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Suggestions from an Ankara Case Study on Exploiting the Sustainable Remediation Opportunities of Landfill Sites

Ankara Örneğinden Hareketle Düzenli Depolama Alanlarında Sürdürülebilir İyileştirme Olanaklarının Değerlendirilmesine Yönelik Öneriler

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Abstract

This study aims to both suggest a comprehensive approach for the sustainable remediation of the Mamak landfill in Ankara, while also addressing the issue of waste management in rapidly urbanizing areas. In this context, the transformation of a historically problematic area into a recreational public space is intended to foster environmental restoration and improve the living conditions of surrounding communities. The project proposes various amenities, such as therapy gardens, greenhouses, playgrounds, and learning centers, to strengthen social bonds. Additionally, educational programs, such as the Recycling Art and Education Center, and the Constructed Wetland Discovery Center, are suggested as ways to encourage public engagement in environmental care and sustainable practices as such programs play a crucial role in the teaching of responsible resource use and waste management to future generations. The conversion of the Mamak landfill into a public park and educational space is a useful model for other cities facing similar challenges related to waste management strategies and urban development. This study contributes to the discourse on sustainable urban development and innovative waste management by demonstrating that neglected areas can be transformed into valuable community resources, while highlighting the role of such projects in the achievement of sustainability goals.

Keywords: Landfill sites, Sustainable remediation, Waste management, Mamak landfill, Ankara

Öz

Bu araştırma, Ankara'daki Mamak çöp sahasının sürdürülebilir bir biçimde temizlenmesi ve hızla kentleşen bölgelerdeki atık yönetimi sorunlarının çözülmesine yönelik kapsamlı bir yaklaşım geliştirmeyi amaçlamaktadır. Bu çerçevede, çevresel bozulma göstermiş bir alanın, rekreasyonel bir kamusal alana dönüştürülmesiyle ekolojik iyileşme sağlanması ve çevreleyen yerleşim bölgelerindeki yaşam koşullarının iyileştirilmesi hedeflenmektedir. Proje, toplumsal bağları güçlendirmek amacıyla terapi bahçeleri, seralar, çocuk oyun alanları ve öğrenme merkezleri gibi unsurlar önermektedir. Ayrıca, Geri Dönüşüm Sanat ve Eğitim Merkezi ile Yapılandırılmış Sulak Alan Keşif Merkezi gibi mekânlar, toplumu çevresel farkındalık ve sürdürülebilir uygulamalara yönlendiren eğitim programlarıyla desteklenmektedir. Bu programlar, kaynak kullanımının ve atık yönetiminin sorumlu bir biçimde öğretilmesi açısından önemli bir rol oynamaktadır. Mamak çöp sahasının kamusal bir park ve eğitim alanına dönüştürülmesi, benzer sorunlarla karşılaşan diğer şehirler için örnek teşkil edebilecek bir model sunmaktadır. Bu yöntemlerin başarılı bir şekilde uygulanması, dünya genelindeki şehirlerin

atık yönetimi stratejilerini ve kentsel alan geliştirme politikalarını yeniden gözden geçirmelerine ilham verebilir. Bu çalışma, ihmal edilen alanların değerli toplumsal kaynaklara dönüştürülmesinin mümkün olduğunu göstererek, sürdürülebilir kentsel kalkınma ve yenilikçi atık yönetiminin sürdürülebilirlik hedeflerine ulaşılmasındaki rolünü vurgulamaktadır.

Anahtar sözcükler: *Düzenli depolama alanları, Sürdürülebilir iyileştirme, Atık yönetimi, Mamak düzenli depolama sahası, Ankara*

Introduction

The United Nations Department of Economic and Social Affairs (UNDESA, 2022) predicts that the global population will reach 9.7 billion by the year 2050. The population increase is creating rapid urbanization and economic development in poorer countries, with an accompanying rise in the amount of goods consumed and produced. This change in demographics is also resulting in excessive waste being produced, especially in cities with dense populations and factories (Ghosh and Ng, 2021). The consumerization of global societies, improved living conditions, and technological advancements have combined to change public behavior relating to consumption. The common preference for single-use products and packaging has increased the production of waste, thus highlighting the urgent need for more effective waste management solutions (Skaf et al., 2021; Lu et al., 2022). On average, each person on Earth produces an average of 0.74 kilograms of waste, with this amount increasing with higher income and faster urban development. The World Bank estimates that by the year 2050, the amount of waste produced worldwide will reach an astonishing 3.40 billion tons (Kaza et al., 2018). This increase in waste production, along with poor waste management practices, is expected to lead to emissions from solid waste rising to the equivalent of 2.6 billion tons of CO_2 each year by 2050 unless improvements are made in waste management (Ferronato and Torretta, 2019).

