REVIEW / DERLEME

# New Generation Waste Governance Framework for Local Governments: Kadikoy Case

## Yerel Yönetimler için Yeni Nesil Atık Yönetişimi Çerçevesi: Kadıköy Örneği

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## ABSTRACT

The provision of public services such as waste management and environmental pollution control lies at the heart of sustainability discussions where the responsibility is retained by local governments. While conventional methods of waste management lack new perspectives in participatory frameworks, there is also a strong need to introduce multi-dimensionality and data-driven analytics approach to a new waste governance framework for local governments. The main objective of this research is to design an innovative, data-driven and holistic waste governance framework for local governments in the information age where the role shifts as an "orchestra chef", not alone-and-only service provider. The framework is developed for Kadikoy Municipality of Istanbul Metropolitan Area where the amount of waste per capita is higher than the average of the whole city. The methodology of the research incorporates a Web-GIS based participatory platform that can collect and manage data within a four-dimensional framework: political, organizational, behavioral and technological. Each dimension is also introduced with a specific set of indicators that can support the operationalization of SDG 11 in a local context. Results indicate that the availability and accessibility of waste collection related data on a Web-GIS platform plays a pivotal role in a participatory governance framework. Additionally, "awareness" and "openness to cooperation" among commercial enterprises are some significant factors in waste behavior where a local government may need to under-stand and analyze. This study was supported by a 100/2000 YÖK doctoral scholarship.

Keywords: Geographic information systems; Kadikoy; sustainability; sustainable development goals; waste governance.

## ÖZ

Atık yönetimi ve çevre kirliliği kontrolü gibi kamu hizmetlerinin sağlanması, sorumluluğun yerel yönetimlerde olduğu sürdürülebilirlik tartışmalarının merkezinde yer alıyor. Geleneksel atık yönetimi yöntemleri katılımcı çerçevelerde yeni perspektiflerden yoksun olsa da yerel yönetimler için yeni bir atık yönetişim çerçevesine çok boyutluluk ve veriye dayalı analitik yaklaşımının getirilmesine de güçlü bir ihtiyaç vardır. Bu araştırmanın temel amacı, yerel yönetimlerin tek başına hizmet sağlayıcı olarak değil, rolünün "orkestra şefi" olarak değiştiği bilgi çağında yenilikçi, veriye dayalı ve bütüncül bir atık yönetişim çerçevesi tasarlamaktır. Çerçeve, kişi başına düşen atık miktarının şehir ortalamasının üzerinde olduğu İstanbul Metropol Bölgesi'nde bulunan Kadıköy Belediyesi için geliştirilmiştir. Araştırmanın metodolojisi, politik, organizasyonel, davranışsal ve teknolojik olmak üzere dört boyutlu bir çerçevede veri toplayabilen ve yönetebilen Web-CBS tabanlı katılımcı bir platformu içermektedir. Her boyut aynı zamanda Sürdürülebilir Kalkınma Hedefi 11'in yerel bağlamda operasyonel hale getirilmesini destekleyebilecek belirli bir dizi göstergeyle birlikte tanıtılmaktadır. Kadıköy ilçesinde toplanan veriler ile belediye için ticari işletmelere yönelik sürdürülebilir, yenilikçi ve operasyonel bir atık yönetişim modeli önerisi geliştirilmiştir. Sonuçlar, atık toplamayla ilgili verilerin bir Web-CBS platformunda bulunmasının ve erişilebilirliğinin, katılımcı bir yönetişim çerçevesinde önemli bir rol oynadığını göstermektedir. Ayrıca ticari işletmeler arasındaki "farkındalık" ve "işbirliğine açıklık", atık davranışında yerel yönetimin anlaması ve analiz etmesi gereken önemli faktörlerden bazılarıdır. Bu çalışma 100/2000 YÖK doktora bursu ile desteklenmiştir.

Anahtar sözcükler: Coğrafi bilgi sistemleri; Kadıköy; sürdürülebilirlik; sürdürülebilir kalkınma hedefleri; atık yönetişimi.

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## 1. Introduction

Cities around the world are facing unprecedented challenges to sustainability (Correia, 2022). The increase in waste with the advance of industrialization and urbanization is a major challenge for environmental protection and the prevention of health risks (Cong et al., 2023). The lack of high-resolution data in waste management causes waste management problems to continue to be seen, especially in developing countries (Singh, 2019). Globally, 2.01 billion tons of urban solid waste is produced annually in the world. The average amount of waste produced per person per day worldwide is 0.74 kilograms. 38% of waste consists of recyclable materials such as plastic, paper, cardboard, metal and glass (Kaza et al., 2018).

According to World Bank data, it is predicted that daily waste production per capita will increase from 1.2 kg to 1.4 kg in 2025, and daily waste production will reach 6,069,703 from 3,532,252 tonnes. By 2030, the world is expected to produce 2.59 billion tonnes of waste per year. Following recent urban growth, 70% of the world's population is projected to live in cities by 2050 (Sarker, 2019). By 2050, worldwide waste production is expected to reach 3.40 billion tonnes. If no improvements are made in the sector, emissions from solid waste are expected to increase to the equivalent of 2.6 billion tonnes of $CO_2e$ per year by 2050 (Kaza et al., 2018).

