Recycling and Sustainable Development

www.rsd.tfbor.bg.ac.rs

RSD

Online ISSN 2560-3132
Print ISSN 1820-7480

Harnessing Construction Pond: Mitigation Climate Change and Reducing Flood Risks

Shuokr Qarani Aziz [a], Khalat Khalid Muhammad Salih [a, b, #], Sazan Mohammed Ali [c]

[a] Salahaddin University-Erbil, College of Engineering, Department of Civil Engineering, Erbil, Iraq
[b] Directorate of Irrigation-Erbil, General Directorate of Water Resources, Ministry of Agriculture and Water Resources, Erbil, Kurdistan Region, Iraq
[c] Noble Private Institute, Department of Surveying, Erbil-Iraq

ARTICLE INFO

Received 27 January 2026
Accepted 25 February 2026

Research article

Keywords:
Biodiversity
Climate change
Construction of ponds
Flood management

Citation: Aziz S. Q., Salih K. K. M., Ali S. M., Harnessing Construction Pond: Mitigation Climate Change and Reducing Flood Risks, Recycling and Sustainable Development, 19 (1), 2026, 1-12. https://doi.org/10.30544/RSD110

ABSTRACT

This study examines the crucial significance of pond construction in urban contexts. These ponds are multifunctional infrastructure features that help manage stormwater, improve water quality, and promote biodiversity in urban environments. The construction of ponds, by absorbing and storing excess rainwater, helps mitigate the negative effects of urbanization on natural systems, such as flooding and pollution. Furthermore, pond construction is a vital component of blue-green infrastructure, helping to mitigate climate change and reduce flood hazards in cities. These ponds assist in controlling the urban hydrological cycle by retaining and slowly releasing stormwater, reducing peak flows and the risk of flash floods. In addition, pond construction provides essential ecosystem services such as wildlife habitat provision and urban green space enhancement. Integrating pond construction into urban planning and architecture represents a long-term solution to climate change and urbanization issues. Cities that incorporate these ponds into green infrastructure projects can increase their resilience to extreme weather events, improve water management techniques, and promote environmental sustainability. Overall, the construction of ponds provides a nature-based solution that benefits urban populations while also helping to conserve biodiversity and improve urban ecosystems.

1. Introduction

Climate change, water management, and biodiversity conservation are all becoming increasingly pressing issues in cities. In response to these difficulties, natural solutions like pond construction have emerged as valuable tools for increasing urban resilience and sustainability. Construction ponds, which are artificial water features used for a variety of functions such as stormwater management and habitat creation, play an important part in minimizing the effects of urbanization on natural systems (Zhou et al., 2016). These ponds are intended to resemble natural water bodies and wetland habitats, serving important roles such as flood control, water quality enhancement, and biodiversity support in urban areas. The constructed ponds significantly contribute to flood control by storing excess stormwater during peak rainfall events, thereby reducing surface runoff and lowering flood risks in urban areas. By temporarily retaining large volumes of water, these ponds help protect infrastructure, minimize property damage, and improve overall stormwater management efficiency in rapidly developing regions (Aziz and Muhammed, 2024).

[#] Corresponding author: khalatkhalid1@gmail.com

Construction ponds help reduce the risk of urban flooding by catching and storing stormwater runoff. They also relieve pressure on drainage systems during heavy rain events. These ponds also provide vital habitat for a variety of plant and animal species, helping to conserve urban biodiversity (Magnus and Rannap, 2019). Constructed ponds are important for flood management and environmental sustainability in urban areas. The capture and subsequent storage of excess rainfall greatly reduce surface runoff and lower the risk of flooding during wet periods. They assist in flood prevention, infrastructure protection, and property damage reduction by holding large amounts of water (Muhammed and Aziz, 2025). To ensure optimal functioning and effectiveness, construction ponds must be carefully designed and implemented, considering hydrology, site capacity, and water supply. Furthermore, to maximize their advantages and prevent environmental risks, constructed ponds must be maintained. Involving the community and stakeholders is also crucial to the success of pond projects since it promotes local support and guarantees the sustainability of these natural solutions over the long run (Krull et al., 2015; Oertli and Parris, 2019).

Given the pressing need to address climate change impacts and improve urban resilience, incorporating building ponds into urban planning and green infrastructure programs has become increasingly vital. Cities that incorporate building ponds into their sustainable development programs cannot only better manage stormwater, but also create green places that improve the overall quality of urban life. This integration is consistent with the broader goals of improving environmental sustainability, increasing biodiversity, and developing climate-resilient urban environments (Zhou et al., 2016). Construction ponds have the ability to convert urban settings into more sustainable, resilient, and ecologically diverse spaces by offering multifunctional benefits such as flood control, water conservation, and biodiversity enhancement (Omofunmi, 2016). Retention ponds help conserve water by altering discharge, sediment transport dynamics, water chemistry, and resource management. They can be fed by either groundwater or surface water; however, groundwater is the more typical source. Ponds can produce either drainable or undrainable water outputs, with drainable outlets frequently regulated to manage excess water. Pond outlet management can help lessen the danger of flooding and drought. Overall, building ponds contributes to water conservation by storing water, controlling water quality, and affecting hydrological processes (Ferk et al., 2020).

In this paper, the authors considered the multifunctional role of construction of ponds as a nature-based solution for urban water management. The researchers started analysis by defining construction of ponds and describing their hydrological functions and impacts on runoff generation and water quality. The central part deals with the design and implementation considerations required for effective pond performance (site selection, pond type, slope protection, hydraulic controls, and maintenance). Later, contribution of ponds was examined to study climate-change mitigation and flood-risk reduction, discuss their integration within blue-green infrastructure, and summarize the socio-institutional aspects (community engagement, policy and regulatory implications. Finally, identifying knowledge gaps and present a set of practical recommendations and a checklist for planning and implementing construction ponds in urban and peri-urban contexts was presented.

