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Evaluation Of The Relationship Between GDP And Solid Waste Management In EU Countrıes, The United Kingdom, And Turkey: An Analysis Of The 2000-2020 Period

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Özet

Bu makale, Avrupa Birliği (AB) ülkeleri, İngiltere ve Türkiye'de GSYİH ile katı atık yönetimi arasındaki ilişkiyi 2000-2020 dönemi boyunca incelemektedir. Katı atık yönetimi, çevre sürdürülebilirliğinin yanı sıra ekonomik büyüme ile çevresel etkiler arasındaki dengeyi anlamak açısından oldukça önem arz etmektedir. Bu çalışmada, katı atık üretimi, geri dönüşüm oranları ve çevresel göstergeler ile GSYİH arasındaki ilişkiyi analiz etmek amacıyla panel veri analizi yöntemi kullanılmıştır. Bulgular, ekonomik büyüme ile daha etkili katı atık yönetimi arasında güçlü bir pozitif ilişki olduğunu göstermektedir. Yüksek GSYİH seviyeleri, genellikle daha etkili katı atık yönetimi uygulamaları ile ilişkilendirilmektedir. Avrupa Birliği ülkeleri, İngiltere ve Türkiye gibi ekonomik olarak gelişmiş bölgelerde, katı atık yönetimi politikalarının ekonomik büyüme ile uyumlu olduğu ve çevresel sürdürülebilirlik açısından olumlu etkiler yarattığı gözlemlenmektedir. Bu çalışma, çevre politikalarının ekonomik büyüme ile çatışmadan bir arada yürütülebileceğini ve hatta birbirlerini destekleyebileceğini göstermektedir. Sonuç olarak, etkili katı atık yönetimi politikalarının benimsenmesi ve uygulanması, çevre sürdürülebilirliği hedeflerine ulaşmak ve ekonomik büyümeyi desteklemek için önem arz etmektedir. Bu çalışma, ekonomik büyümenin çevre etkilerini azaltmaya yönelik kanıta dayalı politika ve stratejilerin geliştirilmesine katkı sağlamayı amaçlamaktadır.

Anahtar Kelimeler:

Katı Atık Yönetimi, Çevre, Gayri Safi Milli Hasıla, Panel Veri Analizi

AB Ülkeleri, İngiltere ve Türkiye'de GSYİH ile Katı Atık Yönetimi Arasındaki İlişkinin Değerlendirilmesi: 2000-2020 Dönemi Analizi

Abstract

This article examines the relationship between GDP and solid waste management in European Union (EU) countries, the United Kingdom, and Turkey during the period 2000-2020. Solid waste management is a significant concern for environmental sustainability and understanding the balance between economic growth and environmental impacts. This study employs panel data analysis to examine the relationship between solid waste production, recycling rates, environmental indicators, and GDP. The findings indicate a strong positive relationship between economic growth and more effective solid waste management.

High GDP levels are generally correlated with more effective solid waste management strategies. In economically advanced regions, such as European Union countries, the United Kingdom, and Turkey, it is observed that solid waste management policies are consonant with economic growth and yield positive environmental sustainability outcomes. This study demonstrates that environmental policies can be harmoniously integrated with economic growth, and indeed, can even exhibit mutually reinforcing relationships Ultimately, the adoption and implementation of effective solid waste management policies are crucial for achieving environmental sustainability goals and supporting economic growth. This study aims to contribute to the development of evidence-based policies and strategies that mitigate the environmental impacts of economic growth.

Keywords:

Solid Waste Management, Environment, GDP, Panel Data Analysis

1. INTRODUCTION

During periods of industrial development and diversification of production methods, consumption habits have also been affected, leading to the formation of a society focused on expenditure and consumption.
With the increase in product variety, the consuming society has become more vocal about how to manage the waste of products in different usage areas. Concepts such as collecting, disposing, and reusing post-consumer waste have entered the agenda of the consuming society.

Increasing awareness of environmental conservation on a global scale and the rising costs of environmental protection have made waste management a parameter of development. The impacts of waste on creating economic value, as well as the collection and disposal of waste, have become indicators of development.

Solid waste management plays a critical role in terms of environmental sustainability for a country. The increase in population and industrialization has made the management of solid waste more complex. Therefore, understanding the relationship between economic growth and solid waste management is crucial. This article aims to assess the relationship between gross domestic product (GDP) and solid waste disposal in European Union (EU) countries, the United Kingdom, and Turkey over the past 20 years. This analysis seeks to understand the impact of environmental policies on economic growth.

