

4TH INTERNATIONAL ARCHITECTURAL SCIENCES & APPLICATIONS SYMPOSIUM

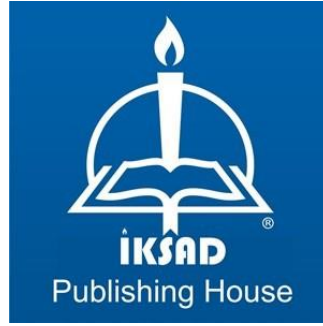
May 30-31, 2024 / Final International University
Kyrenia, Turkish Republic of Northern Cyprus
Online and Face to Face

PROCEEDINGS BOOK

Editor in Chief
Prof. Dr. Atila GÜL

Assistant Editors
Prof. Dr. Öner Demirel
Assoc. Prof. Dr. Seyithan Seydoşođlu
Assoc. Prof. Dr. Nafiya Güden
Asst. Prof. Dr. Seden Turamberk Özerden
Prof. Dr. Zeynep Üstün Onur





IKSAD Publishing House

Institution of Economic Development and Social Researches

**All rights of this book belongs to IKSAD Publishing House.
Without permission of the publisher (IKSAD), can't be duplicate or copied.
Authors of chapters are responsible both ethically and juridically.**

(Licence Number of Publicator: 2014/31220)

TÜRKİYE TR: +90 342 606 06 75 USA: +1 631 685 0 853

E mail: iksadyayinevi@gmail.com

www.iksadyayinevi.com

ISSUED: 30/08/2024

Copyright © 2024 by İKSAD publishing house All rights reserved

IV. International Architectural Sciences and Applications Symposium

(IArcSAS-2024)

<https://www.iarcsas.org/>

May 30-31, 2024, Girne-Turkish Republic of Northern Cyprus

PROCEEDINGS BOOK

(Abstracts & Full Texts)

Editor in Chief

Prof. Dr. Atila GÜL

Assistant Editors

Prof. Dr. Öner Demirel
Assoc. Prof. Dr. Seyithan Seydoşođlu
Assoc. Prof. Dr. Nafiya Güden
Asst. Prof. Dr. Seden Turamberk Özerden
Prof. Dr. Zeynep Üstün Onur

ISBN: 978-625-367-814-2

DOI: 10.5281/zenodo.13623830

All rights of this book belongs to IKSAD Publishing House.
Without permission can't be duplicate or copied.
Authors of chapters are responsible both
ethically and juridically.

Layout Editors

Prof. Dr. Ümit Arpacıođlu
Prof. Dr. H. Tendü Göktuđ
Assoc. Prof. Dr. Őirin Gülcen Eren
Assoc. Prof. Dr. Ertan DüzgüneŐ
Assoc. Prof. Dr. H. Berk Türker
Assoc. Prof. Dr. Ahmet Erkan Metin
Assoc. Prof. Dr. Meryem Bihter Bingül Bulut
Assoc. Prof. Dr. Sultan Sevinç Kurt Konakođlu
Asst. Prof. Dr. Mert Çakır
Asst. Prof. Dr. Gizem Dinç
Asst. Prof. Dr. Yeter Çilesiz
Dr. Çađla Aydemir
Dr. Pelin Fırat Örs
Dr. Sibel Akten
Dr. Tuba Gizem Aydođan
PhD Student, Neriman Gül Çelebi
PhD Student, Halime Gözlükaya
PhD Student, İskender Emre Gül
Masters's Student, Hatice Eda Gül
Undergraduate student, Seniye Ela Gül

ISBN: 978-625-367-814-2

DOI: 10.5281/zenodo.13623830

Cover Design:
Atabek Movlyanov

ISSUED: 30/08/2024

IV. International Architectural Sciences and Applications Symposium

(IArcSAS-2024)

<https://www.iarcsas.org/>

May 30-31, 2024
Girne- Turkish Republic of Northern Cyprus

CONTENTS

Titles	Page Numbers
Symposium ID	1
Organizing Board	3
Science and Advisory Board	6
Symposium Schedule	15
Symposium Photos	73
Abstract List	76
Abstract Contents	100
Full Text List	331
Full Text Contents	345-2177



**FINAL INTERNATIONAL
UNIVERSITY**



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

SYMPOSIUM ID

SYMPOSIUM TITLE

**IV. International Architectural Sciences and Applications Symposium
(IArcSAS-2024)**

DATE AND PLACE

May 30-31, 2024

Final International University, Girne- Turkish Republic of Northern Cyprus

ORGANIZING



The Editorial Board of the Journal of Architectural Sciences and Applications,
Isparta, Türkiye.

<https://dergipark.org.tr/en/pub/mbud>



Institute of Economic Development and Social Research,
Ankara, Türkiye.

<https://www.iksadinstitute.org/>



Final International University,
Girne- Turkish Republic of Northern Cyprus

<https://www.final.edu.tr/>

PRESENTATION

Oral and Online Presentations

EVALUATION PROCESS AND POLICIES

All applications have undergone double blind peer review process. In addition, each paper was accepted and the process of publishing in the book was carried out through editorial oversight. The published papers were presented and discussed at the meeting.

Full texts and abstracts published in accordance with the Symposium Policy have been prepared in accordance with ethical rules and APA standards. Authors of all papers are both ethically and legally responsible.

AIM OF THE SYMPOSIUM

This Symposium aims to bring together qualified scientists from Türkiye and abroad on a common international platform under the umbrella of Architectural Sciences and to enable different disciplines to share their valuable research.



**FINAL INTERNATIONAL
UNIVERSITY**



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

TOPICS OF THE SYMPOSIUM

- Planning (Planning theories, planning paradigms, types of planning, regional planning, watershed planning, landscape planning, urban planning, rural planning, planning and protection, spatial and temporal changes, site selection methods, etc.)
- Design (Design theories, Space, Building, Urban, Landscape, Rural, Village, Tourism, Recreational, Environment, Interior Architecture, Plantation, Industrial Products, Ecological, Universal, Disabled, etc.)
- Sociology / Psychology / Art / Philosophy / History / Identity / Theory / Aesthetics
- Protected Areas / Natural and Cultural Heritage Protection / Documentation / Renovation / Repair / Restoration / Soil sealing
- Tourism / Recreation / Cultural Tourism / Nature Tourism / Ecotourism / Archaeology
- Climate Change / Renewable Energy / Energy saving / Energy Transition / Water / Sustainability / Ecology/ Environment / Sustainable Development
- Smart and Ecological Cities / Urbanism / Landscape / Open and Green Spaces / Green infrastructure / Transportation / Urban Agriculture / Urban Renewal / Transformation
- Building Materials / Green Buildings / Urban Accessories and Furniture / Landscape materials/ Landscape Plant Materials and Using/ Plant Cultivation and Use
- Technology / Artificial Intelligence / Digital Architecture and 3D Software and Printer, GIS, Remote sensing
- Health / Pandemic / Food / Occupational Health and Safety
- Higher Education in Architectural Sciences / R&D / Scientific Researches / Publications
- Economic / Policies / Legislation / Management / Governance / Practices / Sectoral Problems
- Planning and Design Project Competitions and Processes /Applied Project

PARTICIPANTS COUNTRIES

Algeria, Azerbaijan, Germany, Hungary, India, Indonesia, Italy, Kazakhstan, Malaysia, Morocco, Nigeria, Portugal, Pakistan, Poland, Portugal, Romania, South Africa, Spain, Türkiye, Turkish Republic of Northern Cyprus, Vietnam

TOTAL ACCEPTED ARTICLES: 390

Number of Rejected Papers: 30

The Number of Accepted Papers from Türkiye: 182

The Number of Accepted Full Papers from Other Countries: 208

INDEX IN

Index of Academic Documents (IAD), Open AIRE, Google Scholar, ResearchGate, Britishindex Scientific Database



**FINAL INTERNATIONAL
UNIVERSITY**



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

IV. International Architectural Sciences and Applications Symposium

(IArcSAS-2024)

<https://www.iarcsas.org/>

CHAIRS OF THE ORGANIZING BOARD

- **Prof. Dr. Atila Gül**
- Süleyman Demirel University, Faculty of Architecture, Department of Landscape Architecture, Isparta- Türkiye
- **Prof. Dr. Öner Demirel –**
- Kırıkkale University, Faculty of Fine Arts, Department of Landscape Architecture, Kırıkkale- Türkiye
- **Assoc. Prof. Dr. Nafiya Güden**
- School of Tourism and Culinary Arts, Final International University, Girne -TRNC
- **Prof. Dr. Zeynep Üstün Onur**
- Faculty of Architecture and Fine Arts, Final International University, Girne- TRNC
 - **Asst. Prof. Dr. Seden Turamberk Özerden**
 - Final International University, Girne -TRNC

SYMPOSIUM COORDINATORS

- **Assoc. Prof. Dr. Seyithan Seydoşoğlu**
IKSAD Scientific Support Coordinator
 - **Atabek Movlyanov**
IKSAD Scientific Support Coordinator



