Advancing Green and Blue Infrastructure for Konya, Türkiye

In support of the World Bank project design and implementation

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Back cover: Drone view of Konya city. Photo: Murat Rahim Caglak

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Executive Summary

Overview

The traditional approach to infrastructure, sometimes referred to as "gray infrastructure", produces highly engineered solutions that typically serve a single purpose, such as a concrete-lined flood control channel. "Green and blue infrastructure" (GI/BI) refers to infrastructure that typically includes landscape and water features that work with nature to achieve the same functional goals as gray infrastructure, while also providing additional social and ecological benefits. In cities, these benefits can include urban cooling, water supply resilience, mental and physical health benefits for people, biodiversity protection, and others. GI/BI approaches are increasingly being adopted by leading cities worldwide to maximize the benefits of major new infrastructure investments driven by emerging climate change resilience, aging infrastructure, social equity, or conservation goals (World Bank 2024).

Türkiye and the greater Mediterranean Basin have been identified by the IPCC as one of the planet's regions that will be the most impacted by climate change (Ali et al. 2022). As part of its climate resilience efforts, Türkiye has worked with the United Nations to develop both short- and long-term strategic and action plans, including its 2053 Long-Term Climate Strategy and decarbonization goal, and its recently adopted Climate Change Mitigation Strategy and Action Plan for 2024–2030 (World Bank 2023).

Konya is the sixth most populous city in Türkiye. It is the capital city of the Konya province, the largest province in Türkiye by area. In the last four decades, Konya has doubled in area. In 2022, it was identified by the United Nations Development Programme (UNDP) as a pilot municipality for municipality-specific urban climate action plans. Konya's 2024 Sustainable Energy and Climate Action Plan outlines the city's goal to become a "sustainable city" by 2030 (Konya Metropolitan Municipality 2024). As a rapidly growing, culturally rich city with a strong employment center and varied natural environment, Konya has the opportunity to be a climate leader within Türkiye, and among fellow climate-leading cities worldwide.

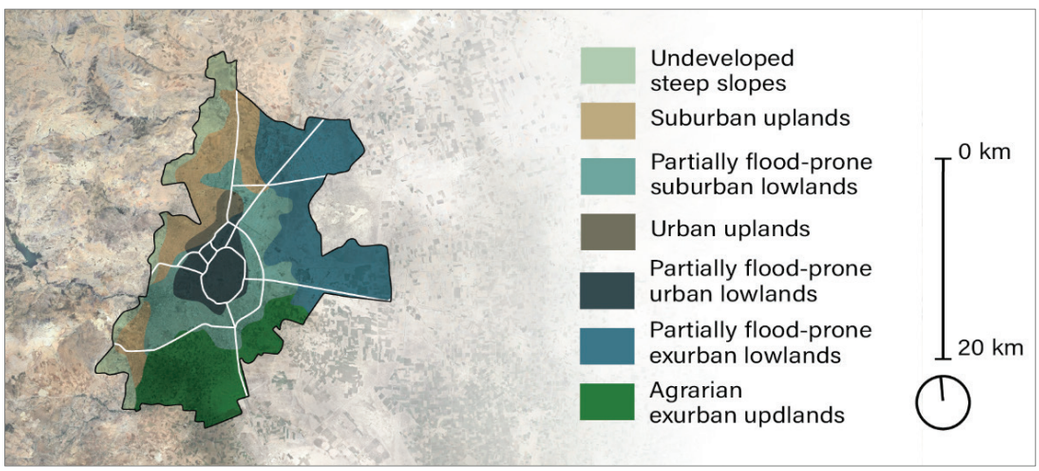
For Konya to make aggressive strides toward resilience and climate leadership, a comprehensive, city-wide GI/BI strategy can guide projects at the site, neighborhood, and city-wide scales to produce large-scale benefits. Such a strategy should also include clear goals and targets for achievement and outline the implementation process from planning to design and construction. The World Bank has already produced a comprehensive resource of nature-based solutions, *A Catalogue of Nature-Based Solutions (NBS) for Urban Resilience* (World Bank 2021), which serves as a framework for identifying appropriate GI/BI design strategies in cities. The UNDP's *Climate Adaptation Action Items for Konya* compiled by stakeholders in 2022 provides a list of Konya-specific climate adaptation priorities. This report builds upon these existing resources to provide a characterization of Konya's ecological context as the foundation for a city-wide GI/BI and NBS framework, and pilot projects that can serve as initial investments. The report concludes with a discussion of recommended next steps for advancing the pilot project concepts to implementation and an overarching GI/BI planning framework for Konya.

Ecological Characterization

The baseline urban ecological characterization includes the following components and is fully described in Appendix A:

- **Existing data review:** review of existing plans, spatial data, and stakeholder climate priorities, as well as identifying data gaps that may be used for more refined ecological characterization in the future
- **Green/Blue Infrastructure Priorities Identification:** review and analysis of the *Climate Adaptation Action Items for Konya*, a list of ideas for climate adaptation compiled by stakeholders in 2022 as part of the UNDP's *Enhancing Adaptation Action in TürkiyeProject*
- **Ecological Framework Characterization (Ecotopes):** development of ecotopes — spatial units made up of analogous ecological conditions involving air, earth, biota, and human/built conditions, to be used for GI/BI and NBS planning purposes.

Figure ES.1. Composite "ecotope" spatial management units showing areas of analogous ecological conditions.



Pilot Projects

Five pilot project concepts that represent key opportunities for advancing GI/BI in Konya were developed. These concepts are tailored to the city's specific ecological context as defined by the ecotopes framework, including soils and geology, landscapes and vegetation, air basins and microclimates, hydrology, built, and social features.

The five pilot project concepts for Konya are:

1. Enhancing the benefits of the Gedavet Park Ecological Corridor Pilot Project
2. Increasing water supply by using Konya's natural alluvial fans for groundwater recharge
3. Green streets and parks for flood mitigation in flood-prone areas
4. Expanding eco-tourism to promote ecological restoration and local social benefit
5. Restoring Konya's historic Akyay Lake

Investment Recommendations and Next Steps

Advance and expand pilot projects

A successful pilot project can build tremendous momentum toward expanding GI/BI in Konya. Pilot project implementation efforts can be initiated before or concurrently with the following investment recommendations to improve their effectiveness and reach.

Complete additional baseline ecological characterization

For Konya to receive the highest resilience benefits

from nature-based GI/BI strategies, projects must be tailored to their unique ecological context, from site-scale to city-scale. A more comprehensive baseline ecological characterization will add additional spatial and design specificity to opportunities and recommendations.

Build upon existing climate action planning efforts and work toward green and blue infrastructure strategic and master plans

For GI/BI strategies to be most successful, they must align with existing planning efforts, building upon the priorities of local stakeholders. Initial concepts, plans, and strategies, such as the information presented in this document and appendix, are typically developed and refined into more detailed plans in a subsequent planning step, such as a formal "strategic plan" addressing decision making and governance structures, and/or a physical "master plan" addressing spatial and design strategies.

Advance Konya as a Global Leader in Green and Blue Infrastructure

Konya is poised to serve as a model for other cities with the support of the World Bank and other partnerships. The pilot project concepts and framework in this document can be leveraged to access broader funding opportunities aligned with the Global Biodiversity Framework's 30x30 Goal, as well as other global resilience initiatives, to address socio-ecological needs within the context of cities facing climate change and extreme weather events. Such funding can advance resilience initiatives in Konya while disseminating lessons learned and providing case studies to other cities.

Photo: Hilal Kayik

1 INTRODUCTION

1.1 Project Overview

The traditional approach to infrastructure, sometimes referred to as "gray infrastructure", produces highly engineered solutions that typically serve a single purpose, such as a concrete-lined flood control channel. "Green and blue infrastructure" (GI/BI) refers to infrastructure that typically includes landscape and water features that work with nature to achieve the same functional goals as gray infrastructure, while also providing additional social and ecological benefits. In cities, these benefits can include urban cooling, water supply resilience, mental and physical health benefits for people, biodiversity protection, and others. GI/BI approaches are increasingly being adopted by leading cities worldwide to maximize the benefits of major new infrastructure investments driven by emerging climate change resilience, aging infrastructure, social equity, or conservation goals (World Bank 2024).

The following report includes an initial evaluation of Konya's ecological context for the purpose of identifying GI/BI needs and opportunities, followed by five project concept "Big Ideas" that may serve as pilot projects for initiating a broader city urban GI/BI program. The report concludes with a discussion of recommended next steps for advancing individual pilot project concepts and an overarching GI/BI planning framework for Konya.

This process began by building upon previous work by the World Bank to produce a City Scan for Konya of baseline ecological data. This resource provides a valuable starting point for identifying resilience challenges and characterizing opportunities and constraints for GI/BI (City Resilience Program 2023). The City Scan includes:

- Hydrological factors with implications for flooding, water quality, and water supply.
- Green spaces, trees, and vegetated landscapes for urban biodiversity, habitat connectivity, and urban cooling.
- Soils and landforms with implications for stormwater retention, groundwater recharge, and slope stability.
- Microclimates with implications for urban cooling, biodiversity, and energy demand.
- Socio-economic factors with implications for community exposure and vulnerability to climate hazards and opportunities for fostering sustainable behavior.

An expanded characterization of baseline ecological conditions for Konya, which is presented in detail in Appendix A, was considered when identifying the Big Ideas concepts. These concepts represent high-priority urban GI/BI opportunities to provide needed local resilience benefits, demonstrate planning and design techniques, and build the case for city-wide implementation of GI/BI solutions.

Achieving urban resilience through GI/BI will be a decades-long endeavor and this report may provide the following purposes at this early stage in the process:

- Serve as a tool for introducing stakeholders, including city administrators, engineers, planners, and operations and maintenance professionals,

to new GI/BI opportunities and encouraging community-driven initiatives.

- Serve as a guide for future investments in infrastructure planning and design in Konya.
- Demonstrate leadership in urban ecological resilience planning by incorporating science-led, place-based ecological opportunities and constraints analyses in infrastructure planning.
- Establish Konya as a leading-edge city in design and planning for urban ecological resilience through GI/BI.

1.2 Background: Climate Change Resilience and Green and Blue Infrastructure

Climate change impacts are occurring and accelerating, increasing the urgency of taking action to support ecological resilience. While projections of specific climate impacts in Konya are limited, the Intergovernmental Panel on Climate Change (IPCC) suggests that a 1.5°C change in global temperature rise will result in irreversible ecosystem change worldwide, increasing temperature extremes and intensification of heavy precipitation and flooding events, among other impacts (IPCC 2023). The IPCC (2023) predicted that this tipping point would be reached around 2040; however, some argue that this temperature threshold will be reached much sooner (Lenton et al. 2023). Given this urgency, our approach to this analysis and recommendations features two overarching principles: (1) apply ecological science-based analyses of local conditions in Konya to anticipate potential site-specific climate impacts and priorities; and (2) be "precautionary" in GI/BI recommendations, whereby resilience measures are aggressively pursued with the understanding that the full and long-term impacts of climate change cannot be fully predicted. In other words, Konya must prepare for a much warmer and uncertain world and the recommendations presented here include pragmatic, yet bold, strategies for GI/BI to support climate change resilience.

The consequences of climate change, such as flooding, heatwaves, or reductions in groundwater, should be managed as changes to local ecosystem processes. As climate change accelerates, so do these ecosystem changes—driving the need for rapid changes to traditional "gray" infrastructure strategies that apply rigid constructed features designed for historical ecological conditions. Going forward, cities must be treated as interconnected and dynamic urban ecosystems where infrastructure solutions are tailored to ecological context and expected change, integrating and updating the historical 20th century single-purpose gray infrastructure systems (e.g., concrete flood channels) with 21st century approaches in which adaptive GI/BI is designed to maximize many types of benefits simultaneously (e.g., a re-engineered creek channels that provides park space, habitat connectivity, groundwater recharge, and water quality improvement while expanding flood control functions). This is the opportunity of GI/BI approaches, to upgrade city infrastructure to accommodate climate change while also adding to the livability and vibrancy of cities. A rigorous ecological planning and design approach is at the core of this transformation.

1.3 Green and Blue Infrastructure and Nature-Based Solutions

GI/BI often employs "nature-based solutions" that carefully consider the urban ecology of a specific site to guide design and provide a range of benefits (van Oorschot et al. 2024). Sustainable development benefits of nature-based solutions can include greater climate and disaster risk resilience, water supply improvements, nature protection, or urban heat mitigation, among many other ecosystem services that can be maximized through effectively designed GI/BI (World Bank 2024). A key feature of nature-based solutions is that they require an ecologically rigorous consideration of project scale and context, including considering the potential impacts or benefits that a strategy at one site may have elsewhere in the watershed or region.

As stated in the World Bank Nature-Based Solutions Opportunity Scan (2024), GI/BI can also be integrated with gray infrastructure if there are broader watershed or ecosystem benefits that outweigh a green or blue infrastructure approach at the same site, such as using an underground cistern to capture and treat stormwater runoff beneath an urban plaza where there is insufficient space for a green infrastructure strategy, such as an above-ground vegetated bioswale. Another common reason gray infrastructure is chosen is when the cost of long-term operation and maintenance of a GI/BI infrastructure approach outweighs the additional benefits the approach may provide. However, nature-based GI/BI approaches often provide valuable ecosystem services that justify their investment, such as urban cooling, habitat connectivity, and air quality improvement (Evans et al. 2022). Achieving these benefits in an urban environment takes care and attention to ecological context, including selecting landscape plant species for habitat value and tolerance to challenging urban conditions such as highly compacted soil, low soil volumes, extreme temperatures, pollutants from soil and stormwater runoff, and vandalism (Grey et al. 2018).

1.4 Konya as a Leading-Edge Resilient City

Türkiye and the greater Mediterranean Basin have been identified by the IPCC as one of the planet's regions that will be the most impacted by climate change (Ali et al. 2022). As part of its climate resilience efforts, Türkiye has worked with the United Nations to develop both short- and long-term strategic and action plans, including its 2053 Long-Term Climate Strategy and decarbonization goal, and its recently adopted Climate Change Mitigation Strategy and Action Plan for 2024 – 2030 (World Bank 2023).

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For Konya to make aggressive strides toward resilience and climate leadership, it needs a clear strategy with goals and targets that can shape GI/BI projects at site-to-regional scales. The strategy should outline the project implementation process from initial planning through design and construction. The World Bank has already produced a comprehensive resource of nature-based solutions to guide GI/BI strategies, *A Catalogue of Nature-Based Solutions for Urban Resilience* (World Bank 2021). The investment strategy in this report builds upon that comprehensive resource, recognizing that for nature-based solutions to perform best, they must be coordinated with the region's broader resilience goals. Therefore, at a high level, the following are recommended and described in further detail in Section 3 of this report:

- An investment and prioritization approach for GI/BI with a strong emphasis on water management — at the heart of many of Konya's resilience challenges including water supply, flooding, urban cooling, and subsidence due to declining groundwater levels.
- A place-based, urban ecological framework that bridges Konya-specific social and ecological opportunities and challenges, providing the basis for goals, targets, and plans.
- A phased implementation timeline, beginning with exemplary pilot projects to demonstrate value, and building towards unified city-wide and regional plans for comprehensive ecological benefits.
- Disseminating this information and process as a blueprint for other cities facing similar challenges.

1.5 Project Approach

The analysis and recommendations presented in this report derive from a leading-edge ecosystem and nature-based-based approach to city-wide GI/BI planning that the project team has applied in Los Angeles and in other cities worldwide (Brown 2017, Brown 2019, UCLA 2024). This approach was originally derived from United States Department of Agriculture's Ecological Sections of the United States, which has been applied to guide ecological management in rural lands settings in the United States for decades (Barnes et al. 1982, McNab et al. 1997). Applying the approach in cities involves (1) recognizing urban ecosystems, which are spatial units that share unique combinations of air, earth, biota, and human/built conditions, and are the building blocks of urban ecology at multiple spatial scales, and (2) partitioning the city into these spatial units, or ecotopes, as areas with shared environmental management and GI/BI needs and opportunities. These units can be incorporated into effective multi-scale planning guidance (i.e., effective for integrating both city-wide and site-specific strategies) to coordinate broad-scale achievement of environmental management goals, such as for an entire city (McNab et al. 1997, Brown 2019). In other words, this approach provides a framework so that analysis, planning, designing, and investments may be coordinated at sites across the city to address broad-scale ecological challenges such as flooding, habitat connectivity, or providing local water supply. It also guided the selection of the five pilot project concepts so that the full variety of major urban GI/BI themes of opportunities and needs relevant to Konya's differing urban ecological contexts could be identified and proposed in this report.