2. Pond Construction: Definition and Purpose

A pond is a small, natural or manufactured standing water basin, usually smaller than a lake that contains shallow water, marsh, aquatic plants, and animals. They are frequently man-made and provide habitat for wetland plants and animals, increasing ecological diversity in landscapes. Ponds are earthen structures used for fish farming that collect and contain water. They use dikes and bottom soil to minimize seepage (Omofunmi, 2016). Decreasing flood flows and absorbing contaminants from non-point sources are two ways that construction of ponds affects water quality. Pollutants that enter pond systems are eliminated from the water column by biological absorption, adsorption to sediments, and sedimentation processes. Stormwater ponds may experience eutrophication due to nutrient-rich runoff from fertilizer application, fecal material inputs, and other urban sources, as a result of high pollutant loads from urban catchments and restricted water circulation. These procedures can lead to excessive algal growth and, in certain situations, the formation of toxic algal blooms, which can endanger the health of people, animals, and pets (Abduljaleel et al., 2023).

Additionally, by raising sediment loads and releasing stored pollutants, runoff that is transported to constructed ponds may negatively impact recipient water bodies. Heavy metals, hydrocarbons, and suspended particles that harm aquatic environments are all carried by roadway runoff, which is a significant source of diffuse pollution. Sedimentation ponds and artificial wetlands are two common mitigation strategies used to lower pollution loads from road runoff and safeguard aquatic habitats downstream (Lusk et al., 2025). Figure 1 shows the Darmeer Pond in Erbil Province as an example of a constructed retention pond implemented for local flood mitigation and groundwater recharge.

2.1. Pond Construction Serves Several Purposes Based on the Project's Setting and Needs

Retention ponds, often known as primary flood controls, serve more than just water management

Figure 1. Darmeer Pond (Source: Erbil Irrigation Directorate, 2025)

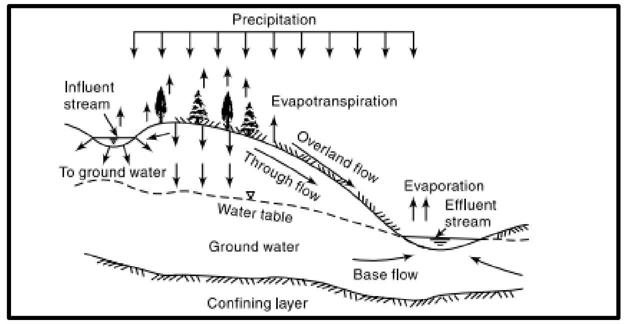

Figure 2. Various routes of runoff (Subramanya, 2017)

purposes. Retention ponds serve not only to reduce flood danger, but also offer additional benefits for city management planning (Valenca et al., 2022). Retention ponds are an excellent way to mitigate urban flood threats. Retention ponds store surplus water during heavy rain or flooding and gradually drain it back into the drainage system when conditions return to normal. This relieves pressure on drainage systems and minimizes waterlogging in metropolitan areas (Keyvanfar et al., 2021). Retention ponds can serve as a unique water tourism attraction, attracting local residents and tourists. They also contribute by increasing local groundwater reserves, reducing flood risks, and supporting water resource sustainability. Urban planning should consider retention ponds as multiple assets, balancing flood control, ecotourism development, and water conservation to create a positive impact on local communities. This approach can provide added value to local communities and contribute to the overall ecosystem (Yulianti and Prasetyo, 2024). Staccione et al. 2021 study the benefits of pond use for water balance and environmental impacts, including increasing water availabilty for irrigation and determining optimal river discharge. In addition, there are reasonable economic grounds for pond installation, including at least the replication cost of more sophisticated designs, with investment in more complex designs guaranteed to pay off due to ecosystem benefits.

3. RunOff

Runoff is the process by which precipitation drains from a catchment area onto a surface channel, indicating the output in a given unit of time. Evapotranspiration, initial loss, infiltration, and detention storage requirements must all be met before proceeding. Excess precipitation flows over land surfaces to smaller channels, known as overland flow, where it accumulates and drains. Surface runoff refers to the continuous flow across the surface and into channels. Infiltration-related runoff travels laterally through soil's upper crusts before returning to the surface (Subramanya, 2017), Figure 2 shows the total amount of interflow.

As the nation grows quickly, runoff from growing impermeable surfaces keeps deteriorating estuaries and freshwater bodies. To lessen these effects, low-impact development (LID) techniques have been put forth and put into practice, which involve improving infiltration and controlling stormwater near its source (Fan et al., 2022). Climate change, industrialization, oil production, and increased vehicle usage have significantly impacted the environment of Erbil, causing variations in rainfall, snow, temperature, wind, cloud, UV index, visibility, and pressure, and causing air pollution (Aziz et al., 2023). Conveying fresh water from Greater-Zab River (GZR) to Erbil City seeks to boost rainfall and snowfall, humidity, visibility, green areas, and tourism, while decreasing air pollution, dust storms, temperature, and desertification. However, the creation of ponds and canals in this area results in flood retention and diversion. Furthermore, storing GZR water in ponds and canals increased the groundwater table in the targeted area (Aziz et al., 2023).

Runoff, or a catchment's response to precipitation, reflects a variety of watershed, climate, and rainfall variables. True runoff is stream flow in its natural state, without human interference. Storage or diversion works impact natural flow, also known as virgin flow (Subramanya, 2017). Natural flow (virgin flow) volume in time the water balance.

The SCS-CN method, created in 1969 by the Soil Conservation Service (SCS) of the United States, is a simple and robust method for estimating direct runoff depth based on storm rainfall. The SCS-CN method is based on the water balance equation of rainfall in a known interval of the time Δt, which can be expressed as:

$$P = Ia + F + Pe \quad (1)$$

Where:

P - total precipitation,
Ia - initial abstraction,
F - cumulative infiltration excluding Ia,
Pe - direct surface runoff.