Landfill is one of the most common methods of waste disposal, despite posing serious environmental risks. The decomposition of waste in landfills generates gas emissions, primarily methane and carbon dioxide, but also other harmful substances, such as ammonia, sulfide, and non-methane volatile organic compounds (VOCs). These gases lead to various environmental problems, including global warming, ecosystem degradation, and acidification, in addition to also harming public health and the overall quality of life (Iravanian and Ravari, 2020). Another significant issue is landfill leachate, which is a harmful liquid that contains heavy metals, organic materials that can decompose, and other dangerous substances. Leachate can cause extensive water pollution by infiltrating the ground and polluting underground water sources and nearby bodies of water (Siddiqua et al., 2022). Furthermore, local ecosystems can be disturbed by the construction of landfills, leading to the loss of habitat, changes in the landscape, and the displacement of wildlife (Chen et al., 2020). From an economic perspective, landfills can lower the value of properties in nearby locations due to negative factors, such as unpleasant odors and contaminated drinking water, which make the surrounding area unfavorable for settlement. Research indicates that the larger the landfills are, the more they diminish local property values (Danthurebandara et al., 2012).

Various methods, including containment and cleanup technologies, have been utilised to address these landfill issues (Joseph et al., 2008; Meuser, 2013; Khalid et al., 2017; Ye et al., 2019; Nedjimi, 2021; Anand and Padmanabhan, 2023). Containment technologies, such as specially designed barriers, caps, liners, and slurry walls, are used to stop harmful substances from causing contamination beyond the landfill site, thereby reducing risks to people and the environment. However, it is important to note that containment technologies do not actually remove the contamination; they only help control its spread. Cleanup technologies, on the other hand, aim to totally remove or neutralize contaminants. There are two methods for dealing with contaminated materials—'ex-situ,' which means treating them after they have been removed from the site, and 'in-situ,' which means treating the contamination directly at the location. In-situ methods, such as bioremediation, soil vapor extraction, and phytoremediation, are more creative solutions that allow for decontamination without disturbing the area. The actual choice of treatment technology depends on various factors, such as the type of contamination, the intended future use of the site, the estimated duration of the cleanup, and the resources available.

Transforming former landfills into public parks is viewed as an alternative method of promoting the creation of green spaces in cities (Lau, 2023). There are numerous examples from all round the world of public parks created from landfills that could provide valuable lessons for the cleanup of the Mamak landfill. Hiriya Recycling Park in Tel Aviv, Israel, for example, where a garbage mountain was transformed into a recycling park, provides insights on the integration of waste management through sustainability initiatives. Another example is Valdemingomez Forest Park in Madrid, Spain, where a landfill was transformed into a public park, along with woods and wetlands, thus demonstrating how landfill transformation can enhance local ecosystems and biodiversity. Moreover, Garraf Landfill in Barcelona, Spain has been transformed into a park inspired by the terraced gardens of Italy. Sai Tso Wan Recreation Ground in Hong Kong was built on a restored landfill and features a multi-purpose grass field for soccer and baseball, batting cages, a playground for children, and a jogging track. Chambers Gully Reserve in Adelaide, Australia, serves as a wildlife sanctuary on a former dump. Thurrock Thameside Nature Park in Essex, England, has turned a former dump into bird conservation area, complete with walking paths and cycling lanes for birdwatchers. A final example is Freshkills Park in New York, USA, which has transformed what was once the largest landfill in the world into a sustainable park designed using layers of soil and infrastructure. The park provides a habitat for wildlife and spaces for recreation, science, education, and art. These examples illustrate how converting former landfills into recreational parks can significantly enhance a city's aesthetic, educational, and ecological value, while supporting environmentally friendly urban development. Harnik (2010) reinforces this idea, emphasizing that closed landfills—due to their favorable location, large size, and relatively low cost—hold great potential for transformation into public parks, particularly in densely populated urban areas. As the global rise in waste generation has created a growing demand for landfill space, contemporary waste management strategies increasingly prioritize the transformation of existing sites into multifunctional landscapes that promote ecological restoration, public engagement, and long-term sustainability.