**FINAL INTERNATIONAL
UNIVERSITY**



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

ORGANIZING BOARD MEMBERS

- Assoc. Prof. Dr. Aminreza Iranmanesh - Final International University, Faculty of Architecture and Fine Arts, TRNC
- Prof. Carmela Gargiulo - University of Naples Federico II, Department of Civil, Architectural and Environmental Engineering, Naples, Italy
- Prof. Dr. Ümit Arpacıoğlu - Mimar Sinan Fine Arts University, Department of Architecture, İstanbul-Türkiye
- Prof. Dr. Niyazi Uğur Koçkal - Akdeniz University, Faculty of Engineer, Department of Civil Engineering, Antalya- Türkiye
- Prof. Dr. Sedef Doğaner-Wentworth Institute of Technology, Wentworth School of Architecture and Design, U
- Prof. Dr. H. Tendü Göktuğ - Adnan Menderes University, Faculty of Agriculture, Department of Landscape Architecture, Aydın-Türkiye
- Prof. Dr. Asena Soyluk - Gazi University, Faculty of Architecture, Department of Architecture, Ankara-Türkiye
- Prof. Dr. Şebnem Ertuş Beşir - Akdeniz University, Faculty of Architecture, Department of Interior Architecture, Antalya- Türkiye
- Assoc. Prof. Dr. Elif Tokdemir Demirel - Kırıkkale University, Faculty of Arts and Sciences, Department of Translation and Interpretation, Türkiye
- Assoc. Prof. Dr. Elif Sönmez - Altınbaş University, Faculty of Engineering and Natural Sciences, Department of Interior Architecture and Environmental Design, İstanbul- Türkiye
- Assoc. Prof. Dr. Ertan Düzgüneş - Karadeniz Technical University, Faculty of Forestry, Department of Landscape Architecture, Trabzon-Türkiye
- Assoc. Prof. Dr. Hayriye Hale Kozlu - Erciyes University, Faculty of Architecture, Department of Architecture, Kayseri- Türkiye
- Assoc. Prof. Dr. Mete Ünal Girgen - Final International University, School of Tourism & Culinary Arts, TRNC
- Assoc. Prof. Dr. Sultan Sevinç Kurt Konakoğlu - Amasya University, Faculty of Architecture, Department of Urban Design and Landscape Architecture, Amasya-Türkiye
- Assoc. Prof. Dr. Şirin Gülcen Eren - Süleyman Demirel University, Faculty of Architecture, Department of City and Regional Planning, Isparta- Türkiye
- Assoc. Prof. Dr. Vibhavari Janhi - Kansas State University, College of Architecture, Planning, and Design, Department of Interior Architecture & Product Design, USA
- Assoc. Prof. Dr. Ahmet Erkan Metin - Uşak University, Banaz Vocational School, Forestry and Forest Products Program, Uşak- Türkiye
- Assoc. Prof. Dr. H. Berk Türker - Uşak University, Faculty of Architecture and Design, Department of City and Regional Planning, Uşak- Türkiye
- Assoc. Prof. Dr. Meryem Bihter Bingül Bulut - Kırıkkale University, Faculty of Fine Arts, Department of Landscape Architecture, Kırıkkale- Türkiye



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

- Assist. Prof. Dr. Farzad Safaeimanesh - Final International University, School of Tourism & Culinary Arts, TRNC
- Assist. Prof. Floriana Zucaro - University of Naples Federico II, Department of Civil, Architectural and Environmental Engineering, Naples- Italy
- Assist. Prof. Dr. Foad Irani - Final International University, School of Tourism & Culinary Arts, TRNC
- Assist. Prof. Dr. Gizem Dinç - Süleyman Demirel University, Faculty of Architecture, Department of Landscape Architecture, Isparta- Türkiye
- Assist. Prof. Dr. Mert Çakır - Süleyman Demirel University, Faculty of Architecture, Department of Landscape Architecture, Isparta- Türkiye
- Assist. Prof. Dr. Pooya Lotfabadi - Final International University, Faculty of Architecture and Fine Arts, TRNC
- Assist. Prof. Dr. Soad Abokhamis Mousavi - Final International University, Faculty of Architecture and Fine Arts, TRNC
- Dr. Çağla Aydemir - Süleyman Demirel University, Faculty of Architecture, Department of Landscape Architecture, Isparta- Türkiye
- Dr. Gerardo Carpentieri - University of Naples Federico II, Department of Civil, Architectural and Environmental Engineering, Naples, Italy
- Dr. Pelin Fırat Örs - Çanakkale Onsekiz Mart University, Faculty of Architecture and Design, Department of Architecture, Çanakkale- Türkiye
- Dr. Kasra Talebian - Final International University, Faculty of Architecture and Fine Arts, TRNC
- Dr. Sibel Akten - Isparta University of Applied Sciences, Department of Park and Horticulture, Isparta- Türkiye
- Halime Gözlükaya - Süleyman Demirel University, Faculty of Architecture, Department of City and Regional Planning, Isparta- Türkiye
- Hatice Eda Gül - Student, Mehmet Akif University, Faculty of Engineering- Architecture, Department of Architecture Burdur- Türkiye
- İlayda Türker - Süleyman Demirel University, Faculty of Architecture, Department of City and Regional Planning, Isparta- Türkiye
- İskender Emre Gül - Akdeniz University, Sciences Institute, Department of Civil Engineer, Antalya - Türkiye
- Seyyed Shahab Miri - School of Foreign Languages, Final International University, TRNC
- Tuba Gizem Aydoğan - Kırıkkale University, Faculty of Fine Arts, Department of Landscape Architecture, Kırıkkale- Türkiye
- Seniye Ela Gül - Demokrasi University, Faculty of Architecture, Department of Architecture, İzmir- Türkiye
- Lecturer Neriman Gül Çelebi - Istanbul Nişantaşı University, Faculty of Art and Design, Vocational School, Türkiye
- Rasiha Kayalar - Final International University, Faculty of Architecture and Fine Arts, TRNC
- Kamiar Yazdani - Final International University, Faculty of Architecture and Fine Arts, TRNC
-



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

Planning Surface Runoff Using Green Infrastructure Systems in Urban Waterways

Nazmiye ERMEYDAN^{1*}

ORCID 1: 0009-0005-7892-9746

¹Istanbul Sabahattin Zaim University, Graduate Education Institute, Department of Architecture, Department of Urbanism and Urban Transformation, İstanbul-Türkiye

*ermeydan.nazmiye@std.izu.edu.tr (Responsible Author)

Serhat ANIKTAR

ORCID2: 0000-0002-7727-5331

²Assoc. Prof. Dr., İstanbul Sabahattin Zaim University, Faculty of Engineering and Natural Sciences, Department of Architecture, İstanbul- Türkiye

serhat.aniktar@izu.edu.tr

Abstract

In cities, the discharge systems for surface waters used so far have been proven inadequate due to changes in precipitation intervals and amounts brought about by climate change, as experienced through increased flooding and droughts. The urban population and the number of impervious surfaces within cities continue to rise dramatically. Reducing the amount of surface runoff has become a top priority for sustainable cities. In urban waterway basins, existing and planned green spaces should be designed to slow down the speed of precipitation and subsequent surface runoff. Temporary water retention areas should be created in both active and passive green spaces located along the waterways. All waterways within the city have a basin, and cities are comprised of these basins. Plans and projects should be based on basins and sub-basins. Key projects at the basin level include green roofs, rain gardens, reduction of impervious surfaces, bioswales, and green infrastructure networks. Planned measures will prevent peak flows and delay their timing. The amount and quality of water reaching the waterways will improve. Furthermore, the amount of surface runoff will decrease, depleted aquifers will refill, and the amount of water reaching underground will increase, resulting in the formation of ecological cities.

Keywords: Urban Waterways, Urban Watersheds, Surface Runoff, Green Infrastructure, Aquifer

1. Introduction

It may be difficult to accept that the human race, which has only existed for less than 1% of Earth's history, could have had such a big impact given what is known about the planet's geological timeline. Given what is known about the Earth's geological timescale, it may be somewhat reluctant to accept the fact that the human species, which has existed for less than 1% of its history, could have had such a significant impact. However, surprise fades when it is realised that human action reshaping the planet has been much faster than natural geological change. More than half of accessible freshwater is used for human purposes (Crutzen & Stoermer 2000).

Cities constitute only 2% of the world's surface area (IPCC, 2014). Cities are also among the areas most affected by the effects of extreme climatic conditions. This is because they are built on the banks of rivers and seas. Their natural surfaces have been modified.

Cities established in the regions where there are waterways have used all the opportunities provided by waterways. The water needed in all areas of human life has been supplied from waterways such as domestic needs, drinking, agriculture, transport, production facilities, discharge of wastewater, etc. The basins of the waterways changed inversely proportional to the permeable and impermeable surface ratios during the first establishment of the cities. Until the industrialisation period, the waterways remained within the limits where they could maintain their

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

ecological tissues in terms of the loads brought to the waterways by the growth of cities. With the industrial age, the ratio between those living in rural areas and those living in cities has reversed. The connection of urban waterways first with the connected basins and then with the floodplains was cut and only the bed of the waterway remained.