In literature and legislation, various definitions of "solid waste" are made. Kaseva and Mbuligwe defined solid waste in 2003 as the unwanted or non-useful solid substances produced in any human community. According to Article 3 of the Solid Waste Control Regulation, solid waste is defined as "solid materials and treatment sludge that the producer wants to dispose of and which must be disposed of in a regular manner, especially for the peace of the community and the protection of the environment." Armağan et al. (2006: 16) define it as solid materials that are unwanted by the producer but have economic and social value when disposed of with the correct methods. Ebin (2004: 3) expresses the concept of solid waste as; the entirety of solid things or waste sludge that is thrown away by its owner and must be collected and disposed of regularly, moving from the purpose of protecting public health and the environment.

According to the Turkish Language Association (2011: 1349), solid waste, in its dictionary definition, refers to all solid materials with no longer any utility to the user, generated at all stages from production to consumption.
According to the Environmental Law, solid waste refers to "solid waste materials that the producer wants to dispose of and which, particularly for the preservation of public order and the protection of the environment, need to be disposed of in an organized manner" (Environmental Law, 1983: Article 2).

Palabıyık and Altunbaş (2004) defined solid waste as follows: materials generated as a result of industrial, commercial, or household activities, discarded by the consumer because they are no longer useful, and which need to be regularly removed and disposed of in an organized manner due to their potential impacts on the environment, human health, and other benefits they may provide to society.

Consumer habits and economic activities over time have led to the emergence of Solid Waste Management (SWM) (Cointreau, 2006). Krishna and Chaurasia (2017) stated that municipal solid waste can be categorized into various types, including food waste, garbage, commercial waste, institutional waste, street cleaning waste, industrial waste, construction and demolition waste, and sanitation waste. These solid wastes, which include recyclable materials such as paper, plastic, glass, metal, toxic substances such as paint, pesticides, used batteries, medicines, compostable organic materials such as fruit and vegetable peels, food waste, as well as contaminated waste such as bloody cotton, single-use syringes, belong to the municipality.

Solid wastes are divided into seven different subcategories based on their sources of generation. These are referred to as household solid waste, industrial waste, hazardous waste, special waste, medical waste, agricultural and garden waste, and construction debris and rubble waste (Gündüzalp ve Güven, 2016).

2. SOLID WASTE TYPES/CLASSIFICATION

Most of the dry waste generated in urban areas falls under the category of municipal solid waste or urban solid waste (USW). This USW category includes household waste, kitchen waste, recyclable materials (such as paper, glass, cardboard, etc.), hazardous waste (such as batteries, bulbs, paint cans, etc.), commercial and institutional waste, public service waste, organic waste, green waste (such as garden, market, and market waste), and bulky waste (such as furniture, appliances, etc.).

However, solid waste elements other than urban solid waste, such as sewage sludge (wastewater sludge), power plant waste, agricultural waste, industrial waste, mining waste, construction, demolition, and excavation waste, typically belong to a separate category. This category may include scrap vehicles, tires, and bulky waste requiring special treatment, as well as medical waste (infected waste, hospital and operating room waste) (Öztürk, 2015: 1-2; Steiner and Wiegel, 2009: 4-6).

2.1. Household Waste

Household solid waste refers to waste generated in places where people use as living spaces, primarily from homes, but waste collected from markets, hotels, or recreational areas is also considered household waste due to their characteristics or contents (Steiner and Wiegel, 2009: 5). Hakami and Abu Seif (2015) define waste consisting of materials such as plastic, paper, glass, metal, discarded by households, as a type of urban solid waste.

According to Sayar (2012: 4), household solid waste includes waste collected by municipal services, which can be sorted, recycled, reclaimed, composted, or incinerated at homes, collection centers, or household waste storage areas. It encompasses waste generated from agricultural and industrial activities, household waste, kitchen waste, and packaging waste, among other elements with household characteristics.

These wastes generally fall into the category of non-hazardous waste and can be simply defined as solid wastes originating from homes. In the Environmental Law No. 2872, household solid waste is defined as "solid waste originating from places such as residences, industries, businesses, recreational areas, which do not have the quality of hazardous or harmful waste."

2.2. Medical Solid Waste

Waste generated from healthcare services, classified by the World Health Organization (WHO) as medical waste, can be infectious or non-infectious. WHO categorizes infectious waste into two groups: sharps and non-sharps. Sharps include items such as needles, syringes, and scalpels, while non-sharps include materials like bandages and gauze. Non-infectious waste, similar to household waste and not in contact with patients, consists of materials such as paper, glass, plastic, metal, etc. (World Health Organization, 2005: 2).

Medical wastes generated from healthcare facilities (including home healthcare services) are hazardous and harmful wastes that can disrupt ecological balance if disposed of in air, water, or soil. Special precautions must be taken for the production, transportation, storage, and disposal of these wastes (Aydoğan et al., 2011: 132).