Increased waste generation has significant impacts on the environment, health and welfare. Landfilling and incineration of wastes are common disposal methods (Thompson, 2013; Akinbile, 2011; Rodrigues et al., 2020). A study established that only 4% of studies focused on reduction and reuse, the two priorities of the waste hierarchy (Hannon, 2020). Understanding how much waste is generated and the types of waste generated, especially due to rapid urbanization and population growth, allows local governments to plan and select appropriate management methods according to future demand. While European Union attempts to design a Zero Waste policy framework, the Sustainable Development Goals (SDGs) 2030, setup by the United Nations (UN), provide a roadmap for all nations at global scale. There are 17 SDGs in total, and these goals have a total of 169 sub-targets. Sub-target 11.6 of SDG 11 'Sustainable Cities and Communities' and sub-targets 12.4 and 12.5 of SDG 12 'Responsible Production and Consumption' are related to waste management. Several studies are about combine business strategy and public policy perspectives to analyse the effects of artificial intelligence on sustainable development (Gedik, 2020; Goralski, 2020; Fenton & Gustafsson, 2017).

Solid waste management in Turkey, which has been carried out by the Ministry of Health under the name of 'cleaning services' since the first years of the Republic, has evolved into a more 'environment-oriented' approach over time (Akdoğan & Güleç, 2007). However, most of the wastes collected within the urban areas still go to landfill sites. Although there are effective prac-

tices in waste management on a global scale, there are serious problems in the separation of even recyclable wastes in Turkey. The amount of waste generated per person per day in Turkey is 1.1 kg (Kaza et al., 2018). Many factors can influence recycling practices. Some of these factors include public participation, recycling behaviors and attitudes, and the role of regulatory structures (Fercoq et al., 2016; Kerdsuwan, 2015; Visvanathan, 2012; Unterseh, 2011; Cochran, 2007; Bom et al., 2017).

The main objective of this paper is to design an innovative, data-driven and holistic waste governance framework for local governments in the information age where the role shifts as an "orchestra chef", not alone-and-only service provider. The framework is developed for Kadikoy Municipality of Istanbul Metropolitan Area where the amount of waste per capita is higher than the average of the whole city. The methodology of the research incorporates a Web-GIS based participatory platform that can collect and manage data within a four-dimensional framework: political, organizational, behavioral and technological. Each dimension is also introduced with a specific set of indicators that can support the operationalization of SDG 11 in a local context. The framework design is based on extensive literature analytics, 4 in-depth interviews and 3 focus meetings with the relevant divisions of Kadikoy Municipality, 22 interviews with commercial enterprises and location based urban data of Kadikoy.

With Geographic Information System (GIS) based participatory framework on a web platform, a more efficient system can be established in waste management. A Web-GIS database helps many stakeholders to enter data directly, to produce policies and to learn waste behaviour. It is an important step to take the opinions of many stakeholders in the planning process. When planning a sustainable of waste governance, participatory methods and local governments need to utilise technology. When this technology is supported by Artificial Intelligence (AI), machine learning systems, future waste projection can be predicted more accurately, and a more efficient model can be developed by taking into account the location-specific dynamics of planning. The model developed in this study will enable the real-time data collection of waste be-haviour and demand of commercial enterprises through a platform that will be used by local governments, and will make it possible to keep the data easily accessible, user-friendly and anonymous by the relevant stakeholders. A web-based platform was trialled in the study. This study was supported by 100/2000 YÖK doctoral scholarship on Remote Sensing and Geographical Information System.

## 2. Literature Review

### 2.1. Towards A New Generation Waste Governance Framework

Waste management typically include collection of waste and transport from a collection point or transfer station to a fi-
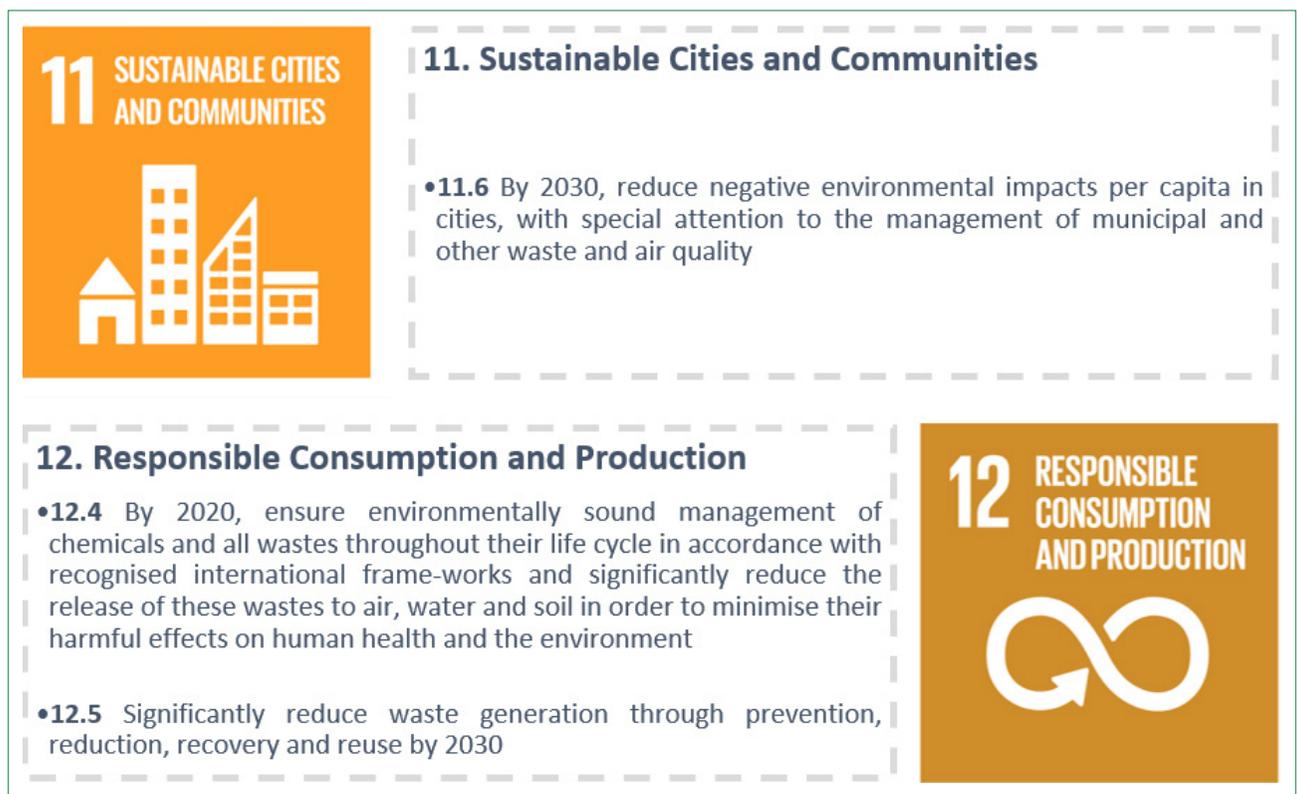
**Figure 1.** Sustainable Development Goals related to waste.

