Environmental map towards water and food self-sufficiency: integrating rainwater harvesting and urban agriculture under different climatic conditions

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Introduction

Population growth, urbanization and climate change are stressing the need for alternative water and food production areas. **Fresh produce** is imported from **distant agricultural areas**, whereas **water availability** is decreasing due to **droughts or** poses a threat due to sudden and **intense rainfall** events. The goal of this contribution is to assess the **environmental performance of different rainwater harvesting (RWH) scenarios** that meet the water **demand for indoor uses and food production** at a household level under different climatic conditions using **Life Cycle Assessment** in order to **optimize global water use**.

Materials & Methods

We selected 21 cities from 11 climatic regions (***Figure 1***) and modeled RWH scenarios in a 156-m^2 **prototype** family house with a 40 m^2 garden. RWH system was sized **using daily rainfall data from each city** and Plugrisost®[1], which resulted in **different tank sizes and % rainwater supply** depending on demand and climate. Scenarios included (***Figure 2***) indoor demand (**toilet flushing and laundry** – constant demand in all cities), outdoor demand (**lettuce production, with medium water demand –** based on evapotranspiration) and a combination of both.

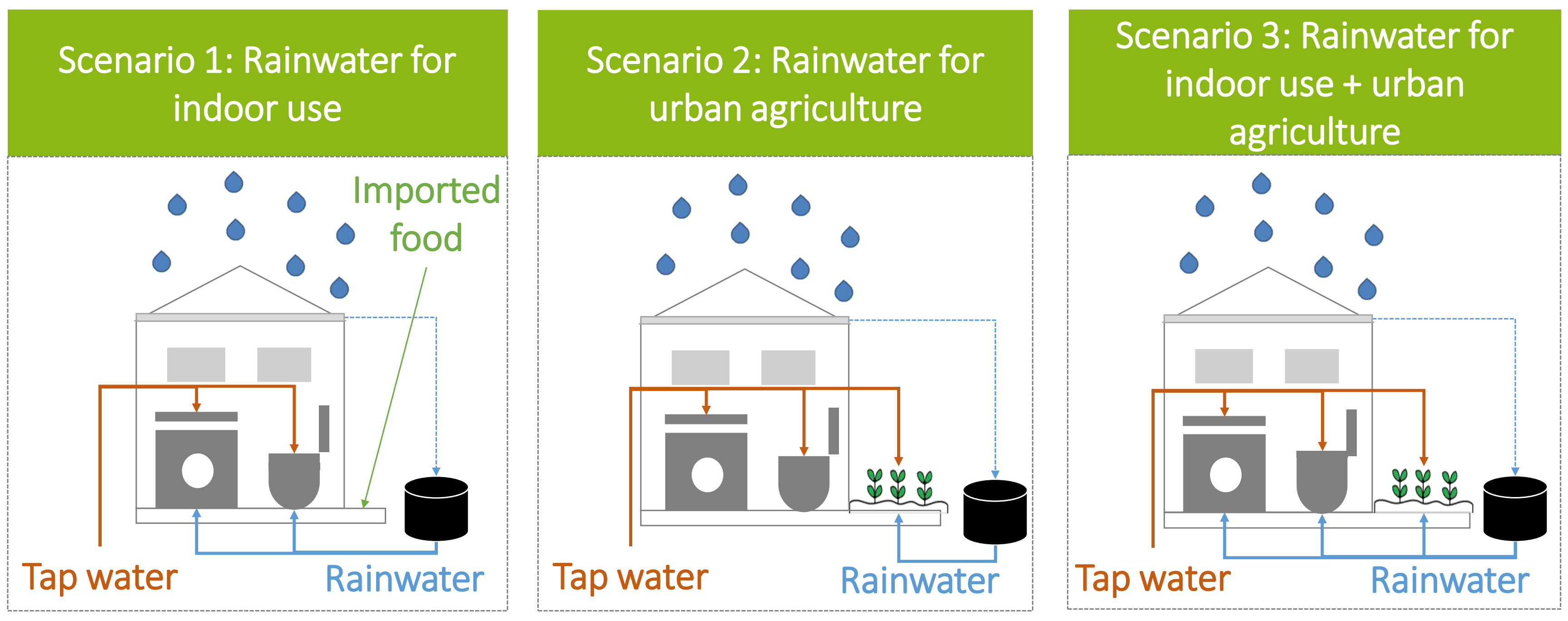
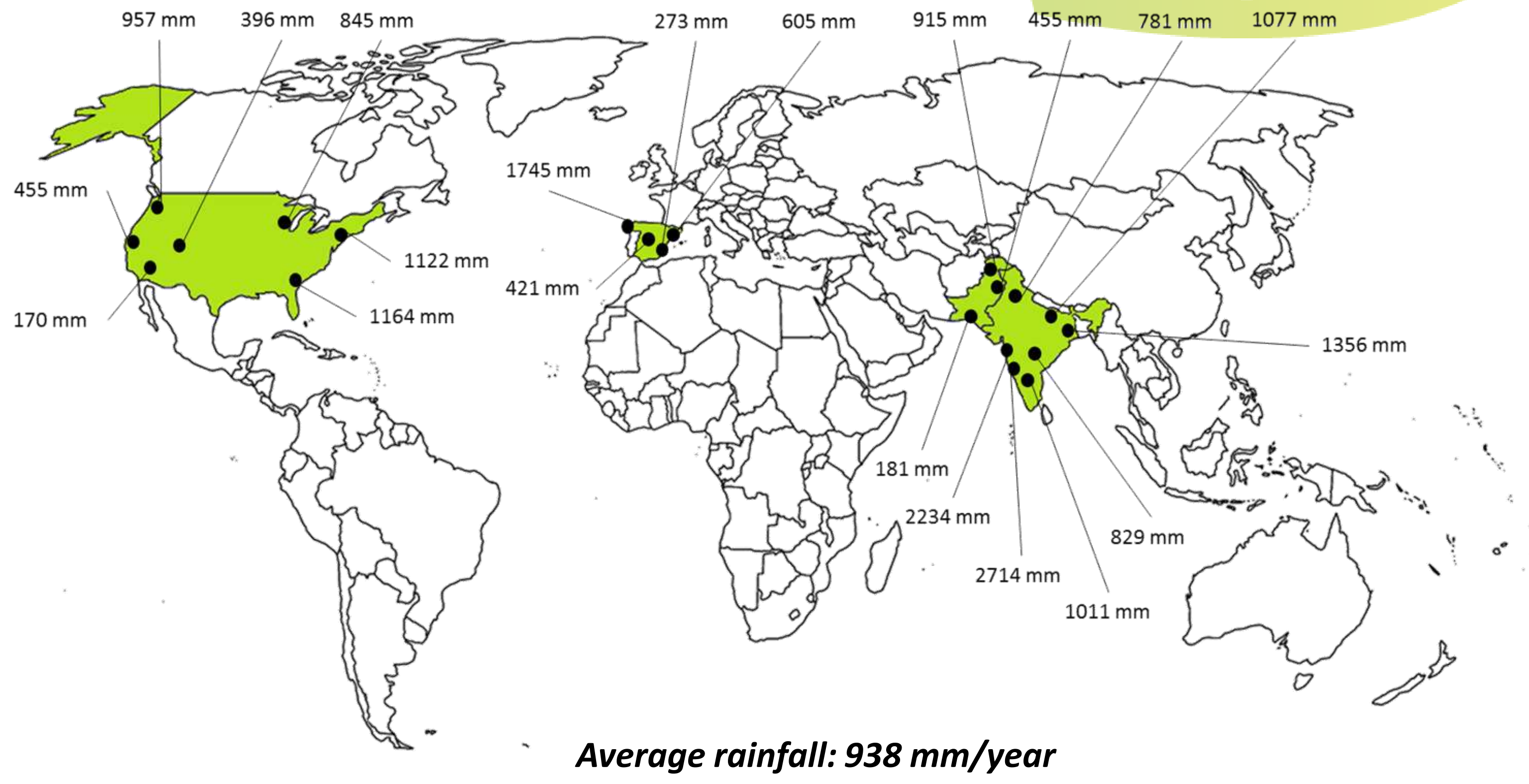

Scenario 1: Rainwater for indoor use
Scenario 2: Rainwater for urban agriculture
Scenario 3: Rainwater for indoor use + urban agriculture

Figure 2 Scenarios for indoor, outdoor or combined rainwater use at a household level



Average rainfall: 938 mm/year

Figure 1 Cities selected for the assessment. The values represented the annual average rainfall