One of the negative effects of urbanization is that a sizable portion of hard terrain has drastically changed the hydrological response, which is now a serious problem. (Zhang et al., 2018b; Chao Xu et al., 2020). Moreover, the ratio of impermeable and permeable surface covers of different settlement types (high and low-density settlements) is an important factor determining the impacts of urbanization on runoff because residential areas are the dominant urban land use (Miller & Hess, 2017; Chao Xu et al., 2020).

Reduced natural vegetation and reducing the areas of forests, results in increased runoff and river flow. (Costa et al., 2003; Foley et al., 2005; Sahin & Hall, 1996). Impervious surfaces developed during urbanisation contribute to more runoff due to reduced infiltration (Arnold & Gibbons, 1996; Schueler, 1994; Schueler et al., 2009). Reduced infiltration leads to higher peak flows even during short periods of low-intensity rainfall, increasing flood risk (Bhaduri et al., 2001; Suriya & Mudgal, 2012). Urban runoff also carries non-point source pollutants such as oil, grease, metals and pesticides to streams and rivers during rainfall events (Arnold and Gibbons, 1996; Blair et al., 2014; Schueler, 1994). Even when urban runoff is captured by a sewerage system and can be conveyed to wastewater treatment plants Combined Sewer Overflows (CSOs) in some highly urbanised areas continue to cause serious water pollution problems (Bhaduri and others, 2001; Passerat et al., 2011; Semadeni-Davies et al., 2008; Chen et al., 2017).

The main consequences of urbanization are: increased road surface areas, reduced drainage capacity, sewerage and engineered water exchanges, sewerage and designed water exchanges, especially between large surface waters and land change for agriculture. Another consequence of urbanization is the change of flow paths in urban basins. This significantly affects urban hydrological cycles.

Urban flooding is an old and recurrent urban phenomenon that occurs approximately every year, sometimes quite severe. It is thought that flood events will become more frequent and intense with climate change. The relationship between the city and water should be re-examined and new solutions should be found.

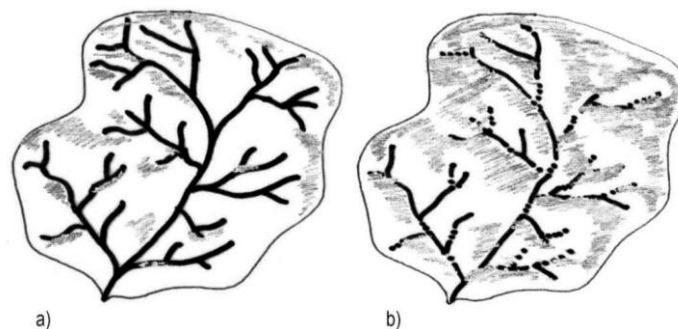


Figure 1. Sketch of a) natural water basin versus b) an urbanized water basin (severely altered with cancelled stream sections). The smudge represents the human settlements. Source: adapted from (Watson & Adams 2010).

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

Drainage systems have been implemented in cities throughout history, especially in urban stormwater management. These systems have been developed over time and have increased in scale and complexity. Most cities have relied on these systems as they are particularly efficient in quickly collecting and efficiently discharging stormwater from the city. Current stormwater management practice still faces many problems that are in line with current priorities and concerns. Some of the negative impacts produced by these systems paradoxically exacerbate flooding in urban areas.

Most conventional drainage systems bury and seal runoff in a network of pipes, further contributing to the degradation of the already impaired urban water cycle. Therefore, decreasing rates of infiltration, evaporation and groundwater recharge are exacerbated. By reducing natural discharge and seepage, aquifers are being depleted, as is the availability of drinking water. In addition, evaporation and transpiration are reduced as rainwater is rapidly removed from urban areas. This fact leads to warmer urban microclimates, although less pronounced. It contributes to exacerbate the urban heat island effect (UHI) (Alcoforado and Andrade, 2008).

Among the negative impacts of urbanization, the large area of hard landscapes significantly transforms the hydrological response and has become a critical issue (Zhang et al., 2018b) (Chao Xu et al., 2020). Moreover, the proportion of impermeable and permeable surface covers of different settlement types (high and low-density settlements) is an important factor determining the impacts of urbanization on runoff because residential areas are the dominant urban land use (Miller and Hess, 2017) (Chao Xu et al., 2020).

Problems with urban rainfall management have their roots in the concentration of the population in a relatively small area. Large impervious areas have been built to make living and transport possible. This causes the hydrological cycle to change. Infiltration and groundwater recharge are reduced, surface and river runoff patterns change, resulting in high peak flows, large runoff volumes and faster transport of pollutants and sediments from urban areas. Thus, the city affects the condition and flow pattern of ecological systems not only within the urban area, but also in and around the entire river system downstream (Niemczynowicz, 1999).

1.1. Current Situation of Cities

In an urbanised drainage basin, the propensity to flood is higher due to conditions that accentuate flood peaks. These include the expansion of the impermeable area, as shown in the Figure 1, which significantly alters the natural water cycle. According to Thomas Schueler's famous study "The Importance of Imperviousness", impervious coverage in residential areas ranges from about 10% in low-density suburban areas to over 50% in multi-family communities, industrial and commercial settlements. The coverage area rises to over 70% , and this rate is even higher in dense metropolises (Schueler, 2000).

- Comparing urban areas with a natural basin,
- More surface runoff with increasing velocities,
- Less infiltration rate,
- As a result, it has a decrease in groundwater supply.

Furthermore, given the extensive underground work going on in cities, such as subway lines or basements of buildings, underground drainage is also significantly impaired and consequently contributes to a greater extent to the flooding of the upper ground area.

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

2. Materials and Methods

2.1. Search for New Solutions to Reduce the Amount and Velocity of Runoff in Watercourse Basins

Since the early days have been developed a variety of processing of rainwater and treatment methods. It is generally recognised that rainwater should be attenuated locally. New methods are based on small-scale, environmentally sound technologies involving natural or artificial biological systems for the treatment of rainwater. These methods include ponds of various types, plant filters, runoff through natural or artificial ecosystems, wetlands, root zone systems, percolation plants, soil filtration, permeable asphalt and many combinations of these (Niemczynowicz, 1999).

It has been recognised that significant benefits can be achieved through the use of open stormwater drainage, i.e. systems in which a portion of stormwater, particularly from new residential areas, is retained on the surface where it can be reduced, treated and possibly recycled. Hundreds of stormwater conveyance and treatment plants based on these principles have been constructed in the world in the last 10 years. There is much experience in the operation of these plants. Some Swedish communities are already routinely building localised systems for rainwater harvesting and reuse in new residential areas (Niemczynowicz, 1999).

The new approaches include land use policy, urban and landscape planning, building construction, development control, strategic environmental assessment, economics, legislation, education and social acceptance issues, local community participation (Mouritz, 1996; Niemczynowicz, 1999).

A chain of ponds and wetlands can be created along an existing stream around the city. This chain can be used as an ecological zone and a beautiful park with high recreational value. The economic value of land and housing around natural and artificial water bodies, ponds and wetlands will increase significantly (Niemczynowicz, 1999).

Currently, almost 20% of the world's population is directly exposed to floods (Sadoff, et al., 2015). In our country, after earthquakes, the disasters that cause the greatest economic losses are floods. (Korkanç, 2005).

Initially high volumes of stormwater runoff can carry larger amounts of pollutants; this process is often described as the "first flush" phenomenon. Generally, the first half inch (1.27cm) of stormwater carries the highest pollution load, making its capture and management a priority for water quality protection. The first 12.7 mm of precipitation must be cleaned (<https://courses.lumenlearning.com/suny-sustainability-a-comprehensive-foundation/chapter/sustainable-stormwater-management/>).

There is a growing global consensus on the shortcomings of traditional hard engineering solutions to tackle urban drainage.

Conventional hydraulic engineering (from gray infrastructure onwards) has historically concentrated on the volume of stormwater to be displaced, with the aim of moving stormwater away from the city as fast as possible, but neglected the issue of stormwater quality. Figure 2. View of the watercourse and catchment <https://www.ajlajournal.org/articles/msimbazi-river-basin-city-park-project>.

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

Grey infrastructure technologies have not only increased pollution in culverted waterways, reduced aquifer recharge, ignored the natural potential of rivers and streams to provide comfort and environmental services, but also exacerbated downstream flooding.

Blockages in culverts accelerate the drainage time and often occur in the upper basins. Furthermore, the reduction of natural hydrological functions such as interception, evaporation, retention and infiltration of rainwater has led to an increase in the volume of rainwater, which "increases the peak, runoff rate and frequency of flooding" (Kozak et al., 2020).

Cities have changed the water cycle to such an extent that experts propose to use the term "urban water cycle" as a distinct and separate concept from the natural water cycle.

The basic structure of the water cycle in urban environments remains the same, but some important aspects have changed due to phenomena such as urbanization, industrialization and population growth.