Photo: Samet Guler

2 GREEN AND BLUE INFRASTRUCTURE Concepts FOR KONYA

2.1 Konya Ecological Resilience Baseline Characterization

The *Climate Adaptation Action Items for Konya* ("Actions List"), a list of ideas for climate adaptation compiled by stakeholders in 2022 as part of the United Nations Development Programme's *Enhancing Adaptation Action in TürkiyeProject*, was referenced to gain a baseline understanding of Konya's ecological resilience context and opportunities for GI/BI. The City Scan and publicly available online resources were used to analyze the existing ecological conditions of Konya. Ecological analysis involved examining air, earth, water, biota, built and social factors. For more information regarding the baseline characterization process and results, see Appendix A.

2.1.1 Synthesis of *Climate Adaptation Actions for Konya* to Identify Green and Blue Infrastructure Priorities

An Excel-based tool was developed to synthesize and prioritize climate adaptation actions from the Actions List. The tool was used to summarize and rank our preliminary understanding of climate resilience priorities for Konya (Table 1). The ranking was based on a simple scoring system that counted how frequently each type of ecological benefit was mentioned in the Actions List, and to what degree the action was likely to provide the desired ecological benefit. The Actions List and ranking were used as a basis for identifying and selecting the five GI/BI infrastructure pilot projects described in the next section. It is important to note that this list is preliminary for the purposes of initial identification of opportunities. See Appendix A.4 for more information on this prioritization exercise. The Excel-based tool may also be useful during later planning steps and is available upon request.

Table 1. Preliminary priorities for Konya Green and Blue Infrastructure

Priority ranking	Action types and associated ecological benefits
Higher priority ↑	➤ Drought mitigation ➤ Water pollution mitigation ➤ Stormwater management ➤ Habitat connectivity ➤ Community enrichment ➤ Developmental footprint mitigation ➤ Habitat enhancement
	➤ Local water supply improvement/ protection ➤ Flood mitigation ➤ Extreme heat mitigation ➤ Carbon emissions reduction ➤ Access to nature ➤ Edge effects mitigation ➤ Urban forest benefits ➤ Urban heat island (UHI) mitigation
	➤ Vegetation mortality mitigation ➤ Extreme wind mitigation ➤ Toxic air pollution mitigation ➤ Carbon storage ➤ Landslide and sinkhole mitigation
↓ Lower priority	➤ Soil contamination mitigation ➤ Fire mitigation ➤ Pest and invasive species mitigation ➤ Noise reduction ➤ Litter reduction

2.1.2 Synthesis of the City Scan to Identify Place-Based Ecological Opportunities for Green and Blue Infrastructure

The other product of the baseline characterization process was a preliminary classification of spatial management units for GI/BI planning, or "ecotopes" (Table 2). Ecotopes represent a synthesis of the City Scan and other environmental data to map zones of generalized, shared ecological conditions across Konya, describing differences in air, earth, water, biota, built, and social factors. Combining ecological factors in this way is a long-standing tool of ecosystem management that helped to identify and provide spatial specificity to the five pilot project concepts presented in Section 2.2 (Barnes et al. 1982, McNab et al 2007). These subregional-scale units of broadly similar ecological conditions, climate resilience priorities, and associated ecological opportunities and needs serve as an initial spatial framework for city-wide GI/BI planning. See Appendix A.5 for more detailed descriptions of the ecotopes.

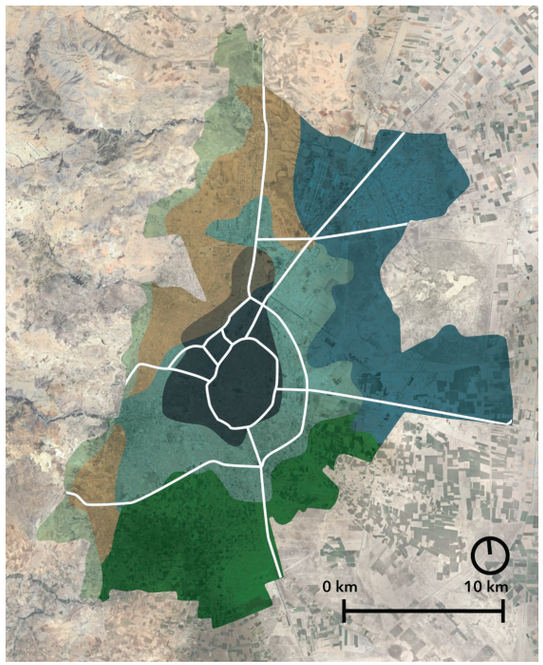


Table 2. Preliminary Ecotopes for Konya

Spatial unit	Proposed characterizations			
	Air	Earth / Water	Biota	Human / Social
Undeveloped steep slopes	Moderate to relatively hot, especially closest to built-up areas. Medium PM 2.5 pollution.	High slope, erosion-prone, mostly east-facing. Some flood risk, which is almost entirely concentrated around Meram Creek, a channelized water body and topographic low point.	Primarily dry grasslands with some built-up land.	Low population density, lower income with lower access to resources, especially at northern and southern edges of the city.
Suburban uplands	Relatively cool, medium-to-high levels of PM 2.5 pollution, increasing closer to the urban core.	Moderate slope with ridges and swales. Potential alluvial fans and permeable soils, indicating potential for groundwater recharge. Low risk of flood, with risk concentrated around Meram Creek.	Dry, low amounts green space especially in the north, mostly built-up land.	Moderate population density, higher relative wealth compared to exurban areas and suburbs to the east.
Partially flood-prone suburban lowlands	Relatively cool, high levels of PM 2.5 pollution.	Low to moderate slope. High risk of both rainwater and river flooding, especially rainwater flooding.	Mix of built-up land and irrigated green space. High tree canopy compared to other urban areas.	Mostly moderate to higher population density, higher relative income
Urban uplands	Moderate temperatures with higher temperatures to the east, closer to city center. High PM 2.5 pollution.	Moderate to low slope, low elevation. Little flood risk.	Almost entirely built-up land with some trees and green space.	High relative wealth, high to moderate population density.
Partially flood-prone urban lowlands	Moderate temperatures with cooler pockets around areas of high urban green space and at the periphery of irrigated exurban. High PM 2.5 pollution.	Moderate to low slope, low elevation. High flood risk in patches, roughly following topographic ridges.	Almost entirely built-up land with some trees and green space towards the south.	High relative wealth, especially within the innermost ring roads. High population density.
Partially flood-prone exurban lowlands	Hot, especially in dry grasslands and bare areas. Moderate to high levels of PM 2.5 pollution, especially near the airport.	Very low slope and likely poor infiltration potential, with mixed (low/high) levels of flood risk. Likely flash flood conditions.	Mix of built-up land (airport), dry grasslands, and bare earth.	Mostly lower population density, lower income, and resource-poor except for recent urban growth surrounding the airport.
Agrarian exurban uplands	Cool temperatures, with pockets of heat in built-up areas to the west. Moderate PM 2.5 pollution, high higher concentrations in more densely-populated areas.	High to moderate slope, with higher slope closer to the western mountains. Some flood risk. Potential for infiltration and conveyance projects.	Almost entirely irrigated agricultural land, with small amounts of grassland and built-up land on the western edge.	Highly mixed levels of relative wealth, with lower wealth in most intensively irrigated areas and areas with highest flood risk. Moderate population density, decreasing in agricultural areas to the south.

2.2 Pilot Project Concepts Tailored to the Konya Urban Ecosystem

Synthesis of the above information led to the identification of five pilot project concepts that represent key opportunities for advancing GI/BI in Konya. These concepts are tailored to the city's specific ecological context, including soils and geology, landscapes and vegetation, air basins and microclimates, hydrology, built, and social features. The following information provides an initial basis for advancing concepts forward toward implementation and each should be evaluated further for feasibility and modified as needed to integrate additional contextual information specific to the project sites, including soil conditions, slope, aspect, distance to groundwater table, neighborhood context and community needs, local politics, land ownership, and other considerations.

Five Concepts for Konya presented on the following pages include:

1. Enhancing the benefits of the Gedavet Park Ecological Corridor Pilot Project
2. Increasing water supply by using Konya's natural alluvial fans for groundwater recharge
3. Green streets and parks for flood mitigation in flood-prone areas
4. Expanding eco-tourism to promote ecological restoration and local social benefit
5. Restoring Konya's historic Akyay Lake

01. EARLY ACTIVATION PROJECT: GEDAVET PARK ECOLOGICAL CORRIDOR

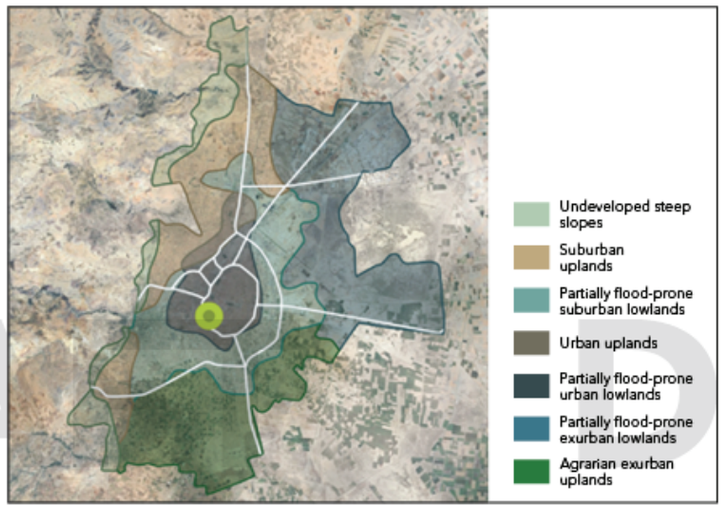
OPPORTUNITIES TO ENHANCE BENEFITS FROM A PREVIOUSLY-PROPOSED PROJECT

THE MAIN IDEA

Gedavet Pedestrian Road has been identified by the Konya Metropolitan Municipality as a site to pilot green and blue infrastructure strategies for Konya. There is a current proposal for the Gedavet Park Ecological Corridor project that focuses on awareness-building around green infrastructure, lowering carbon emissions, and using vegetation to improve air quality and reduce urban heat.

This Concept includes expanding the ecological design of the current plan to account for additional opportunities and needs considering the full ecosystem context of the site. Additional opportunities around stormwater treatment and groundwater recharge, flood control, and urban biodiversity enhancement are likely. A complete ecological baseline characterization of the site is recommended as a next step for design optimization. By fully optimizing the site ecosystem, Gedavet can maximize its effectiveness as a pilot project and foundation for expanding Konya green and blue infrastructure programs.

THE ECOLOGICAL MANAGEMENT APPROACH



ECOLOGICAL CHARACTERIZATION

Gedavet Pedestrian Road, the site of future Gedavet Park Ecological Corridor, is located within Konya's city center. It is a highly-visited area that experiences higher-than-average summer temperatures and levels of PM 2.5 air pollution. Konya sees the most rain in winter, receiving around 4 cm per month from October through May on average. Summers are hot and dry. Average low temperatures are below freezing from November to mid-March which is relatively cool compared to other Mediterranean climates.

While located in a flood risk zone, Gedavet Park is somewhat topographically elevated, and not at high risk. Located within a historic alluvial plain, it may have high groundwater infiltration potential.

Gedavet Park is located just southwest of two moderately-sized central green spaces, Alaadin Tepesi Park and Kültür Park. There are multiple other green spaces within a one-mile radius of the site, including one park and three tree-lined cemeteries. It is located roughly between two significant areas of bird habitat: the wetlands of the Taurus Mountains to the southwest, and the salty lakes to the northeast.

PROPOSED MANAGEMENT STRATEGY

Tailor the current ecological strategy for stormwater management to site conditions to optimally support water supply, groundwater recharge, flood control, and potentially additional urban cooling. The region is semi-arid so evaporative cooling could be utilized to reduce heat in public spaces. In addition to infiltrating stormwater for water supply, consider biofiltration in water features to induce evaporative cooling in public spaces.

Gedavet Ecological Corridor should be evaluated for its potential to act as a habitat "patch" and "stepping stone" between larger green spaces within the city, both to benefit biodiversity and to provide urban dwellers greater opportunity to experience nature in their neighborhoods.

NATURE-BASED SOLUTIONS TOOLKIT

ENHANCEMENT OPPORTUNITIES FOR GEDAVET PARK ECOLOGICAL CORRIDOR

[A] Planting for biodiversity and carbon sequestration

Incorporate plants and features that provide habitat for appropriate native biodiversity and integrate biodiversity education. Maximize trees longevity and size to maximize carbon sequestration benefits.

[B] Ecological and social connectivity

Planting layout and structure that enhances ecological connectivity with surrounding green space. Integrate ecology with the social fabric of the neighborhood.

[C] Maximize benefits of rainwater that falls within the Gedavet watershed.

Include interventions that enhance permeability for groundwater recharge, prevent runoff to adjacent flood-prone areas, and maximize evaporative cooling potential

[D] Optimizing cooling abilities

Study shade, aspect, and evaporative cooling potential to optimize design and location of features for maximum cooling with trees, shade structures, water features, and hardscape and softscape materials.

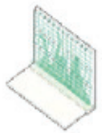
OVERALL STRATEGY

To enhance an existing proposal for the Gedavet Ecological Corridor with strategies that fully consider the ecological context of the site.

NATURE-BASED STRATEGIES

[1] Bioswales

Vegetated bioswales for stormwater conveyance, treatment, evaporative cooling, and habitat value.

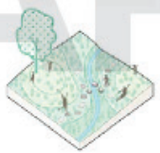


[4] Ground-planted green facades

Provide shade and habitat value. These features have greater survival rates and require less maintenance than green walls.

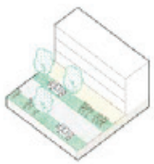
[2] Urban forests and habitat patches

Identify locations for biodiversity in urban areas. These spaces can provide mental health benefits from contact with nature, cooling, and water quality benefits.



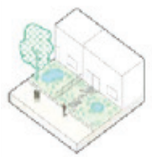
[5] Green-blue nature playgrounds and gardens

Parks and recreation spaces can be designed to maximize ecological benefits and educational opportunities to foster conservation behavior in younger generations.



[3] Permeable pavement

Apply in areas with permeable soils to provide groundwater infiltration. These features are less appropriate for soils with naturally slow infiltration rates such as clay soils.



[6] Small-scale infiltration

French drains, rain gardens, and other smaller interventions should be used to retain and use or infiltrate the maximum amount of rainfall hitting the project area.

Nature-Based Strategies diagrams credit: A Catalogue of Nature-Based Solutions for Urban Resilience (World Bank 2021).

PRIORITIES AND OPPORTUNITIES

KEY STUDY QUESTIONS FROM TECHNICAL EXPERTS

? WATERSHEDS

What is the watershed of Gedavet Park Ecological Corridor and what is the potential for stormwater capture and groundwater infiltration?

? SHADE AND TEMPERATURE

Has a shade study been performed to optimize tree, native plant, and shade structure placement and design? What native plants are being used and have their growing needs been effectively considered for success (such as cool vs warm season native solar exposure).

? ECOLOGICAL CONNECTIVITY

Has a connectivity study been completed to identify other parks to connect the project to in support of a broader green corridor network?

? HISTORIC MERAM CREEK

What is the current subterranean alignment of Meram Creek, and also its historical alignment? Do they coincide with some of the existing open spaces above including Gedavet?

GREEN AND BLUE INFRASTRUCTURE BENEFITS

As-proposed
The proposal presentation about the planned Gedavet Park Ecological Corridor describes:

Increased permeability, storm water collection, solar power generation, reduced urban heat island, improved air quality, and increased awareness of clean energy and climate change.

With enhancements
Suggested enhancements to Gedavet Park Ecological Corridor would connect the park to its surroundings. Interventions for infiltration and storm water collection could be tailored to also mitigate runoff into downhill, flood-prone areas. Plant palettes and vegetation structures would be chosen to provide an optimal habitat stepping stone between larger patches of green space within the city and its periphery to the west. Planting BMPs would ensure that vegetation can grow as long and large as possible to maximize carbon sequestration.

KONYA'S CLIMATE ADAPTATION OPPORTUNITIES FOR ACTION

The following climate action opportunities that were identified by expert stakeholders at the 2022 Enhancing Adaptation Action in Turkey Project meeting in Konya.

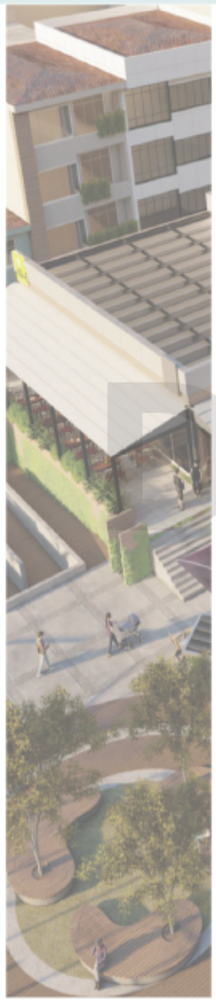
KNT4 **City**
Conducting exemplary neighborhood pilot practices compatible with climate change.