This study aims to address the environmental, social, and economic challenges posed by landfill sites, with particular focus on the Mamak landfill in Ankara, Türkiye. The goal of this research is to assess the potential of transforming landfills into multifunctional urban spaces, thus reducing their ecological footprint. By emphasizing the importance of integrating waste management strategies with urban sustainability goals, the study demonstrates how landfill remediation can lead to a cleaner environment, as well as enhanced public health and community well-being. The importance of this study lies in its potential to contribute to global sustainability targets.

Responsible waste management is one of the United Nations' most highlighted Sustainable Development Goals (SDGs): SDG 11 promotes the idea of sustainable cities and stresses the need for safe and effective waste services; SDG 3 focuses on public health by reducing the detrimental effects of pollution; SDG 6 seeks to improve water quality by reducing hazardous waste discharges; SDG 7 promotes the use of clean energy; SDG 8 calls for inclusive economic growth, including a comprehensive improvement of the livelihoods of waste pickers; SDG 12 highlights responsible consumption, stressing the need for environmentally sound waste management; SDG 13 addresses climate action, and urges a reduction in solid waste-related emissions; and SDG 14 aims to stop waste contamination of ocean environments (Rodić and Wilson, 2017). These goals together emphasize the importance of creative and eco-friendly methods of waste management aimed at reducing environmental damage.

In addition to sustainability, waste management needs to be integrated into broader frameworks such as urban ecology, a circular economy, and ecosystem services, if its long-term effectiveness is to be ensured. Urban ecology emphasizes the interrelation between natural and built environments, where landfills often disrupt ecological networks and create fragmented habitats. Restoring landfills with ecological functions strengthens urban biodiversity and reconnects ecological corridors. Moreover, the ecological restoration of degraded urban areas contributes to the resilience of urban areas confronting climate change and urban stressors (Elmqvist et al., 2013; Alberti, 2024). Landfills are seen as both a failure of linear systems and a chance for the recovery of resources. When viewed from the standpoint of a circular economy, effective landfill mining and material recovery techniques can support the transition to circularity by recovering valuable metals, plastics, and organic matter for reuse. Circular principles also emphasize the minimization of waste generation and the reintegration of waste into produc-

tion cycles (Sesay & Ping, 2025; Jain et al., 2023). Furthermore, remediated landfills provide critical ecosystem services. The transformation of degraded sites into multifunctional green spaces offer regulating, provisioning, and cultural ecosystem services that enhance the quality of urban life, while also supporting sustainability goals (Costanza et al., 2017; Yılmaz Kaya & Uzun, 2019).

Considering these broader sustainability goals, this study focuses on the sustainable cleanup of the Mamak landfill in Ankara, and aims to demonstrate how local action can align with, and contribute to, global sustainability targets. The site, which has a history of environmental damage and health risks, offers a chance to adopt sustainable practices which support Sustainable Development Goals. This study evaluates strategies to address problems related to pollution and waste management, aiming to improve public health and the environment in the region. Moreover, the successful transformation of the Mamak landfill demonstrates how specific actions can help restore polluted areas, thus providing an example for other cities dealing with similar issues. By converting the site into a safe and useful area that uses sustainable methods, Ankara is able to make important progress toward achieving its goals for sustainable development, helping to create a cleaner, healthier, and more sustainable city for its residents. In the case of the Mamak landfill in Ankara, the ongoing efforts to transform the site into a public park and educational area align with the above-mentioned examples. The creation of parks, learning centers, and the integration of sustainable practices into the site's redevelopment plan reflects strategies used in international projects. Furthermore, the Mamak landfill project could offer similar opportunities as Freshkills Park in the promotion of environmental awareness and the fostering of community engagement. There is no doubt that the Mamak cleanup project has the potential to provide significant benefits, not only for the local environment, but also as a model for other cities facing similar challenges.

Study Area

There are three main stages to the methodology of this study. In the first stage, a comprehensive literature review is conducted to provide historical context to and the current status of the development in the area of study. The review includes an examination of key concepts and the best international practices in sustainable waste management and landfill transformation, thus providing a foundation for the development of the conceptual design approach. In the second stage, fieldwork is carried out, including a detailed site visit to conduct an inventory and analyze the physical, ecological, and social characteristics of the Mamak landfill and its surrounding environment. During this process, the site's existing problems, constraints, and potentials are identified and documented. In the final stage, a conceptual plan is developed based on the synthesis of the data collected through literature review and site analysis.