Figure 2. Su yolu ve havzası görünüşü <https://www.ajlajournal.org/articles/msimbazi-river-basin-city-park-project>

Human activities to treat water resources and bring them up to standards acceptable to humans have changed the journey of water from basins to reservoirs and treatment, to domestic taps and from homes to nature.

Concrete and pavements in cities limit water infiltration and create runoff, which brings pollution and waste into stormwater systems as well as limiting the replenishment of groundwater aquifers. In short, human intervention has altered water circulation at the city level, changing the quality and availability of water resources (Figure 4) (Marsalek et al., 2008).

2.2. New sustainable solutions for the management of runoff in urban basins

Basically, adopting the terminology of the Source Path Receiver model to interpret urban flood risk, the focus of contemporary approaches is on managing flow at the source rather than the traditional approach of increasing the transmission capacity of the transmission system" (Kozak et al., 2020).

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

Instead of building massive drainage structures, the search for innovative techniques that aim to capture, retain and reuse rainwater within the basin, closer to the source of runoff, has become dominant (Kozak et al., 2020).

In basins of urban waterways

- From which surface runoff can evaporate,
- Temporary or permanent storage,
- where it can leak, where it can be cleaned,

it is necessary to develop projects.

One of the alternatives to achieve a more natural solution for rivers and society in urban areas,

- Utilisation of green and blue infrastructure (GBI-BBC) in multifunctional landscapes.
- The other is to ensure community participation and to raise public awareness.

Methods of establishing Green Infrastructure:

- a) By planning existing and green areas to be created,
- b) By establishing wetlands,
- c) By establishing rain gardens,
- d) By establishing roof gardens,
- e) By establishing water reserve areas,
- f) By establishing areas that can temporarily store rainwater,
- g) By allowing rainwater to infiltrate into the soil,
- h) By returning reinforced concrete waterways to their natural state,
- i) By turning the levelled waterways into meandering ones,
- j) By restoring floodplains that have been destroyed in watercourses,
- k) By restoring lost buffer zones along waterways,
- l) By unearthing the waterways buried underground,
- m) By unearthing the waterways buried underground,
- n) By linking the waterways with the green areas in its catchment,
- o) By creating a favourable environment for the return of flora and fauna lost from waterways,
- p) By reducing impervious surfaces in watercourse catchments to less than 20 per cent,
- q) By ensuring that the aquifers drained in the cities are recharged with clean water,

2.3. Community Involvement

Recognising the importance of community involvement, many initiatives involve local residents and organisations in improving waterways. This can include voluntary clean-ups, education programmes and advocacy of sustainable practices. The simplest example is balcony gardens.

Those living in the city can be encouraged to grow flowers in front of their balconies and windows. This makes a significant contribution to reducing surface runoff.

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure 3. Balcony garden sample

3. Findings and Discussion

3.1. Planning of Existing and to be Created Green Areas

Existing and planned green areas within the basins of urban waterways will mitigate the velocity of surface flows during and after rainfall, function as temporary water retention zones, purify particles carried by surface runoff, and establish an integrated green, grey, and blue infrastructure network. This network facilitates the transportation and transfer of rainfall and surface water between green areas in the basin, thereby preventing flood disasters and enabling the recovery of rainwater.

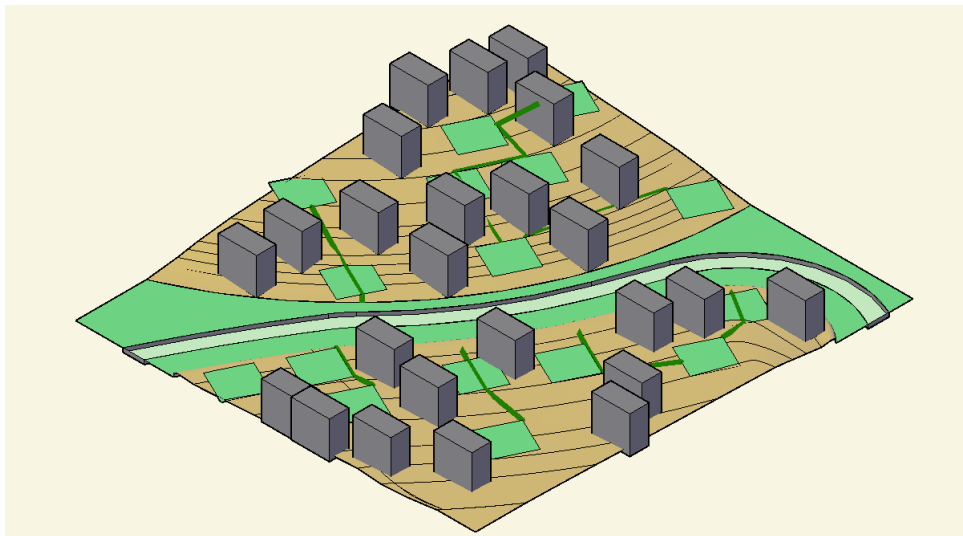


Figure 4. Visual drawing of urban waterway and basin

Bjerkedalen Park is located on the banks of the Hovinbekken stream in Oslo, Norway, in the centre of a residential area that used to have few public spaces. The restoration project involved the reopening of 300 m of the previously culverted stream to improve water quality, prevent flooding and create new green spaces. Some of the blue green infrastructure design criteria were applied in the design of the Bjerkedalen park. Open grassy areas were created on the slopes of the park and trees were planted. The park has a meadow area of 36.000 m². Permeable materials were used in the construction of perennial flower beds and hard surfaces. Designs such as stream channels and ponds have been developed in the park. Wetlands were created in the park to ensure the survival of flora and fauna. Since the park area is located by the waterway, it is also functionalised as a water retention area during heavy rainfall (Marković, 2021). By re-planning green areas in the

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

basins of waterways, flood disasters can be prevented and the load on the beds of waterways can be reduced, and more sustainable, nature-friendly projects and rehabilitation works can be realised.

By re-planning green areas in waterway basins, flood disasters can be prevented and the load on the beds of waterways can be reduced, and more sustainable, nature-compatible projects and rehabilitation works can be carried out.



Figure 5. Oslo Park integrated with the waterway <https://hovinbekken.org/>,
https://oslobyleksikon.no/side/Walks+Talks:_Bjerkedalen_Park
<https://una.city/nbs/oslo/bjerkedalen-park-and-reopening-hovin-river>

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure 6. General view of Oslo Bjerkedalen park (<https://una.city/nbs/oslo/bjerkedalen-park-and-reopening-hovin-river>)

3.2. Establishing Wetlands and Rain Gardens

The definition of wetlands is areas where water covers the soil or is present on or near the surface of the soil all year round or at various times of the year, including the growing season (EPA).

Wetlands are areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season (EPA).

Rain gardens are gardens created in not very deep hollow areas where rainwater is directly without any treatment and plants can be grown on it. Rain gardens based on the principle of collecting and reusing rainwater are also called "micro-bioretenion areas" (Rain Garden Application Guide Ministry of Environment and Urbanisation).

Some of the other definitions of rain garden

It is a shallow depression with free draining soil.

It is defined as a vegetated depression in small-scale and urban areas, designed to collect, store, infiltrate and filter stormwater runoff over a small area.

It is a vegetated area where runoff is discharged, attenuated and stored and water infiltrates into the soil or is taken up by plants (Castellar and others, 2021; Dickie and others, 2010; Graham and others, 2012).

Rain gardens are an effective way to incorporate sustainability and aesthetics into urban watercourse planning. By retaining and filtering rainwater, they help manage stormwater runoff and reduce the burden on conventional drainage systems. They can also be aesthetically designed with a variety of plants, bringing a touch of nature to cityscapes.

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

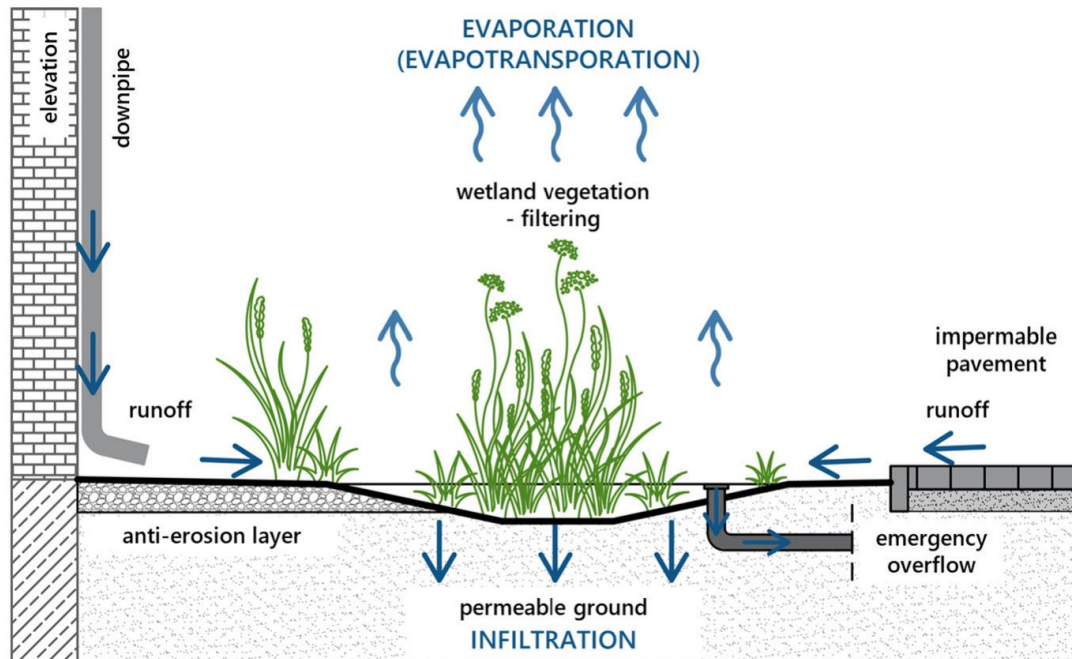


Figure 7. Rain garden schematic (modified by Szpakowski et al., 2018).