nal disposal site, treatment and disposal of waste (Kaza et. al. 2018). In the current waste management approach, it is not possible to segregate waste at the source or to increase the number of waste bins according to the type of waste, or to send waste collection vehicles to areas where waste is concentrated according to vehicle capacities. In this regard, a data-based and holistic waste governance framework would make waste management more effective.

Globally, solid waste management was initially organised within different departments of both central and local governments in the 1930s. Some studies provide a review of the current situation to effectively achieve a sustainable circular economy in waste management through technology (Sebastian, 2022; Bijos et al., 2022 Nelles et al., 2016; Cheah et al., 2022; Sarc et al., 2019; Wang & Yuan, 2020; Jibril et al., 2012; Cucchiella, 2017). In contrast to traditional waste management, there is also work on zero waste, which focuses on ensuring the sustainability of the movement to reduce waste generation by emphasizing the issues of failure, inertia and a growing sense of crisis associated with the waste management paradigm (Hannon & Zaman, 2018; Anderson, 2011; Silva et al., 2016; Silva et al., 2017; Hannon, 2015). The Zero Waste Movement encompasses a variety of perspectives and approaches (Zaman, 2015; Song et al., 2014). Sustainable development can be defined as "development that meets the needs of the present without compromising the ability of fu-

ture generations to meet their own needs (WCED, 1987; Meschede & Mainka, 2020). Cities are increasingly recognizing their important role in achieving the SDGs (Alhola & Nissinen, 2018; Alhola et al., 2019; Terama et al., 2019; Kalfas et al., 2023; Dolley et al., 2020; Sharma et al., 2022). UN Sustainable Development Goals 11. Sustainable Cities and 12. Responsible Production and Consumption are related to waste. Waste related sub-targets are shown in the Figure 1.

In the UN Sustainable Development Goals, several targets are defined within the sub-targets related to waste management. There is no Sustainable Development Goal directly related to sustainable management. Today, the waste problem, which increases with the increase in population, is among the main problems of local administrations. Therefore, one of the important objectives for achieving development is to ensure sustainable waste management. In addition to waste minimisation, providing sufficient incentives to increase recycling, involving all relevant stakeholders in the process, developing a holistic model can be shown among other sub-targets that can be added.

Recent studies focus on the scientific principles underpinning the use of GIS, present an analytical methodology using a combination of GIS techniques as well as statistical and numerical optimisation methods to assess solid waste generation in large urban areas, and create a GIS database (Longley, 2020; Chen et al., 2020; Fazzo et al. 2020; Karkanias, 2013).

**Table 1.** Specific sustainable waste management project of Kadikoy Municipality

| Project | Location in Kadikoy (Neighborhood) |
| --- | --- |
| Waste-Free Living Street | Zuhtupasa |
| Waste-Free Living Shop | Caddebostan, Feneryolu |
| Less Waste, More Coffee | Rasimpasa |
| Less Waste, More Water | Acibadem, Caddebostan, Caferaga, Egitim, Erenkoy, Feneryolu, Goztepe, Hasanpasa, Kosuyolu, Kozyatagi, Merdivenkoy, Sahrayıcedid, Rasimpasa, Zuhtupasa |