There are two other concepts as below that are also used with the above equation:

The first concept is that the ratio of direct runoff (Pe) to maximum potential runoff (Pia) is equal to the ratio of actual infiltration (F) to prospective maximum retention (or infiltration). In general, after runoff, Pe ≤ P and F ≤ S. Possible runoff P- Ia.

$$\frac{Pe}{(P-Ia)}=\frac{F}{S} \quad (2)$$

In general:

Pe ≤ P

After rainfall begin:

Fa ≤ S

Potential rainfall:

P-Ia

SCS assumption:

$$\frac{Fa}{S}=\frac{Pe}{(P-Ia)} \quad (3)$$

Solve for rainfall excess:

$$Pe=\frac{(P-Ia)}{(P-Is+S)} \quad (4)$$

Where:

P = total rainfall.
Pe = rainfall excess (runoff).
Ia =initial abstraction.
Fa = continuing abstraction.
S = potential maximum storage (Subramanya, 2017).

4. Role of Pond Construction in Climate Change Mitigation

Global development and population growth pose a significant danger to freshwater ecosystems and biodiversity. This has led to increased nutrient inputs and eutrophication in receiving waters, particularly lakes. Climate change is another issue that exacerbates the symptoms of eutrophication, species movement, and loss. Despite extensive research, conclusive evidence of the consequences of climate change remains fragmented. This is due to the uncertainty of climate models and emission scenarios, as well as the varied methodologies for studying their effects (Jeppesen et al., 2014). Rapid urbanization and climate change have produced new challenges in urban water management. Floods have numerous causes, including natural circumstances and human development, necessitating cautious planning. Retention ponds can help manage water and address urban flood hazards (Ramos et al., 2013). Ramos et al. (2013) explain flood management strategies must also integrate sustainability aspects. The solution must have a long-term positive impact without harming the surrounding environment. Sustainable water and environmental management must be the focus in planning and executing this strategy. Infrastructure development must take into consideration future needs and prepare for potential climate changes. Recent studies illustrated that by storing freshwater resources and allowing large-scale pumped storage hydropower to balance variable renewable energy (like solar and wind), engineered water bodies like pumped seawater reservoirs in coastal depressions can significantly help mitigate climate change. This reduces dependency on fossil fuels and increases energy system flexibility. These systems are a promising part of sustainable energy transitions because they use coastal topography to optimize energy storage capacity and combine clean power generation with water resource management (Fan et al., 2026).

The influence of construction ponds on local ecosystems can impair stream integrity and alter environmental conditions along its path. Artificial ponds placed on the stream can dramatically influence the integrity of the stream ecosystem by disturbing diatom assemblages typical of stream habitats. The development of artificial ponds can vary environmental elements such as the concentration of ammonium ions, dissolved oxygen, conductivity, and total suspended material in the water, which affects the benthic diatom assemblages along the stream. However, building artificial ponds may not necessarily improve the stream's biological status, as demonstrated in a study analyzing the effects of restoration approaches using diatoms as bioindicators (Nowicka-Krawczykauthor, 2015).

5. Contribution of Ponds for Flood Reduction

Retention ponds contribute significantly to flood control efforts by storing excess water volumes after heavy rain or flooding and slowly draining them back into the drainage system, relieving pressure on drainage systems, and preventing waterlogging in metropolitan areas. They can also function as water tourism destinations and contribute to water conservation by enhancing local groundwater reserves. Furthermore, retention ponds can contribute to environmental sustainability by providing natural habitats and promoting biodiversity (Yulianti and Prasetyo, 2024). Ponds are Nature-Based Solutions NBS that can mitigate the effects of both flooding and drought. Ponds help to reduce flood severity by storing water and minimizing surface runoff, which is critical given the considerable damage that floods wreak in the region each year. Ponds also retain water, which increases soil moisture content and provides relief during droughts (Gautam and Corzo, 2023). Hofman and Paalman, (2014) examined the impact of rainwater collecting (ponds) on floods and droughts in the basin using NBS. In situ rainwater harvesting (IWRH) is a widely utilized approach for dealing with both heavy rainfall and dry times. (Gautam and Corzo, 2023) addressing floods and droughts together is tough due to their opposing character. However, this analysis reveals that ponds have a moderate but significant potential for alleviating both. In Malaysia's Segamat river basin, pond depth was compared to various flood mitigation methods, such as rainwater harvesting systems and permeable pavers, to determine their effectiveness. Detention ponds were shown to be the most effective flood mitigation option and should be prioritized for flood risk reduction. However, the study emphasized the limitations of rainwater collection systems and permeable pavers in lowering flood hazards in urban areas (Liew et al., 2021). Ponds, small reservoirs, and afforestation are all part of flood mitigation strategies. Ponds can help reduce peak discharge, especially for small events, but their effectiveness decreases for larger flood peaks. Micro-ponds may have a limited impact on extreme flood events. Afforestation can also help prevent landslides and erosion. These measures are more effective for small to medium events but have negligible effects during the largest flood events. It is important to consider the spatial distribution and storage capacity of these measures in the catchment area for optimal effectiveness (Vojinovic et al., 2021).

6. Design and Implementation of Pond Construction

Thorough planning and design are crucial for the creation and execution of pond construction. It is necessary to take into account factors such as catchment hydrology, the link between rainfall and runoff, water demand, and losses due to seepage and evaporation. The pond's parameters, encompassing its size, shape, side slopes, and water control devices, must be established according to the necessary capacity and catchment area. The pond's depth should be sufficient to minimize both evaporation losses and seepage. There are various options for the shapes of agricultural ponds, and square ponds are more cost-effective compared to rectangular ones. Choosing the right location is of utmost importance and should take into account aspects such as soil quality, land elevation, ability to drain water, and precipitation patterns (Reddy et al., 2012).

The design and implementation of construction ponds require several essential considerations to ensure the project's success and sustainability. Table 1 summarizes the key variables and design parameters considered for construction pond planning and implementation.