KNT6 **City**
Afforestation plans to create shade in urban areas and reduce pollution.

KNT1 **City**
Changing surface materials and pedestrianizing roads to combat the urban heat island effect.

BEK8 **Biodiversity/Ecosystem Services**
Creating ecological corridors to combine fragmented habitats.

CONCEPT 01 RECOMMENDATIONS



IMPLEMENTATION TIMELINE

- Near-term
- Medium-term
- Long-term

Near-term
This Concept should be addressed immediately, before the Gedavet Ecological Corridor design is completed. Providing a design concept that fully considers ecological opportunities will establish a strong foundation and precedent for future green and blue infrastructure in Konya and beyond.

NEXT STEPS CHECKLIST

✓ **Align with existing plans and engage with stakeholders**
The Gedavet Park Ecological Corridor project is already aligned with select goals from the Konya Metropolitan Municipality Strategic Plan and the 12th Turkey Development Plan. Engage with local stakeholders to align with local resources, needs, priorities, and opportunities; and to foster local ownership early in the process.

✓ **Baseline characterization**
Gather data and identify data gaps related to project priorities, including shade mapping to optimize for cooling, a soils study to understand infiltration potential, local watershed mapping, and biodiversity assessment to identify focal species, habitat design strategies, and connectivity mapping.

✓ **Set goals and targets**
Use the complete ecological baseline characterization to confirm project goals and make adjustments to the current design as needed. Additional goals may further expand goals for urban heat reduction, biodiversity, connectivity, water supply and capture, flood management, and air quality. Quantitative targets are ideal and design strategies should be estimated to confirm that targets can be met. Example quantitative targets include estimated degrees cooled compared to other urban settings, wildlife species present, or cubic meters stormwater captured.

✓ **Implement, monitor, and look forward**
Make a plan to monitor the ecological performance of the site and implement "adaptive management" to ensure long-term performance. Evaluate and share the results and lessons learned to guide greater Green and Blue Infrastructure master planning efforts.

02. INCREASING GROUNDWATER: BLUE INFRASTRUCTURE FOR KONYA'S ALLUVIAL FANS

INCREASING INFILTRATION TO PROVIDE WATER SUPPLY RESILIENCE

THE MAIN IDEA

For regions like Konya that regularly face drought, a secure water supply is a critical component of climate resilience. Areas of Konya that sit upon highly permeable alluvial deposits from rivers that typically have ideal soil conditions for groundwater recharge. Increasing groundwater is emerging as a top priority worldwide because groundwater levels are dropping, the potential for storage in the ground is very large, and underground storage is often more effective and beneficial than above-ground storage such as reservoirs.

This Concept maximizes how much runoff Konya is able to store in the ground for future water supply, or other ecological benefits, such as the restoration of surrounding groundwater-dependent Akyay and Tuz Lakes. Groundwater recharge infrastructure can also provide co-benefits such as reduced flooding, reduced urban heat, increased access to green space, and urban habitat and ecological connectivity.

KEY STUDY QUESTIONS FROM TECHNICAL EXPERTS

? **Where are the most infiltrative soils located?**

? **What land can be acquired or used for infiltration and blue infrastructure?**

? **Where have streams been paved over, and how can we daylight or redirect them?**

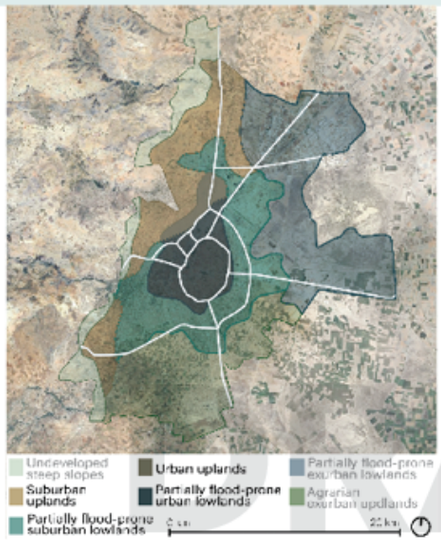
THE ECOLOGICAL MANAGEMENT APPROACH

ECOLOGICAL CHARACTERIZATION

Alluvial features, or landforms created by streams and rivers, are found throughout the city of Konya. On the western side of Konya, rivers leave steeper mountain or foothill areas and deposit sand, gravel, and cobbles in features known as alluvial fans. These natural features are often ideal for capturing and storing storm water runoff in the ground because their soils are very permeable and have a large capacity to store groundwater.

Our baseline data review and ecological characterization revealed the presence of alluvial fans and other infiltrative soils (see Appendix A). A 1950s soils survey (below, right) provided a key reference dataset for understanding which areas may have the highest infiltration potential.

Additionally, review of baseline information for the Konya region revealed that several lakes and wetland habitat areas near Konya are threatened by depleted groundwater. Groundwater storage measures in Konya may also benefit these features are in fact hydrologically connected.

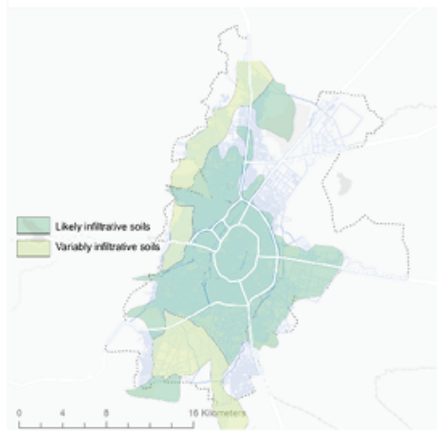


PROPOSED MANAGEMENT STRATEGY

Opportunities for large-scale infiltration facilities and for restoring natural alluvial fan conditions should be evaluated.

There are many benefits to storing water in the groundwater table. Water stored in the ground is naturally protected from evaporation, resulting in substantial water savings compared to surface storage in hot climates like Konya. Over-extraction of groundwater has led to subsidence and sinkholes in Konya, so restoration may also reduce these impacts.

When natural alluvial fans are paved over and compacted, they lose these benefits – meaning storm water runs off without being captured, and may even contribute to flooding downstream. Removal of impermeable surfaces on these features is another potential priority.



PRIORITIES AND OPPORTUNITIES

CONCEPT 02: GREEN AND BLUE INFRASTRUCTURE BENEFITS

Water Management
Increased local water supply, flood mitigation, runoff treatment and water quality.

Green Space
Large infiltration infrastructure can be developed to also function as public green space. Increased green space also helps to mitigate impacts of extreme heat. Infiltrating groundwater reduces risk of subsidence.

Ecological connectivity
Creation of additional green spaces, especially following creeks, can create ecological corridors to support biodiversity.

KONYA'S CLIMATE ADAPTATION OPPORTUNITIES FOR ACTION

This Concept is supported by the following climate action opportunities that were identified by expert stakeholders at the 2022 Enhancing Adaptation Action in Turkey Project meeting in Konya:

SUY1 **Water**
Strengthening the basin-based water management approach

SUY12 **Water**
Afforestation work in areas at risk of flood, accelerating upstream flood control works

BEK5 **Biodiversity/Ecosystem Services**
Updating the Basin Flood Management Plan by adding ecosystem-based disaster risk reduction (Eco-DRR)

BEK8 **Biodiversity/Ecosystem Services**
Add protections to areas where critical species are concentrated, such as streams and natural steppes

NATURE-BASED SOLUTIONS TOOLKIT

OVERALL STRATEGY

To divert runoff and river flow into more porous areas to infiltrate it into the groundwater table.

LIKELY ALLUVIAL FANS WITH BEST GROUNDWATER RECHARGE OPPORTUNITIES

OPPORTUNITY AREAS

[A] Very large undeveloped lots
Very large parcels of undeveloped or disused land may provide maximum potential infiltration, including large-scale floodplain restoration or creation of industrial-scale recharge infrastructure.

[B] Large undeveloped lots
Larger lots of undeveloped land that are adjacent or close to bodies of water are also ideal for large-scale infiltration.

[C] Small undeveloped lots
Smaller lots of undeveloped or disused land that are in alluvial fan areas may be designed to divert smaller amounts of runoff. Incentives may be needed to encourage actions on private lands.

[D] Natural-bottom streams
Meram Creek and Sile River have variable amounts of water that follows a natural course and is controlled by dams upstream. Allowing additional water to flow in these areas may provide similar or greater water supply benefits compared to storage in reservoirs.

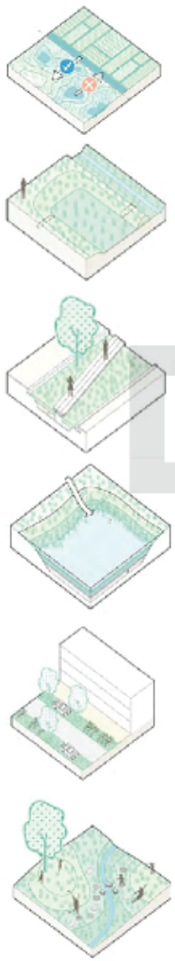
[E] Under-grounded / buried streams
Portions of streams that are directed into tunnels beneath the city may either be daylit and restored to provide infiltration, or directed to infiltration infrastructure.

[F] Channelized/concrete-bottom streams
Portions of streams with concrete walls and /or beds may be re-designed for infiltration. They also support greater biodiversity.

[G] Residential development
Landscapes within residential areas such as sidewalks, roads, and residential amenity areas may be redesigned for infiltration.

[H] Developed open spaces, parks, parkways, and streetscapes
Publicly-accessible landscaped areas may be re-designed to support infiltration.

NATURE-BASED STRATEGIES



[1] Drainage reduction
Lots that are next to water bodies (B, C) or wide portions of natural stream corridors (D can be used to slow down water and infiltrate it slowly.

[2] Multi-purpose, multi-benefit groundwater infiltration ponds
Very large lots (A) can be developed into infiltration ponds with recreational space. Undergrounded streams (E) can be directed towards infiltration ponds.

[3] Bioswales and rain gardens
Runoff can be diverted to permeable neighborhood-scale projects (C, G, H)

[4] Constructed alluvial fans
Lots near water bodies (B, D, E, F) and water bodies can be modified to meander and spread like parts of the original alluvial fan, providing infiltration and habitat value.

[5] Permeable pavement
Areas that require hardscape (G, H) should utilize permeable pavement and other materials with higher infiltration rates.

[6] Green-blue nature playgrounds and gardens
Small sites near residential areas (C, G, H) can be developed into recreational spaces designed around infiltration features and provide an opportunity for educational play.

CONCEPT 02 RECOMMENDATIONS

IMPLEMENTATION TIMELINE

- Near-term
- **Medium-term**
- Long-term

Medium-term
Given the complexities of understanding groundwater recharge potential and appropriate design strategies, this Concept will take some time to implement. An initial small-scale pilot project in an opportunity zone could begin immediately. The baseline characterization and an overall master plan would be necessary to fully realize benefits and integrate these measures into the local water management system.

NEXT STEPS CHECKLIST

✓ Align with existing plans and engage with stakeholders

Groundwater studies are currently being carried out by the Directorate General of State Hydraulic Works (DSI).

Review existing plans for water supply to determine the appropriateness of this Concept.

✓ Baseline characterization

Soils and groundwater analysis are needed to identify appropriate locations and potential

Review water supply system to identify appropriateness and role of this opportunity within the overall Konya water supply program.

✓ Set goals and targets

Once appropriateness of this Concept is determined, establish ambitious goals to build momentum and strategies around.

Determine reasonable capacity for infiltration and storage and set appropriate targets to guide specific design strategies and programs.

✓ Design and Implementation

Goals and targets for groundwater supply are needed determine appropriate design strategies

Large-scale groundwater recharge programs are best addressed through master plans that consider watershed and city-scale actions.

PRECEDENT PROJECTS

PROJECT 1
SEVEN OAKS DAM AND GROUNDWATER RECHARGE SPREADING GROUNDS HIGHLAND, CA

BACKGROUND

Seven Oaks Dam was completed in 2000 by U.S. Army Corps of Engineers to provide flood protection and support groundwater recharge for water supply in downstream alluvial fan areas. Groundwater recharge facilities have been designed to mimic natural conditions to provide habitat for native biodiversity, including to support recovery of threatened and endangered species. This example of a multi-benefit blue infrastructure project could be applicable in Konya at a smaller scale on large parcels within the alluvial fans of Meram and Sille Creeks.

NATURE-BASED STRATEGIES

[1] Drainage reduction

[2] Multi-purpose, multi-benefit groundwater infiltration ponds

[4] Constructed alluvial fans

OPPORUNITY AREAS

[A] Very large undeveloped lots

[B] Large undeveloped lots

[D] Natural-bottom streams

BENEFITS

Expands local groundwater recharge for water supply

Increases flood protection

Restores habitat

Provides access to nature

PROJECT 2
ELMER AVE NEIGHBORHOOD RETROFIT SUN VALLEY, CA

BACKGROUND

The Elmer Avenue neighborhood green and blue infrastructure project within urban Los Angeles was completed in 2010 to reduce street flooding and capture rainwater to recharge groundwater for water supply. The site was selected because of the need to address a local flooding problem and the opportunity of natural permeable alluvial fan soils beneath the neighborhood that are ideal for groundwater recharge. A similar combination of factors is present within Konya within alluvial fan and lowland areas.

NATURE-BASED STRATEGIES

[3] Bioswales & rain gardens

[4] Permeable pavement

[6] Green-blue nature playgrounds and gardens

OPPORUNITY AREAS

[C] Small undeveloped lots

[G] Residential development

[H] Developed open spaces, parks, parkways, and streetscapes

BENEFITS

Increase long-term groundwater suply

Enhance community greenspace and biodiversity

Mitigate street flooding

Promote water conservation education

Filter stormwater and improve water quality

03. REDUCED FLOODING: PROTECTIVE NETWORK OF GREEN STREETS AND PARKS

GREEN INFRASTRUCTURE TO REDIRECT AND CAPTURE FLOOD WATER IN FLOOD-PRONE AREAS

THE MAIN IDEA

Despite substantial alteration and reduction in natural flows in Meram and Sille Creeks, Konya is prone to major flash flooding. This is because large areas of the city have been constructed upon naturally flood-prone ecosystems, such as the former Akyay Lake area. Flood risk can be exacerbated when heavy rains compound with snow melt from the mountains. These floods can be very dangerous to human health and property: in November 2023, a 62-year-old man died when his car was swept into a canal by flash flood waters.

This Concept focuses mitigating floods in at-risk developed areas by creating a network of green streets to slow runoff, collect storm water, and redirect it to areas of the city with the highest capacity for storage and infiltration. While relatively infrequent, effectively capturing water from major flood events and using it as a new water supply source is a key focus for other Mediterranean cities such as Los Angeles.

KEY STUDY QUESTIONS FROM TECHNICAL EXPERTS

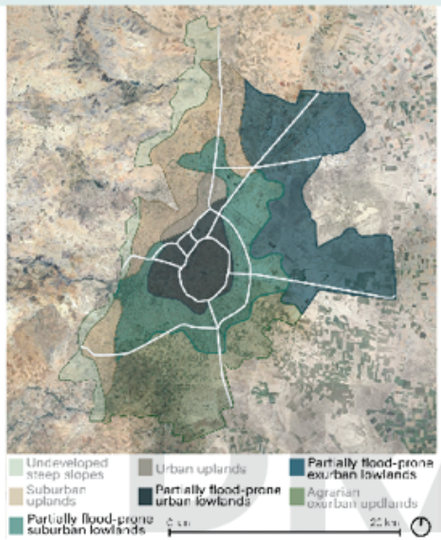
- ? **What is the hydrography for creeks that drive flooding?**
- ? **Where are soils with the best conditions for infiltration and those with most risk for ponding of water?**
- ? **What factors most affect potential infiltration rates might constrain blue infrastructure approaches, especially in topographically low opportunity spots?**
- ? **How can infrequent and large flood flows be effectively captured for water supply considering Konya's existing water management infrastructure approach?**
- ? **What is the optimal design for urban stormwater infrastructure to effectively manage both smaller, more frequent rain events and larger, infrequent flood events?**

THE ECOLOGICAL MANAGEMENT APPROACH

ECOLOGICAL CHARACTERIZATION

Konya's natural topography and built land cover result in rapid runoff from steeper western areas of Konya that then accumulates in naturally flat topography to the east of the City. Historically, these areas were likely natural ephemeral lakes, marshes, and salt flats that have since been developed upon (see Concept 5). A lack of conveyance and retention infrastructure appears to be a major issue.