**Table 2.** Challenges of waste management

| Political | Organizational | Behavioral | Technological |
| --- | --- | --- | --- |
| • Lack of incentives<br>• Waste management difficulties due to intensive waste generation (weekend population exceedingly twice the district population) | • Lack of coordination between departments<br>• Confusion of authority<br>• Unavailability of waste bins suitable for the type of waste collected most from the location (due to district municipality-provincial municipality jurisdictions) | • Lack of awareness in the target group<br>• Inability to take operational action due to lack of knowledge of the waste behaviour of the target group | • Inadequacy of waste bins<br>• Inadequate waste collection vehicles<br>• Restricted access of waste collection vehicles to some areas with containers due to vehicle type<br>• Vehicles travelling to waste containers that are not full due to the fact that the fullness level of the wastes cannot be seen real-time |

The inclusion of recyclable waste in the circular economy is an important step in waste management. GIS have the integrative ability to contextualize survey data, location-based environmental data and thus provide a common denominator for a subsequent relationship analysis (Marans & Stimson, 2011). This concept was first proposed by Marans (2003), who underlined the possibilities of analysis for planning and policy-making. Some studies using GIS have examined the statistical relationships of objective and subjective indicators mapped to spatial units (Keul & Prinz, 2011; McCrea et al., 2005; McCrea et al., 2006; McCrea, 2007; Von et al., 2015). Similar findings have examined the statistical relationships of objective and subjective indicators at the scale of regions, districts and cities for different types of public service provision (Liao, 2009; Oswald & Wu, 2010; Türksever, 2001; Mershdorf et al. 2020). However, there has been a little evidence on the integration of both indicators through a GIS based data-analytics approach.

This research puts an effort in designing a multi-dimensional but also a sustainable new generation waste governance framework. The framework has been designed for Kadikoy Local Municipality of Istanbul Metropolitan Area. The reasons for the selection of Kadikoy district are i) existence of a policy target to support the zero-waste project in the Strategic Plan, ii) being one of

the densely populated districts of Istanbul, iii) the amount of waste per capita is higher than Istanbul in general, and iv) the willingness for innovative practices related to waste management. Using the data collected in Kadikoy district, a sustainable, innovative and operational waste governance model proposal is developed for commercial enterprises for the municipality.

For the framework design, 4 interviews and 3 focus meetings have been conducted with Kadikoy Municipality and 2 waste management facility site visits were conducted. 1 focus meeting was held with the Kadikoy Municipality Climate Change and Zero Waste Directorate with the participation of 4 people from the municipality. 1 interview and 1 site visit were conducted. 2 focus meetings were held with Kadikoy Municipality Directorate of Cleaning Affairs with the participation of 3 people from the municipality. 3 interviews and 1 site visit were conducted. Table 1 summarizes specific sustainable waste management projects with responsible departments in the municipality.

In the light of the interviews and focus meetings, in total 11 challenges were identified were identified as the main challenges related to waste management (Table 2). These challenges of waste management were classified in four main dimensions based on both extensive literatures, the interviews and focus meetings.
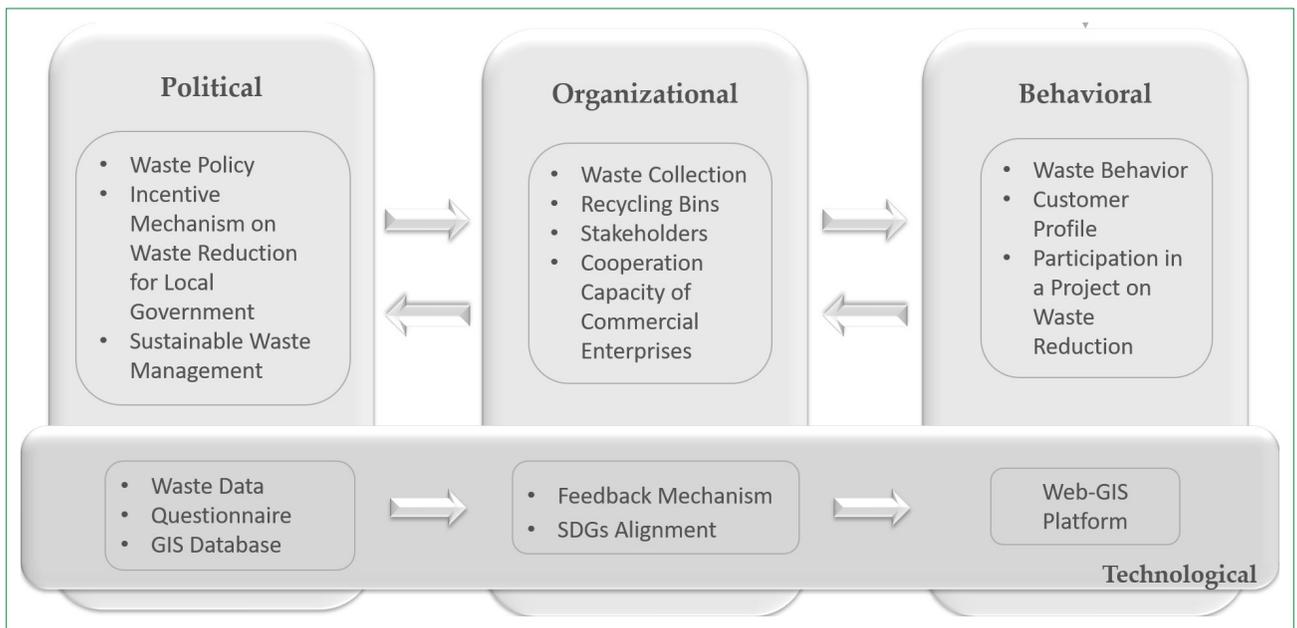
**Figure 2.** New generation waste governance framework on commercial enterprises for local government.