Rain gardens benefit neighbourhood landscapes by absorbing stormwater runoff and allowing runoff to percolate through the soil environment. This process helps to remove pollutants and slow runoff.

In addition to enhancing water quality, rain gardens provide the significant benefit of slowing down water runoff.

Reduced runoff into streams and rivers means less chance of flooding and riverbed erosion. As well as being a useful solution for retaining stormwater runoff, rain gardens are also an attractive alternative to turf landscaping alone and can offer the opportunity to provide a variety of plantings with a range of qualities to store water, remove pollutants and add vibrancy to turf areas. (<https://www.pleasanthillowa.org/681/Rain-Garden-Benefits>).

Stormwater gardens should be supported by integrated stormwater management, assessment of local stormwater impact, green infrastructure planning and green technologies (Kasprzyk et al., 2022).

Green infrastructure, especially rain gardens and ditches, create permeable pavements to restore the water balance by capturing, retaining and enhancing infiltration capacity in urban areas. Moreover, such systems can better treat stormwater runoff, restore groundwater levels, increase soil moisture to mitigate the effects of drought, and lower temperatures through evaporation-transpiration (Atanasova and others, 2021; Katsou and others, 2020; Oral and others, 2020; Veldkamp and others, 2021; Venvik and Boogaard, 2020).

In recent years, the use of rain gardens as a Nature-Based Solution to create blue-green infrastructure has received much more attention as a multifunctional solution for stormwater management to adapt existing urban areas to climate changes through the prevention of flash flooding, intensification of infiltration and evaporation processes, and has been found successful

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

in reducing the heat island effect and increasing biodiversity (Atanasova et al., 2021; Kisser et al., 2020; Pearlmutter et al., 2020; Raymond et al., 2017; Skar et al., 2020).

Having conducted its research on Stormwater Gardens, the approach to stormwater management in Gdańsk has changed, especially in terms of design proposals. The first rainfall (up to 30 mm) should be retained by urban greenery. Precipitation over 30 mm should be directed to rainwater harvesting storage tanks. The final stage rainwater is directed to the municipal stormwater drainage system (Gdańskie Wody, 2020).

In cities, 12.5 mm of rainfall is polluted in terms of water quality and appearance. When this amount is retained with green areas or green infrastructure systems, the quality of surface water will be improved.

A rain garden, in particular, slows, filters and stores rainfall runoff for a certain period of time, which then infiltrates into the ground soil and improves water quality by filtering pollutants and recharging groundwater (Castellar et al., 2021; Dickie et al., 2012). others, 2010). Furthermore, species that can tolerate short-term flooding should be planted (Graham et al., 2012).

Rain gardens can be integrated with adjacent hard surfaces. In case of overflow, rain gardens can be integrated into an existing drain or another rain garden.

General benefits of establishing rain gardens;

- Reducing the amount of stormwater runoff and therefore the risk of flooding,
- Improving the quality of discharged rainwater,
- Improving the quality of life and health of people,
- Increasing biodiversity,
- Reduction of charges for water services,
- Improving the aesthetics of urban areas,
- An additional advantage of rain gardens is the possibility to combine them into an extended system - the Urban Small Retention System, which allows to gradually reduce the surface runoff of rainwater and improve its quality (Szpakowski et al., 2018).

Due to the uptake of water by plants through physiological processes and its transpiration (i.e. evaporation of water from above-ground plant parts), the final volume of water is significantly reduced. However, phytoremediation (the ability of plants to remove pollutants) improves the quality of the discharged water. A rain garden can be designed both as an infiltration solution for rainwater and as an impervious solution that fulfils mainly a retention function. In both cases, total outflow is minimised through evaporation and transpiration (Boano et al., 2020; Graham et al., 2012; Schwarzer, 2020; Walsh et al., 2005).

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure 8. Examples of existing entrances from rain gardens in Gdańsk (photo by M. Kasprzyk)

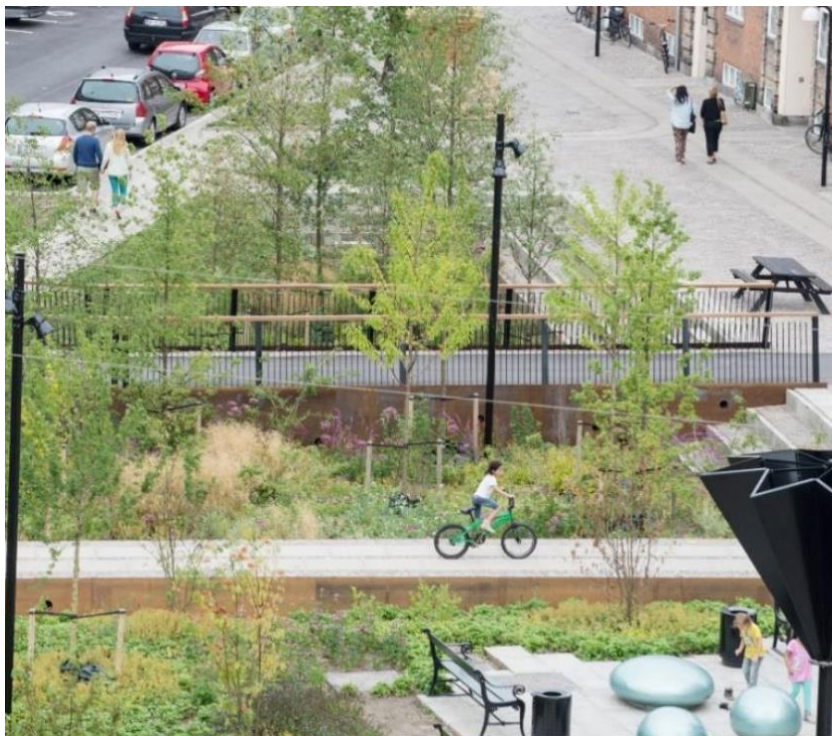


Figure 9. Copenhagen stormwater garden (Silva, Costa, 2016)

If rain gardens can be integrated into each other in the basin, excessive fluctuations will not occur in the surface flows reaching the waterways. The loss of fresh water in waterways whose downstream is the seas will be reduced and the seas will not be polluted.

If green areas in urban basins are planned as rain gardens at maximum level, hydrological and ecological problems of urban waterways will be solved. Areas where wetlands can be created in the basins should be planned as wetlands. It is important in terms of flora and fauna and waterways.

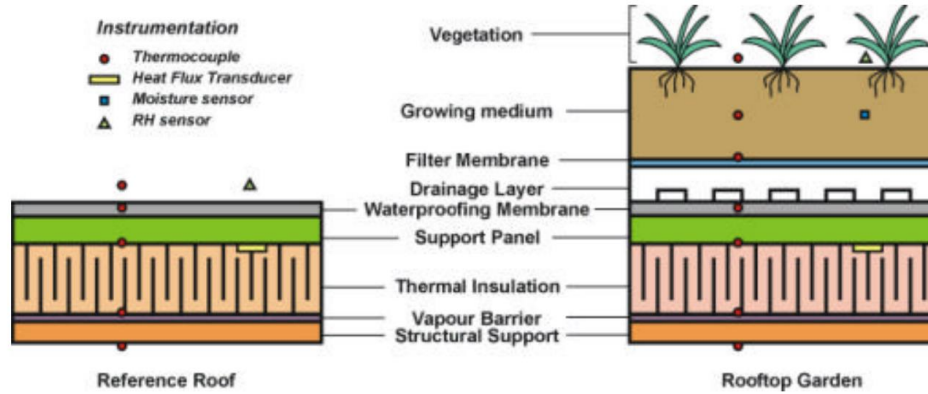
3.3. Construction of Roof Gardens and Diversion of Water to Underground Sources

Green roofs absorb rainwater, reducing runoff by at least 50%, and filter polluted runoff water before it enters sewers, rivers and lakes. Pollution is absorbed from the air by the plants in the garden, thus reducing air pollution and dust. Rooftop gardens are one of the most innovative and cost-effective ways that cities can use to improve the deteriorating urban environment (COTTHEM, 2005).

