Supplementary data: defining co-benefits

S1. Greener Oslo and impact on aesthetical value of the neighborhood

Inclusion of wadi's, green roofs and rain gardens in urban areas have a positive impact on aesthetical value and appreciation of the neighborhood. These benefits can be monetarized through a Willingness-to-Pay (WTP) equivalent. Seip & Strand (1992) found an annual WTP for natural values in Norway of NOK 200 per person (in 2020, NOK 382) which was applied in this study. It is assumed that all inhabitants of Grefsen (6563 according to CityPopulation (2021) experience this benefit when the maximum area suitable for wadi's (23,780 m2), green roofs (142,000 m2) and raingardens (n=681) in Grefsen are achieved. The monetarization of this benefit is derived through calculating the percentage of inhabitants experiencing these benefits based on realized wadi/green roofs/raingardens per scenarios, multiplied by NOK 382.

S2. Increased house prices

Green roofs are known to increase house prices up to 20% although large differences between countries may apply (Bianchini and Hewage, 2012; Mahdiyar *et al.*, 2016). However, in this study a conservative value of 5% has been selected, considering the current green character of the Grefsen neighborhood. Following Lekkerkerk (2020) and Li et al. (2020) only roofs with a slight slope (<5%) are considered suitable for green roofs and a GIS assessment revealed that maximum of 225 buildings are suitable for green roof installation in Grefsen. The monetarization of this benefit was derived by the number of houses equipped with green roofs for the different scenarios multiplied with 5% house price increasing applying an average building price of NOK 5,272,000 in Oslo (Statista, 2021). The one-time benefit was only applied during the investment year.

S3. Prevented sewage water treatment

BGI measures prevent rainwater to enter the combined sewage system and thus the treatment of waste water in WWTP. Firstly, the average annual rainfall was defined and found to be 763 mm in Oslo. However, in the BAU not all rainwater reaches the combined sewage system and WWTP due to interception and transpiration from hard surfaces. Thus the annual rainfall amount was deducted by a factor to take transpiration from hard surfaces into consideration in the BAU. Van de Ven and Voortman (1985) found that in regions such as in Oslo an average of 9% rainwater is intercepted from hard surfaces. The annual rainfall on hard surfaces reaching the combined sewage system in the BAU was set at 694 mm. Furthermore, all houses are regarded to be connected to combined sewage system in Grefsen.

In addition, the annual additional water retention capacities of BGI measures differs among them. Some measures collect rainwater from a broader area (e.g. wadi's) while others only collect the rainwater that directly falls on the surface area where BGIs are installed (e.g. green roofs). Furthermore, some measures completely prevent annual rainwater entering the combined sewage system (thus the 694 mm compared to BAU is then completely prevented entering the combined sewage system) while others only partially prevent rainwater entering the combined sewage system. An overview of the applied methodology to derive the annual rainwater retention capacity per unit of measure is presented in table S1.

Table S1

Expected additional annual rainwater retention capacity per unit of BGI measures compared to BAU.

Measure	**Annual retention capacity per unit**	**Details**
Wadi's	17.4 m^3 / m^2	Assume that 25 m^2 of paved area will discharge water per m^2 wadi based on expert judgment (694mm * 25m^2).
Green roofs	0.3 m^3 / m^2	Rainwater on green roofs will partially be removed from the system through evapotranspiration. Only rainwater falling directly on green roofs surface areas will be collected. A conservative rate of 45% was selected

		considering the rather cold climate in Oslo (Broks et al., 2015). The remaining water is assumed to enter the combined sewage system. (694mm * 1m^2 green roof * 0.45).
Rain gardens	46.9 m^3 / garden	Normal gardens can be redesigned to improve infiltration. For annual water retention calculations an average garden size of 45 m^2 was selected. In addition, we assume that 50% of the roof area per house will be disconnected from the combined sewage system and discharges water into the garden as well to allow infiltration into the soil.
Rain barrels	15.6 m^3 / barrel	Average roof size of houses in Grefsen is 45 m^2 (Li et al., 2020). Given the dimension of average roofs in Grefsen we assumed that half of the roof surface area will discharge water to installed rain barrels. In case rain barrels reach their full capacity, we assume that surplus water is discharged to open spaces (e.g. gardens) and thus will not reach the combined sewage system.
Infiltration crates	19.8 m^3 / 1m^3 unit	Capacity of infiltration crates is defined by the following formula: capacity crates (liter) = amount of hard surface area connected to crates (m2) * retention capacity (mm / m2) (BUMA, 2021). Based on this formula the amount of hard surface connected to 1m^3 infiltration crate unit is estimated taking the retention capacity of a peak rainfall event of 35 mm in one hour (= 28.57 m^2 / m^3 infiltration crate). This amount was multiplied by 694 mm to assess annual average storage capacity of a 1 m^3 infiltration crate unit.
Water square	0 m^3	The current location for a potential water square is an open and flat grass field (BAU) and we assume that regular rainfall will be infiltrated into the soil instead of discharging to the combined sewage system. Further, when the grass field is transposed to a watersquare, we assume that flood water will be stored in the watersquare and later infiltrated into the soil instead of going to the CSO. However, in both cases (BAU and for the watersquare scenario) the flood water does not reach the WWTP.
Seperate Sewer System	19.8 m^3 / 1m^3 unit	Capacity of SSS is defined by the following formula: capacity SSS (liter) = amount of hard surface area connected to crates (m2) * retention capacity (mm / m2) (BUMA, 2021). Based on this formula the amount of hard surface connected to 1m^3 SSS unit is estimated taking the retention capacity of a peak rainfall event of 35 mm in one hour (= 28.57 m^2 / m^3

infiltration crate). This amount was multiplied by 694 mm to assess annual average storage capacity of a 1 m^3 SSS unit.

S4. Fresh water savings

Water from rain barrels is particularly used for watering gardens and thus reducing drinking water requirements which is regarded as irrigation water source to be used in the BAU situation. The price of drinking water in Oslo is 7.9 NOK/m^3 (Statistics Norway, 2021). Further, it is assumed that 50% of the water entering the rain barrels is annually used for this purpose as in winter-times the watering of gardens is not occurring.

Additional references

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