Table 1
Key variables and design parameters for construction of pond development

Variable / Item	Short description / role in pond design
Site selection	Accessibility, geology and soil impermeability, topography, drainage connectivity, proximity to pollution sources, security, and land-use constraints.
Pond type and components	Embankment vs excavation; inlet/outlet structures; forebay, main basin, wet/dry zones; overflow and safety spillways.
Design issues	Freeboard, slope stability, seepage control (liners), scour protection, overtopping prevention, and hydraulic capacity.
Slope protection	Vegetation, riprap, geotextile/erosion mats; upstream wave protection and downstream toe protection.
Technical considerations	Hydraulic controls, staged outlets, sediment forebays, bypass for high flows, water quality treatment train (settling, vegetation).
Design phases and investigations	Site investigation (soil and permeability tests), hydrologic/hydraulic analysis (CN/rational/HEC/HEC-HMS), design alternatives, cost estimate, constructability review.
Factors influencing design	Catchment area & land use, rainfall intensity and design storm, evaporation, groundwater interactions, available storage, and maintenance capacity.
Maintenance and operation	Sediment removal schedule, vegetation management, routine inspection of outlets/spillways, desludging plan, safety/lighting, and community stewardship.

To calculate Peak flowdifferent methods can be used for this purpose such as the rational method, SCS method, and HEC1 model.

1. Rational method:

The rational method is an effective way to calculate peak flow, especially for small catchment basins.

$$Qp = 0.278 \cdot C \cdot I \cdot A \quad (5)$$

Where:

Q = peak runoff rate in m^3/s,
C = runoff coefficient,
I = design rainfall intensity, mm/h,
A = Catchment area in km^2.

2. SCS Method:

The SCS-CN method, developed in 1964 by Soil Conservation Services (SCS) of the USA, is a simple, predictable, and stable method for estimating direct runoff depth based on storm rainfall depth, relying on CN and based on land-use, land-cover, and soil conditions.

$$CNIII = \frac{CNII}{(0.427 + 0.00573CNII)} \quad (6)$$

$$CNI = \frac{CNII}{(2.281 - 0.01281CNII)} \quad (7)$$

$$S = \frac{2500}{CN} - 254 \quad (8)$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \quad (9)$$

Where:

S = representing the potential maximum retention depends upon the soil–vegetation–land use [mm],
Q = maximum daily runoff [mm],
P = maximum daily rainfall [mm],

Time concentration can be calculated based on the Kirpich formula (1940):

$$Tc = 0.0195 \cdot Lo\hat{}0.77 \cdot S^{-0.385} \quad (10)$$

Various approaches can be used to calculate lag time, including the relationship between it and concentration time:

$$L = 0.6Tc \quad (11)$$

$$Tp = \left(\frac{tr}{2} + 0.6Tc\right) \quad (12)$$

$$Qp = 2.08 \cdot \frac{A}{Tp} \quad (13)$$

7. Interactions with Blue-Green Infrastructure

Blue-Green Infrastructure includes both natural and built measures that mitigate urban flood risk and improve environmental quality. Examples include parklands, swales, ponds, green roofs, and permeable pavements. The BGI strives to reduce flood risk, improve air and water quality, increase biodiversity, and promote public health (Well and Ludwig, 2022). It is a comprehensive method that considers both water management and green places. The need to enhance urban green and blue infrastructure for sustainable development and climate change adaptation is widely recognized, resulting in the rapid growth of greening initiatives in cities worldwide. We expect this approach to directly influence the inhabitants' quality of life and public health. Despite the many advantages, green and blue infrastructure can potentially have unforeseen and unpleasant health-related consequences (Lõhmus and Balbus, 2015). Stormwater retention ponds contribute to blue-green infrastructure by enhancing flood resilience, improving water quality, creating wildlife habitats, and increasing amenity and biodiversity values (Krivtsov et al., 2020). Ponds improve water quality by acting as natural filters, reducing contamination risk. They regulate stormwater runoff by storing excess water during heavy rainfall, reducing flooding and erosion, support biodiversity by providing habitats for diverse plant and animal species, enhance aesthetic appeal of green spaces, providing opportunities for recreation and wildlife observation, aid in climate adaptation by mitigating impacts of extreme weather events, cooling urban environments and Integration of ponds into blue-green infrastructure planning can create sustainable urban landscapes benefiting both the environment and public health (Lõhmus and Balbus, 2015). Figure 3 illustrates the blue-green city concept and highlights how ponds are integrated into multifunctional urban blue-green infrastructure.

Figure 3. Blue-Green City (Blue Green City, 2024)

8. Community Engagement and Stakeholder Collaboration

Engaging with local people raises awareness about the benefits of building ponds. Educating residents on their purpose, upkeep, and ecological importance develops a sense of ownership.

Involving community members in the planning process ensures that ponds meet their needs and desires (Hassall, 2014). Stakeholder engagement can improve pond biodiversity by raising awareness about nature and supporting environmental protection activities. Urban wetlands, especially ponds, provide opportunities for public participation in scientific study and conservation activities, resulting in rapid progress toward sustainability (Hassall, 2014). The growth in publications on pond biodiversity since the Rio Conference of 1992 illustrates the increased interest in freshwater conservation; nonetheless, more study on ponds is still required to properly comprehend their role in global biodiversity conservation (Oertli et al., 2010). Creating new ponds and managing existing ones can have a positive impact on biodiversity, with species colonizing quickly following floods, stressing the necessity of proactive pond management measures (Oertli et al., 2010). Community members can actively monitor water quality, wildlife presence, and general pond health. Citizen science activities enable residents to provide valuable data. The key advantages of stakeholder collaboration in pond construction projects include identifying and prioritizing adaptation strategies, adjusting costs and benefits using stakeholder-assigned weights, internalizing costs and benefits, including non-monetary costs and benefits, and facilitating negotiations among different stakeholders who may not normally interact with one another. Stakeholder engagement aids in analyzing different adaptation options and prioritizing them based on net benefits, as demonstrated in several case studies (Lunduka et al., 2012).