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure

10. Roof garden section (Liu, 2002)

Roof gardens have been very important in Europe since the 1980s; in Germany, Switzerland, the Netherlands and Belgium, people have recognised and started to take advantage of the widespread benefits that green roof infrastructure offers to cities, and green roofs are now being built in North America and Canada. Regulations have also been introduced in Europe: Governments have imposed taxes on runoff water and many people have greened their roofs to avoid these taxes.

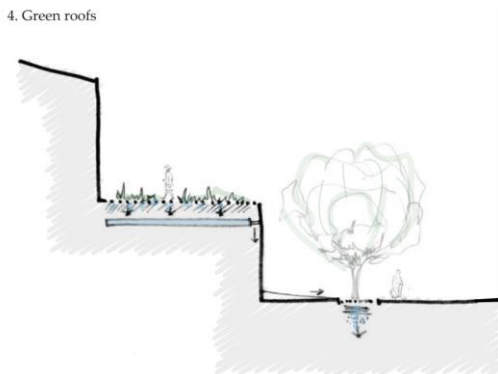


Figure 11. Green roof section (Silva, Costa, 2016). Figure 12. Vanhoever roof garden (Google Earth Image, 02/12/2023)



If roof gardens are adequately implemented in urban areas, they can help to improve stormwater runoff.

Part of the rainwater is temporarily stored in the roof garden and is taken up by plants and returned to the atmosphere through evaporation.

Roof gardens delay the flow into the sewerage system, helping to reduce the frequency of combined sewer overflow events in particular.

Plants and the growing medium can also filter pollutants from the rain-washed air, thus improving the quality of runoff.

The roof garden delays runoff and reduces the rate and volume of runoff.

In a Canadian study, rain events were recorded over a 12-hour period. The recorded data showed that the roof garden delayed runoff by 45 minutes, absorbing at least 2 mm (0.1 in) of the runoff before it occurred (Liu, 2002). It reduced runoff by 75 per cent during the first event and retained

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

45 per cent of the rainfall with a relatively moist growing medium. These data clearly demonstrated that the roof garden effectively retarded peak runoff and reduced runoff rate and volume when the normally impermeable roof surface was replaced with a permeable substrate (Liu, 2002).

Green roofs have been widely utilised in the greater Vancouver area. One of the best known of these roofs was installed on the Vancouver Public Library's Central Branch building. In 2003 and 2004, the roof was monitored over an eight-month period, showing a 48 per cent reduction in the volume of stormwater runoff from the roof compared to a conventional roof.

During the region's wetter winter months, stormwater runoff was also reduced by between 5 and 30 per cent. In the drier summer months, peak flows were reduced by more than 80 per cent. As with other green roofs, peak reductions were greatest during smaller, less heavy rainfall events and least during larger rain events (Kloss & Calarusse, 2006).

3.4. Reduction of Impervious Soils and Creation of Permeable Soil Alternatives

Pavements currently account for approximately 25 per cent of impervious surfaces in urban environments (Mullaney & Lucke, 2013). Typically, two-thirds of rainfall falling on potentially impervious surfaces in urban catchments falls on pavements (Ferguson, 2009). Pavements produce significant amounts of runoff, often contaminated with heavy metals and hydrocarbons (Fletcher et al., 2004; Hatt et al., 2009; Mullaney & Lucke, 2013).

Permeable pavements encourage infiltration of rainwater through the pavement and structure by filtering it through the various pavement layers. The filtered rainwater is then collected for reuse or slowly released into the underlying soil or stormwater drainage system.

Permeable pavements in good working condition have infiltration rates from 130 mm/h to several thousand mm/h (Volder et al., 2009). They can manage runoff from rainfall events exceeding 1 runoff event in 100 years (Voldera et al., 2009). Permeable pavements help to increase infiltration in urbanised areas and reduce pressure on existing stormwater infrastructure (Mullaney & Lucke, 2013).

Permeable pavements provide many benefits for managing stormwater runoff at source (Lucke & Beecham, 2011).

Permeable pavements in good working condition have infiltration rates from 130 mm/h to several thousand mm/h (Volder et al., 2009). They can manage runoff from rainfall events exceeding 1 runoff event in 100 years (Voldera et al., 2009). Permeable pavements help to increase infiltration in urbanised areas and reduce pressure on existing stormwater infrastructure (Mullaney & Lucke, 2013).

They help to restore infiltration capabilities and restore the natural hydrological cycle of urban areas. This reduces runoff volumes and the risk of flooding. They filter and treat infiltrating runoff by capturing pollutants that could otherwise contaminate groundwater and stormwater (Sansalone et al., 2008).

Recently, permeable pavement has also been proposed to replace the traditional asphalt pavement laid around street trees. The ability of permeable pavement to allow water and air to infiltrate into the root zone can potentially improve the health of street trees and minimise pavement damage (Mullaney & Lucke, 2013). Permeable pavements can also be used on clay soils (Mullaney & Lucke, 2013).

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

Permeable pavements are suitable for a wide range of applications in residential, commercial and industrial areas. Common applications include car parks, low traffic volume streets, pedestrian paths, residential driveways, shopping areas and cycle paths (Scholz & Grabowiecki, 2006).

- Permeable pavements have different design variations and there are four commonly used types:
- Permeable interlocking concrete pavers
- Concrete and plastic grated paving stones.
- Porous asphalt.
- Porous concrete.



Figure 13. Permeable interlocking concrete pavers (Silva & Costa, 2016)

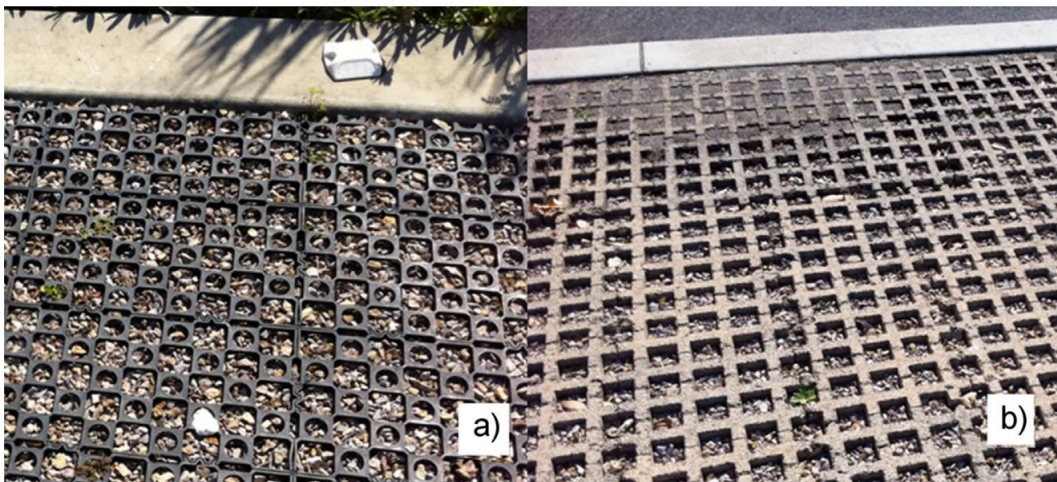


Figure 14. Concrete and plastic grated pavers. (Silva & Costa, 2016)

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girmé- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure 15. Porous asphalt. Porous asphalt (Silva & Costa, 2016)

Figure 16. Modern permeable pavement tanked system example with water recycling facility at Sanders Garden World (near Bristol, England, UK); picture taken by Mr. P. Smith in 2001.)

When a project made in Barcelona, Spain was examined,

- This project consists of the widening of Carrer Major de Can Caralleu in Barcelona, Spain, and the conversion of a dual carriageway road into a street with two downhill lanes and one uphill lane. Characteristic aspects include the case of topographic asymmetry (steep road and lower flat basin) and the use of permeable pavement as a design tool. More specifically, two types of porous pavement were used: turf, which naturally favours micro-harvesting, rainwater retention and infiltration; and gravel reinforced with recycled plastic cells on substrates with aggregates of different sizes.



Figure 16. Figure 3.10 - Detail of Can Caralleu Parking lot and street. Different pavements were used. Almost half of the total area of intervention includes permeable pavement. Source: (Vidiella & Zamora 2011, p.160; Silva & Costa, 2016)

- The lower areas of the pavement function both as car parking and as rainwater retention areas, which are collected thanks to the porosity of the permeable pavement. A cistern is

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

also located at the lowest point of the car parking area. As there is a high risk of oil spillage in the car park areas due to the long periods of inactivity of the vehicles, the proposed design also acts as an intermittent cleaning filter based on raindrops. Overall, the permeable area corresponds to about 45% of the total area (4,062.30 m²), while the impermeable area corresponds to about 55% (5,021.70 m²) (Vidiella and Zamora, 2011).

