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Figure 1. Case study area: Amsterdam Airport Schiphol, showing the different types of catchment surfaces.

The Netherlands qualify as a delta area in a temperate climate and as such are endowed with an abundant and high-quality fresh water supply. However, occasional water shortages occur in summer, resulting in damage to both nature and the economy. Climate change is expected to result in more frequent and prolonged periods of drought combined with an increased water demand. One of the negative side effects will be an increased saline intrusion in the lower parts of The Netherlands[1]. Thus, both the optimisation of water distribution through the public water supply system and an increased self-sufficiency are required. Rainwater harvesting and storage can contribute to this ambition.

Rainwater can be utilised as a fit-for-purpose alternative to piped drinking water for uses that do not require potable water including toilet flushing, cleaning, irrigation, building cooling and firefighting. Traditionally, the application of rainwater harvesting has focussed on single buildings with the roof as a catchment[2,3]. However, self-sufficiency in terms of water supply requires rainwater harvesting on a larger, regional scale. This study assesses the feasibility of rainwater harvesting on the scale of Amsterdam Airport Schiphol (Figure

1). Large areas suitable for rainwater harvesting in combination with a mix of household and industrial water demand make the airport area an interesting case study.

The airport's water demand equals that of a city with 30.000 inhabitants and is distributed in hotels and offices with household type demand, but also in terminals and terminal buildings with a more industrial type of demand. This study assesses the potential water supply (i.e. amount of rainwater that can be harvested) and the economic feasibility of rainwater harvesting in this semi-industrial delta [4].

Amsterdam Airport Schiphol is one of the four largest airports in Europe and it is located in the economic heart of the Netherlands, 5 meters below sea level. The total land area of the case study area is 21 km^2. Increasing saline intrusion is a specific water-related challenge in this delta area. This study includes a feasibility analysis of rainwater harvesting for replacing drinking water on site as well as supplying fresh water to its surrounding areas through a system of ditches, canals, and rivers during dry periods to counter further salinization.

Water balance

To assess the potential for rainwater harvesting at Schiphol Airport, a numerical model was developed describing the water balance, using an hourly time-step. The water balance has three components as shown in Figure 2:

- Rainwater supply and catchment
- Storage and treatment
- Fit-for-purpose (non-potable) water demand

Harvest scenarios were developed for different combinations of catchment surfaces and volumes of storage capacity, for a dry-, an average and a wet year (based on historical data of the past 20 years). Three different types of catchment surfaces were assessed in the model: roofs, paved airside and paved landside. The hourly non-potable water demand was determined using bi-monthly demand totals. The data was transformed into weekly and daily water demand patterns based on models provided in the literature[2,5]. The fraction of drinking water which can be replaced by non-potable rainwater supply was determined for each building type (terminal, hangar, hotel, etc.).

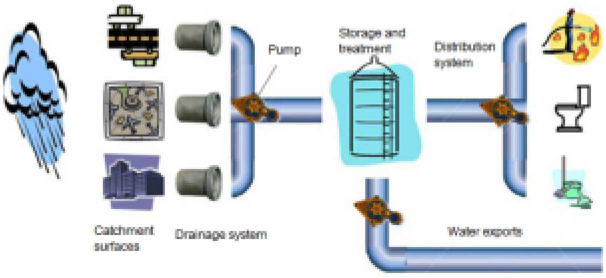

Figure 2. Components of the rainwater system at an airport.

Performance of the rainwater harvesting and supply systems was assessed on an hourly basis using historical rainfall data from the national meteorological institute[6]. Performance is measured using the parameter RUR: 'rainwater utilisation rate' indicating the fraction of the total, non-potable water demand that is covered by rainwater supply[7]. Costs for infrastructure and operation of all harvest and storage systems were assessed using net present valuation.

Results

All non-potable water demand at Schiphol can be supplied through rainwater harvesting, saving the airport 58% on its water bill. Using only roofs as catchment surfaces to meet all demand requires large storage capacity (Figure 3). Also, less frequent and more intense rainfall patterns associated with climate change will increase the storage capacity required. Adding other catchment surfaces (paved landside and paved airside) decreases the required storage capacity and increases harvesting dramatically. In an average year, potential harvesting from all catchment surfaces amounts to nearly 7 million m^3, which is about ten times the total non-potable demand at the airport. The optimal combination of storage capacity and catchment areas is found at the level where marginal costs of adding an extra unit equals 1 for both these factors. Hence, aiming for a RUR of 100% is not optimal.

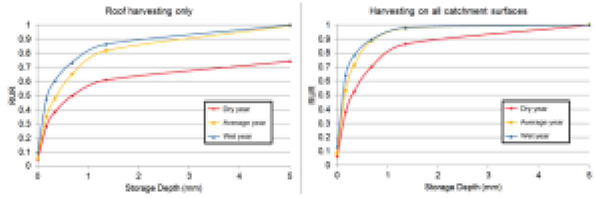

Figure 3. Rainwater utilisation rate (RUR) with variable storage capacity for systems

with different catchments for years with
different rainfall totals.

Because of the low, whole sale based water charges (amounting to €0.80 per m^3), the only economically attractive option is a small scale system for the supply of water to firefighting drills. The return period on investment for this small-scale system is the only one under 15 years. However, using Dutch non-industrial water prices (€1.40 per m^3), or even higher prices found in other European countries[8], larger scale systems become feasible as well. Most notably, supply of all installations at Schiphol and the supply of terminal uses with runoff from roofs and paved landside become feasible.

Conclusion: Rainwater harvesting at the scale of an airport?

Amsterdam Airport Schiphol can harvest enough rainwater to meet all its non-potable demand using roofs as catchment surfaces. When paved landside and paved airside catchment surfaces are added to roof catchments, rainwater harvesting can exceed the non-potable water demand by ten times, allowing Schiphol to function as a water supplier to its surrounding polders to fight saline intrusion.

When considering a rainwater harvesting system that supplies the local demand at the airport, the low industrial water charges make most configurations of the system economically unfeasible. Only a small scale application seems realistic, for example supplying weekly firefighting drills with rainwater. However, when water rates increase due to scarcity both in quantity and quality, results suggest that larger systems or even full scale application of rainwater harvesting may become feasible at the scale of airports or comparable sites with combined household and industrial non-potable water demand.

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