The Mamak landfill site covers an area of 25 hectares to the southeast of Ankara, Türkiye's capital and second-largest city. Approximately 3 hectares of the site is currently being used for waste disposal (Figure 1). Imrahor Valley is to the west, Natoyolu Avenue to the east, Doğukent Street to the north, and the Ankara Çevre Yolu motorway is to the south. İnce (2019) explains that the landfill was created after the Tuzluçayır Dump site was closed in the mid-1980s, with the Mamak site initially operating as an uncontrolled dump without the necessary barriers to prevent pollution. The predominant reason for choosing this location was its distance from the city centre. However, political changes, delays, and a lack of action left the landfill site neglected for many years. In 1990s, middle-class activist groups pressured the local government to address the environmental, social, and economic issues caused by the landfill. Major concerns included bad smells spreading throughout the city, the danger of a methane gas explosion, and the risk of harmful chemicals being released into the environment negatively affecting public health. Furthermore, both human and animal activities at the site led to diseases being carried by insects to nearby communities. Currently, the Mamak landfill is used for the garbage from the Çankaya, Mamak, Altındağ, Keçiören, Yenimahalle, and Gölbaşı districts. Statistics show that the landfill processes about 1,500 tons of waste every day, including paper, plastics, metals, glass, textiles, ash, debris, and organic materials.

A Swiss company, ITC (Invest Trading & Consulting AG), took over the site in 2005 with the aim of creating an environmentally friendly "zero waste landfill". ITC implemented several methods to improve the site, such as covering 1,000,000 square meters with safe soil, and setting up a system to collect methane gas for the production of energy for nearby homes, shopping centres, and to heat greenhouses located on the site. Organic waste, such as leftover vegetables, fruit, and garden de-

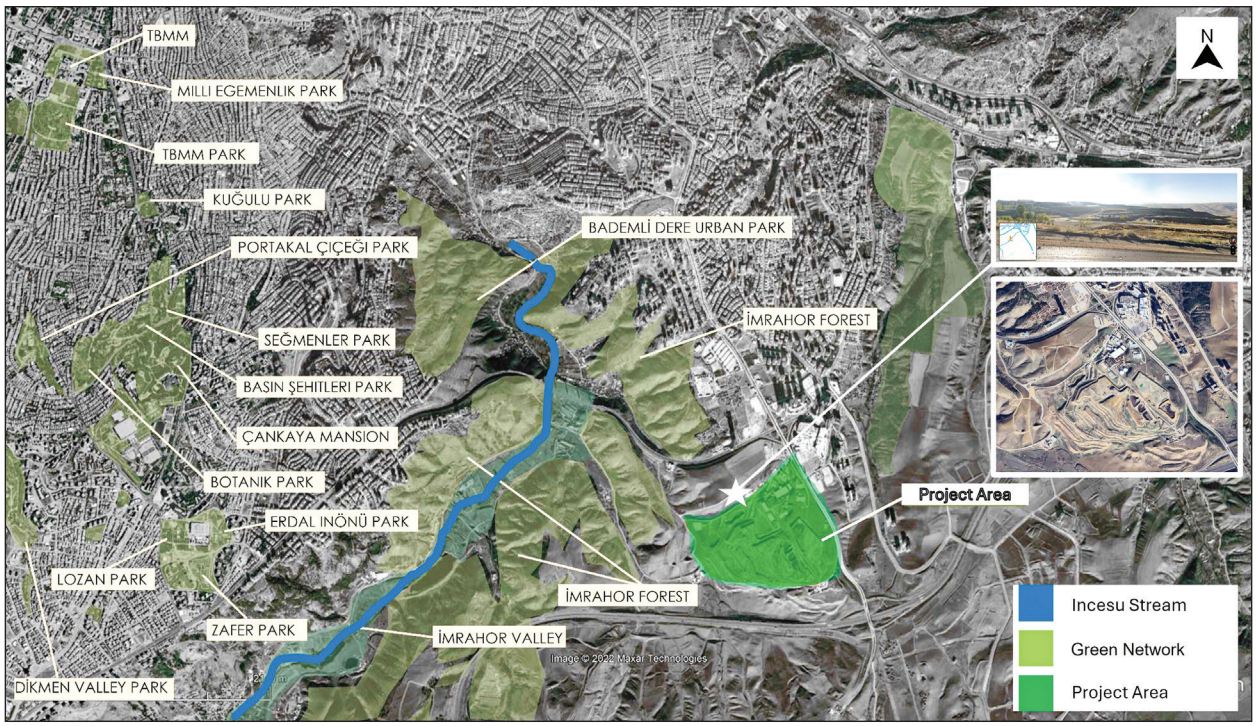

Figure 1. The location of the Mamak Landfill within the green system of the city of Ankara.
Source: Designed by Didem Dizdaroğlu on Google Earth map.