9. Policy Implications and Regulatory Framework

There is currently sufficient research to support policy suggestions for ponds. The Ramsar Convention, the Convention on Biological Diversity, and other international environmental legislation, such as the WFD in Europe, should specifically recognize pond capes for ecological reasons. We advocate including ponds, ponds capes, and ecological services in policy:

1. Environmental context: Identifying clusters of key sites as management units (recommended by the WFD; EC 2003) is more cost-effective and logistically easier than monitoring and protecting individual ponds, as they are often connected by critical terrestrial habitats.
   Defining pondscapes as management units allows for better monitoring and identification of objectives for each pond (Biggs et al., 2017). Permitting pond alterations, whether positive or negative, is a policy instrument that considers each pond's position in the pondscape. It also requires applicants to maintain or improve a pond's capacity to sustain natural biodiversity. Environmental organizations, whether local or non-governmental, can effectively maintain ponds and provide permits (Hill et al., 2018).

2. Urban planning: Planning rules might prioritize open water sustainable urban drainage systems, among other nature-based alternatives (Dadson et al., 2017). To mitigate pond loss during development, consider the pondscape as a whole rather than creating specific habitats. Urban development should prioritize zero ecological loss over zero habitat loss, and ponds can play an important role in this strategy. Stormwater ponds have the potential to support high biodiversity in certain situations (Hassall and Anderson, 2015). Separating clean water ponds (e.g., roof water) from contaminated water ponds (e.g., from roadways or parking lots) is crucial in the treatment process. Diverting runoff water to ponds in urban areas can boost biodiversity, reduce flooding, and retain contaminants (Hill et al., 2018).

3. Flood management: Pondscapes can be included in policy as natural flood management becomes more prevalent. Ponds can be easily integrated into open water flood storage strategies due to their smaller size and similar volume of water, making them less logistically challenging. It could potentially be pretty simple to include multiple small ponds in Examples of urban or rural land management plans include the "sponge city" concept, which is currently popular in China (Liu et al., 2017).

4. Agriculture: Some EU agri-environment projects offer financial incentives to maintain farming ponds with high biodiversity value (Attwood et al., 2009). Modify incentives to reward the protection and creation/restoration of pond networks at a higher rate than individual ponds, with collaborative agreements between numerous landowners (Hill et al., 2018).

5. Education: "Pond schools" and "forest schools" can be similar in that they emphasize nature as an integral part of education. Schools in both urban and rural areas can benefit from using local ponds for educational and health purposes. Schools can build "frog ponds" to foster outdoor play and kitchen gardens, benefiting both students and communities. Designating globally or nationally significant pondscapes in human-dominated landscapes helps raise public awareness of their importance (Austin et al., 2016).

10. Challenges and Future Directions

The International Union for the Conservation of Nature (IUCN) defines NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems that effectively and adaptively address societal challenges, such as climate change, while simultaneously providing human well-being and biodiversity benefits (IUCN, 2020). The problems and future directions for building ponds include optimizing the entire microalgae-to-biofuel supply chain, tackling high production costs, technological issues, and environmental concerns. Research is required to cut costs, improve technologies, and tackle environmental challenges (Neiland et al., 2001).

Biodiversity conservation in cities involves a number of challenge-related issues. Cities increasingly appreciate ponds for their environmental functions. Several new urban projects have installed stormwater and groundwater recharge ponds. These provide "natural" habitat, reducing pond loss and preserving biodiversity in new projects (Hassall and Anderson, 2015). The Biodiversity Strategy for 2030 in Europe emphasizes the relevance of NbS in combating biodiversity loss, climate change, and other vital concerns. Using NbS can help deliver various Nature's Contributions to People (NCP) that improve people's quality of life (Brondízio et al., 2019).

11. Discussions

Construction ponds represent multifunctional nature-based solutions that integrate hydrological regulation, ecological enhancement, and socio-economic benefits. The findings of this review demonstrate that their effectiveness depends not only on hydraulic storage capacity but also on proper planning, ecological design, and long-term governance frameworks. When strategically implemented, green water retention ponds contribute to flood attenuation, water quality improvement, irrigation supply, biodiversity conservation, and climate change adaptation. However, these benefits are maximized only when ponds are developed within a broader network-based planning framework rather than as isolated infrastructure elements.

From an agricultural and environmental perspective, construction ponds can enhance irrigation reliability while promoting sustainable land use. A network-based approach improves ecosystem service delivery by identifying ecological hotspots, strengthening biodiversity corridors, and facilitating landscape connectivity. Furthermore, the conversion of previously uncultivated land into productive agricultural areas through pond-supported irrigation can increase farmers' income and enhance regional food security. Nevertheless, although these environmental and agricultural benefits are substantial, they are not always directly reflected in financial returns for landowners or society. This gap highlights the need for tailored financial incentives and policy mechanisms capable of internalizing ecosystem service values and supporting long-term sustainability (Staccione et al., 2021).

Urban construction ponds also play a crucial role in biodiversity conservation and environmental education. Small urban ponds, frequently located in residential gardens or integrated into stormwater systems, provide important habitats for aquatic organisms and contribute to urban ecological networks. However, homogenization in pond design, simplified vegetation structures, and excessive engineering control may reduce ecological complexity and biodiversity potential. Effective pond development therefore requires incorporating variable depth zones, native vegetation, and buffer strips to enhance habitat heterogeneity. Understanding urban freshwater ecosystems is particularly important in rapidly developing regions, where anthropogenic pressures significantly influence ecological processes (Hassall, 2014).

Water quality management remains one of the most critical technical considerations in construction pond development. While flood control ponds are designed to attenuate peak discharge and reduce downstream flooding, their performance can be compromised when nutrient loading and insufficient wastewater treatment lead to eutrophication. The failure of treatment systems to adequately remove nutrients may result in excessive algal growth, oxygen depletion, and degradation of aquatic communities. Improving treatment performance through modular system expansion, enhanced nutrient removal technologies, and recycling of treated effluents can significantly increase long-term sustainability and water resource resilience (Manzo et al., 2020). These findings emphasize that hydraulic design must be integrated with water quality monitoring and adaptive management strategies to maintain ecological balance.

