € Potential for producing biomass based products Avoided medical costs € Health and social value of clean air Avoided cost of negative climate impacts € Possibility for compensation of carbon emission in the built environment € Recreational value of fishing and bird watching Value of gene pool for future use Market value of arts and other cultural products inspired by nature € Marketing value of aesthetic landscape Identity value Social and cultural values of environment Tourism incomes €	Relatively low cost solutions depending on the design; wetlands can be constructed on a variety of scales and types varying from large natural wetlands to urban wetland parks.	Typical landscape maintenance. Vegetation management possibly requires specialist equipment.	Requires large areas of land. In order to create proper circumstances for water quality management the wetland must receive enough water. However, well designed wetlands can be very effective in pollutant removal.

		Employment € Value of educational environments and learning Social, economic, intrinsic and health value of innovations and knowledge			
Filter strip	Water filtration Mediation of waste and toxins Habitats, genetic diversity and pollination	Value of clean groundwater and surface water € Avoided costs of extensive water cleansing € Avoided health risks Value of clean groundwater and surface water € Avoided costs of extensive water cleansing € Avoided health risks Recreational value of fishing and bird watching Value of gene pool for future use	Low construction costs.	General landscape management costs.	Requires space so solution is not commonly used in dense urban areas.

* See the toolsheet “*Sustainable stormwater management solutions*” for definitions of each technique.

** Only the benefits that are relatively certain in each case have been listed here. See more on **TABLE 2: Ecosystem service potentials of sustainable stormwater management techniques**.

*** The produced values depend strongly on the design, location and other qualities of the solution. See more on **TABLE 1: Ecosystem services values of sustainable urban drainage solutions**.

References:

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Other qualities and cost estimations:

Susdrain, The community for sustainable drainage:

<http://www.susdrain.org/delivering-suds/using-suds/suds-components>

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https://www.hel.fi/static/hkr/julkaisut/2014/kaupunkipuu/taustaselvitys_web_osa2.pdf

An extensive literature review of costs and benefits of SUDS:

http://www.susdrain.org/files/resources/ciria_guidance/ciria_rp993_literature_review_october_2013_.pdf