bris, makes up half of the waste produced by local households. This organic waste is separated and sent to special containers called anaerobic digesters in order for it to be broken down, without oxygen, to more quickly produce methane gas and high-quality compost. The methane gas generated is used to grow high-quality tomatoes which are then sold to the inhabitants of the city. Recycling centres, a facility for sorting waste, a plant for generating energy, and storage units for gas were also set up, as was a system for the collection and transportation of leachate for treatment elsewhere. After the area had been cleaned up, the local government implemented several major projects for the transformation of the urban landscape of Mamak. These developments brought significant change within a kilometre of the landfill, particularly with the opening of the Metro Gross Market in 2008 and the NataVega Shopping Centre and IKEA in 2011. As a result, the area became a more luxurious district after no longer being typified by low land values and squatter settlements (Tuçaltan, 2019).

According to the Köppen climate classification, Ankara experiences a Dsa Hot Summer Continental climate, which means it has cold winters and hot, dry summers. The average temperatures in summer are around 30.3°C in July, and 30.5°C in August; while in winter they are about −3.2°C in January and −2.2°C in February. The city receives a total of 392.4 mm of rainfall each year, with May (averaging 51.4 mm) and December (averaging 44.2 mm) being the wettest months. The main wind direction in Ankara is from the northeast and north. There is a disused landfill, which was previously used for the storage of coal, located on a hill, with the highest point on the east side and the lowest on the west. Although the landfill is no longer active, digging in the area shows that trash is still buried underground, and leachate from the Mamak landfill has been identified as a source of contamination for Ankara Creek. The main nearby water sources are the creeks of Imrahor and Çaylak Creeks. Imrahor creek is fed by Lake Eymir, which is located to the southwest. Especially during the rainy season, it collects rainwater and eventually flows into Ankara Creek. Çaylak Creek carries contaminated water from waste site and releases it into Imrahor Creek, about 2.5 kilometers away (Çelik et al., 2007).

Following the improvements made to the landfill area, the northern neighborhood has become mostly urban, with many high-rise buildings and facilities that attract new residents. On the other hand, the southern valley neighborhood feels like it is in the countryside as it is still mostly rural with fewer developments. Cleaning up the Mamak landfill was a demanding task and involved the use of landfill capping, a common technique for managing waste sites where caps are used to cover the landfill which, in turn, stops harmful substances from leaking into the environment. These caps work best when the landfill has a proper lining system and when most of the waste is located above the groundwater level. Caps are usually made of compressed clay, soil, and a semi-permeable layer that stops water from seeping into the waste, which helps reduce contamination from leachate. Plants struggle to grow in the area due to the large amount of waste that had been dumped, but forestation is still possible.

1:2000 scale Conceptual Plan and Design Strategies

The following design strategies will be implemented (Figure 2) based on site analysis:

Remediation of Past Waste

The first step of the process is to clear out the waste that has accumulated over the years before covering it with a protective layer of soil. This is done by digging down through the current layers until the old waste is reached. The best way to deal with this waste is by transporting the majority of it to a new sanitary landfill that meets environmental standards. The Sincan Çadırtepe landfill, which has been in operation since 1999 and is the second-largest landfill in Ankara, is a suitable option. Any leftover waste will be burned using systems designed to treat landfill gases, the most common method for managing and treating the gases produced by landfills. Technologies such as flares, incinerators, boilers, gas turbines, and internal combustion engines could be used to safely eliminate harmful substances found in landfill gas. When dealing with the removal and disposal of old waste, excess gases can be controlled using techniques like Soil Vapor Extraction (SVE) and air sparging. These methods help to extract the harmful vapors created when chemicals turn into gas from the ground, which allows them to be treated above ground. The SVE technique uses a vacuum to suck out vapors from the soil that is above the water level. Air sparging involves drilling wells into the soil that is soaked with groundwater which is below the water level. An air compressor on the surface pushes air down through these wells, creating bubbles that rise through