At a broader landscape scale, pondscapes contribute substantially to ecosystem services and aquatic biodiversity. Despite their importance, small water bodies are often underrepresented in national and international conservation policies. Integrating pondscapes into biodiversity strategies and climate adaptation frameworks would align environmental governance with current scientific understanding. Compared with larger water bodies, ponds may be easier to manage and maintain, offering cost-effective opportunities for enhancing natural capital and human well-being. Transitioning from site-specific conservation toward resilient, landscape-based planning approaches can strengthen ecological connectivity and improve long-term environmental outcomes (Hill et al., 2018).

Overall, the development of construction ponds requires a systematic approach that integrates hydrological design, ecological principles, socio-economic considerations, and institutional support mechanisms. Clear definition of objectives, comprehensive site assessment, appropriate sizing and sediment management, biodiversity-oriented design, and long-term operation and maintenance planning are essential elements for successful implementation. When these components are addressed in a coordinated manner, construction ponds can function as resilient infrastructure systems capable of mitigating climate change impacts, reducing flood risks, and promoting sustainable development.

12. Conclusions

This article emphasizes the important role that construction ponds play in urban settings. These artificial water features are adaptable infrastructure elements that help manage stormwater, improve water quality, and conserve biodiversity in cities. Pond construction, which resemble natural water bodies and wetland ecosystems, help reduce the negative impacts of urbanization on natural systems. The study highlights the importance of incorporating constructed ponds into urban planning and green infrastructure programs to enhance urban resilience, address climate change challanges, and mitigate flood risks. Pond construction helps regulate the urban hydrological cycle by capturing and storing stormwater runoff, reducing pressure on drainage systems, and minimizing waterlogging in metropolitan areas. Furthermore, these constructed ponds provide valuable habitat for a variety of plant and animal species, supporting urban biodiversity conservation efforts. To ensure the effectiveness and sustainability of constructed ponds, careful design, implementation, and maintenance are required. Stakeholder and community involvement are also essential for the success of pond projects, as they foster local support and long-term viability. By integrating constructed ponds into urban development plans, communities can promote environmental sustainability, improve water management practices, and create resilient landscapes that benefit both human well-being and natural capital. Overall, constructed ponds are a nature-based solution that offers numerous benefits to urban environments, including climate change mitigation, flood risk reduction, and biodiversity enhancement. By leveraging the potential of constructed ponds, communities can adopt sustainable water and environmental management practices, resulting in a more resilient and ecologically balanced urban environment.

Reference

Abduljaleel Y., Salem A., ul Haq F., Awad A., Amiri M., Improving detention ponds for effective stormwater management and water quality enhancement under future climate change: a simulation study using the PCSWMM model, Scientific Reports, 13 (1), 2023, 5555, https://doi.org/10.1038/s41598-023-32556-x

Attwood S. J., Park S. E., Maron M., Collard S. J., Robinson D., Reardon-Smith K. M., Cockfield G., Declining birds in Australian agricultural landscapes may benefit from aspects of the European agri-environment model, Biological Conservation, 142 (10), 2009, 1981-1991, https://doi.org/10.1016/j.biocon.2009.04.008

Austin C., Knowles Z., Richards K., McCree M., Sayers J., Ridgers N. D., It's natural to play: Creating enabling environments for physically active play in the forest setting, In Skelton T., Nairn K., Kraftl P., (Eds.), Space, Place and Environment, 2, 115-136,

Aziz S. Q., Ahmed B. M., Mahmod A. A., A Improvement of Erbil City Environment and Increasing Irrigated Areas through Simulated Hydraulic Design from Greater-Zab River Water, Academic Journal of Nawroz University, 12 (4), 2023, 752-777, https://doi.org/10.25007/ajnu.v12n4a1656

Aziz S. Q., Muhammed K. K., Modern Methods and Artificial Intellegnce in Stormwater Harvesting as Sustainable Solutions. The 3rd International Conference on Engineering and Innovative Technology (ICEIT 2024), October 30-31, 2024, Erbil, Kurdistan Region, Iraq,

Biggs J., Von Fumetti S., Kelly-Quinn M., The importance of small waterbodies for biodiversity and ecosystem services: implications for policy makers, Hydrobiologia, 793, 2017, 3-39, https://doi.org/10.1007/s10750-016-3007-0

Brondízio E. S., Díaz S., Settele J., Ngo H. T., Guèze M, Aumeeruddy-Thomas Y., Bai X., Geschke A., Molnár Z., Niamir A., Pascual U., Simcock A., Jaureguiberry J., Chapter 1: Assessing a planet in transformation: Rationale and approach of the IPBES Global Assessment on Biodiversity and Ecosystem Service, In: Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Brondízio, E. S., Settele, J., Díaz, S., Ngo, H. T. (eds), IPBES secretariat, Bonn, Germany, 2019, 48, https://doi.org/10.5281/zenodo.3831852

Blue Green City, Interreg Europe, [Online]. Available: https://projects2014-2020.interregeurope.eu/bluegreencity/, Receved in 25.11.2024.,

Dadson S. J., Hall J. W., Murgatroyd A., Acreman M., Bates P., Beven K., Heathwaite L., Holden J., Holman I. P., Lane S. N., O'Connell E., A restatement of the natural science evidence concerning catchment-based 'natural'flood management in the UK, Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, 473 (2199), 2017, 20160706, https://doi.org/10.1098/rspa.2016.0706

Erbil Irrigation Directorate (2025). (Small Soil Dam in Darmeer Valley in Erbil). Available at: https://erbilirrigation.krd/darmeer-pond-shaqalw/ (Accessed: 06.03.2025.),

Fan G., Lin R., Wei Z., Xiao Y., Shangguan H., Song Y., Effects of low impact development on the stormwater runoff and pollution control, Science of The Total Environment, 805, 2022, 150404, https://doi.org/10.1016/j.scitotenv.2021.150404

Fan Y., Qiu J., Guo B., Du B., Chen D., Xu B., Peng Y., Xu B., Li F., Planning of Seawater Pumped Storage Hydropower in Coastal Depressions of China, Renewable Energy, 2026, 125186, https://doi.org/10.1016/j.renene.2026.125186