For more than thirty years in Seoul, South Korea, the Cheonggyecheon River was underground and crossed by a multi-lane road and an elevated motorway. In a political initiative, the mayor, Lee Myung-bak, proposed to invest in restoring the flow of the river, not in renewing the traffic infrastructure. Within two years the river was uncovered and transformed into a 5.8 km linear park that now runs through the city centre. The resulting benefits include improved capacity to maintain a flow rate of 118 mm/hour and flood protection up to a 200-year flood event (Kwon, 2007).



Figure 17. Cheonggyecheon river (Dutta & Sarkar, 2020)

Formerly a source of traffic congestion, pollution and drought, it is now a thriving and environmentally healthy public space. Today, the Cheonggyecheon River is a popular park among city residents, with clean water for people to swim in and more than a few natural habitats. Sites of historical and cultural significance are also being renovated, further contributing to the enhancement of social identity.

Other public spaces resulting from stream improvement projects include Kallang River in Bishan Park, Singapore; Ribeira das Jardas, Sintra, Portugal; Catharina Amalia Park in Apeldoorn, the Netherlands;

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

3.5. Methods for Underground Infiltration of Rainwater, Establishment of Water Reserve Areas and Areas for Temporary Storage of Rainwater

3.5.1. Urban furniture as a temporary and permanent reserve area for runoff reduction

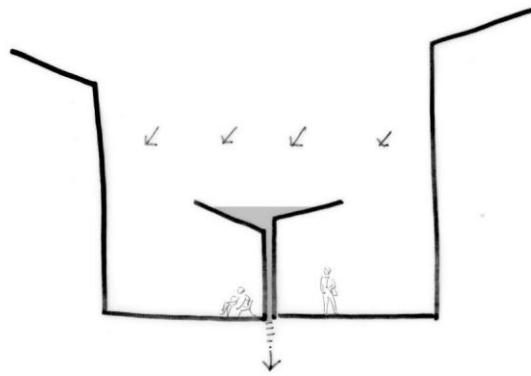


Figure 18. Inverted umbrella application for reserve area (Silva & Costa, 2016)

a. Inverted umbrellas and art entelations

Urban furniture as an element contributing to flood adaptation has started to encompass innovative ideas, especially when faced with the challenges of climate change. Ideas that have been realised include 'inverted umbrellas' and 'art installations' for specific purposes.



Figure 19. Left: Mega water collection structure on Expo Shanghai boulevard. Image credit: Tonylaw, 2010. Right: Inverted umbrella implemented in a small playground at the Woolworths Shopping Centre in Walkerville, Australia. Image credit: Universal Magazines Pty Ltd, 2013)

- Inverted umbrellas, as the name suggests, resemble traditional inverted umbrellas and come in various shapes and sizes (Figure 19). In inverted umbrellas, the incoming water flows towards the central column, which can direct it to a storage tank or drainage system for efficient reuse or distribution of rainwater. In addition to utilising rainwater as a valuable resource through harvesting and storage functions, this measure can also serve as a shading structure, thus further contributing to microclimatic improvement through albedo reduction. This measure is particularly adequate for adaptation to extreme floods. Examples of intervening umbrellas include the mega water harvesting structure at Expo Shanga boulevard or the small inverted umbrella implemented in a playground at the Woolworths Shopping Centre in Walkerville, Australia.

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure 20. Type of adaptation measure: Art installations. (Silva & Costa, 2016)

- The Water Table / Water Glass intervention at the Ellington Condominiums plaza in Seattle, Washington, represents a metaphor formed by two elements, "glass" and "table", both of which are fountains. Both fountains are fed by rainwater that accumulates on the roof of the ten-storey towers: The "glass" is filled by the south tower, while the fountain inside the "table" is filled by the north tower. The 2.4-metre-high conical "glass container" is a container that also serves as a holding tank. The collected rainwater is expected to be used for irrigation purposes (Buster Simpson, 2015).

b. Blue roofs:

- Blue roofs, also known as water roofs, are similar to green roofs, but instead of vegetation they use a variety of flow controls to regulate, block or store water. More specifically, blue roofs often utilise downpipe valves, gutter storage systems and cisterns (CCAP 2011).
- For example, walkways can be built on blue roofs, through a floating or elevated structure, or even placed on a permeable pavement connected to a cistern. Blue roofs can also serve as a water feature to be appreciated by the surrounding public spaces, as can be seen in the example of the Walterbos Complex in Apeldoorn).
- Once rainwater is collected by the blue roofs, it can be channelled to the adjacent public spaces and different adaptation measures.

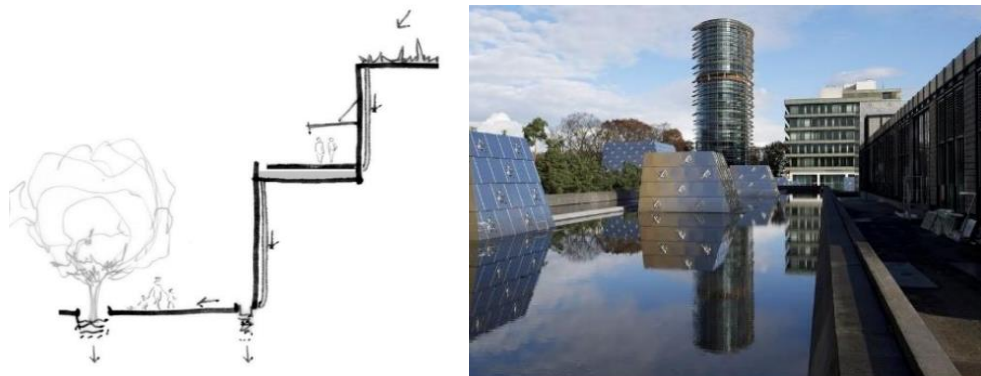


Figure 21 and Figure 22. Type of adaptation measure: 5. Blue roofs. Source: author's sketch. Left: Blue roof at Walterbos Complex in Apeldoorn, Netherlands. Image credits: Bart van Damme, 2010. Right: Blue roof implemented in a building at Trancas Canyon Malibu, US. Source: Douglas Bush Design, 2006. (Silva & Costa, 2016)

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

c. Infiltration Ditches:

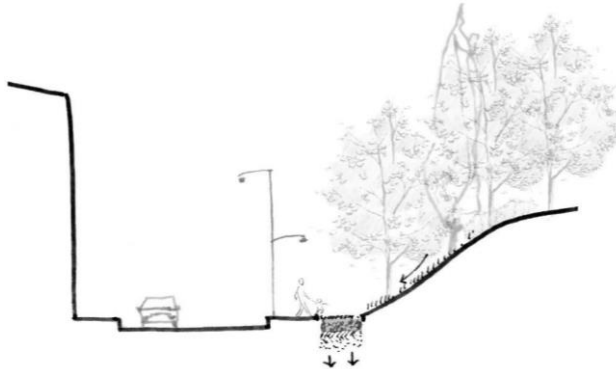


Figure 23. Type of adaptation measure: 18. Infiltration trenches. (Silva & Costa, 2016).

Figure 24. Ornamented infiltration trench at Etna Butler Street in Pittsburgh, US. Image credits: BH Buchart Horn Engineers Architects Planners, 2014. (Silva & Costa, 2016).

- Infiltration trenches collect and retain rainwater until it infiltrates underground or evaporates into the atmosphere. Such a measure not only reduces peak volumes in downstream catchments, but also improves the quality of stormwater discharge to the receiving environment through its porous and filtering layers.
- Infiltration trenches can generally be characterised by having a relatively shallow depth (no more than one metre), a slightly concave depression and a longitudinal development. They are relatively easy to implement and not very costly (LNEC 1983). The constituent layers of such measures usually include a layer of gravel surrounded by geotextile fabric, in which sediment, leaves and debris are retained.

In Istanbul, infiltration trenches can be planned on green slopes of TEM and E-5 highway edges. Also, it can be applied in areas with topographical slopes.

d. Green Gutter:

It is a thin and shallow landscape strip that can be placed between the road and the pavement. Similar to infiltration trenches, this type of measure is developed longitudinally and is mainly designed to manage stormwater runoff through the infiltration process, although it also has a lower volume capacity. Accordingly, this measure is usually placed below the street gutter and requires less space for implementation. Other benefits include improving the overall comfort of the streetscape and providing a physical separation between pedestrians and the traffic lane. The design of the edging should bear in mind that pedestrians, cyclists or cars will be prevented from falling into the green gutter. It is therefore a measure that cannot be considered sufficient for areas of high pedestrian use, such as outdoor markets, children's playgrounds or parks. Its management requires the traditional maintenance of green spaces.

IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>



Figure 25. Type of adaptation measure: Green gutter. (Silva & Costa, 2016).

Figure 26. Green gutter example. Image source: (City of Philadelphia 2014). (Silva & Costa, 2016).



