Life Cycle Assessment of Cloudburst Management Plans in Adaptation to Climate Change in Copenhagen, Denmark

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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
The City of Copenhagen has developed Cloudburst Management Plans to flood-proof the city with regards to an expected increase in extreme rain events due to climate change (The City of Copenhagen, 2012). The plans are largely based on green infrastructure, as opposed to traditional solutions based on underground pipes and retention basins.

While cost and flood risk assessments are inherent parts of storm water management (SWM), the environmental impacts are often not analyzed. In this study, these impacts were quantified using Life Cycle Assessment (LCA), and compared for two different SWM scenarios for the sub-catchment Nørrebro (2.6 km²):  

- “Green” scenario: Green infrastructure is utilized to retain, infiltrate and discharge runoff above the surface as proposed in the Cloudburst Management Plan;  
- “Grey” scenario: Runoff is handled in underground pipes and retention basins, and is cleaned at a wastewater treatment plant before discharge.

Figure 1 – Copenhagen sub-catchments (based on [1])

Figure 2 – Exemplary project from the Cloudburst Management Plan for Nørrebro, Copenhagen [1]

The allocation shows that managing of small rain events (domain A) causes little impacts in both systems. Handling runoff during events with a return period of up to 10 years (domain B) causes by far the largest share of impact in the “grey” system, while extreme events (domain C) only account for minor impacts. In the “green” scenario, where main elements are designed to handle both domain B and C events, these domains cause equally large impacts (Figure 6).

RESULTS & DISCUSSION

Eight midpoint impact categories were selected. The impacts of both scenarios are dominated by the material production life cycle stage, which accounts for 42 to 75% of the total impacts in the “green” scenario, and 62 to 96% in the “grey” scenario. Production of concrete is contributing significantly in both systems. Additionally, in the “grey” scenario, steel for basins and road materials cause high environmental impacts.

The sensitivity analysis shows that the major uncertainties relate to the accuracy of the input data extracted from planning documents, and to the 100 year time horizon of the assessment. Even though the results deviate significantly from the baseline scenario (up to 72% for the “green”, and up to 18% for the “grey” solution), the impacts of the “grey” scenario remain higher in all tested configurations (Figure 6).

The Life Cycle Assessment shows that the environmental impacts of a green infrastructure based (“green”) system are lower than for a subsurface (“grey”) alternative in the Nørrebro catchment.

CONCLUSIONS

- The Life Cycle Assessment shows that the environmental impacts of a green infrastructure based (“green”) system are lower than for a subsurface (“grey”) alternative in the Nørrebro catchment.
- Material production is the main contributing life cycle stage. This highlights the possibility to significantly influence the environmental impacts of systems in the design phase.
- The sensitivity analysis shows that single parameters significantly influence the results, but the impacts for the “grey” system remain higher for all tested scenarios.
- The choice of flood safety targets influences the environmental impacts, which can be assessed by allocating the impacts to the different safety levels.
- Management of extreme events (domain C) causes higher impacts in the “green”, than in the “grey” system. Small rain events (domain A) cause minor impacts in both systems.


The Ministry of Science, Technology and Innovation in Denmark, and VCS Denmark, HOFOR, and Aarhus Vand funded the Industrial PhD project in which this research was done. Margit Lund Christensen, Nina Fink, and Jeppe Rasmussen are gratefully acknowledged for providing data for the test case. The authors also thank Christian Ammitzøe for providing continuous feedback and input, and Anders Damgaard for the modelling support.

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