2.3. Special Solid Wastes

Wastes requiring special disposal methods include radioactive wastes, hazardous industrial wastes, wastes containing harmful chemicals, cleaning materials, batteries, automobile tires, wastewater sludges, construction and demolition wastes, hospital wastes, and end-of-life electrical and electronic equipment. These types of solid wastes necessitate disposal methods that require special precautions and procedures (Palabıyık, 2001: 28; Palabıyık and Altunbaş, 2004: 106).

Batteries, accumulators, used tires, and waste oils, which do not dissolve in nature for a long time, are included in the special waste category. Similarly, commercial and institutional wastes, agricultural wastes, and excavation wastes can also be considered under this special waste category. Commercial and institutional wastes tend to cause long-term damage to the ecosystem and can pose as serious an environmental threat as household wastes. Agricultural wastes, on the other hand, are not inclined to harm the environment as they represent the waste of plants or agricultural products. Excavation wastes are more prevalent in areas with intense construction activity. They are wastes generated during the construction or renovation of buildings, bridges, roads, etc. (Meriç, 2014: 8-10). Excavation wastes are waste materials produced during construction activities and are more common in regions with intense construction activity (Hasanoğlu, 2012: 5).

2.4. Industrial Solid Wastes

Some portion of solid wastes originates from industrial activities and production processes (Abduli, 1996: 335). These wastes result from various activities such as construction/excavation, manufacturing, agriculture, commerce, and mining (Tchobanoglous and Kreith, 2002: A.9). These wastes may contain substances such as aluminum, iron, copper, lead, nickel, cadmium, mercury, arsenic, and selenium, which can have toxic effects (Artiola, 2019: 377).

Waste generated as a result of industrial activities can be classified into two main categories: hazardous and non-hazardous industrial wastes. Industrial enterprises should focus on minimizing the quantity and level of these wastes as much as possible. The collection, transportation, segregation, and storage of industrial wastes should be carried out in accordance with relevant regulations such as the Hazardous Waste Control Regulation (Gündüzalp and Güven, 2016:3).

3. SOLID WASTE MANAGEMENT

The primary factors contributing to environmental pollution include rapid population growth, urbanization, industrial and technological advancements, as well as industrial, agricultural, tourism, and other human and economic activities. The increase in both the quantity and types of solid waste can also be attributed to these factors. The proliferation of new production techniques, the widespread use of different raw materials to reduce costs, the release of various products into the market altering consumption habits, and increasing demands have all contributed to the growth of waste issues.

To achieve a specific objective, the careful selection and utilization of appropriate resources are denoted as 'management.' The ultimate objective in solid waste management is the proper disposal and management of undesirable materials. In order to attain this objective, technical, environmental, administrative, economic, and political considerations need to be taken into account. Hence, solid waste management (SWM) can be defined as a managerial process in which the control, storage, collection, transfer, transportation, disposal, and recycling processes of solid waste production are meticulously planned and executed.

An increase in the quantity of waste and its changing composition has led to two significant outcomes by the end of the twentieth century. Firstly, the environmental impacts of waste have intensified, resulting in rapid depletion of natural resources, loss of raw materials, and energy wastage. Consequently, waste management has become an increasingly significant challenge for local government authorities responsible for municipal sanitation services. Despite substantial budgets allocated to these services in waste-related endeavors, it is noted that effective waste disposal remains elusive.

Secondly, waste has transitioned from being a problem previously addressed from the perspectives of human and environmental health, requiring removal from people's living spaces, to evolving into an industrial sector shaped by the aim of adding value to the economy. This new understanding defines waste services as a process consisting of stages such as "cleaning, collection, transportation, segregation, recycling, composting/storage/incineration," emphasizing the interconnectedness of these stages, collectively termed as "solid waste management" (Yaslıkaya, 2004: 156).

The increase in population in urban areas not only leads to an increase in the quantity of solid waste generated but also results in an increase in the per capita waste generation. The nature and quantity of solid waste vary from country to country and even among regions or cities within the same country. Among the reasons for these variations are consumers' income levels, consumption habits, and usage patterns. Through an appropriate solid waste management system, it is possible to effectively control all wastes to prevent uncontrolled waste accumulation. In this context, the importance of planning and operating an integrated solid waste management system is emphasized to prevent uncontrolled waste accumulation (Eren, 2010: 4).

In summary, solid waste management begins with waste reduction at the source and collection of generated waste, followed by activities such as reuse, recycling, and final disposal, as well as post-disposal monitoring, control, and supervision (Waste Management Regulation, 2015).

3.1. Components of Solid Waste Management

A series of methods have been developed to ensure that different types of solid waste do not harm the environment and human health. These methods are referred to as Solid Waste Management Elements. Processes such as waste collection, transportation, reuse, recovery, recycling, incineration, landfilling, and treatment are carried out through these elements.