GIS: Geographic Information System; SDGs: Sustainable Development Goals.

The political challenges of waste management are mainly due to the lack of incentives and the large non-resident population. Lack of coordination between different departments of local governments stands out as organizational difficulties in waste management. Authority confusion appears to be another challenge. In addition, waste containers placed without taking into account the most collected recyclable waste types in a region are also important challenges. One of the most important behavioral challenges in waste management is the lack of awareness among the target audience, commercial enterprises. Failure to take operational action due to lack of information regarding the waste behavior of the target group is another behavioral challenge. Technological challenges in waste management are the insufficiency of waste bins, the inadequacy of vehicles collecting waste, the inability of vehicles to enter the area where waste is collected in some private properties, and the presence of vehicles going to waste containers that are not full due to the fact that the fullness of the waste cannot be seen instantly. The new generation new generation waste governance framework proposed for local governments in the study to reduce these challenges is shown in Figure 2.

In the political dimension of new generation waste governance, it is important to examine waste policies and establish incentive mechanisms for waste minimization. In order to ensure sustainable waste management, it is important to ensure the coordination of all relevant stakeholders. In the organizational dimension, it is essential to cooperate with relevant stakeholders, especially in the collection of waste in commercial enterprises. Waste behavior and expectations of customers in commercial enterprises regarding environmental issues, as well as the proj-

ects that enterprises are involved in for waste reduction, contribute to the identification of the existing potential. The main new generation waste governance framework proposed by this study is to keep all the collected data spatially in a database, to provide feedback to relevant stakeholders in the database, and to create a Web-GIS platform to show how local governments are working in line with the UN Sustainable Development Goals. The theoretical lack of a data-based and holistic approach to waste governance emphasizes the importance of studies on this issue. In this context, the four key dimensions of new generation waste governance that revealed from the literature review and fieldwork are described in Section 2.2.

## 2.2. Dimension of New Generation Waste Governance

### 2.2.1. Political Dimension

One dimension of the new generation waste governance that is addressed within the scope of the article is policy. The reason for addressing the policy dimension is the keywords such as sustainability, waste management, circular economy etc. The key-words waste management policy documents at global, national and local level were examined and interviews and focus meetings were held with the local administration in Kadikoy, which is the study area. The global, national and local level policy documents examined within the scope of the article are summarized in Table 3.

Solid waste management is often designed in response to local conditions, such as the availability of financing, the spatial organization of communities, and the ability of citizens to pay for services. In the USA, underground pneumatic waste collection

**Table 3.** Policy documents analyzed at the global, national and global level

| Global | National | Local |
|---|---|---|
| • Sustainable Development Goals<br>• Resource Conservation and Recovery Act<br>• Waste Framework Directive | • Environmental Law<br>• Metropolitan Municipality Law<br>• Municipality Law<br>• National Smart City Strategy and Action Plan (2030)<br>• Climate Change Mitigation Strategy and Action Plan (2024–2030)<br>• National Climate Change Adaptation Strategy and Action Plan (2023–2030)<br>• Energy Efficiency 2030 Strategy and II. National Energy Efficiency Action Plan<br>• Draft Climate Change Law<br>• Regulation on Landfilling of Wastes<br>• Regulation on the Procedures and Principles to be Followed in Determining Tariffs for Wastewater Infrastructure and Municipal Solid Waste Disposal Facilities<br>• Zero Waste Regulation<br>• Regulation on Control of Waste Batteries and Accumulators) | • Istanbul Climate Change Action Plan<br>• IBB Strategic Plan (2020–2024)<br>• Kadikoy Municipality Strategic Plan (2020–2024)<br>• Kadikoy Municipality Sustainable Energy Action Plan<br>• Kadikoy Municipality Climate Adaptation Action Plan |

system is used (Chaban et al., 2015). In Europe, waste is separated at source and recyclable waste is collected and sent to recycling facilities. In Turkey, product-oriented waste collection activities have been carried out (Dağıdır, 2020). Incentive mechanisms to reduce waste production seem to have an important place in new generation waste governance. Waste separation, which has been practiced for many years, especially in European cities, and the separation of waste according to waste codes has been continuing for many years due to the financial cost of throwing waste into waste containers without being separated. Implementation of methods that encourage the reduction of use, reuse, and recycling and upcycling of circular waste, which can contribute to the circular economy in our country, reduce environmental pollution and contribute to sustainable development, is also fundamental for new generation waste governance.

Objective indicators identified for the political dimension of new generation waste governance are number of commercial enterprises, types of waste in the commercial enterprises, amounts of waste of commercial enterprises, number of waste recycling bins, type of waste recycling bins, location of waste recycling bins, number of waste collection centers in the district and number of mobile waste collections in the district. Subjective indicators are waste policy of local government, good practices on waste, existence of a strategic plan aligned with the UN Sustainable Development Goals, the company's zero waste policy implementation status and adequacy of the

incentive mechanism. By collecting these indicators in the study area and monitoring them in certain periods, it will be possible to improve the waste management of local governments in commercial enterprises. The waste related policies of Kadikoy Municipality, which is the study area at the local level, should be handled operationally in a way to establish a relationship with each other. The policies related to waste of Kadikoy Municipality, which is a working area at the local level, need to be handled operationally in a way to establish a relationship with each other. The subjective and objective indicators defined for the political dimension of new generation, innovative and new generation waste governance are shown in Table 4.