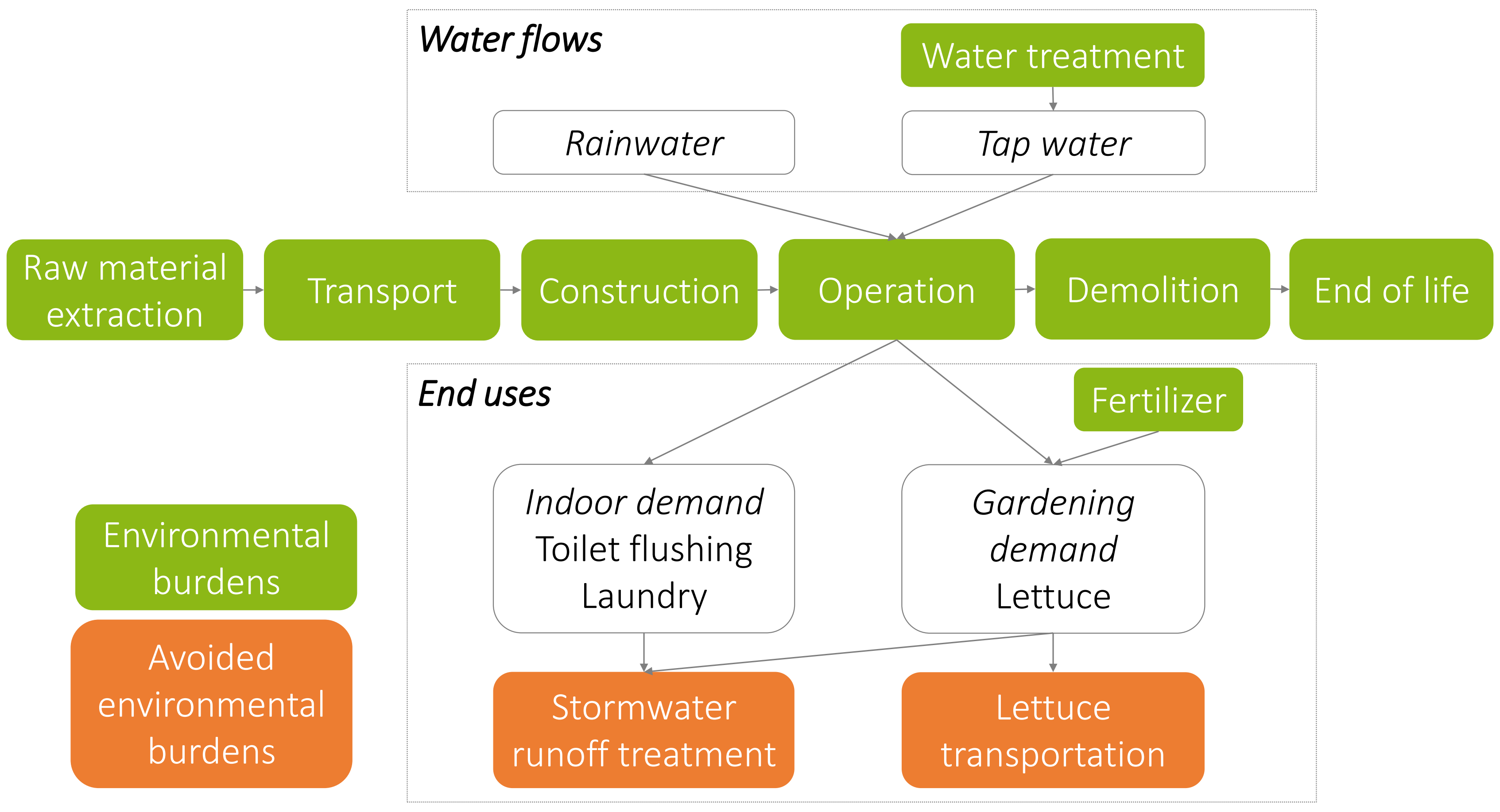

Water flows
Water treatment
Rainwater
Tap water
Raw material extraction
Transport
Construction
Operation
Demolition
End of life
End uses
Fertilizer
Environmental burdens
Avoided environmental burdens
Indoor demand
Toilet flushing
Laundry
Gardening demand
Lettuce
Stormwater runoff treatment
Lettuce transportation

Figure 3 System boundaries of the LCA, including the environmental impacts and avoided burdens of the RWH scenarios

The functional unit (FU) **1 m^3 of water supplied with rainwater and potable water for laundry, toilet flushing and food production**. The life cycle stages involved in the RWH and agriculture assessment are shown in ***Figure 3***. The results were based on theoretical and modelled values. We used ecoinvent v3 [2], Simapro 8 [3] and the ReCiPe (H) method [4] to model the impacts. Only the **Global Warming Potential** (GWP) is shown.