For sustainable waste management, the environmental and economic impacts of each of these management elements should be considered, and the continuous operation of this mechanism should be ensured. Selecting the most cost-effective and environmentally friendly waste management elements will contribute to the creation of a sustainable waste management system with minimal interference in the community's lifestyle and the least amount of waste generation.

The level of development of a country and societal habits are important factors in the selection of waste management elements. Decisions regarding the feasibility of the chosen element should be based on these insights. In low- and middle-income countries, methods such as accumulation at collection centers and final disposal are frequently employed, whereas in developed countries, methods such as source reduction, segregation, or recycling are implemented more effectively.

The reduction of waste generation requires the prevention of unnecessary consumption and waste. It is necessary to recover waste as energy or material. Final disposal should also be managed in line with these objectives and goals. The solid waste management system encompasses waste generation (source, quantity, composition, and storage), collection, transfer and transportation, processing or treatment, and final disposal stages.

3.2. Collection of Solid Waste

The solid waste problem caused by human activities is being addressed through various methods. These methods include open dumping, sanitary landfilling, composting, reuse, recycling, recovery, and incineration, which represent different solutions (Yılmaz and Bozkurt, 2010: 13).

Waste collection refers to the process of not only collecting waste but also determining the appropriate routes where collection vehicles will take the waste. This process involves the emptying of waste into containers by specialized vehicles and transporting the waste to designated routes (Dhindaw, 2004).

In a study conducted by Cointreau Levine in 1994, it was found that waste collection costs accounted for 79% of management costs in low-income groups, 74-79% in middle-income groups, and 55-70% in high-income groups. This indicates that waste collection is the most costly aspect in waste management.

Waste collection is a critical process that requires logistical planning. Therefore, emphasis should be placed on logistical planning and optimization activities to ensure the efficient operation of the system. In such optimization studies, variables such as cost, time, and environmental protection need to be balanced. When creating a solid waste management plan, it is essential to consider the cost factor, especially in the waste collection process, as this factor constitutes a significant financial aspect of waste management.

3.3. Source Reduction, Reuse, Recycling

One of the fundamental principles of waste management is the reduction of waste generation. This principle can be implemented in production processes by using alternative materials with lower environmental impacts, producing repairable products beyond economic factors, and eliminating unnecessary practices in product packaging stages. Additionally, in line with the principle of source reduction, emphasis is placed on the applicability of environmentally friendly options at the household level, such as preferring products with minimal or no packaging at supermarkets and using products multiple times.

Efforts for waste reduction or source reduction involve initiatives aimed at reducing waste generation at the points of waste generation (e.g., households and workplaces) through prevention, reduction, and reuse. This can be achieved by redesigning products or altering production and consumption habits (Hoornweg and Bhada-Tata, 2012: 28).

Waste minimization or waste reduction refers to methods, processes, or procedures that prevent or reduce waste generation. These methods are applied at the source of waste. Waste reduction is a process that offers many long-term benefits (Karpuzcu, 2014: 151). The implementation of waste reduction involves various processes aiming to minimize both household and industrial solid waste. Household solid waste reduction methods may include practices such as promoting recycling through a deposit system, separate collection of waste, and the use of garbage disposals for organic waste. On the other hand, industrial solid waste reduction requires more detailed planning. It involves selecting raw materials, products, and technologies that will produce less waste, as well as reviewing and restructuring production processes (Karpuzcu, 2014: 153).

According to Yılmaz and Bozkurt (2010: 14), reuse is defined as the practice of using waste multiple times for the same purpose without requiring any additional processing other than cleaning. Reuse involves using certain materials repeatedly without undergoing any process other than cleaning. Reusing solid waste, especially packaging materials, for the same or different purposes in their original form, is a preferred method compared to recycling processes. This is because solid waste can be reused without the need for any special processing or transformation (Palabıyık and Altunbaş, 2004: 108).

According to Steiner and Wiegel (2009: 18), the repeated use of products or certain parts of products is referred to as reuse. Reuse is commonly defined as the repeated use of items such as packaging materials, bottles, boxes, and similar products. For example, reusing bags from supermarkets, beverage bottles, or machine/car parts are examples of reuse. Reusing a product or packaging extends its useful life and reduces the amount of effort and resources needed for its disposal. Additionally, reusing a product prevents the need for raw materials for the production of a new product, thereby reducing energy, material, labor, and transportation costs (Karpuzcu, 2014: 154).

According to Palabıyık and Altunbaş (2004: 108), the process of subjecting solid waste to physical or chemical treatments to be reintroduced into the production process as a secondary raw material is termed as recycling. With this raw material, it is possible to produce both the same product and new products. Additionally, this raw material can also be used to generate energy.