### 2.2.2. Organizational Dimension

Solid waste strategies and plans at both national and local levels enable institutions to comprehensively understand the current situation, set future goals, and outline a detailed action plan to advance the solid waste management sector. Cities follow various models of waste collection. Waste management is mostly managed in a decentralized manner by municipalities. Inter-municipal cooperation is common in European Union countries such as France, Italy and the Netherlands (Chiatto et al., 2023).

Waste strategies in Turkey are basically managed in line with the framework drawn by the central government. Local governments follow the instructions prepared by the central

**Table 4.** Indicators on political dimension of sustainable waste governance for local governments

| Dimension | Objective indicators | Subjective indicators |
|---|---|---|
| Political | • Number of commercial enterprises<br>• Types of waste in the commercial enterprises<br>• Amounts of waste of commercial enterprises<br>• Number of waste recycling bins<br>• Location of waste recycling bins<br>• Number of waste collection centers in the district<br>• Number of mobile waste collection in the district | • Waste policy for local government<br>• Good practices on waste<br>• Existence of a strategic plan aligned with the UN Sustainable Development Goals<br>• The company's zero waste policy implementation status<br>• Adequacy of the incentive mechanism |

**Table 5.** Indicators on organizational dimension of sustainable waste governance for local governments

| Dimension | Objective indicators | Subjective indicators |
|---|---|---|
| Organizational | • Number of NGOs working on waste in the city<br>• Number of NGOs working on waste in the district<br>• Number of street collectors in the district<br>• Non-resident population visiting in the district<br>• Open days of commercial enterprises<br>• Busy days of commercial enterprises<br>• Local government's annual budget for waste<br>• Number of events with multi-stakeholder participation organized by the local government regarding waste | • The level of openness of business to cooperation with stakeholders regarding recycling<br>• Waste-related personnel capacity of the local government<br>• Degrees of willing to corporate<br>• Stakeholders in the organizational structure affecting waste governance |

government. In this regard, local governments, who know the details of site-specific waste production, have more authority, which can make waste governance more effective. The objective indicators for the organizational dimension of new generation waste governance are number of NGOs working on waste in the city, number of NGOs working on waste in the district, number of street collectors in the district, non-resident population visiting in the district, open days of commercial enterprises, busy days of commercial enterprises, local government's annual budget for waste and number of events with multi-stakeholder participation organized by the local government regarding waste. Subjective indicators are level of openness of businesses to co-operation with stakeholders regarding recycling, waste-related personnel capacity of the local government, degrees of willing to corporate and stakeholders in the organizational structure affecting waste governance. By collecting these indicators in the study area and monitoring them in certain periods, it will be possible to improve the waste management of local governments in commercial enterprises. The organizational structure related to waste of Kadikoy Municipality, which is the study area at local level, should be holistic and need-oriented. The subjective and objective indicators defined for the organizational dimension of new generation, innovative and new generation waste governance are shown in Table 5.

### 2.2.3. Behavioral Dimension

Ajzen (1991) discovered the Theory of Planned Behavior, which is best known for its introduction as a typical social psychology framework in 1991. Based on the idea of the Theory of Planned Behavior, a person's intention guides his behavior (Blake, 1999). According to this theory, individuals will be more willing to perform the behavior when they have positive attitudes towards performing the behavior, when they perceive more social pressure and expectations to perform the behavior (Xu et al., 2020). As reported by Wang et al. (2019), Theory of Planned Behavior is a powerful and influential theory widely used to explain various personality behaviors, including pro-environmental behaviors such as energy conservation. There are also various studies on waste behavior in the literature. A study on this subject emphasizes that taking the perspective of future generations can have an impact on individuals' thoughts and preferences regarding sustainable waste management behavior (Krestyanpol, 2023). To promote linkage and information exchange between the national government and local governments, public officials and employees can take on roles at other levels of government.

Waste generating behavior is refers to national policies. It is important that current policies are encouraging in order

**Table 6.** Indicators on behavioral dimension of sustainable waste governance for local governments

| Dimension | Objective indicators | Subjective indicators |
|---|---|---|
| Behavioral | • Number of customers visiting the commercial enterprises<br>• Customer profile visiting the commercial enterprises<br>• Presence of a recycling bin in the commercial enterprises | • Use of environmentally friendly products in the commercial enterprises<br>• Environmental practices regarding waste in which the commercial enterprises are involved<br>• Behavior of the commercial enterprises to throw its recyclable waste into the recycling bin |

to transform waste behavior with a focus on recycling. Governments can benefit when visitors to businesses provide feedback on waste management services. Collecting GIS-based data to obtain feedback from businesses is important to produce location-specific solutions. The objective indicators identified for the behavioral dimension of new generation waste governance are number of customers visiting the commercial enterprises, customer profile visiting the commercial enterprises, presence of a recycling bin in the commercial enterprises. Subjective indicators are the use of environmentally friendly products in the commercial enterprises, environmental practices regarding waste in which the commercial enterprises are involved and behavior of the commercial enterprises to throw its recyclable waste into the recycling bin. By collecting these indicators in the study area and monitoring them in certain periods, local governments will be able to improve waste management in commercial enterprises. The waste behavior of businesses and the types of waste they produce can be different. One of the important steps for good waste governance is the need for data analytical systems that can understand geodemographic lifestyles and make evaluations on waste. In order to understand the waste-related behavioral structure of commercial enterprises in Kadikoy, which is the study area at the local level, it is expected that a survey will be conducted, the answers will be shared on a common platform where local governments and relevant stakeholders can see them, and relevant stakeholders will strengthen waste governance according to the survey results. In this way, a holistic and tailored plan can be put into practice. The subjective and objective indicators defined for the behavioral dimension of new generation, innovative and new generation waste governance are shown in Table 6.