Our preliminary ecological characterization revealed two general conditions of concern in flood-prone, highly built up areas within Konya. 1) Steeper topography in central and western parts of the city with dangerous flows along stream and drainage channels. 2) Low slope areas on the eastern side of Konya where flood water accumulates and soils are likely less infiltrative.

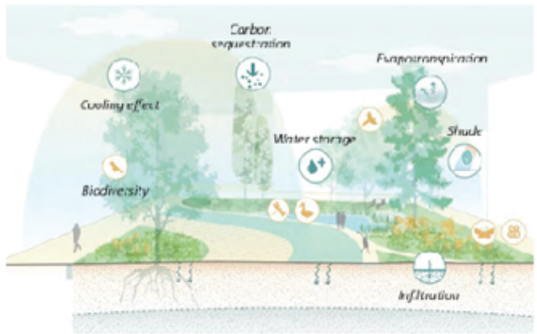


PROPOSED MANAGEMENT STRATEGY

Priority will be to reduce the amount of hazardous concentrated runoff by identifying opportunities to intercept flood flows along its flow path through western and central parts of the city and provide space for storage of accumulating flood flow in flatter eastern parts of the city.

Opportunities to convey, retain, or infiltrate runoff should be evaluated. The exact strategy will depend on available land and its location within the city's greater ecological context.

Areas with more moderate slope may be more ideal for infiltration (see Concept 2). Areas with lower slope, may be less ideal for infiltration and large retention facilities may be needed. Convey runoff through adequately-sized blue-green systems to areas of the city with highest storage capacity and lowest risk of endangering human health and welfare, or damaging property.



Functional diagram credit:
A Catalogue of Nature-Based Solutions for Urban Resilience (World Bank 2021).

PRIORITIES AND OPPORTUNITIES

GREEN AND BLUE INFRASTRUCTURE BENEFITS

Flood reduction, water capture, & biodiversity

Conveying water to areas of permeable soils (such as alluvial fans) for infiltration can maximize groundwater as a potential water source, if properly designed. Infiltration may also support the restoration of groundwater-dependent ecosystems and biodiversity.

Creating space for larger retention facilities, even conveying water to historic Akyay Lake (see Concept 05), may provide maximum flood reduction and biodiversity benefits.

Access to green space & urban cooling

The northeastern portion of the city is experiencing increased development activity. With limited green space, park need is likely unmet and urban heat burden is likely high. Large flood management facilities can also serve as park space, providing cooling benefits.

KONYA'S CLIMATE ADAPTATION OPPORTUNITIES FOR ACTION

This following relevant climate action opportunities that were identified by expert stakeholders at the 2022 Enhancing Adaptation Action in Turkey Project meeting in Konya:

KNT9 — **Transportation**
Water retention in urban areas and buildings and establishment of storage systems

SUY12 — **Water**
Afforestation work in areas at risk of flood, accelerating upstream flood control works

ULY9 — **Transportation**
Study to identify streams and stream beds that have been paved and covered by roads and propose restoring them as green/blue infrastructure.

KNT3 — **City**
Producing urban risk maps and developing and implementing urban design guidelines for climate resilience.

NATURE-BASED SOLUTIONS TOOLKIT

OVERALL STRATEGY

To develop a network of urban green spaces and corridors throughout the watershed that convey water to more permeable areas or detain it for future use or ecological restoration.

OPPORTUNITY TYPOLOGIES IN FLOOD-PRONE AREAS

[A] Akyay Lake
Diversion of additional flood flows into Akyay Lake may provide ecological restoration, biodiversity, and cultural benefits (see Concept 05).

[E] Paved medians and transportation infrastructure
Streets with paved medians, or tram tracks may be designed to retain flood water.

[B] Large undeveloped lots
Larger lots of undeveloped land that are adjacent or close to highly-paved areas are useful for diverting and holding runoff.

[F] Channelized/underground streams
Portions of streams with channelized edges, or that are underground altogether, may be used for conveyance.

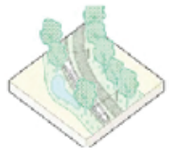
[C] Small undeveloped lots
Smaller lots of undeveloped or disused land that are in alluvial fan areas may be designed to divert more local-scale amounts of runoff.

[G] Residential development
Residential-scale interventions such as green roofs and directing downspouts to residential rain gardens would infiltrate rain closer to where it falls.

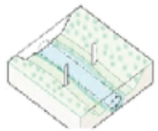
[D] Streets with planted medians
Streets with planted medians, usually planted with shade trees and irrigated turf, can be re-graded to utilize storm water for irrigation.

[H] Developed green corridors and parks
Publicly-accessible landscaped areas may be ideal for diverting and holding flood flows. Flooding is infrequent, so impacts to usability are negligable.

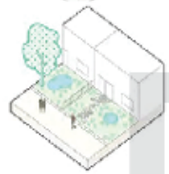
NATURE-BASED STRATEGIES



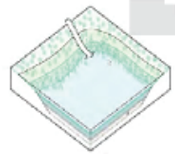
[1] Green corridors
Adding corridors along paved roads and transportation infrastructure (E) and enhancing drainage and permeability of existing green corridors (H).



[2] Daylighting paved streams
Streams that have been paved (F) over can have flooding issues. Uncovering them ("daylighting") and combining with other green infrastructure can mitigate risk.

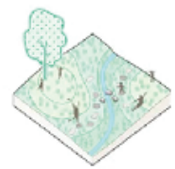


[3] On-street and off-street (residential) rain gardens
Runoff can be diverted from sidewalks and building roofs to irrigate rain gardens at various scales (B, C, G).



[4] Retention ponds
Larger parcels (B) can have retention ponds which hold onto water to treat or convey elsewhere for infiltration. They also create habitat and human recreational value.

[5] Restoration of naturally flooded ecosystems
Flooding is especially problematic in areas that naturally flooded prior to development. Pursue restoration of these areas and the flood protection benefits they provide (A).



[6] Green-blue nature playgrounds and gardens
Infiltration, retention, and conveyance infrastructure can be integrated into public green spaces (B, C, D, H) with opportunities for educating through signage and demonstration gardens.

CONCEPT 03 RECOMMENDATIONS

IMPLEMENTATION TIMELINE

- Near-term
- **Medium-term**
- Long-term

Medium-term
This Concept will require extensive analysis of the flooding regime to ensure effective solutions. Flooding is also best addressed at the city master plan-scale and integrated with other strategies such as water supply management (Concept 02) and ecological restoration (Concept 05). Such complexity requires a longer timeline for implementation.

NEXT STEPS CHECKLIST

✓ **Align with existing plans and engage with stakeholders**
The baseline characterization process revealed that flooding is a top priority for Konya and the topic is addressed in many plans. Effective integration of this multi-disciplinary challenge across plans is essential.

✓ **Baseline characterization and set goals**
Gather existing data and identify data gaps related to project priorities. Collect data into an accessible, comprehensive geohub portal.

Establish clear performance goals and targets, such as a specific quantitative targets for reduction flooding exposure and multiple benefits provided by strategies.

✓ **Identify an exemplary pilot project**
Use the stakeholder engagement process and the baseline characterization process to identify opportunity areas: sites where a public Green Infrastructure project would be particularly impactful for flood mitigation, ecological, and public benefits.

✓ **Regional and city planning**
Complex water management challenges require watershed and city-scale approaches to be effective. A "whole-system" water plan for Konya is recommended that simultaneously addresses flooding, water supply, water quality, urban cooling, biodiversity and recreation topics.

04. ECO-TOURISM: INTEGRATING ECOLOGICAL RESTORATION AND SOCIOECONOMIC BENEFITS

AN INVESTMENT PROGRAM TO PROTECT CLIMATE-VULNERABLE NATURAL SITES AND ENRICH LOCAL COMMUNITIES

THE MAIN IDEA

Konya is surrounded by diverse natural bodies of water with high cultural and ecological significance, many of which are threatened by water diversion, climate change, and biodiversity loss. Beyşehir and **Suğla Lakes, both popular recreation destinations and valuable wetlands, are threatened by** water withdrawals and heatwaves. Meram Creek, the source of Konya's largest alluvial fan and home to significant historic architecture, has lost most of its flow from water supply diversions upstream. Tuz Lake, a large source of Konya's salt mining revenue, and a designated Special Environmental Protection Area for its high-value bird habitat, is drying up due to groundwater over-extraction and surface water diversions to reservoirs.

This Concept involves developing an ecotourism program around these culturally significant resources to fund restoration and access improvements that will benefit Konya's residents and ecosystems. The challenge of balancing limited water resources between human use and ecosystems is a key topic globally – leading-edge solutions are needed.

KEY STUDY QUESTIONS FROM TECHNICAL EXPERTS

- ? **What protections are in place nationally to secure the future of natural and cultural assets?**
- ? **Are there plans, policies, and standards to secure water supply and practice sustainable freshwater planning and conservation?**
- ? **What are hotspots for local and regional (eco) tourism? What barriers prevent expanding ecotourism to other areas in the region?**
- ? **Are there programs (similar to California's Sustainable Groundwater Management Act) in place to regulate groundwater pumping and uses, such as encouraging crops more appropriate to the local semi-arid conditions?**

THE ECOLOGICAL MANAGEMENT APPROACH

ECOLOGICAL CHARACTERIZATION

Four major opportunities sites occur within the Konya region and posses extremely unique ecological characteristics: (B - following page) Tuz Lake is threatened by over-extraction of groundwater and is a hypersaline shallow lake that is pinkish in color and a primary breeding ground for Turkish flamingos (Phoenicopterus roseus); Kızören Sinkhole is a unique geological formation with cultural significance; (D) Lake Suğla has a longstanding fishing trade that is being impacted by the siphoning of water from the lake and has unique wetland habitat. (C) Lake Beyşehir is a National Park and is threatened by water over-extraction.

These tourism destinations also cut through areas with highly varied socio-economic conditions, access to resources, and public health.

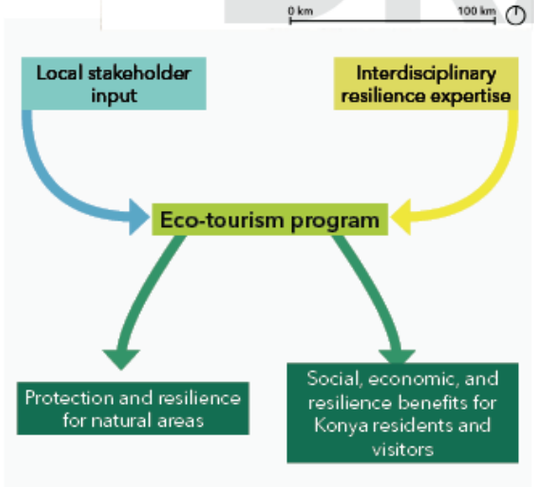
PROPOSED MANAGEMENT STRATEGY

A regional network of "ecotourist" sites for local, national, and international users will maximize investment potential. Programs should be part of city and regional planning efforts due to the far-reaching benefits and user base.

Educational programs should focus on cultural heritage, the existential value of these natural resources, and the critical biodiversity they support.

The ecotourism may be coupled with agritourism that features climate appropriate crop production and innovative or ancient water conservation techniques and approaches that benefit downstream natural features.

The ecotourism should feature the highest standards in sustainable practices and become part of an ethos of the place. Costa Rica is an example of place that has cultivated a culture that emphasizes this.



PRIORITIES AND OPPORTUNITIES

GREEN AND BLUE INFRASTRUCTURE BENEFITS

Biodiversity and ecological connectivity
Investments can be focused towards threated natural areas with significant habitat value.

Public health and social benefits
Recreation and improved livability for local residents through new destinations. May also serve as a refuge from urban heat. Revenue generated from tourism activity can be used to fund programs for the community.

Conservation awareness and behavior
Education leads to awareness and perceived value of resources. While often not an immediate return on investment, these benefits are reveled over the long term – even over generations – and drive ecological changes that also require long time frames to achieve.

KONYA'S CLIMATE ADAPTATION OPPORTUNITIES FOR ACTION

The following climate action opportunities that were identified by expert stakeholders at the 2022 Enhancing Adaptation Action in Turkey Project meeting in Konya:

TUR7 — **Tourism/Heritage**
Implement a program to evaluate climate risk to cultural heritage sites and develop protections.

SUY12 — **Tourism/Heritage**
Tourism facilities to protect natural resources, especially water resources.

TUR5 — **Tourism/Heritage**
Creating regional "discovery routes", using the tourism focus to strengthen bike and public transportation infrastructure

BEK8 — **Biodiversity/Ecosystem Services**
Neighborhood-level inventory of urban infrastructure that needs improvement, especially in areas with disadvantaged communities.

NATURE-BASED SOLUTIONS TOOLKIT

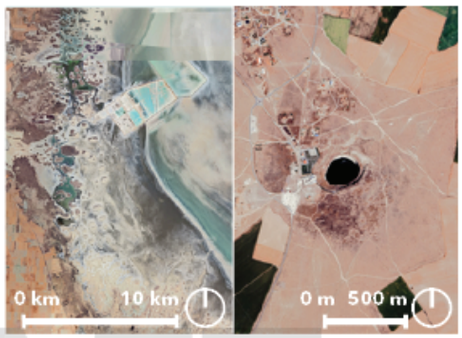
OVERALL STRATEGY

To develop a tourism program that both provides protections for ecologically significant areas, generates revenue for local communities, and improves livability and conservation behavior

POSSIBLE ECOTOURISM SITES IDENTIFIED IN CLIMATE ADAPTATION ACTIONS LIST

[A] Meram Dere

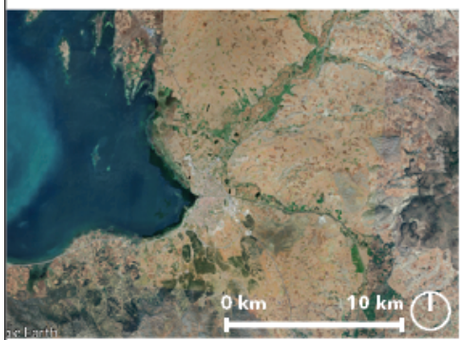
Meram Creek flows through Konya and is a key water source for many of the other potential ecotourism destinations. Meram Bağları, located at a section of the creek at the edge of city, attracts tourists today. It is surrounded by historic architecture and public squares along the western edge of the city. It is also the location of much of the agricultural land in Konya. Meram Creek is also the source of flooding problems and provides opportunities for groundwater recharge (Concept 02).



[B] Tuz Gölu and Kızören Obruğu

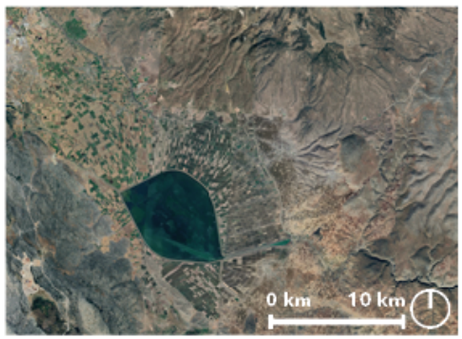
Tuz Lake is the second largest lake in Turkey and is designated by UNESCO as a special environmental protection area. The lake provides important Turkish flamingo habitat and is slowly disappearing as a result of reduced groundwater.

Kızören Sinkhole is a karst lake on the historic silk road and is an important part of migratory bird habitat. The lake's continued existence is also challenged by reduced groundwater.



[C] Beyşehir Gölu

Outside the city in the Taurus Mountains, Lake Beyşehir National Park and Lake Suğla are popular for recreation and are valuable wetland habitats. Water over-extraction threatens both lakes.



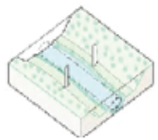
[D] Suğla Gölu

Suğla Lake has unique habitat and a longstanding fishing trade that is impacted by the water over-extraction. It has public landscaped areas that may benefit from re-design with nature-based solutions.

NATURE-BASED STRATEGIES

[1] Restoration of riverbanks and riverbeds

Restore appropriate areas of Meram Creek and provide access opportunities.



[2] Daylighting paved streams

Meram Creek is piped through much of Konya. Restore a more natural channel and provide access. Additional flow may be needed.

[3] Restoring groundwater- and runoff-dependent ecosystems

Develop programs to ensure that sufficient water reaches key features through restoration of natural hydrologic processes. Irrigation efficiency for urban landscapes and agricultural areas is likely key to success. Restoring groundwater and providing more natural flow from rivers is also important.