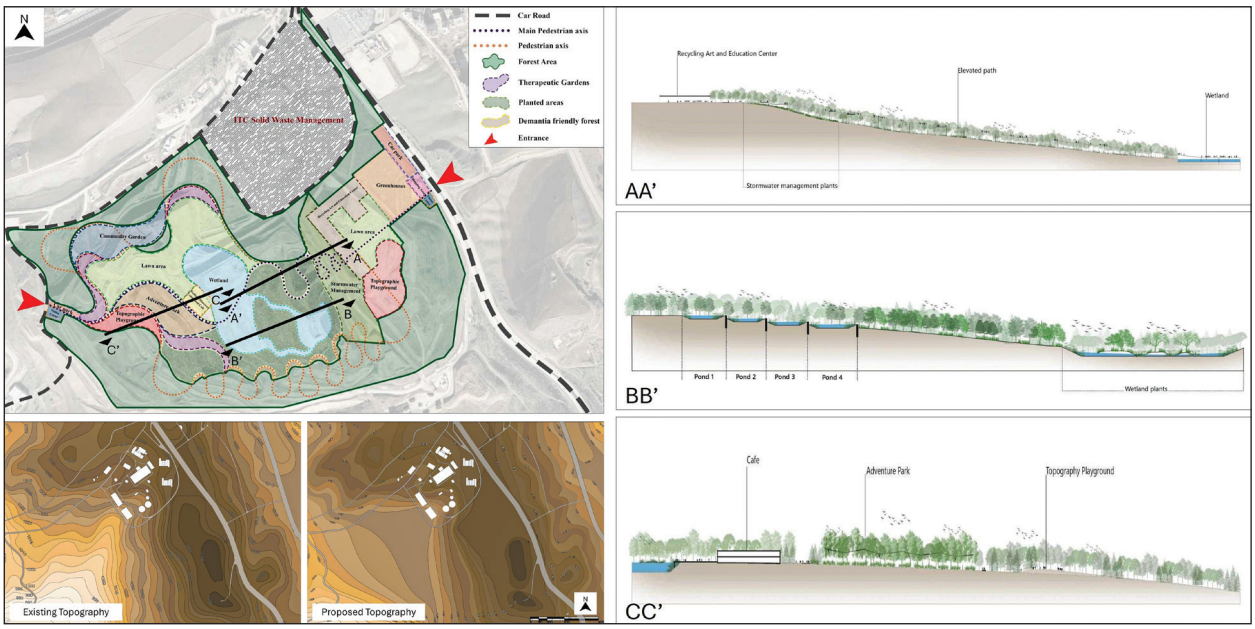

Figure 2. 1:2000 scale conceptual plan and sections.
Source: Designed by Didem Dizdaroğlu, Heyem Nisan Yiğit, Nazlı Hilal Ersoy, Gulnur Kakabayeva, Beyza Çetin and Ege Dündar Altınöz.

the groundwater, thus moving harmful vapors up into the soil above the water level. The SVE technique then involves the removal of this mixture of air and vapors for further treatment (Symons and Greene, 2003).

After these steps, a soil capping system will be put in place, which usually consists of several layers stacked from top to bottom: (1) Topsoil Layer (Vegetative Layer) (Thickness: 30 cm) – this layer supports plant growth to prevent soil erosion and enhances visual and environmental quality by blending the area with its natural surroundings; (2) Subsoil Layer (Thickness: 60 cm) – this layer provides a space for plant roots to grow; (3) Drainage Layer (Material: Usually made of sand, gravel, or special drainage materials) – this layer ensures that surface water drains properly, preventing water from collecting on the cap and reducing the amount of water that seeps into the waste layers; (4) Impermeable Layer (Material: Clay or synthetic waterproof membrane) – this layer serves as a barrier to stop water from entering the landfill waste, thus helping to control gas emissions from decomposing waste by preventing diffusion into the air. (5) Gas Collection Layer (Material: Gravel or a synthetic material) – this layer is designed to safely collect and release gases produced in a landfill, either by venting them into the air or burning them off; (6) Protection Layer (Material: Sandy soil or another loose material) – this layer safeguards the impermeable layer beneath it from being damaged by the weight of materials above or other external influences; (7) Grading Layer (Material: Compacted soil) – this layer ensures the landfill has the right slope and shape for proper drainage, helps manage how the landfill settles over time, and minimizes the amount of water that can seep into it (Cossu and Stegmann, 2019).