Recycling is considered one of the most positive and effective practices in solid waste management. It involves separating recyclable materials from municipal waste streams to enable these materials to be reused in the market. Recycling has numerous positive impacts; the most significant is its contribution to conserving valuable but limited resources. This reduces the need for extracting materials from natural resources, thereby decreasing the environmental impact associated with mining and mineral processing. Additionally, recycling reduces energy consumption.

Recycling also reduces the amount of waste deposited in solid waste landfills, thus helping to extend the use of storage capacity for a longer period. Additionally, recycling encourages the separation of non-combustible materials such as metals and glass from other waste, which increases the efficiency of incineration and composting facilities and enhances ash quality. However, for recycling programs to be effective, environmental responsibility and good planning are necessary. In regions supported by economic conditions, incentives and authorizations contribute to the growth of recycling. Stable markets should be established for recycled materials for a successful recycling program. For example, a market should be created for the papers obtained from paper recycling (Tchobanoglous et al., 2002: 9-10).

The concept of recycling is closely linked with reverse logistics. Reverse logistics encompasses various aspects such as material reuse, waste reduction, waste disposal, refurbishing, repair, and remanufacturing (Stock, 2001, cited in Stock, 2001:1). Handling recyclable waste is an essential component of reverse logistics and is considered a crucial element of waste management (Şengül, 2010: 2). Reverse logistics is one of the fundamental processes applied in supply chain management. It involves planning, implementing, and controlling activities to efficiently dispose of products and information from consumption points to production points to reclaim economic value or properly eliminate them (Nakıboğlu, 2007: 183).

In summary, recycling is a waste management practice that involves transforming recyclable materials into secondary raw materials through various physical and/or chemical methods to reintegrate them into the production process. The primary objective is to produce new products from waste materials. Examples include the recycling of waste paper into paper products or the conversion of waste glass back into glass materials (Umut et al., 2015: 265, cited in Wheeler, 2004: 94).

3.4. Storage

Storage has been a fundamental method used throughout history to remove waste from residential areas. Initially, this method was simply implemented by disposing of waste in natural areas, but over time, it has been criticized due to the environmental impacts of waste. As a result of these criticisms, more organized storage methods have been developed. Modern solid waste management places great importance on the planning and control of storage areas. Through engineering methods, organized and hygienic storage areas are created.

Storage is a method used for the disposal of solid waste and can encompass all materials within the solid waste management system. Other methods, such as biological or thermal treatment, may ultimately generate waste and residues that require storage. As a result, solid waste management always includes a need for storage. From many perspectives, storage is the simplest and most economical way of waste disposal.

Despite efforts aimed at minimizing solid waste disposal, landfilling remains the predominant method globally. Landfilling entails the systematic collection and containment of waste in designated areas situated away from inhabited zones. Integral to an environmentally sustainable approach to solid waste management is the organized disposal of solid waste. Nonetheless, in certain regions, there persists the irregular dumping of solid waste in open spaces outside residential areas. Hence, it is pertinent to delineate two distinct types of landfilling methods.

Illegal dumping, or open dumping, refers to the unregulated disposal of solid waste in a disorderly and mixed manner onto open spaces outside residential areas, leading to its removal from living environments in an unplanned manner. Such practices contribute to the formation of garbage dumps, resulting in issues that pose threats to both society and the environment, including foul odors, harmful gases, and leakage. Moreover, aside from these detrimental effects, irregular dumping exposes solid waste to external factors such as sunlight, air, and moisture, causing materials to degrade and lose their economic value.

Due to all these adverse effects, open dumping is gradually becoming an abandoned method. For instance, according to the 2018 data from the Turkish Statistical Institute (TÜİK), approximately 67% of the waste collected in Turkey is sent to controlled landfill sites. This percentage has increased from about 55% in 2010 and 33% in 2001, while it was less than 5% in 1994 (TÜİK Environmental Statistics, 2018).

The establishment of a solid waste management system should prioritize efforts to rehabilitate or rehabilitate open dumping sites. Dumping waste in open areas in a mixed manner brings a series of disadvantages. Specifically, storing less harmful waste with more harmful waste in the same disposal area can increase environmental risks. Additionally, recycling costs increase, and there may be a loss of economic benefit from the recovery of valuable waste.

3.5. Compost

Biologically degradable materials are separated under controlled conditions, a process known as composting, which is one of the most effective methods for reclaiming organic waste for agricultural purposes (Topal, Topal, 2013: 86). Compost is not only used as a soil conditioner but also preferred in gardens and landscaping applications, reducing the quantity of infectious and harmful substances in waste through this method (Renkow, Rubin, 1998: 340).