POLICY-BASED STRATEGIES

Landscape Protection Program

Turkey has a thriving tourism industry, these critical natural assets should be integrated into a cultural landscape protection program – either at UNESCO scale or national-scale. This would create multi-benefit opportunities: securing freshwater supply, which is scarce; providing unique and critical habitat and plant communities; enticing economic investment; bringing visibility, interpretation and education to the natural resources that inspired people to settle in these areas originally

Freshwater Management Planning

Create or modify plans, policies, and standards to practice sustainable, whole-systems freshwater planning and conservation of water-dependent ecosystems. Incorporate nature-based solutions focused on infiltration, stormwater capture and possible floodwater diversion, retention and infiltration, building soils, responsible farming techniques with low to no chemical inputs, soil care, and precision irrigation.

CONCEPT 04 RECOMMENDATIONS

IMPLEMENTATION TIMELINE

- Near-term
- Medium-term
- Long-term

Medium- to long-term
Because of the socioeconomic, cultural, and environmental interrelationships associated with ecotourism, this Concept's success is dependent upon the successful integration and collaboration of climate change, natural sciences, transportation, urban planning, education, and social services sectors with local expertise and leadership.

NEXT STEPS CHECKLIST

✓ Align with existing plans, engage with stakeholders, set priorities

Concept 04 has the opportunity to integrate with the widest array of resilience strategies. The Konya Climate Adaptation Actions list suggests that climate resilience has intersections with cultural heritage, disadvantaged communities, public transportation networks, and threatened natural areas. A tourism program is an opportunity to invest in all of those intersections. Use the stakeholder engagement process and the baseline characterization process to identify opportunities in which ecological restoration and social benefit may line up.

✓ Baseline characterization

Understanding the impacts to hydrologic processes threatening these sites will require careful study. Economics studies will be necessary to understand tourism potential and appropriate investment.

✓ Meram Creek as a pilot project

Work with local stakeholders to develop investment plans that benefit Konya residents in addition to benefiting tourists. One potential pilot project with the greatest local benefit is the restoration of the urban portion of Meram Creek, in the west of the city, near the city center. In parts, it is totally encased in concrete; in other parts, it is nearly completely natural. Several parks nearby have potential for integrated green infrastructure.

Home to historic architecture and agricultural land, Meram Creek's restoration could bring new ecological, economic, and cultural value. A river restoration and revitalization project could create habitat, encourage groundwater infiltration and local water supply, add flood protection capacity, and build on the area's rich cultural history. Urban river walk projects are expanding worldwide, such as Cheonggyecheon in Seoul, South Korea, Bishan-Ang Mo Kio Park in Singapore, and the Los Angeles River.

05. BIODIVERSITY STEWARDSHIP: RESTORATION OF HISTORIC AKYAY LAKE

RESTORING A MARSH AND LAKE FOR BIODIVERSITY, CARBON SEQUESTRATION, AND HUMAN BENEFIT

THE MAIN IDEA

The ephemeral water body, Akyay Gölü, directly adjacent to the City to the east, is possibly impacted by groundwater reduction in a similar manner to Tuz Lake to the northeast. Diversion of stormwater and flood water are also impacting the area. Portions of the area are heavily impacted from past development and military activity. As a recognized Important Bird Area and Plant Area, its restoration may provide significant habitat, groundwater recharge, carbon sequestration, recreation, and cultural benefits.

KEY STUDY QUESTIONS FROM TECHNICAL EXPERTS

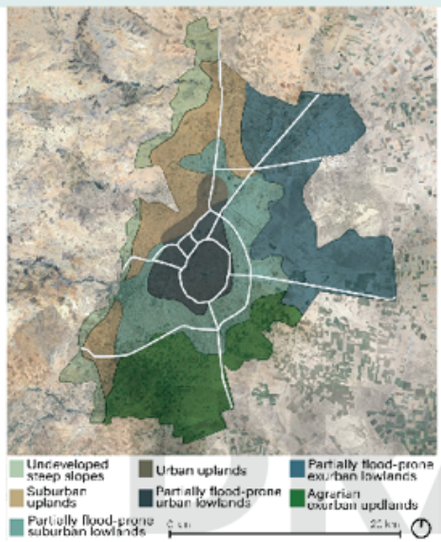
- ? **What was this historical hydrology and ecology of the feature and how has it changed?**
- ? **When and how often is the lake naturally flooded in recent times?**
- ? **Has restoration been considered and are there any associated documents?**
- ? **Is there a hydrologic connection between green and blue infrastructure in Konya and Akyay Gölü, and can activities in both locations be mutually beneficial?**

THE ECOLOGICAL MANAGEMENT APPROACH

ECOLOGICAL CHARACTERIZATION

Akyay Gölü appears to be a typical arid-region endorheic (terminal) lake that occurs where rivers discharge from mountainous terrain in to flat plains. The flat areas reduce and spread flow leading to a large seasonally flooded, or ephemeral, water body during the rainy season that may disappear during the dry season. Their size depends on the annual amount of rain and snow falling in the upper watershed. Often, these lakes are shallow and include extensive marsh areas that provide high value wildlife habitat and carbon sequestration.

Akyay Gölü is typically depicted as a marsh in historical maps, suggesting that much more water was present in the past, and confirming that the water was likely ephemeral rather than a permanent lake. These maps also suggest the significance of the feature in the past and potential cultural benefits of restoration.



PROPOSED MANAGEMENT STRATEGY

Restoring key elements of the natural hydrology while balancing other water demands for water flowing into Akyay Gölü is key for restoration. Similar marshes and ephemeral lakes are common in Mediterranean climate zones and are the subject of large-scale restoration efforts in California including the Owens Lake, the Salton Sea, and Tulare Lake. Integration of cultural and habitat programs are often central to effective restoration strategies.

REFERENCING HISTORIC MAPS

1. A map (left, top) from 1940 depicts a marshy area around Akyay Gölü. https://maps.lib.utexas.edu/maps/ams/turkey/txu-pclmaps-oclc-10127923-konya-g-7.jpg

2. Another historical map from 1860 (left, middle) also depicts a large marsh northeast of Konya. https://www.oldmapsonline.org/map/rumsey/4807.104

3. The oldest map we found from 1788 (left, bottom) suggests a very large wetted area east of Konya fed by Meram Creek. https://collections.leventhalmap.org/search/commonwealth:kk91fq45r

PRIORITIES AND OPPORTUNITIES

CONCEPT 05: GREEN AND BLUE INFRASTRUCTURE BENEFITS

Biodiversity and ecological connectivity

As a designated Important Plant and Bird Area, restoration of this feature has regional, and potentially global, implications for biodiversity. Investments may provide significant habitat value.

Public health and social benefits

Access to nature and biodiversity has been shown to provide mental health, cognitive development in children, and increased conservation behavior. Historic cultural significance may also be important.

Water Supply

Restoration of the natural hydrology of Akyay Gölü may provide groundwater recharge, water quality, or other benefits to local water supply. However, restoration may also require trade-offs with other water demands.

KONYA'S CLIMATE ADAPTATION OPPORTUNITIES FOR ACTION

The following relevant climate action opportunities were identified by expert stakeholders at the 2022 Enhancing Adaptation Action in Turkey Project meeting in Konya:

KNT7 — **City**
Utilizing decommissioned military areas for green and blue infrastructure.

BEK9 — **Biodiversity/Ecosystem Services**
Plans for monitoring critical species and water levels in important wetlands

BEK5 — **Biodiversity/Ecosystem Services**
Updating the Basin Flood Management Plan by adding ecosystem-based disaster risk reduction (Eco-DRR)

SUY7 — **Water**
Monitoring and recording ecosystem services of significant water bodies, such as Tuz Lake.

NATURE-BASED SOLUTIONS TOOLKIT

OVERALL STRATEGY

To provide regional habitat resilience, cultural, and carbon sequestration benefits by restoring historic Akyay Gölü (Akyay Lake).

EXISTING CONDITIONS AT HISTORIC AKYAY LAKE

[A] Canals
Human-made canals carry water through the area and around its boundary. These may provide a water source if appropriate.

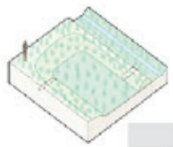
[B] Areas of former intensive use
Areas that show evidence of former use that may have polluted and compacted the ground below.

[C] Geologically disturbed areas
The southwestern portion of the site shows evidence of the ground being disturbed.

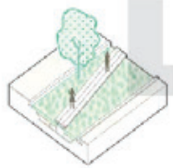
[D] Remnant marsh
Areas where some water continues to flow are marshy and provide examples of historic conditions across a much broader area. These areas are potential locations for initial restoration actions.

NATURE-BASED STRATEGIES

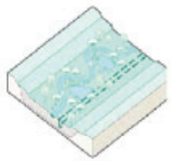
[1] Ecological restoration
Restoration of natural hydrology and plant communities.



[2] Groundwater infiltration areas
If there are groundwater connections to Akyay Gölü then groundwater infiltration measures in Konya may also benefit restoration.



[3] Bioswales in adjacent areas
Biofiltration of runoff from adjacent urban areas in Konya to improve water quality in Akyay Gölü.



[4] Restoration of adjacent creeks and floodplains
Historically, creeks likely flowed from the west through Konya to Akyay Gölü. Restoration of these creeks is integral to restoration of Akyay Gölü.

[5] Ecological connectivity analysis to inform location of early restoration projects
Restoration strategies should be informed by a broader connectivity analysis to identify the locations that best connect to nearby existing habitat areas.

CONCEPT 05 RECOMMENDATIONS

IMPLEMENTATION TIMELINE

- Near-term
- Medium-term
- Long-term

Long-term
This Concept is an ambitious opportunity to create great ecological value within the city.

Due to the unknowns surrounding the land's ownership status and past use, as well as the scale of restoration required, its implementation will be challenging and long-term. As a runoff and groundwater-dependent ecosystem, its success may be tied to other stormwater and groundwater management activities across Konya.

NEXT STEPS CHECKLIST

✓ **Align with existing plans and engage with stakeholders**
Akyay Gölü has national-level attention as an Important Plant and Bird area and could tie into national/international conservation efforts.

✓ **Identify an exemplary pilot project**
Due to its size and complex state of land ownership, this project is likely to be part of a longer-term vision. However, a pilot project could be useful for building momentum towards this larger goal. A pilot project could involve restoring a small portion of Akyay Lake, such as the inlet area in "D" of the opportunities section of this page.

✓ **Baseline characterization**
Historical and present-day ecology analysis is an important first step. This analysis can support the development of conceptual ecological models that identify the relationship between hydrology and restoration to guide strategies, goals, and targets.

✓ **Regional and city planning**
Given its focus on restoration of a significant water body, as well as restoration of the area into something with human value, Concept 05 has potential to be aligned with the Ecotourism Program described in Concept 04.

Photo: Kateryna Maistrenko

3 INVESTMENT RECOMMENDATIONS AND NEXT STEPS

This final report section describes recommendations and outlines the next steps based on the work presented above. The primary focus of the recommendations is to advance the five pilot project concepts, along with other potential initiatives, as pilot projects. These efforts should be carried out in parallel with necessary baseline studies, physical planning, and infrastructure assessments, to set Konya on a path to long-term resilience. As we have seen in other cities, these types of actions can maximize return on investment in the short-term which can in turn catalyze momentum toward long-term planning needs and implementation.

3.1 Complete Additional Baseline Ecological Characterization Steps

For investments in early GI/BI projects to be most strategic and effective, a clear understanding of Konya's baseline environmental and social conditions, opportunities, and resilience needs is foundational. Refinement of the preliminary baseline characterization provided in Appendix A and the City Scan is recommended.

A more comprehensive baseline characterization will add additional spatial and design specificity to opportunities and recommendations. Such a characterization will also enable more refined partitioning of Konya into effective ecotope management units.

It is highly recommended that this next step also includes a full assessment of the regional watershed, as several proposed concepts include actions related to rainfall, runoff, and river flows. Watershed analysis may include integrated hydrologic and hydraulic modeling of the existing condition and proposed project concepts. Watershed-scale analysis is critical for such projects because the implementation of one project may impact the strategies of another project downslope or downstream. For example, providing increased infiltration of runoff in upstream alluvial fan areas (such as Concept 2) may influence groundwater depth and flood characteristics downstream in the watershed (such as Concepts 1,3, and 5). A formal characterization of these existing conditions will enable effective watershed modeling to support optimization of design for future projects. An example of a process that integrates watershed modeling to provide recommendations is the Los Angeles River California Environmental Flows Framework (Stillwater Sciences 2024).

The data-collection process may involve both gathering existing and raw data, including the key data gaps identified in Appendix A.3, and creating a common GIS database. This will require effective institutional coordination, as the diverse data needed for integrated GI/BI planning at the city-scale are often "siloed" in individual departments. For example, within the field of urban heat planning, combatting the urban heat island effect requires public health, disaster response, urban design, and green infrastructure measures. These activities are often carried out by different departments that do not often collaborate or share data.

The complete baseline dataset can be synthesized into a more complete opportunities and constraints analysis with input from key local stakeholders. Additionally, the baseline characterization can provide

a comprehensive measurement of existing ecological conditions that can be used as a benchmark for setting specific quantitative or qualitative targets for improvement. These measurements can be complied into a "report card" of different ecological indicators to track changes to conditions over time as has been done in the UCLA Sustainable Los Angeles Grand Challenge Ecosystem Health Report Card (Reid-Wainscoat et al., 2021). "Changes" may include measuring ecological improvement that results from implementation of GI/BI which can also demonstrate the value of associated investments. While implementation of a GI/BI framework will increase Konya's climate resilience, it is important to acknowledge that the baseline analysis and recommendations will need to be updated with climate change, or other social and ecological changes, and an adaptive management process is recommended. Climate change may accelerate trends such as increases in temperature and severity of precipitation events, as well as human responses including extreme heat-related illness and death, and overextraction of groundwater in response to drought. These changes may alter conditions sufficiently to require new strategies and an updated baseline characterization. An adaptive management plan is a standard component of most long-term and large-scale environmental management strategies.

As more of the formal baseline characterization work is completed, further pilot projects (see Section 3.2) can be strategically located across different ecotopes to maximize regional ecological benefits and demonstrate context-specific solutions for addressing unique resilience needs in different neighborhoods.

3.2 Advance and Expand Pilot Project Concepts

Any of the five project concepts discussed above, or other ideas, may serve as pilot projects to advance in the near term. A successful pilot project is ideally relatively fast to plan and fast to implement, taking advantage of existing opportunities and stakeholder resources whenever possible. Pilot projects can begin before the formal baseline assessment and goal-setting process is complete but should be considered strategically to maximize their value toward expanding a broader city-wide GI/BI program, such as implementing a concurrent city-wide GI/BI strategic action plan effort. In fact, it is strategic to do so, because of the potential momentum and benefits that are possible with a successful pilot project.

As a strategy, pilot projects have several benefits:

- **Earlier tangible benefits for residents of Konya.**
  Due to their size and speed of implementation, pilot projects would be the first to provide benefits to the people. The design and construction process creates jobs for local professionals. The public engagement process is, for most residents, the first opportunity to become informed, provide input, and potentially get involved in the project itself. And finally, once the project is complete, residents receive ecological benefits, such as cooling, flood reduction, and access to green space.

- **Testing strategies, benefits, and evaluation methods through adaptive maintenance.**
  The pilot project implementation, operation, and maintenance processes all provide opportunities to test strategies, measure achievement of previously assumed benefits, and refine evaluation methods. The projects themselves will demonstrate how different GI/BI strategies work in a real-world setting. After implementation, the monitoring process will reveal whether current evaluation methods are effective, and whether benefits targets estimated during the design phase were appropriate and accurate. Information gathered can be integrated into the design, implementation, and maintenance of future projects.

- **Building ownership and momentum for further planning and projects**
  The pilot project development, operation, and maintenance processes provide important opportunities to engage stakeholders who are like-

ly to be part of future GI/BI projects and plans. It is an opportunity to build ownership and to advance regional priorities. The Gedavet Park Ecological Corridor Project represents an excellent early opportunity for an exemplary pilot project: it is already in process, and it is likely to benefit many people due to the area's high use. Taking an ecological approach to the site-specific investments for Gedavet Park means that the project can have benefits that extend beyond the site itself.

Overarching recommendations for all pilot projects include:

- **Developing plans and securing funding for operations, maintenance, and monitoring.** Maintenance should at minimum include: maintenance of new plants to prevent overgrowth, plant disease, and settlement of invasive species; maintenance of water infiltration and conveyance infrastructure such as sediment removal and diversion structure upkeep; maintenance of recreational and tourism sites throughout the region including the functionality and cleanliness of site lighting, pathways, signage, and installations. Long-term monitoring will provide the necessary opportunities to learn from the pilot project, adjust approaches as needed, and integrate learning into other projects.