Establishing a Suitable Environment for Planting

After cleaning the site, phytoremediation is implemented. The method involves using plants, and the microorganisms that inhabit them, to break down, contain, or neutralize harmful substances in the soil or groundwater (Jaswal et al., 2022). Plants that can absorb heavy metals, including local species like *Betula pendula, Fraxinus angustifolia, Acer pseudoplatanus, Quercus ilex, Robinia pseudoacacia, Alnus glutinosa, Aesculus hippocastanum, Populus alba, Salix babylonica,* and *Pinus nigra,* are preferred as they are known for their ability to accumulate these metals (Özbek, 2015). Treating landfill leachate, which is the liquid that drains from landfills, is difficult because of its complicated chemical makeup and high resistance. As traditional methods for treating wastewater can be very expensive to operate and maintain, a constructed wetland (CW), which is a sustainable and environmentally friendly way to treat landfill leachate, is suggested (Bakhshoodeh et al., 2020; Mishra et al., 2023). Constructed wetlands are man-made systems designed to treat wastewater by imitating natural wetlands. They clean contaminants using various methods, including physical processes (like filtering), chemical reactions, and biological actions (like the breakdown of waste by microorganisms and the absorption of nutrients by plants). The effectiveness of these systems comes from the collaboration of tiny organisms, the materials they grow in, and the plants themselves. Some of the preferred plant species for these wetlands include *Iris pseudacorus, Juncus effusus, Lemna gibba, Lemna minor, Phragmites australis, Schoenoplectus tabernaemontani, Sparganium erectum, Typha latifolia, Alisma sp., Carex sp., Colocasia sp., Cyperus sp., Equisetum sp., Glyceria sp., Hydrocharis sp., Hydrocotyle sp., Iris sp., Juncus sp., Lemna sp., Myriophyllum sp., Oenanthe sp., Phragmites sp., Ranunculus sp., Salix sp., Schoenoplectus sp., Scirpus sp., Sparganium sp., and Typha sp.* (Bütünoğlu, 2018). An additional advantage of planting local vegetation is to help restore the environment.

Inclusive Amenities Celebrating Diverse Socio-Cultural Perspectives

The suggested site for improvement is situated on the edge of Ankara, away from the busy city center, and it is expected that most visitors will come from nearby neighborhoods. However, it is hoped that people from all parts of the city, regardless of their background, lifestyle, or daily routines, will be attracted to the area. With this aim in mind, the project seeks to promote inclusivity and community involvement, making the site a place that appeals to a wide range of people. To accomplish this, the development plan includes various innovative and interactive features. A major highlight will be the Recycling Art and Education Center, where visitors can discover creative ways to reuse waste materials and learn about sustainability through hands-on workshops and exhibitions. This area will promote awareness of the environment and creativity by providing programs for people of all ages. There will also be greenhouses demonstrating sustainable farming methods. These greenhouses will not only serve as educational tools, but will also provide

fresh, locally grown fruits and vegetables, emphasizing the importance of eco-friendly farming. Moreover, community and therapeutic gardens will be designed to offer visitors a calm and relaxing space. The Constructed Wetland Discovery Center will be another key feature, which is a place where visitors can learn about water filtration and the ecosystems of wetlands. This center will demonstrate how wetlands act as natural water treatment systems and highlight their vital role in protecting the environment by providing educational experiences. A cafe will be located in this area, providing a space for people to relax, enjoy snacks and drinks, and appreciate the view. For families and younger visitors, there will be topographic playgrounds and an adventure park, encouraging children to interact with nature in a fun and active way. These spaces will focus on being eco-friendly, using natural materials, and promoting physical activity through creative landscape features such as hills, tunnels, and climbing structures. Elevated pathways and trails will connect all these features, offering visitors a beautiful route to explore the area.

Barrier-Free Trails and Pathways

Paths and trails are designed to align with the natural shape of the land, allowing visitors to explore without harming the environment. The needs of people with different mobilities were taken into consideration during the design, ensuring that the paths are accessible to everyone, including those who use wheelchairs or walking aids. This accessibility is a crucial part of the design, ensuring that everyone, regardless of their physical abilities, can enjoy the area. The plan includes three main pathways that will lead visitors through the site. The first, and main, path is raised above the ground, providing visitors with a unique view as they walk through the landscape of trees and nature. This thoughtful design not only reduces harm to the environment, but also enhances the experience for visitors by offering clear views of the surrounding flora and a closer connection to the treetops. The other two paths will pass through the wooded areas of the site, offering an immersive natural experience. These forest trails are surrounded by thick clusters of trees, creating a peaceful, natural space for walking and exploring. In addition, the trails provide important opportunities for social interaction, encouraging people from different backgrounds to connect and build a sense of community. By creating a space that fosters casual conversations, shared experiences, and an appreciation of nature, these paths help alleviate feelings of loneliness, especially in crowded cities. In summary, the user-friendly design, beautiful scenery, and opportunities for social and educational activities, make these trails an important part of the cleanup project. Beyond offering practical advantages such as inclusivity and accessibility, the trails also enhance the emotional and mental health of visitors by strengthening the connection with nature and the community.