Ferk M., Komac B., Loczy D., Management of small retention ponds and their impact on flood hazard prevention in the Slovenske Gorice Hills, Acta geographica Slovenica, 60 (1), 2020, 107-125, https://doi.org/10.3986/AGS.7675

Gautam K., Corzo G., Evaluating the impact of ponds on flood and drought mitigation in the Bagmati River Basin, Nepal, Hydrology Research, 54 (10), 2023, 1163-1180, https://doi.org/10.2166/nh.2023.050

Hassall C., The ecology and biodiversity of urban ponds, Wiley Interdisciplinary Reviews: Water, 1 (2), 2014, 187-206, https://doi.org/10.1002/wat2.1014

Hassall C., Anderson S., Stormwater ponds can contain comparable biodiversity to unmanaged wetlands in urban areas, Hydrobiologia, 745, 2015, 137-149, https://doi.org/10.1007/s10750-014-2100-5

Hill M. J., Hassall C., Oertli B., Fahrig L., Robson B. J., Biggs J., Samways M. J., Usio N., Takamura N., Krishnaswamy J., Wood P. J., New policy directions for global pond conservation, Conservation Letters, 11(5), 2018, e12447, https://doi.org/10.1111/conl.12447

Hofman J. A. M. H., Paalman M., Rainwater harvesting, a sustainable solution for urban climate adaptation?, KWR Watercycle Research Institute, Nieuwegein, The Netherlands, 2014, 64,

IUCN Global Standard for Nature-based Solutions, A user-friendly framework for the verification, design and scaling up of NbS, (First edition), Gland, Switzerland: IUCN, 2020, Available at: https://portals.iucn.org/library/sites/library/files/documents/2020-020-En.pdf,

Jeppesen E., Meerhoff M., Davidson T., Trolle D., Sondergaard M., Lauridsen T., Beklioğlu M., Brucet S., Volta P., González-Bergonzoni I., Nielsen A., Climate change impacts on lakes: an integrated ecological perspective based on a multi-faceted approach, with special focus on shallow lakes, Journal of Limnology, 73 (s1), 2014, 88-111, https://doi.org/10.4081/jlimnol.2014.844

Keyvanfar A., Shafaghat A., Ismail N., Mohamad S., Ahmad H., Multifunctional retention pond for stormwater management: A decision-support model using Analytical Network Process (ANP) and Global Sensitivity Analysis (GSA), Ecological Indicators, 124, 2021, 107317, https://doi.org/10.1016/j.ecolind.2020.107317

Krull W., Berry P., Bauduceau N., Cecchi C., Elmqvist T., Fernandez M., Hartig T., Mayerhofer E., Naumann S., Noring L., Raskin K., Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities, Final report of the Horizon 2020 expert group on nature-based solutions and re-naturing cities, 2015, 71,

Krivtsov V., Birkinshaw S., Forbes H., Olive V., Chamberlain D., Lomax J., Buckman J., Yahr R., Arthur S., Takezawa K., Christie D., Hydrology, ecology and water chemistry of two suds ponds: detailed analysis of ecosystem services provided by blue-green infrastructure, 7th International Conference on Flood and Urban Water Management, FRIAR 2020, 28 - 30 September 2020, 167-178, Editors: S. Mambretti, D. Proverbs, Publisher: WIT Press, ISSN (Print):1743-3509, https://doi.org/10.2495/FRIAR200151

Liew Y. S., Mat Desa S., Md. Noh M. N., Tan M. L., Zakaria N. A., Chang C. K., Assessing the Effectiveness of Mitigation Strategies for Flood Risk Reduction in the Segamat River Basin, Malaysia, Sustainability, 13(6), 2021, 3286, https://doi.org/10.3390/su13063286

Liu H., Jia Y., Niu C., "Sponge city" concept helps solve China's urban water problems, Environmental Earth Sciences, 76 (14), 2017, 1-5, https://doi.org/10.1007/s12665-017-6652-3

Lõhmus M., Balbus J., Making green infrastructure healthier infrastructure, Infection Ecology & Epidemiology, 5 (1), 2015, 30082, https://doi.org/10.3402/iee.v5.30082

Lunduka R.W., Bezabih M., Chaudhury, A. Stakeholder-focused cost benefit analysis in the water sector: A synthesis report, International Institute for Environment and Development (IIED), London, UK, 2012, 45,

Lusk M. G., Bean E. Z., Iannone III B. V., Reisinger A. J., Stormwater ponds: Unaccounted environmental challenges of a widely-adopted best management practice in urban landscapes, Journal of Environmental Management, 374, 2025, 124170, https://doi.org/10.1016/j.jenvman.2025.124170

Magnus, R., Rannap R., Pond construction for threatened amphibians is an important conservation tool, even in landscapes with extant natural water bodies, Wetlands Ecology and Management, 27, 2019, 323-341, https://doi.org/10.1007/s11273-019-09662-7

Manzo L. M., Epele L. B., Horak C. N., Kutschker A. M., Miserendino M. L., Engineered ponds as environmental and ecological solutions in the urban water cycle: a case study in Patagonia, Ecological Engineering, 154, 2020, 105915, https://doi.org/10.1016/j.ecoleng.2020.105915

Muhammed K. K., Aziz S. Q., Performance evaluation of recently constructed ponds for flood mitigation in Erbil City and their impacts on the environment, Global Nest Journal, 27 (7), 2025, 07248,

Neiland A. E., Soley N., Varley J. B., Whitmarsh D. J., Shrimp aquaculture: economic perspectives for policy development, Marine Policy, 25 (4), 2001, 265-279, https://doi.org/10.1016/S0308-597X(01)00017-3

Nowicka-Krawczykauthor P., The cascade construction of artificial ponds as a tool for urban stream restoration - The use of benthic diatoms to assess the effects of restoration practices, Science of The Total Environment, 538, 2015, 591-599, https://doi.org/10.1016/j.scitotenv.2015.08.110

Oertli B., Céréghino R., Hull A., Miracle R., Pond conservation: from science to practice, Pond conservation in Europe, 2010, 157-165, https://doi.org/10.1007/978-90-481-9088-1_14