Figure 27. Examples of Ayamama Creek and San Pedro Creek,
(<https://spcculturepark.com/about/the-project/>)

4. Conclusion and Recommendations

For the effective management of urban surface runoff, each watershed is considered as a puzzle. By assigning sustainable functions to the components of this puzzle, the flood risks that persist as a continuous cycle with precipitation can be prevented from causing destructive consequences. After the quantities of permeable and impermeable surfaces of urban watercourses basins are determined by various measurement methods:

- Rain Gardens,
- Roof Gardens,
- By installing permeable hard surfaces,
- Using methods that allow rainwater to evaporate and infiltrate underground,
- By designing the main and secondary roads of cities with shade trees,
- By Managing Surface Runoff Planning at the Source of Precipitation in Our Cities

Hydrological and ecological problems of rainwater discharged into waterways will be eliminated, the effect of flood disasters will be reduced, problems arising from climate change will be solved and breathable livable cities will be created.

Thanks, and Information Note

The article complies with national and international research and publication ethics.



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

References

- Atanasova, N., Castellar, J.A.C., Pineda-Martos, R., Nika, C.E., Katsou, E., Istenič, D., Pucher, B., Andreucci, M.B., Langergraber, G. (2021). Nature-based solutions and circularity in cities. *Circ. Econ. Sustain.* 1, 319–332. <https://doi.org/10.1007/s43615-021-00024-1>
- Branković, M., D., Marković, M. (2021). Revitalizing small urban streams as an instrument of urban planning in creating resilient cities Udc 502.171:546.212 627.152.15:711.4, *Facta Universitatis Series: Architecture and Civil Engineering* Vol. 19, No 2, 2021, pp. 193-205 <https://doi.org/10.2298/FUACE211203015D>,
- Castellar, J.A.C., Popartan, L.A., Pueyo-Ros, J., Atanasova, N., Langergraber, G., Säumel, I., Corominas, L., Comas, J., Acuña, V. (2021). Nature-based solutions in the urban context: terminology, classification and scoring for urban challenges and ecosystem services. *Sci. Total Environ.* 779, 1–63. <https://doi.org/10.1016/j.scitotenv.2021.146237>.
- Chen, J., Theller, L., Gitau, M., W., Engel, B., A., Harbor, J., M. (2017). Urbanization impacts on surface runoff of the contiguous United States, *Journal of Environmental Management* 187 (2017) 470e481, journal homepage: www.elsevier.com/locate/jenvman,
- Cotthem, V., (2005). Rooftop Gardening, a big step to the future, First International Summit for Afforestation Roof Gardens in China April 2005,
- Crutzen, P., J., and Stoermer E. F. (2000). The Anthropocene. *Global Change Newsletter* (41): 17–18.
- Dutta, S., Sarkar, S. (2020), Canal-Oriented Development: Integrating an urban canal front with the city, *TRIA* 24 (1/2020) 47-66/ e-ISSN 2281-4574 DOI 10.6092/2281-4574/6954 www.tria.unina.it
- Gdańskie Wody Company, (2020). Gdansk Policy of Urban Surface Small Retention System (in Polish: Gdańska Polityka Małej Retencji Miejskiej). Available online: <http://www.gdmel.pl/component/attachments/download/11>.
- Graham, A., Day, J., Bray, B., Mackenzie, S. (2012). Sustainable Drainage Systems: Maximising the Potential for People and Wildlife. – A Guide for Local Authorities and Developers. <https://doi.org/10.3390/w7052272>.
- <https://courses.lumenlearning.com/suny-sustainability-a-comprehensive-foundation/chapter/sustainable-stormwater-management/>.
- <https://hovinbekken.org/> ,https://oslobyleksikon.no/side/Walks+Talks:_Bjerkedalen_Park
<https://una.city/nbs/oslo/bjerkedalen-park-and-reopening-hovin-river>
- <https://spcculturepark.com/about/the-project/>
- <https://una.city/nbs/oslo/bjerkedalen-park-and-reopening-hovin-river>
- <https://www.epa.gov/wetlands/what-wetland#:~:text=Wetlands%20are%20areas%20where%20water,includin%20during%20the%20growing%20season.>
- <https://www.pleasanthilliowa.org/681/Rain-Garden-Benefits>



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Girne- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

- IPCC. (2014). Summary for policymakers in: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change ed C B Field et al (Cambridge University Press) (Cambridge, United Kingdom and New York, NY, USA)
- IPCC. (2014). In: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A. (Eds.), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change <https://doi.org/10.1017/cbo9781107415416>.
- Kasprzyk, M., Wojciech Szpakowski, E., Poznańska, E., Floris, C. Boogaard, F., C., Bobkowska, K., B, G., Gajewska, M., (2022). Technical solutions and benefits of introducing rain gardens – Gdańsk case study, Contents lists available at ScienceDirect Science of the Total Environment journal homepage <http://dx.doi.org/10.1016/j.scitotenv.2022.155487> Received 20 February 2022; Received in revised form 12 April 2022; Accepted 20 April 2022 Available online 26 April 2022,
- Kloss, C., Calarusse, C., Stoner, N. (2006). Rooftops to rivers: Green strategies for controlling stormwater and combined sewer overflows. Natural Resources Defense Council, Washington D.C.
- Korkanç, S. Y. (2005). Sel ve Taşkınlardan korunmada erken uyarı ve önemi. *FORESTIST* (eski adıyla *İstanbul Üniversitesi Orman Fakültesi Dergisi*), 55 (1), 123-134. <http://dergipark.gov.tr/jffiu/issue/18711/197342>,
- Kozak, D., Hayley Henderson, H., de Castro Mazarro, A., Demián Rotbart, D., and Aradas, R., Blue-Green Infrastructure (BGI) in Dense Urban Watersheds. The Case of the Medrano Stream Basin (MSB) in Buenos Aires, sustainability, MDPI,
- Lucke, T., Beecham, T. (2011). Field investigation of clogging in a permeable pavement system, *Building Research & Information*, ISSN: 0961-3218 (Print) 1466-4321 (Online) Journal homepage: <http://www.tandfonline.com/loi/rbri20>, <http://dx.doi.org/10.1080/09613218.2011.602182>,
- Lui, K. (2002). Energy efficiency and environmental benefits of rooftop gardens, A version of this document is published in / Une version de ce document se trouve dans: Construction Canada, v. 44, no. 2, March 2002, p. 17, 20-23, NRCC-45345.
- Marsalek, J., Jimenez-Cisneros, B., Karamouz, M., Malmquist, P.A., Goldenfum, J., Chocat, B. (2008). Urban water cycle processes and interactions. Taylor & Francis, Leiden, The Netherlands. ISBN 978-0-415-45346-2.
- Meyer, G. E., Franti, T. G. and Mortensen, D. A. (1997). Seek and destroy machine vision identifies weeds for spot spraying. *Resource Magazine, Engineering and Technology for a Sustainable World*. Vol.4(12),13-14, <http://water.usgs.gov/wrri/AnnualReports/1998/NE98.pdf>,
- Mullaney, J., Lucke, T. (2013). Practical Review of Pervious Pavement Designs, Faculty of Science, University of the Sunshine Coast, Health, Education and Engineering, Maroochydore, QLD, Australia, DOI: 10.1002/clen.201300118.



IV. International Architectural Sciences and Applications Symposium

May 30-31, 2024, Gime- Turkish Republic of Northern Cyprus

<https://www.iarcsas.org/>

- Mullaney, J., Lucke, T. (2013). Practical Review of Pervious Pavement Designs, Faculty of Science, University of the Sunshine Coast, Health, Education and Engineering, Maroochydore, QLD, Australia, DOI: 10.1002/cfen.201300118.
- Niemczynowicz, J. (1999). Urban hydrology and water management ± present and future challenges, *Urban Water* 1 (1999) 1±14, www.elsevier.com/locate/urbwat, UrbanWater,
- Sadoff, C.W. (2015). Securing Water, Sustaining Growth: Report of the GWP/OECD Task Force on Water Security and Sustainable Growth; University of Oxford: Oxford, UK.
- Sansalone, J., ASCE, M., Kuang, X., Ranieri, V. (2008). Permeable Pavement as a Hydraulic and Filtration Interface for Urban Drainage, DOI: 10.1061/ ASCE0733-9437 2008134:5 666, *Journal of Irrigation and Drainage Engineering* © Asce / September/October 2008,
- Scholz, M., Grabowiecki, P. (2007). Review of permeable pavement systems, *Building and Environment* 42, 3830–3836, doi:10.1016/j.buildenv.2006.11.016,
- Schueler, T. R. (2000). The importance of imperviousness, *Feature article from Watershed Protection Techniques*. 1(3): 100-111.
- Silva, M., M., Costa, J., P. (2016). Flood adaptation measures applicable in the design of urban public spaces: proposal for a conceptual framework, *Water* 2016, 8, 284; doi:10.3390/w8070284, Research Centre for Architecture, Urbanism and Design
- Szpakowski, W., Rayss, J., Lademann, D. (2018). Ogród deszczowy w 5 krokach. Gdańskie Wody (in Polish).
- Xu, C., Rahman, M., Haase, D., Wu, Y., Su, M., Pauleit, S. (2020). Surface runoff in urban areas: The role of residential cover and urban growth form, *Journal of Cleaner Production* 262 (2020) 121421.
- Yağmur Bahçesi Uygulama Kılavuzu (2018). Ankara,