Discussion and Conclusions

The increasing global population and subsequent urbanization is creating significant challenges for waste management systems (Devi et al., 2024). The increasing amount of waste caused by the expansion of countries underlines the urgency of effectively addressing waste disposal problems and finding new ways to clean up the environment (Ansari et al., 2024). In this context, successful international models that offer innovative solutions to waste management challenges need to be considered as they provide valuable insights that can be applied to local contexts in terms of sustainable waste management. For example, many European countries have implemented "Zero Waste" policies that aim to drastically reduce waste sent to landfills through the promotion of recycling, reuse, and composting. In Sweden, over 99% of waste is recycled for energy production. France's "Anti-waste Law" aims to cut food waste, and requires that retailers donate unsold food. In Japan, advanced recycling systems have been in use for decades, with local governments imposing strict regulations for separating and processing waste. In South Korea, the government has implemented a waste disposal policy known as the "Pay-As-You-Throw" system, which encourages residents to reduce waste by imposing charges based on the amount of waste generated. South Korea has also integrated waste-to-energy technologies into their waste management system, thus ensuring that even residual waste is converted into usable energy. Canada has made significant progress with their "Extended Producer Responsibility" programs. These programs hold manufacturers accountable for the entire lifecycle of their products, thus encouraging the design of products that are easier to recycle or reuse (Bury, 2013; Albizzati et al., 2019; Wamba et al., 2023; Wang et al., 2023; Kandasamy & Ramyea, 2024).

Drawing on successful strategies from countries like Sweden, France, Japan, South Korea and Canada, the Mamak landfill in Ankara serves as a significant case study for addressing the challenges, and identifying potential

solutions, for sustainable waste management. The plan to clean up the Mamak landfill aims to address the long-standing issues related to this site, while also providing new opportunities for community involvement and restoring the local environment. The plans outlined, such as removing old waste, covering contaminated soil, and creating parks, are crucial for reducing environmental damage and improving public health. Moreover, the integration of diverse amenities and inclusive design elements in the redevelopment plan aligns with contemporary urban planning principles that emphasize sustainability and community well-being. The project plans to create parks, learning centers, and easy-to-navigate paths to build a strong community and improve the appearance of the area. The project also emphasizes educational programs like the Recycling Art and Education Center and the Constructed Wetland Discovery Center, which encourage people to care for the environment and engage in sustainable practices. These programs are essential for teaching future generations about responsible resource use and waste management. Transforming the Mamak landfill into a public park and educational area will serve as a model for other cities facing similar challenges. Successfully implementing these cleanup methods could inspire cities around the world to reconsider how they handle waste and develop urban areas. By demonstrating that it is possible to turn neglected areas into valuable community resources, this study contributes to the broader discourse on sustainable urban development, and how innovative waste management can help meet sustainability goals.

The roadmap for implementing sustainable waste management has been enhanced with several recommendations to provide a framework for local governments and stakeholders in response to the increasing demand for effective solutions (Levine, 2018). This includes creating public-private collaborations, ensuring funding through green financing mechanisms, and fostering community engagement through educational programs. Local governments can develop policies supporting the integration of circular economy principles into waste management strategies, drawing on examples from successful international models. These policies can be accompanied by continuous monitoring frameworks to track progress, adjust strategies, and ensure sustainability (Bolger & Doyon, 2019). Additionally, the active involvement of various stakeholders, including local businesses, non-governmental organizations and community organizations, is essential for the successful implementation of these strategies (Leal Filho et al., 2024). Collaborative partnerships help ensure that waste management initiatives are inclusive and effective. Financial mechanisms can be utilized to support the long-term sustainability of the cleanup process (Leknoi et al., 2024), while it is essential to educate the local community through public awareness and educational programs about sustainable practices, as well as encouraging active participation in waste reduction efforts (Kumari & Dutta, 2024).

In summary, the sustainable cleanup of the Mamak landfill in Ankara offers a comprehensive approach to tackling the high-priority issues of waste management in rapidly urbanizing areas. By transforming a historically problematic site into a recreational public area, the initiative seeks to restore the environment and improve the living conditions for nearby residents. Additionally, this research highlights the importance of collaboration among various stakeholders, such as government bodies, local communities, and environmental groups, to ensure the effective implementation of suitable strategies. The lessons learned from the cleanup of the Mamak landfill can guide future city planning efforts, encouraging urban areas to adopt new waste management methods that prioritize sustainability and community health. As increasing populations and consumption present global challenges, the Mamak landfill project demonstrates how such difficulties can be transformed into positive changes. By aligning with the SDGs and prioritizing sustainable practices, cities are able to pave the way for a cleaner, healthier, and more equitable urban future.

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