Household solid waste typically contains approximately 50-70% of easily compostable materials. Composting technology is regarded as an appealing approach in waste recycling policies. This process is utilized to produce soil amendments and compounds such as humus by economically reclaiming organic household and garden waste. Composting has been effectively implemented for the recycling of organic waste in numerous countries for many years (Zurbrugg, 2004).

3.6. Incineration

Incineration is a solid waste disposal method that converts solid waste into solid, liquid, and gaseous substances and heat energy through chemical oxidation (Steiner and Wiegel, 2009: 61). Thermal conversion or solid waste incineration/gasification is a process that allows combustible waste to become an inert residue at high temperatures. With this process, the volume and weight of the waste are reduced, thus minimizing its impact on the environment and public health (Öztürk and Alp, 2015: 215).

In other words, the incineration method is used to reduce the volume of municipal solid waste, provide stabilization, sterilization, and generate energy from waste. This method is carried out by directly burning municipal solid waste without any pretreatment or by burning waste-derived fuel obtained by separating combustible and non-combustible parts from mixed municipal solid waste (Aynur, 2011: 7).

Solid waste management practices offer an alternative disposal option, which is incineration. However, particularly in municipal solid waste management, priority should be given to other assessment methods before resorting to incineration. Incineration technology is an assessment method for waste with high calorific (thermal) value and energy recovery is of great importance for the incineration process (Aynur, 2011: 7). Depending on the characteristics of each type of waste, incineration may not be suitable. If the residues remaining after incineration are non-hazardous (domestic) or inert, these residues should be disposed of in appropriate sanitary landfills. Depending on the type of waste, if the residues generated as a result of the incineration process are hazardous or medical waste, these residues should be disposed of as hazardous waste. Incineration of solid waste can significantly reduce the amount of waste that needs to be sent to landfills.

Burning waste for energy recovery purposes can significantly reduce the volume of waste to be disposed of, with this reduction being more pronounced in waste streams containing bulky materials such as packaging materials, paper, cardboard, plastic, and garden waste. Recovering the energy value present in the waste before the final stage of waste disposal, which is landfilling, is considered a preferred method for soil filling operations as well. This is important not only for cost-effective energy recovery but also for pollution control in the waste going to the landfills. Generally, the incineration method without energy recovery is not a preferred option due to high costs and environmental pollution. Open burning of waste is not recommended, particularly due to severe air pollution associated with low-temperature burning (Hoornweg and Bhada-Tata, 2012: 29). This method is particularly preferred by countries facing storage space constraints for the disposal of waste that cannot be composted or recycled.

4. METHODOLOGY

This study examines the Gross Domestic Product (GDP) data and solid waste management data for the period 2000-2020 for EU countries, the United Kingdom, and Turkey. The data were obtained from national statistical institutes, environmental agencies, and international sources. Regression analysis is used in the study to statistically evaluate the relationship between GDP and the collection, recycling, incineration, and composting of solid waste in these countries. Regression analysis is a statistical analysis type that examines the relationship between a dependent variable and one or more independent variables.

4.1. Independent Variables

4.1.1. GDP in EU Countries, UK and Turkey

The table below presents the Gross Domestic Product (GDP) values for Turkey, the EU (European Union), and the United Kingdom by year. GDP is a significant economic indicator that measures the economic size and health of a country.

Table 1. GDP in EU Countries, UK and Turkey

Year	Turkey	EU	UK
2000	4.278,00	16.947,00	28.290,00
2005	7.369,00	27.343,00	42.131,00
2010	10.615,00	32.969,00	39.693,00
2015	10.851,00	30.484,00	45.071,00
2020	8.561,00	34.330,00	40.318,00

Source:

https://ec.europa.eu/eurostat/databrowser/view/tec00115/default/table?lang=en (Date of Access: 15.09.2023).
https://data.worldbank.org/indicator/NY.GDP.PCAP.CD (Date of Access: 15.09.2023).
https://data.tuik.gov.tr/Bulten/Index?p=Yillik-Gayrisafi-Yurt-Ici-Hasila-2020-37184 (Date of Access: 15.09.2023).

Turkey's GDP started at 4.278 billion USD in the year 2000 and experienced rapid growth until 2010. However, after 2010, it showed a more moderate growth. In 2020, the GDP was recorded as 8.561 billion USD. During this period, it is evaluated that there was an economic decline due to both domestic dynamics and the international impact of COVID-19.

The GDP of the EU has shown a continuous increase from 2000 to 2020. The GDP, which was 16.947 billion USD in 2000, rose to 34.330 billion USD in 2020. It is observed that the economy of the EU has grown steadily during this period.