Results & Conclusions

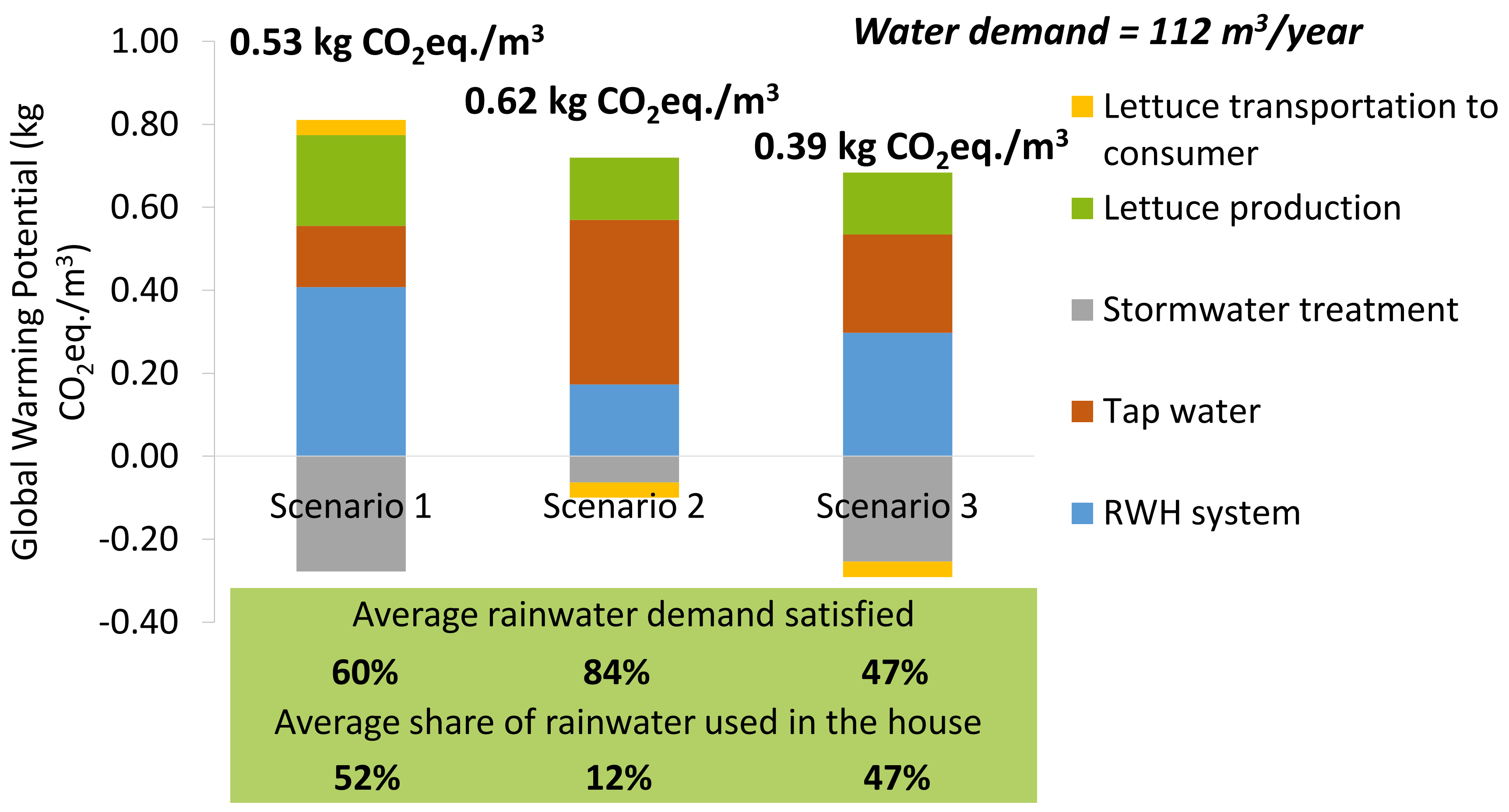


Figure 4 Average GWP and rainwater supply resulting from the RWH scenarios applied to the sample of cities

Figure 4 shows the average water demand and GWP of each scenario considering the selected sample (***Figure 1***). **Scenario 3 was the best option (0.39 kg CO$_2$eq./m^3)**, as it combined the benefits of **tank optimization, reduced stormwater treatment and reduced transportation emissions. Scenario 2** resulted in increased water treatment impacts, as rainwater meets **12% of the total demand**. Scenario 1 benefited from reduced stormwater treatment, but the tank was comparatively bigger than that of Scenario 3 and transportation emissions were larger. This novel approach will help to **map the areas of the world** where the use of RWH might be environmentally feasible **given the rainwater rainfall variability**. Additionally, the most suitable configuration and end uses will be identified according to the features of each region.

References

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