- **Integrating with broader planning frameworks.** To be most effective, pilot projects must align with existing planning efforts and stakeholder needs. As a strategic action plan does not yet exist, these pilot projects should be developed alongside a Green/Blue Infrastructure strategic action plan and featured in the plan as built examples of early implementation projects.

- **Perform modeling to optimize pilot project effectiveness.** To ensure that pilot projects are meeting the strategic plan performance targets and overall goals, performance analysis should guide design and implementation decisions. Models that address site or ecotope-specific ecological functions should be integrated into the pilot project design process, such as shade studies, airflow modeling for cooling and air quality improvement, stormwater runoff hydrology and infiltration studies, or habitat connectivity and vegetation site suitability modeling.

- **Integrate with existing gray infrastructure.** Nature-based strategies must be carefully integrated with existing gray infrastructure, in line with existing best management practices outlined in the *Integrating Green and Gray* report (World Bank/World Resources Institute 2019.)

Conduct cost/benefit analyses at the project level. Cost-benefit analyses should be used to prioritize, compare, and guide decision-making regarding different design strategies for a given project's performance needs, including green, blue, and gray infrastructure, following the World Bank Global Program on NBS for Climate Resilience guide for assessing at project level.

Recommendations for advancing the 5 proposed project concepts are as follows (see above spreads "Next Steps" for additional information):

Concept 1: Early Activation Project: Gedavet Park Ecological Corridor

This is the first of the five pilot projects proposed because it is integrated with ongoing planning and design of the Gedavet Ecological Corridor project. Therefore, this project may be implemented the most quickly to demonstrate on-the-ground GI/BI solutions.

Immediate next steps include: ensuring that the current plan for the project aligns with existing resilience plans at the local, regional, and national levels; engaging with local stakeholders to better understand how to connect with local existing infrastructure, project

opportunities, and stakeholder needs and priorities through GI/BI approaches that may be unfamiliar; and performing additional baseline ecological characterization of shade, soil, watershed, and biodiversity conditions to ensure that design solutions fully consider site-specific ecological opportunities. Existing project designs should be modeled and refined to optimize how effectively they provide desired benefits such as shade, cooling air currents, improved air quality, and efficient and quality pedestrian connectivity with surrounding areas. Any gaps in functionality or data can also be identified during this step.

Once stakeholder engagement has been performed and data gaps addressed, the next step is to set specific ecological resilience goals and benefits targets to ensure that GI/BI design solutions maximize potential benefits as aligned with the priorities determined during the plan review and stakeholder engagement processes. Lessons learned during stakeholder engagement and baseline ecological characterization processes can be integrated into enhancements to the current project design so that the project is better aligned with resilience goals and performance targets.

Finally, once the project is implemented, a plan to monitor aspects of the site's performance to confirm achievement with pre-established goals and benefits targets is recommended. If goals and targets are not met, adaptive management actions, potentially including design modifications or changes to maintenance, should be implemented to achieve success or alter performance expectations. Lessons learned from adaptive management and monitoring should be used to guide other projects and future, larger-scale GI/BI city-wide master planning efforts (see Section 3.3).

Concept 2: Increasing Groundwater: Blue Infrastructure for Konya's Alluvial Fans

Concept 2 is a large-scale, ambitious effort to increase groundwater that may be critical for Konya's future climate resilience. The concept is oriented around natural alluvial fan areas that are well suited for high infiltration of stormwater runoff into groundwater pools. Increasing infiltration may benefit potable water supply, and provide improved water quality, protection from drought, reduced flood risk, habitat restoration, and reduced risk of land subsidence. GI/BI that supports infiltration may provide additional valuable benefits such as reduced urban heat, increased access to urban green space, and increased habitat and ecological connectivity.

An important next step is to align with existing plans for water supply, watershed management, and other related efforts and to find opportunities to integrate groundwater infiltration. Some examples include the groundwater studies being carried out by the Directorate General of State Hydraulic Works (DSİ), and the updating of the Basin Flood Management Plan, an opportunity that is called out in the Actions List (action item BEK5). Additional next steps would be to: conduct baseline characterizations of soils, groundwater pools, and land availability (to identify appropriate locations for infiltration and potential quantitative benefits); characterize Konya's water supply system (to further support efforts to align with other water supply plans); and to conduct stakeholder engagement to inform opportunities and priorities. Once this information is collected and analyzed, it is recommended to establish goals and specific quantitative targets for infiltration.

Implementation of Concept 2 will likely need to be gradual, starting with a pilot project and eventually integrating into larger watershed planning efforts, including watershed-wide groundwater recharge infrastructure feasibility studies. While large-scale groundwater recharge programs are best addressed through master plans that consider watershed and city-scale actions, an initial small-scale pilot project could begin immediately, once a location within a suitable ecotope is identified. This pilot project could utilize one or more of the strategies identified in the Concept 2 Nature-Based Solutions Toolkit to develop a project with the best-suited ecological functionality to the needs and benefits of the site.

Once pilot projects for this concept have been implemented, performance monitoring efforts should focus on measurement of groundwater infiltration, flood risk mitigation, and species richness. Subsequent adaptive management actions should be applied as necessary.

Concept 3: Reduced Flooding: Protective Network of Green Streets and Parks

Concept 3 is complementary to Concept 2; it is similarly a large-scale effort that will impact resilience at a regional level. While Concept 2 is best suited to areas of high infiltration potential, Concept 3's network of green streets and parks are proposed for downslope areas of high flood risk (and may have more limited infiltration potential).

Immediate next steps include expanding baseline analysis of regional flooding conditions, including more detailed information on watersheds, topography, and slope; soil conditions; landcover and runoff characteristics; the existing drainage network; and an inventory of existing flood mitigation and protection infrastructure. The concept should also be aligned with existing plans that involve flood protection, such as the Basin Flood Management Plan, as well as watershed management, urban design, and other climate-related hazards.

Similar to Concept 2, Concept 3 is best addressed at the city or watershed master-plan scale, but implementation may be started with a pilot project. The pilot project selection process would be informed by the preliminary baseline analysis, as well as stakeholder input. The ideal pilot project would take advantage of existing opportunities to provide multi-benefit ecological functions such as flood mitigation, urban cooling, providing access to green space, improving air quality, and improving ecological connectivity between the larger patches of habitat found in the larger green spaces within the most flood-prone areas of Konya.

Once pilot projects for this concept have been implemented, performance monitoring efforts should focus on measurement of effectiveness of stormwater capture, flood reduction, and other targeted co-benefits such as urban cooling or urban biodiversity improvement, followed by subsequent adaptive management actions as necessary.

Concept 4: Eco-Tourism: Integrating Ecological Restoration and Socioeconomic Benefits

While all five concepts will have positive impacts on quality of life, public health, and economic activity, Concept 4 has the most explicit cultural and socioeconomic programming. It also can integrate with the widest array of resilience strategies due to the varied geography of the potential project sites. To find opportunities to integrate Concept 4's strategies, it is critical to align with existing plans and engage with stakeholders. The Actions List suggests that climate resilience has intersections with cultural heritage, disadvantaged communities, public transportation networks, and threatened areas; an eco-tourism program would require investments in each of these areas.

This concept is recommended for medium-to-longer term implementation, with integration into greater GI/BI master planning efforts, as well as other planning efforts related to tourism and cultural heritage.

One recommendation for a pilot project is to restore the urban portions of Meram Creek in the west region of the city. Meram Creek ranges from being fully encased in concrete (and at times buried underground), semi-naturalized, and fully natural with riparian vegetation.

Home to historic architecture and agricultural land, Meram Creek's restoration could bring new ecological, economic, and cultural value. A river restoration and revitalization project could create habitat for fish and wildlife, encourage groundwater infiltration and local water supply, add flood protection capacity, and build on the area's rich cultural history. Several parks nearby have potential for integrated green infrastructure. Urban river walk projects are expanding worldwide, such as Cheonggyecheon in Seoul, South

Korea, Bishan-Ang Mo Kio Park in Singapore, and the Los Angeles River. A feasibility study of restoration opportunities and design concepts along all or portions of Meram Creek within Konya is a key recommended next step.

Concept 5: Biodiversity Stewardship: Restoration of Historic Akyay Lake

Concept 5 is different from Concepts 2, 3, and 4 in that it focuses on a specific site. Due to the site's size, and the potential complexities associated with its ownership and any remediation needed from contamination due to previous use, this concept is most likely to be suited for longer-term implementation. However, a nearer-term multi-benefit pilot project could involve working with a small portion of Akyay Lake to restore the lake's historic natural marsh habitat, infiltrate groundwater, and create access to green space. Additionally, in the nearer term, a baseline hydrologic analysis of the lake and broader watershed can establish a baseline for restoration opportunities, needs, and constraints. A feasibility study of large-scale restoration concepts for the Lake would follow the baseline characterization.

3.3 Build Upon Existing Climate Action Planning Efforts and Work Toward a Green and Blue Infrastructure Strategic and Master Plans

For GI/BI strategies to be successful, they must align with existing planning efforts, building upon the priorities of local stakeholders. Initial concepts, plans, and strategies, such as the information presented in this document and appendix, are typically developed and refined into more specific and detailed plans in a subsequent planning step, such as a formal "strategic plan" addressing decision making and governance structures, and/or a physical "master plan" addressing spatial and design strategies. As a first step toward such plans, the baseline characterization presented above should be expanded to also consider other existing and potential plans listed in the "data gaps" list in Appendix A 4.3 including the Konya Metropolitan Municipality Strategic Plan, the Konya Local Climate Change Adaptation Strategy and Action Plan, the 12th TürkiyeDevelopment Plan, and others. Following the baseline characterization, the following steps are recommended to produce strategic and master plans for Konya GI/BI.

3.3.1 Strategic Planning Framework

Effective long-term funding and governance agreements built around a strategic plan visioning process sets the stage for multi-year phased implementation of Konya's future GI/BI. As a reference point, in the United States, such strategic plans typically range in cost from US $400K-$600K depending on the level of stakeholder engagement involved and the size and complexity of the planning area. The typical stepwise process of creating a strategic plan is as follows:

Step S-1: Visioning Process—Establish clear mission statement with purpose, needs, and objectives that Konya leadership envisions for the city's future growth and development of GI/BI. This visioning process is best suited to an open and inclusive stakeholder-based workshop setting where active participation in the development of mission and purpose is integrated into a concise vision document. A series of workshops organized by subject matter areas (such as water supply or biodiversity) can be used to build consensus and integration across disciplines and will set the stage for future stakeholder buy-in during the more detailed Strategic Plan preparation. It is also an opportunity to integrate lessons learned from early pilot project implementation, monitoring, and maintenance. Bringing an effective baseline characterization to the visioning with stakeholders is essential so the Strategic Plan is informed by a clear understanding of existing conditions, opportunities, and constraints.

Step S-2: Governance Roles and Responsibilities— Defining clear roles and responsibilities to support the future governance of Konya's GI/BI program will build the organizational structure needed to imple-

ment funding strategies and funnel future investment to the appropriate programs. Lessons learned from implementation of pilot projects are helpful in determining the governance structure as new funding channels open doors for leadership within agencies and communities. The Strategic Plan is intended to capture these examples while building out the future governance needs for larger programmatic pieces of the GI/BI planning process. Creating an organizational chart along with flow diagrams to document the process for carrying out individual and collective decision-making is key to building this governance piece. Ultimately, the key leadership will need to own and implement these roles and responsibilities, and, therefore, will need to contribute to the descriptions and refinement of governance structure. A series of focused meetings that push decision-makers toward creating clear descriptions of governance roles is key to this step in the process.

Step S-3: Green/Blue Infrastructure Strategic Action Plan Framework—Once a vision and general roles and responsibilities are defined, preparation of a more detailed Strategic Plan Framework document to guide the overall development and implementation of governance/organizational structure is essential to the long-term sustainability of Konya's GI/BI program. This framework incorporates output from earlier visioning workshops and meetings while identifying the essential funding mechanisms and agreements needed to fully vet and implement Konya's vision for the program. The document will serve as a roadmap with guidance on how to clearly execute roles, responsibilities, and the path forward. Creating a timeline with milestones aligned to Konya's mission, along with a phased plan and success metrics, will lay the groundwork for advancing projects and implementation agreements among participants.

At this stage, stakeholder engagement should aim to establish agreement on resilience priorities. It should then proceed with setting specific goals and targets along with the strategies and design measures to achieve them, and incorporating lessons learned from pilot projects.

Finally, this framework should outline how new GI/BI will integrate with Konya's existing infrastructure. A nature-based approach using the recommended ecotopes framework and other watershed contextual information will be essential to ensure appropriate selection of green, blue, or gray infrastructure (existing or new) for an individual project site considering the site's broader ecological context, goals, and tradeoffs.

The following components are typically included within strategic and master planning frameworks and are defined as follows:

- **Priorities and goals** refer to overall themes of resilience risks and benefits of significance. For example, stakeholders could agree that it is a priority to address dangerous flash flooding in flood-prone urban areas.
- **Targets and metrics** are used to measure the success of addressing priorities and goals and achieving associated benefits. Targets may include specific quantitative performance thresholds of significance, such as a quantity of water to be infiltrated into the ground, or volume of water diverted from the flood-prone areas. Metrics typically refer to the measurement methods used to determine whether targeted benefits are achieved.
- **Strategies or measures** are the different design and planning actions used to act on priorities and achieve targeted performance. One strategy involving GI/BI could be to enhance a built area's ability to infiltrate water into the ground within areas of favorable soils by replacing existing concrete surfaces with permeable materials. Another strategy could be to divert stormwater runoff away from less permeable soils in flatter, more flood-prone areas through a network of green streets to channel water to areas of more permeable soils, where it can be infiltrated into groundwater to improve potable water supply or support restoration of culturally significant groundwater-dependent ecosystems.

- **Early implementation projects**, or pilot projects, are used as demonstrations of framework strategies and principles, and can be used to create buy-in for future projects, build coalitions and expand project teams to support broader application, and to test and refine GI/BI design approaches.

The above components, considered within a comprehensive ecological resilience framework, such as a fully refined ecotopes framework, should be systematically evaluated with stakeholders and decision makers to craft planning products, identify ecological and social benefits that are likely outcomes, and establish appropriate time frames for achievement. The process should also incorporate the Excel-based Actions List spreadsheet (available upon request) discussed in Section 2.1.1 which can be adapted to additional existing or future climate action planning efforts.

Step S-4: Governance Agreements and Funding Mechanisms—Following key input from Konya leadership and meetings with funders, governance agreements should be developed by key parties involved in pilot projects and overall implementation of Konya's GI/BI program. Funding mechanisms should be identified, addressing both initial capital investments for design and construction, and long-term operations. In the US, pilot projects are often funded through grants. Funding for large-scale application of GI/BI is typically provided in agency budgets, with major new investments often funded through voter-approved taxes or bonds.

Step S-5: Adoption of Strategic Plan—The final step in the Strategic Plan process includes adoption of the Strategic Plan and institutionalization of the plan into governance structures and processes of participants.

3.3.2 Master Planning Framework

Implementation of the Strategic Plan by way of a GI/BI Master Plan for physical design of the area of interest is the most comprehensive way to optimize multiple performance goals and achievement of performance targets; coordinate priorities across large areas like cities, watersheds, or districts; and to develop projects that build upon each other leading to greater benefits than individual projects alone. Without such a physical plan, some projects can still happen, but likely to a smaller extent and in an uncoordinated way that reduces efficiency and performance. Master plans typically include comprehensive spatial planning guidance such as zoning overlays, best management practices or design guidelines applicable to many project types and locations across the plan area; a physical masterplan that identifies specific project opportunity locations, city-scale urban design and infrastructure framework concepts, and phasing strategies; and policies that guide implementation and address non-compliance. Complex water management challenges are a clear theme for Konya and a whole-systems water plan that simultaneously addresses flooding, water supply, water quality, biodiversity, urban cooling, and recreation is a priority recommendation and central component of such a master plan. The large-scale impacts of rapidly approaching climate change tipping points will also necessitate implementation of GI/BI at a master plan scale to be effective.

The master planning processes is similar to the strategic planning process but is focused on physical planning and design rather than governance and visioning. Master planning processes can span one to several years in duration and range in cost from around US $500K to several million dollars depending on the size and complexity of the plan area. A typical master planning scope of work includes the following tasks:

Step M-1: Consensus and Team Buildin—Directly engaging agencies with regulatory authority over resilience-related fields (e.g., natural resources, urban planning, public health, disaster preparedness) and stakeholders and infrastructure managers within the communities and neighborhoods that will receive design solutions is key to building a coalition that can guide master plan solutions and effectively advocate for the integration of priorities across disciplines.