### 2.2.4. Technological Dimension

Data is increasingly forming the basis for decision-making in waste management. The accurate and complete information provided allows local governments to design and carry out more efficient operations and save costs (Kaza et al., 2018). Technology is widely used to support reducing the amount of waste produced globally and to modify production processes to reduce waste or increase recyclability. Packaging in-

novations such as biodegradable forks and bags reduce plastic waste (Vaughan, 2016; Oosterhout et al., 2023). According to the World Bank Report on this subject, mobile applications that will assist urban waste collection systems are also being implemented. Mobile applications are used to inform people about waste collection and waste separation rules at source (Kaza et al., 2018). The location-specific waste governance system developed within the framework of the four dimensions mentioned in this article is important in terms of providing an efficient process design for local governments.

In the technology and data dimension of the new generation waste governance, especially GIS-based data and spatial analysis of waste data collected from commercial enterprises are important for increasing its applicability in other pilot regions. Geographic Information Systems (GIS) is a map-based structure that enables easy spatial analysis. In this context, it is possible to spatially present data and information on the types and quantities of waste generated in enterprises, the presence of recycling bins, waste disposal methods, and whether they are open to cooperation. The objective indicators for the technological dimension of new generation waste governance are GIS-based land use map presence of local government, types of vehicles collecting waste and number of vehicles collecting waste. Subjective indicators are the availability of local government's waste data in GIS database, licensed applications purchased within the local government and routes of vehicles collecting waste. By collecting these indicators in the study area and monitoring them in certain periods, it will be possible to improve the waste management of local governments in commercial enterprises. Especially with artificial intelligence and machine learning, it can be ensured that the future risks of waste management can be minimized when future projections of existing data are made. It will be possible to transfer the waste-related data of the commercial enterprises in Kadikoy, which is the study area at the local level, to a technological infrastructure and create a common platform that local governments and relevant stakeholders can see, and the relevant stakeholders can minimize possible risks by analyzing the data. While metropolitan municipalities can adapt to technology more easily, district municipalities may lag behind in terms of policy making and
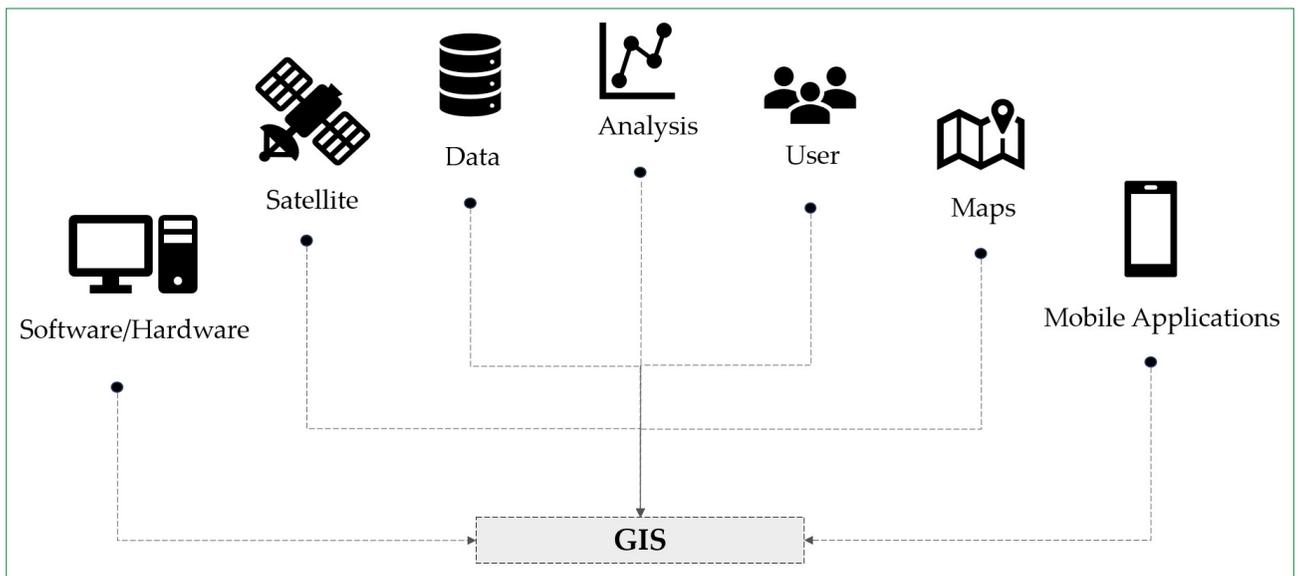
**Figure 3.** General structure and components of GIS.