Oertli B., Parris K. M., Toward management of urban ponds for freshwater biodiversity, Ecosphere, 10 (7), 2019, e02810, https://doi.org/10.1002/ecs2.2810

Omofunmi O. E., Basic and Technical Considerations on Pond Design and Construction, British Journal of Applied Science & Technology, 15 (4), 2016, 1-10, https://doi.org/10.9734/BJAST/2016/24815

Ramos H. M., Teyssier C., López-Jiménez P. A., Optimization of Retention Ponds to Improve the Drainage System Elasticity for Water-Energy Nexus, Water Resour Manage, 27, 2013, 2889-2901, https://doi.org/10.1007/s11269-013-0322-3

Reddy K. S., Kumar M., Rao K. V., Maruthi V., Reddy B. M. K., Umesh B., Babu R. G., Reddy K. S., FARM PONDS: A Climate Resilient Technology for Rainfed Agriculture Planning, Design and Construction, Central Research Institute for Dryland Agriculture, Santoshnagar, Saidabad, Hyderabad-500059, Andhra Pradesh, India, 2012, 60,

Soil Conservation Service (SCS), National Engineering Handbook, Section 4: Hydrology, Department of Agriculture, Washington DC, ,1964, 450,

Staccione A., Broccoli D., Mazzoli P., Bagli S., Mysiak J., Natural water retention ponds for water management in agriculture: A potential scenario in Northern Italy, Journal of environmental management, 292, 2021, 112849, https://doi.org/10.1016/j.jenvman.2021.112849

Subramanya K., Engineering Hydrology, 4th Edition, McGraw-Hill, New Delhi, 2017, 552, ISBN-10: 1259029972,

Valenca R., Garcia L., Espinosa C., Flor D., Mohanty S. K., Can water composition and weather factors predict fecal indicator bacteria removal in retention ponds in variable weather conditions?. Science of the Total Environment, 838, 2022, 156410, https://doi.org/10.1016/j.scitotenv.2022.156410

Vojinovic Z., Alves A., Gómez J. P., Weesakul S., Keerakamolchai W., Meesuk V., Sanchez A., Effectiveness of small-and large-scale Nature-Based Solutions for flood mitigation: The case of Ayutthaya, Thailand, Science of The Total Environment, 789, 2021, 147725, https://doi.org/10.1016/j.scitotenv.2021.147725

Well F., Ludwig F., Integrated Planning and Implementation of a Blue-Green Architecture Project by Applying a Design-Build Teaching Approach, Land, 11 (5), 2022, 762, https://doi.org/10.3390/land11050762

Yulianti E., Prasetyo E., Optimization of Retention Pond in Flood Control Efforts in Pekanbaru (Urban Flood System Improvement Project), International Journal of Social Science, 3 (5), 2024, 561-580, https://doi.org/10.53625/ijss.v3i5.7425

Zhou Q., Leng G., Huang M., Impacts of future climate change on urban flood risks: Benefits of climate mitigation and ad-aptations, Hydrology and Earth System Sciences, 2016, 1-31. https://doi.org/10.5194/hess-2016-369

Iskorišćavanje retencionih jezera: Mitigacija klimatskih promena i smanjenje rizika od poplava

Shuokr Qarani Aziz [a], Khalat Khalid Muhammad Salih [a, b, #], Sazan Mohammed Ali [c]

[a] Salahadin univerzitet u Erbilu, Fakultet inženjerskih nauka, Odsek za građevinarstvo, okrug Kurdistan-Irak
[b] Direkcija za navodnjavanje u Erbilu, Generalna direkcija za vodne resurse, Ministarstvo poljoprivrede i vodnih resursa, Erbil, okrug Kurdistan-Irak
[c] Privatni institut Noble, Odsek za geodeziju, Erbil, Irak

INFORMACIJE O RADU

Primljen 27 januar 2026
Prihvaćen 26 februar 2026

Pregledni rad

Ključne reči:
Biodiverzitet
Klimatske promene
Retenciona jezera
Upravljanje poplavama

Citiranje: Aziz S. Q., Salih K. K. M., Ali S. M., Harnessing Construction Pond: Mitigation Climate Change and Reducing Flood Risks, Recycling and Sustainable Development, 19 (1), 2026, 1-12. https://doi.org/10.30544/RSD110

I Z V O D

Ova studija ispituje ključni značaj izgradnje retencionih jezera u urbanim sredinama. Ova jezera predstavljaju multifunkcionalne infrastrukturne elemente koji doprinose upravljanju atmosferskim vodama, poboljšanju kvaliteta vode i očuvanju biodiverziteta u urbanim ekosistemima. Izgradnja retencionih jezera, putem apsorpcije i skladištenja viška kišnice, pomaže u ublažavanju negativnih efekata urbanizacije na prirodne sisteme, kao što su poplave i zagađenje. Pored toga, retenciona jezera predstavljaju važnu komponentu plavo-zelene infrastrukture, doprinoseći ublažavanju klimatskih promena i smanjenju rizika od poplava u gradovima. Ona omogućavaju regulaciju urbanog hidrološkog ciklusa zadržavanjem i postepenim ispuštanjem atmosferskih voda, čime se redukuju vršni protoci i rizik od bujičnih poplava. Takođe, izgradnja jezera obezbeđuje značajne usluge ekosistemu, uključujući obezbeđivanje staništa za divlji svet i unapređenje urbanih zelenih površina. Integracija izgradnje retencionih jezera u urbano planiranje i arhitekturu predstavlja dugoročno rešenje za izazove koje nameću klimatske promene i urbanizacija. Gradovi koji uključuju ovakve objekte u projekte zelene infrastrukture mogu povećati svoju otpornost na ekstremne vremenske prilike, unaprediti sisteme upravljanja vodama i doprineti održivom razvoju. U celini posmatrano, izgradnja retencionih jezera nudi rešenje zasnovano na prirodi koje donosi direktnu korist urbanom stanovništvu, istovremeno doprinoseći očuvanju biodiverziteta i unapređenju kvaliteta urbanih ekosistema.