Step M-2: Refined Baseline Characterization—Evaluate priorities and resiliency goals of existing plans (such as the strategic plan) and associated baseline ecological conditions at increasingly fine spatial scales is essential to identify the design solutions needed to achieve goals and targets. This would add additional detail beyond the baseline characterization that has been completed thus far.

Step M-3: Master Plan Visioning, Goals and Performance Targets—Utilize the baseline characterization and strategic plan for a refined vision focused on specific GI/BI design strategies with the stakeholders and agencies. This would include developing an in-depth understanding of shared (and sometimes conflicting) management priorities to refine goals and associated specific performance targets for design and physical planning strategies. Performance targets for design projects could consider environmental, economics/cost, and social performance (sometimes referred to as "the triple bottom line") as a measure of resilience and sustainability.

Step M-4: Master Plan Concepts and Alternative Scenarios Development—Develop initial master plan concepts focused on city-wide or district-scale GI/BI design concepts. Concepts are often organized into a set of plan alternatives that demonstrate different approaches or levels of achievement associated with the established vision, goals, and performance targets. Alternative scenarios can be helpful for discovering opportunities and comparing potential design solutions leading to a preferred scenario that draws the most appropriate components from each alternative.

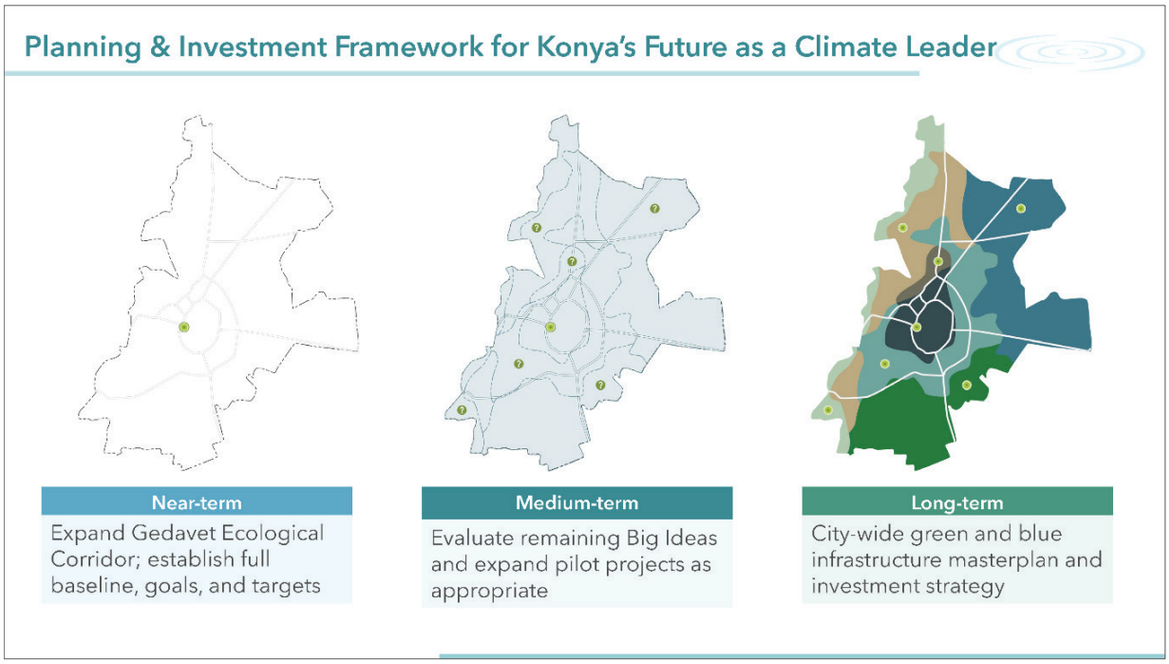
Step M5: Preferred Master Plan Scenario Selection and Refinement—Lead a collaborative, structured decision-making process with stakeholders to select a preferred alternative master plan that maximizes achievement of goals and targets. The preferred scenario is often carried forward to a more detailed level of design and is used to structure implementation programs, define project build-out phasing, budget long-term funding strategies, and identify early implementation and pilot projects.

Step M-6: Implementation and Policy integration—Master plans may be implemented through a variety of mechanisms such as zoning and building codes, design guidelines, and/or specific major projects for implementation. This step may involve the development of decision support tools to help guide individual projects toward alignment with the plan, such as GIS-based tools to inform individual projects of how the master plan is intended to be implemented at a specific location, or to provide project review protocols for agencies in charge of overseeing plan implementation.

Step M-7: Performance Monitoring and Adaptive Management—It is critical to monitor implementation of the master plan to determine whether projects are being implemented as planned and that goals and targets are being achieved, and to implement adaptive management when necessary to improve outcomes. Formal monitoring protocols and tools should be included as part of an adaptive management plan component of a master plan to aid in tracking progress.

A master plan is the typical long-term outcome of a successful GI/BI planning process that has already begun with the initial Gedavet Ecological Corridor pilot project. The figure below represents the overall process stages and major products presented in the above recommendations.

Figure 2: Recommended Investment Planning Framework



3.4 Advance Konya as a Global Leader in Green and Blue Infrastructure

Konya is poised to serve as a model for other cities through targeted investment by the World Bank Urban Nature Program and other partnerships, as demonstrated through the pilot project concepts in this framework document. These concepts directly translate to next steps that can be leveraged to access broader funding opportunities aligned with the Global Biodiversity Framework's 30x30 Goal, as well as other global resilience initiatives, to address socio-ecological needs within the context of urban cities facing climate change and extreme weather events. Such funding can advance resiliency initiatives in Konya while disseminating lessons learned and providing case studies to other cities.

The steps below demonstrate how Konya can align with the Global Biodiversity Framework's 30x30 biodiversity targets. These steps may are informed by the experience of some of the Western United States cities.

Step L-1: Attendance in 30x30 Global Meetings— Leverage opportunities to network with 30x30 global thought leaders to maximize Konya's exposure on the world stage in relation to GI/BI opportunities and biodiversity. In particular, such meetings would allow for dissemination of Konya's vision to be a transformative leader integrating climate resiliency, water management, biodiversity initiatives, tourism, and other themes. Align with world-class Lighthouse Cities of the Urban Nature Program and 30x30 Global Biodiversity Framework metrics to build key relationships and leadership networks. This action can be a building block for developing collaboration opportunities with new partners, refining Konya's resilience narrative, and developing framework for future public relations and media messaging.

Step L-2: Public Relations and Media—Create a Konya-specific public relations and media package that highlights visual storytelling and talking points for how Konya uniquely promotes the City's leadership in GI/BI from a global perspective. Other media planning can include a website, GIS storymap, edu-

cational resource materials, and posts to social media platforms, depending on budget and partnership opportunities.

Step L-3: Signatory on 30x30 Global Agreements— Align with like-minded leaders on 30x30 global agreements with the intent of signing on Konya as a 30x30 leader in climate resiliency and related biodiversity agreements. Leverage the launch of the World Bank Urban Nature Program and conference to showcase Konya's leadership and progress on GI/BI investments, such as five project concepts presented above. Partner with Lighthouse Cities such as the City of Los Angeles and others who are champions for implementing similar programs utilizing pilot projects that accelerate grassroots community involvement and access to nature, along with metrics, indices, and report cards that demonstrate progress toward 30x30 Global Biodiversity Framework metrics and similar resiliency goals.

Photo: temizyurek

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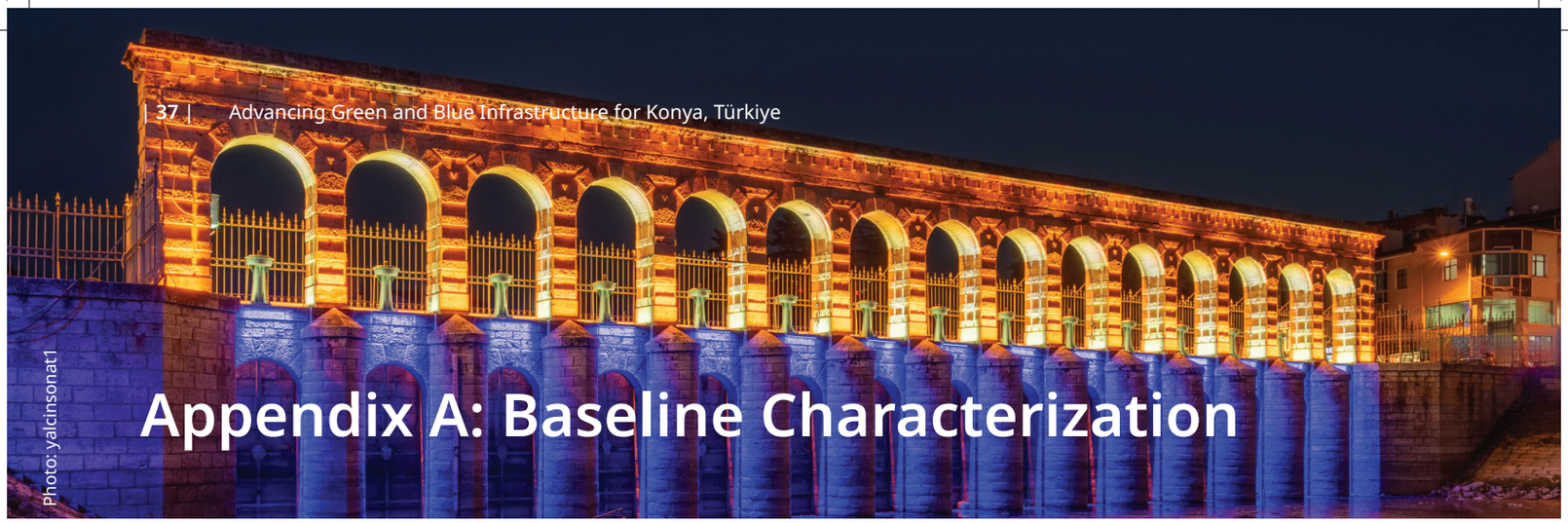

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Appendix A: Baseline Characterization

A.1 Baseline Ecological Characterization Overview

Climate-driven changes to local ecosystems, such as watersheds, groundwater basins, landscapes, and weather patterns, are central to addressing the risks that cities face from climate change. At the nexus between ecosystems and cities, urban green and blue infrastructure ("GI/BI") serves as the foundation for resilience and sustainability as cities face these coming changes. Therefore, a strong, science-based characterization of the changing ecosystems that underpin the city, and their relationship to the infrastructure and built forms that have been constructed upon them, is key to identifying appropriate GI/BI solutions. Designing for this changing local ecological context is often referred to as "nature-based solutions". The following Appendix provides an inventory and characterization of key ecological and urban data layers that are relevant to understanding the opportunities, constraints, and appropriate design strategies for nature-based GI/BI solutions that are presented in the main body of this document.

A.2 Existing Data Review

The following data sources were provided by the World Bank Group and served as the starting point for this baseline ecological characterization:

City Scan Konya

Published in February 2023, the City Scan Konya follows a spatial analysis framework that includes geophysical, demographic, land use, socioeconomic, and environmental hazard data, which are primarily visualized in map format. Most data layers are clipped to the extent of the Konya boundary. Expanding this mapping beyond the city boundary will be important for many key aspects of future GI/BI planning.

Water supply information

Five KML files of water source basins, including three named for local water bodies and two named more generally, were provided.

Urban Planning and Zoning

A series of PDF files and access to a public online portal including data such as parcel boundaries; neighborhood boundaries; district boundaries; public lands; locations of resources such as healthcare, emergency centers, public buildings, and other institutions; and land use/development plans.

Climate Adaptation Action Items for Konya (*see Section 1.4 for more information*)

In May 2022, the Enhancing Adaptation Action in TürkiyeProject hosted a meeting in Konya. The Climate Adaptation Action Items for Konya list was created in 2022. It contains a list of opportunities, compiled by stakeholders from throughout the nation and a variety of industries. The final list contains 131 actions, comprising 12 topic areas: Agriculture and Food, Biodiversity and Ecosystem Services, City, Disasters, Energy, Industry, Interdisciplinary Actions, Public Health, Social, Tourism and Heritage, Transportation and Communications, and Water Resources Management.

The final list contains 131 actions, comprising 12 topic areas: Agriculture and Food, Biodiversity and Ecosystem Services, City, Disasters, Energy, Industry, Interdisciplinary Actions, Public Health, Social, Tourism and Heritage, Transportation and Communications, and Water Resources Management.

This list has been sorted and prioritized based on relevance to green and blue infratructure project applications in Appendix B of this report.

A.3 Existing Data Gaps

The following data gaps were identified. Gathering this data will likely be useful, or necessary, for advancing GI/BI projects in future phases of the project:

Watersheds

While some regional-scale watersheds were provided related to water supply, subregional or finer-scale watershed boundaries within the City are needed to support comprehensive blue infrastructure planning. In the absence of existing watershed boundary data, topographic data can be used to produce general watershed boundaries (urban drainage systems can be more nuanced though, depending on drainage infrastructure system design).

Groundwater basins

The Stillwater Sciences team was informed that groundwater recharge data is unavailable as of the project period, as studies are currently being carried out by the Directorate General of State Hydraulic Works (DSİ).

Topography

Topography factors such as slope, aspect, and detailed elevation data are important for understanding microclimates and flooding. High resolution (5-meter or finer) digital elevation model data is available for Konya through public sources.

Land Use or Zoning designations

The development plans for the Gedavet Ecological Corridor Urban Design Preliminary Project include symbology that is not defined within the documents. This will be needed for all pilot areas as a next step.

Additional plans and projects in motion related to Green and Blue Infrastructure

Other plans may contain information that may shape the GI/BI Framework (e.g., City growth plan). Other infrastructure projects in progress may become more effective at achieving regional goals by including them in the GI/BI Framework (e.g., flood control projects).

The following table summarizes the above data gaps, and others, and potential data availability.

Geospatial Data - Ecological	Available Y/N
Watershed map (subregional-scale or finer within the City)	Appears to be unavailable for areas within the City of Konya and suitable spatial resolution
Geology map	Available: https://www.mta.gov.tr/en/sayfalar/maps/images/1-500/KONYA.jpg
Soil map	Assumed to be available
Permeable soils map	Available: T. de Meester (Ed.), 1950
Stormwater/drainage/flood control system map	Assumed to be available
Water supply system map	Assumed to be available
Groundwater basins (within the city)	Groundwater recharge data is unavailable, studies are currently being carried out by the Directorate General of State Hydraulic Works (DSİ)
Soil or groundwater pollution maps	Unknown
Parks and open space system	Assumed to be available
Protected areas/conservation areas (habitat)	Assumed to be available
Sensitive species of conservation concern	Assumed to be available
Digital elevation map (DEM) at 5-meter pixels or contours, or finer	Publicly available from various global geospatial datasets. High-resolution DEMs may be available locally. Slope and aspect maps can be easily produced from the DEMs.
Slope map (1%-2% intervals)	
Aspect map (8 classes)	

Geospatial Data – Built/Demographic	Available Y/N
Road classification system	Assumed to be available
Vacant and disused land	Unknown
Vulnerable populations	Unknown
Disadvantaged communities	Unknown

Reports and Plans	Available Y/N
The UNDP document that is the basis for the Konya Climate Adaptation Actions Matrix	Likely ongoing - https://www.undp.org/turkiye/news/climate-adaptation-action-enhancing-turkey
Other past Konya green infrastructure projects or pilot plans	Unknown if available
Strategic plans/urban growth plans	Available: Konya Metropolitan Municipality 2019-2024 Strategic Plan
Agricultural system description and plans	Unknown if available
Characterization of/plans for vulnerable populations, disadvantaged communities, etc.	Unknown if available
Climate change impact/vulnerability description	Unknown if available
Water supply, sewer, drainage/stormwater, flood control systems description & plans	Assumed available
Parks and open space system & plans	Assumed available
Biodiversity/conservation system & plans	Unknown if available

A.4 Konya Climate Adapation Actions Items - Green/Blue Infrastructure Priorities Identification

The Climate Adaptation Action Items for Konya document provides as a diverse list of opportunities for climate resilience in Konya, as identified by experts across a variety of impacted areas. However, the list does not provide application guidance, including how to prioritize these actions, how the various actions are interrelated, or their applicability to GI/BI projects. The Stillwater Sciences team developed an interactive Excel file (the "Functional Priorities Framework") to identify and prioritize actions related to a specific project type or study question as Appendix B of this report. This file was used to support the identification, selection, and recommendations for the "Big Ideas" presented in the main body of the report.

The table to the right presents a preliminary ranking of GI/BI priorities for Konya. The ranking was based on a simple scoring system that counted how frequently each type of ecological benefit was mentioned in the Actions List, and to what degree the action was likely to provide the desired ecological benefit. It is important to note that this list is preliminary for the purposes of initial identification of GI/BI opportunities and may not fully reflect current or future priorities and opportunities. It is essential to obtain input and verification of priorities from local stakeholders.