GIS: Geographic Information System.

adapting to innovation. GIS can be used more actively in waste management to provide real-time data and location-based solutions. The use of technology can bring some challenges. It is especially important to prevent dangers such as cyber-attacks. In a technology-based database, various operational interventions can be made, such as ensuring the security of the data, limiting the ability to interfere with the content, and sharing only the content with the relevant stakeholders. On the other hand, the use of technology is important in terms of bringing practicality and the ability to intervene quickly in waste management. It is useful in terms of the ability to receive data directly from the field and to take immediate action.

The presence of some hardware features as technological infrastructure in the new generation waste governance will accelerate the transition to digitalization. These hardware features include sensor ownership, 5G communication technologies, etc. If the local government already collects data on waste, integrating it into the platform to be created will make it easier to connect related issues with each other. In particular, ensuring the usability of the technology by local governments is critical. No matter how advanced the existing infrastructure is, if local governments cannot utilize this technology, the

waste management problem will continue. Therefore, capacity building in local governments and provision of necessary hardware support are among the issues that come to the forefront. GIS and Remote Sensing techniques are generally used to keep location-based information, especially in matters such as data collection, storage, updating and analyzing data. GIS consists of 5 basic components: hardware, software, data, users and methods (Korkulu, 2021; Fu, 2015; Kapluhan, 2014). The general structure and components of GIS are shown in Figure 3. According to the figure, software, hardware, satellite, data, analysis, user, maps and mobile applications appear to be the basic components that make up the structure of GIS.

According to the findings of the literature analysis, local governments need to manage the waste of commercial enterprises with objective and subjective indicators identified in political, organizational, behavioral and technological dimensions. Monitoring the indicators specified in the table by local and central governments has an important place in terms of showing in which areas more operational action should be taken in waste management. The subjective and objective indicators defined for the technological dimension of new generation, innovative and new generation waste governance are shown in Table 7.

**Table 7.** Indicators on technological dimension of sustainable waste governance for local governments

| Dimension | Objective indicators | Subjective indicators |
|---|---|---|
| Technological | • GIS-based land use map presence of local government<br>• Types of vehicles collecting waste<br>• Number of vehicles collecting waste | • Availability of local government's data in GIS database<br>• Licensed applications purchased within the local government<br>• Routes of vehicles collecting waste |

## 3. Discussion

Academic studies generally address issues such as route optimization for waste management and landfill site selection. The current system is not sustainable, especially for developing countries. In new generation waste governance, especially the use of technology and data collection provides faster data analysis. In the literature analytics, it appears that studies on data obtained using technology are increasing. Therefore, it is important to plan sustainable waste governance for local governments, especially from a holistic perspective. In many metropolitan areas, including Turkey, waste governance is becoming more challenging with population growth. It is understood that there is a need for a sustainable of participatory and empowered waste governance that incorporates new technologies. Ensuring the participation of all stakeholders, user-friendly and anonymization have an important place in the framework developed for new generation waste governance. This paper elaborates on the current state of sustainable waste governance in international and national literature in political, organizational, behavioral and technological dimensions.

Thes study draws a framework for new generation waste governance. This framework is supported by data obtained from case study. By collecting data from commercial enterprises through a common database or platform, local governments can see both potential waste production amounts and distribution of waste types and develop site-specific solution suggestions. With the Kadikoy case study, the importance of openness to cooperation and awareness in waste governance was highlighted through interviews and questionnaires. The findings show that there is a lack of coordination in current waste management due to the fact that all relevant stakeholders are not included in the process and the issue is not handled from a holistic perspective. A Web-GIS based platform will facilitate data transfer and follow-up of relevant stakeholders and contribute to the reduction of current waste management problems. The case study highlights the importance of developing more efficient waste management systems, reducing waste quantities, the importance of waste management in extraordinary situations such as pandemics, and managing waste generation behaviors through various tax and incentive mechanisms of local and central governments.

In particular, real-time data from sensors placed in waste bins plays an important role in determining the types of vehicles and trips that will go to that area. Knowing which type of recyclable waste is produced more in which region is also likely to affect the location of recycling facilities. The case study also emphasizes that this issue should be addressed seriously, especially in order to eliminate the lack of data. Results indicate that the availability and accessibility of waste collection related data on a Web-GIS platform plays a pivotal role in a participatory governance framework. Additionally, awareness and openness to cooperation among commercial enterprises are some significant factors in waste behavior where a local government may need to analyze.

Nowadays, technology has greatly enhanced our ability to access data and information. For this reason, it is clear that the substrates prepared especially by using GIS will enable waste data to be kept in real time and the collected data to be analyzed quickly. Waste is not an issue that only concerns central or local governments. The active participation of all stakeholders in the process is important. Developing feedback mechanisms for the target group will ensure that waste governance is more effective. New generation waste governance provides more information about waste behavior in businesses and enable local governments to develop and implement more appropriate policies on waste. In the proposed new generation waste governance model, by integrating artificial intelligence, machine learning sub-systems and a software for forecasting, it will be clearer how to approach the future waste issue holistically and which regions will be more critical in terms of waste. Thus, it will be possible to develop location-specific solutions when there is a problem with waste. It is clear that Web-GIS-based hubs to be developed for new generation waste governance will become more manageable when more stakeholders can address the issue holistically.

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