The GDP of the United Kingdom also increased from 28.290 billion USD in 2000, but experienced a decline after the 2008 global financial crisis. Finally, in 2020, the GDP was recorded as 40.318 billion USD. It is evaluated that the UK's economy followed a fluctuating course due to significant political events such as Brexit.

4.2. Dependent Variables

4.2.1. Amount of Waste Collected (Annual/Million tons)

The following table presents the solid waste quantities collected annually for Turkey, the European Union, and the United Kingdom.

Table 2. Amount of Waste Collected (Annual/Million tons)

Year	Turkey	EU	UK
2000	31	220	34
2005	31	221	35
2010	30	222	32
2015	34	214	31
2020	33	232	31

Source:
https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=File:Municipal_waste_landfilled,_incinerated,_recycled_and_composted,_EU-27,_1995-2019.png&oldid=514868 (Date of Access: 16.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 15.09.2023).
https://data.tuik.gov.tr/Bulten/Index?p=Atik-Istatistikleri-2020-37198 (Date of Access: 15.09.2023).

In Turkey, although the amount of waste collected has shown a 10% increase over the years, it is generally considered to have remained unchanged.

In the EU, the amount of waste collected was 220 million tons in 2000, while in 2020, there was a 5% increase with 232 million tons of waste collected.

In the UK, the amount of waste collected was 34 million tons in 2000, and this figure decreased by 10% to 31 million tons in 2020.

4.2.2. Amount of Solid Waste (Kg/Per Person)

Per capita solid waste generation is an important indicator for evaluating a country's waste production and waste management performance. The table below displays per capita waste generation rates in Turkey, the European Union, and the United Kingdom.

Table 3. Amount of Solid Waste (Kg/Per Person)

Year	Turkey	EU	UK
2000	465	513	577
2005	458	506	581
2010	410	503	509
2015	424	480	483
2020	415	521	463

Source:
https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Municipal_waste_statistics#Municipal_waste_generation (Date of Access: 15.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 15.09.2023).
https://data.tuik.gov.tr/Bulten/Index?p=Atik-Istatistikleri-2020-37198 (Date of Access: 15.09.2023).

In Turkey, the per capita solid waste generation was 465 kg in 2000, and it decreased to 415 kg in 2020.

In the EU countries, the per capita solid waste generation was 513 kg in 2000, and it increased to 521 kg in 2020.

In the UK, the per capita solid waste generation was 577 kg in 2000, and it decreased significantly to 463 kg in 2020. This reduction is considered a success in terms of the UK's efforts to reduce waste generation or implement more effective waste management strategies.

4.2.3. Amount of Recovery (Million Tons)

The recovery rate reflects the amount of waste that is recycled or processed for reuse. The data regarding the recycling quantities in Turkey, the European Union, and the United Kingdom are shown in Table 4.

Table 4. Amount of Recovery (Million Tons)

Year	Turkey	EU	UK
2000	0,00	38	3
2005	0,00	46	6
2010	0,00	55	8
2015	0,00	63	9
2020	4,15	67	8

Source:
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 16.09.2023).
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics#Municipal_waste_treatment
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 16.09.2023).
https://data.tuik.gov.tr/Bulten/DownloadIstatistikselTablo?p=NUv/MRWqsrmNSBVZcggq5hJNlRWs/aKZFA0AatKwsWYga24JgC0jYEd425oldoNv (Date of Access: 16.09.2023).

Between 2000 and 2015, there is no recorded data available in the literature regarding the recovery rate in Turkey. Therefore, the recovery rate in Turkey is noted as 0 million tons during this period. However, in 2020, the recovery rate was recorded as 4.15 million tons. This indicates that Turkey has increased its recycling and waste management practices or has improved its waste recovery capacity.

The recovery rate in EU countries has increased from 2000 to 2020. In 2020, the recovery rate was recorded as 38 million tons, and in 2020, it increased to 67 million tons. This situation can be explained by the effectiveness of the EU's recycling policies and practices, leading to more waste being recovered.

The recovery rate in the UK has shown an increase from 2000 to 2020. In 2020, the recovery rate was recorded as 3 million tons, and in 2020, it increased to 8 million tons. This suggests that the UK has improved its waste management and recycling processes or engaged in more recycling activities.

4.2.4. Recovery Rate %

The data concerning the recycling rates in Turkey, the European Union, and the United Kingdom are presented in Table 5.

Table 5. Recovery Rate %

Year	Turkey	EU	UK
2000	0	17,27	8,82
2005	0	20,81	17,14
2010	0	24,77	25
2015	0	29,45	29,03
2020	12,57	28,89	25,8

Source:
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 17.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 17.09.2023).
https://data.tuik.gov.tr/Bulten/DownloadIstatistikselTablo?p=NUv/MRWqsrmNSBVZcggq5hJNlRWs/aKZFA0AatKwsWYga24JgC0jYEd425oldoNv (Date of Access: 17.09.2023).