The following action types from the above list have been identified as high priority for Konya but are not comprehensively addressed in the actions list based on our analysis (see Appendix B for more information). These action types represent impactful next steps for refinement and should be a priority for further analysis, baseline data gathering, and planning.

- Stormwater management
- Flood mitigation
- Extreme heat mitigation
- Access to nature
- Carbon emissions reduction
- Carbon storage

Priority ranking	Action types and associated ecological benefits
Higher priority ↓	➤ Drought mitigation ➤ Water pollution mitigation ➤ Stormwater management ➤ Habitat connectivity ➤ Community enrichment ➤ Developmental footprint mitigation ➤ Habitat enhancement
	➤ Local water supply improvement/ protection ➤ Flood mitigation ➤ Extreme heat mitigation ➤ Carbon emissions reduction ➤ Access to nature ➤ Edge effects mitigation ➤ Urban forest benefits ➤ Urban heat island (UHI) mitigation
	➤ Vegetation mortality mitigation ➤ Extreme wind mitigation ➤ Toxic air pollution mitigation ➤ Carbon storage ➤ Landslide and sinkhole mitigation
Lower priority	➤ Soil contamination mitigation ➤ Fire mitigation ➤ Pest and invasive species mitigation ➤ Noise reduction ➤ Litter reduction

A.5 Konya Spatial-Ecological Framework Characterization

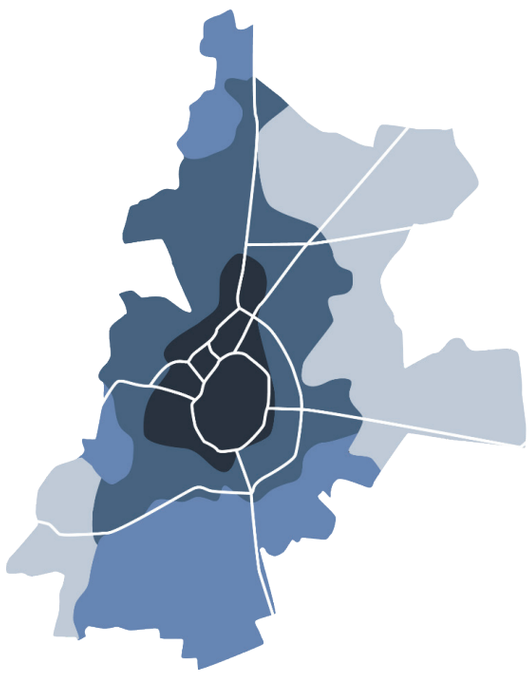
For Konya to receive the highest resilience benefits from nature-based GI/BI strategies, projects must be tailored to their unique ecological context, from site-scale to city-scale. Therefore, the Stillwater team employed an ecological approach to spatial characterization of the city as a first step of synthesizing baseline data into a framework for GI/BI recommen-

dations. An ecological approach to urban and environmental planning involves (1) recognizing urban ecosystems, which are made up of unique combinations air, earth, biota, and human/built conditions, and (2) partitioning the city into spatial units with analogous conditions, management needs, and GI/BI opportunities (Barnes et al., 1982, Brown 2019). This "city-as-ecosystem" approach provides a framework so that analysis, planning, designing, and investments may be coordinated across the city with an understanding of how one site impacts another, while also serving individual projects to tailor GI/BI strategies to the unique opportunities and conditions of a project site.

The following preliminary framework of ecological units for Konya applies urban ecosystem mapping techniques drawn from the United States Department of Agriculture's Ecological Sections of the United States, and the Los Angeles Ecotopes Framework (McNab et al. 1997, Brown 2019). Mapping of the following four categories of factors of the urban ecosystem, air, earth, biota, human/social, are used to characterize the Konya urban ecosystem. A synthesized map of unique combinations of the four factors follows and is used to identify the major ecosystem types of Konya. These "composite ecotopes" are also presented in the main body of this report to help organize and contextualize the "big ideas" recommendations.

It is important to note that while the City Scan data was an extremely useful starting point for this mapping exercise, formal geospatial analysis of the City Scan data and addressing the data gaps listed above will be necessary to improve spatial accuracy of this preliminary ecotope mapping and should be completed if this approach is to be used further.

A.5.1 Air



Proposed characterizations	
Cooled exurban	Far from the urban core, has areas of relatively moderate/low PM 2.5 pollution and cooler-than-average summer surface temperature potentially due to irrigation or veg.
Hot exurban	Far from the urban core, has areas of relatively moderate/low PM 2.5 pollution and hotter-than-average summer surface temperature due to dry conditions and/or industrial use.
Urban mix	Just outside of the urban core. Relatively high PM 2.5 pollution and a mix of summer temperature conditions.
Urban core	The city's densest space. Highest PM 2.5 pollution and relatively average summer surface temperatures, with coolest areas near urban green space.

City Scan data layers used

Summer surface temperature, PM 2.5 Pollution

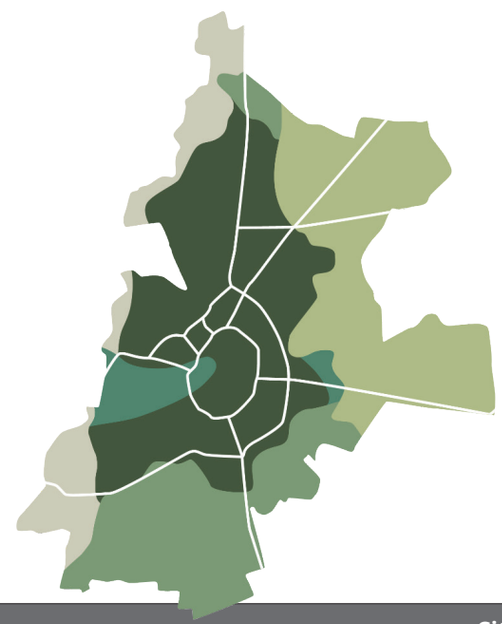
A.5.2 Earth and water

Proposed characterizations	
Steep and erosion prone	Areas of high elevation and slope. Mostly low areas of flood risk, except for river paths and other low points.
Infiltration potential	Areas of moderate elevation and slope. Mostly built-up land cover, but some areas of grassland and agriculture. Likely ideal slope and soil conditions for groundwater recharge.
Flat dry urban	Areas of relatively low elevation and slope, with some local high points and ridges. Mostly built-up land cover. Likely ideal for storm water conveyance and retention with some areas suitable for infiltration
Flat flood-prone urban	Areas of relatively low elevation and slope with relatively higher risk of storm water and river flooding. Likely to benefit from flood mitigation measures. Potential for infiltration.

City Scan data layers used

River flood risk, Pluvial flood risk, Elevation, Slope, Land cover, Urban extent and change

A.5.3 Biota



Proposed characterizations	
Dry hills	Areas of high slope and summer surface temperature, with lower human development and higher amounts of grassland.
Dry exurban	Mix of built-up areas and dry natural areas, overall lower human development.
Irrigated exurban	Areas of relatively higher green space, as evidenced by land cover and summer surface temperature, utilized for agriculture or lower-density residential.
Urban built-up	Areas of primarily built-up land cover and high population density.
Urban with green space	Areas in high-density urban core with a relatively higher amount of green space, as evidenced by tree cover and summer surface temperature.

City Scan data layers used

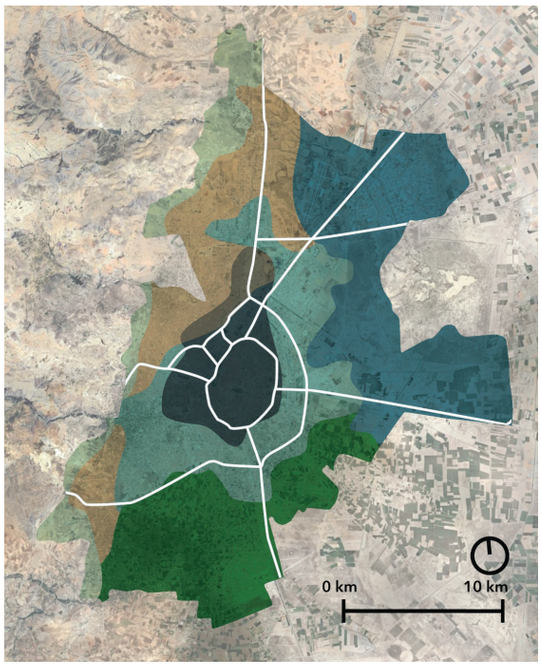
Green spaces, Forest and deforestation, Elevation, Land cover, Summer surface temperature

A.5.4 Human and social factors

Proposed characterizations	
Higher concentration of wealth and resources	Areas of higher levels of economic activity and relative wealth, and both closer proximity to and a larger quantity of schools, health facilities, and police stations.
Moderate concentration of wealth and resources	Areas of average levels of economic activity and relative wealth, and moderate proximity to and availability of schools, health facilities, and police stations.
Lower concentration of wealth and resources	Areas of lower economic activity and relative wealth, and remotely located from schools, health facilities, and police stations.

City Scan data layers used

Population density, Infrastructure assets, Relative wealth, Access to schools, Access to health care, Urban extent and change



Spatial unit	Proposed characterizations			
	Air	Earth / Water	Biota	Human / Social
Undeveloped steep slopes	Moderate to relatively hot, especially closest to built-up areas. Medium PM 2.5 pollution.	High slope, erosion-prone, mostly east-facing. Some flood risk, which is almost entirely concentrated around Meram Creek, a channelized water body and topographic low point.	Primarily dry grasslands with some built-up land.	Low population density, lower income with lower access to resources, especially at northern and southern edges of the city.
Suburban uplands	Relatively cool, medium-to-high levels of PM 2.5 pollution, increasing closer to the urban core.	Moderate slope with low ridges and valleys. Potential alluvial fans and permeable soils, indicating potential for groundwater recharge. Low risk of flood, with risk concentrated around Meram Creek.	Dry, low amounts green space especially in the north, mostly built-up land.	Moderate population density, higher relative wealth compared to exurban areas and suburbs to the east.
Partially flood-prone suburban lowlands	Relatively cool, high levels of PM 2.5 pollution.	Low to moderate slope. Areas of high risk of both rainwater and river flooding, especially rainwater flooding.	Mix of built-up land and irrigated green space. High tree canopy compared to other urban areas.	Mostly moderate to higher population density, higher relative income
Urban uplands	Moderate temperatures with higher temperatures to the east, closer to city center. High PM 2.5 pollution.	Moderate to low slope, low elevation. Little flood risk.	Almost entirely built-up land with some trees and green space.	High relative wealth, high to moderate population density.
Partially flood-prone urban lowlands	Moderate temperatures with cooler pockets around areas of high urban green space and at the periphery of irrigated exurban. High PM 2.5 pollution.	Moderate to low slope, low elevation. Areas of high flood risk in low areas following historic stream courses.	Almost entirely built-up land with some trees and green space towards the south.	High relative wealth, especially within the innermost ring roads. High population density.
Partially flood-prone exurban lowlands	Hot, especially in dry grasslands and bare areas. Moderate to high levels of PM 2.5 pollution, especially near the airport.	Very low slope and potentially poor infiltration potential, with mixed (low/high) levels of flood risk.	Mix of built-up land (airport), dry grasslands, and bare earth.	Mostly lower population density, lower income, and resource-poor except for recent urban growth surrounding the airport.
Agrarian exurban uplands	Cool temperatures, with pockets of heat in built-up areas to the west. Moderate PM 2.5 pollution, high higher concentrations in more densely-populated areas.	High to moderate slope, with higher slope closer to the western mountains. Some flood risk. Potential for stormwater infiltration and conveyance projects.	Almost entirely irrigated agricultural land, with small amounts of grassland and built-up land on the western edge.	Highly mixed levels of relative wealth, with lower wealth in most intensively irrigated areas and areas with highest flood risk. Moderate population density, decreasing in agricultural areas to the south.

Spatial unit	Proposed characterizations			
	Air	Earth / Water	Biota	Human / Social
Undeveloped steep slopes	Moderate to relatively hot, especially closest to built-up areas. Medium PM 2.5 pollution.	High slope, erosion-prone, mostly east-facing. Some flood risk, which is almost entirely concentrated around Meram Creek, a channelized water body and topographic low point.	Primarily dry grasslands with some built-up land.	Low population density, lower income with lower access to resources, especially at northern and southern edges of the city.
Suburban uplands	Relatively cool, medium-to-high levels of PM 2.5 pollution, increasing closer to the urban core.	Moderate slope with low ridges and valleys. Potential alluvial fans and permeable soils, indicating potential for groundwater recharge. Low risk of flood, with risk concentrated around Meram Creek.	Dry, low amounts green space especially in the north, mostly built-up land.	Moderate population density, higher relative wealth compared to exurban areas and suburbs to the east.
Partially flood-prone suburban lowlands	Relatively cool, high levels of PM 2.5 pollution.	Low to moderate slope. Areas of high risk of both rainwater and river flooding, especially rainwater flooding.	Mix of built-up land and irrigated green space. High tree canopy compared to other urban areas.	Mostly moderate to higher population density, higher relative income
Urban uplands	Moderate temperatures with higher temperatures to the east, closer to city center. High PM 2.5 pollution.	Moderate to low slope, low elevation. Little flood risk.	Almost entirely built-up land with some trees and green space.	High relative wealth, high to moderate population density.
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A.5.5 Composite Ecotopes

The following ecotopes represent a high-level, initial partitioning of areas of analogous ecological conditions considering four general "layers" that differentiate urban ecosystems: air, earth/water, biota, and human/social factors (Brown 2019).

A.6 Example Applications of Actions within the Spatial Framework

The ecotopes framework can be used both for site- and regional-level GI/BI analysis and planning. The two tables below represent two example analyses: a site-level characterization and preliminary analysis of the Gedavet Ecological Corridor Pilot Project, and a regional-level priorities and strategy analysis of the Earth/Water ecotope units. Items marked with an asterisk (*) denote strategies sourced from the Climate Adaptation Actions for Konya list.

Preliminary site-level characterization and analysis: Gedavet Ecological Corridor Pilot Project		
Ecotope layer	**Site characterization**	**Preliminary site recommendations**
Air	At the urban core, this area is hotter in the summer and experiences worse than average air quality. There appears to be some slope across the project site.	• Summer shade mapping can be useful for additional optimization and identifying areas in need of cooling. • Produce an aspect map to identify further cooling needs/opportunities.
Earth & Water	Project appears to be situated on high ground without flooding issues. Prepare watershed and drainage map to confirm. Depending on the soils, there may be opportunities for groundwater infiltration.	• Maximize stormwater retention to reduce flooding downstream. Consider bioswales or cisterns. • Consider permeable paving materials, French drains. • Riparian plains to direct runoff from built-up areas*
Biota	The project site is in a highly-built up area, but with several larger green spaces nearby, including such as nearby Alaaddin Tepesi and Kültür Park.	• Identify urban biodiversity suitability. Optimize planting pattern and structure for target species. • Evaluate urban wildlife connectivity with adjacent green spaces, develop connectivity strategy. • Carbon sequestration: maximize tree size, tree longevity, minimize maintenance emissions, compost pruned material. • Calculate air quality benefits. Select species that maximize benefits.
Human & Social	Located by the city center, where there are many schools, resources, shops, restaurants, and cultural institutions. Currently a heavily-used area.	• Include eco education programs to build awareness and conservation behavior. Integrate with local school curricula. • Quantify human benefits to show value of the project: improved air quality, access to green space, flood reduction, etc. • Explore opportunities for integrating tourism. • Share exemplary application of urban ecological thinking through publications, awards, etc.

Regional-level priorities and strategy analysis: Earth and Water		
Ecotope characterization	**Overall strategy**	**Possible actions and BMPs**
Steep and erosion-prone	Erosion control. These areas are likely at lowest risk of flood, except for river paths and other low points. Landslides and other earth movement may be a concern here.	• Native vegetation adapted to growing on slopes can be used for erosion control, which also create connectivity and can function as living windbreaks*
Infiltration potential (Moderate slope areas)	Likely the highest infiltration potential due to alluvial fans.	• Larger agricultural lands, decommissioned military lands*, and empty lots in this area to be developed as possible as infiltration grounds
Flat, dry urban	Prevent runoff into downhill, flood-prone areas.	• Water conveyance and retention. • Opportunity for stormwater capture, treatment* • Develop neighborhood-level typologies for carving out space for green spaces, especially in areas with low access to nature (Vacant lots, High setbacks on new construction)
Flat, flood-prone urban	Flood mitigation	• Flooding corridors that divert from transportation infrastructure* • Riparian plains to direct runoff from built-up areas*

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