Between 2000 and 2015, the recovery rate in Turkey is indicated as zero due to the absence of recorded data in the literature. However, it is believed that this lack of data leads to this result. The recovery rate increased to 12.57% in 2020. Nevertheless, it is still observed that the recovery rate remains relatively low.

It is observed that the recycling rate in EU countries has increased between 2000 and 2020. The recycling rate, which was 17.27% in 2000, rose to 28.89% in 2020. This is believed to indicate the effectiveness of the EU's environmental policies and the increase in waste recycling.

In the UK, the recycling rate, which was 8.82% in 2000, has shown improvement over time, reaching 25.8% in 2020.

4.2.5. Amount of Solid Waste Burned (Million Tons)

The data on the incinerated solid waste quantities in Turkey, the European Union, and the United Kingdom are displayed in Table 6.

Table 6. Amount of Solid Waste Burned (Million Tons)

Year	Turkey	EU	UK
2000	0,36	36,00	2,5
2005	0,17	45,00	2,9
2010	0,13	53,00	4,1
2015	0,07	57,00	9,9
2020	0,02	60,00	13,8

Source:
https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Municipal_waste_statistics#Municipal_waste_treatment (Date of Access: 17.09.2023).
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 17.09.2023).

It can be observed that the amount of solid waste incinerated in Turkey decreased from 0.36 million tons in 2000 to 0.02 million tons in 2020. This suggests that Turkey has improved its waste management policies or started to adopt alternative waste disposal methods.

Between 2000 and 2020, the amount of solid waste incinerated in EU countries increased from 36 million tons to 60 million tons. This increase indicates that EU countries have been utilizing waste incineration methods for energy production or waste disposal purposes.

In the UK, the amount of solid waste incinerated increased from 2.5 million tons to 13.8 million tons. This increase suggests that the UK has been employing waste incineration strategies for energy production or waste disposal purposes.

4.2.6. Burned Solid Waste Rate %

The incineration rate of solid waste is an environmental indicator that shows how much of the collected waste is burned for energy production or other processes. The data on the incineration rates of solid waste are provided in the table below.

Table 7. Burned Solid Waste Rate %

Year	Turkey	EU	UK
2000	1,16	16,36	7,35
2005	0,55	20,36	8,28
2010	0,43	23,87	12,81
2015	0,21	26,64	31,93
2020	0,06	25,86	44,52

Source:
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 18.09.2023).

The incineration rate of solid waste in Turkey decreased from 1.16% in 2000 to 0.06% in 2020. This indicates that Turkey has started to burn less waste for energy production or waste disposal and is shifting towards alternative waste management strategies.

The incineration rate of solid waste in the EU countries increased from 16.36% in 2000 to 25.86% in 2020. This increase indicates that EU countries have adopted a strategy of burning more waste for energy production or waste disposal, and it reflects changes in waste management policies.

The incineration rate of solid waste in the UK has also increased. The incineration rate, which was 7.35% in 2000, rose to 44.52% in 2020. This indicates that the UK has adopted a strategy of burning more waste for energy production and waste disposal, and it reflects changes in waste management practices.

4.2.7. Amount of Compost (Million Tons)

The data on compost quantities in Turkey, the European Union, and the United Kingdom are presented in Table 8.

Table 8. Amount of Compost (Million Tons)

Year	Turkey	EU	UK
2000	0,23	23,00	0,90
2005	0,34	26,00	3,00
2010	0,19	29,00	4,70
2015	0,15	33,00	5,10

2020	0,12	43,00	5,30

Source:
https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Municipal_waste_statistics#Municipal_waste_treatment (Date of Access: 19.09.2023).
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics#Municipal_waste_generation (Date of Access: 19.09.2023).
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 19.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 19.09.2023).
https://data.tuik.gov.tr/Bulten/DownloadIstatistikselTablo?p=NUv/MRWqsrmNSBVZcggq5hJNlRWs/aKZFA0AatKwsWYga24JgC0jYEd425oldoNv (Date of Access: 19.09.2023).

The amount of compost in Turkey has generally decreased from 2000 to 2020. The compost quantity, which was 0.23 million tons in 2000, decreased to 0.12 million tons in 2020. This decrease indicates that organic waste is being less segregated or that compost production processes have become ineffective.

In the EU countries, the amount of compost has increased from 2000 to 2020. The compost quantity, which was 23 million tons in 2000, has risen to 43 million tons. This increase indicates that more organic waste is being converted into compost and sustainable waste management strategies are being implemented.

The compost quantity in the UK has also increased. The compost amount, which was 0.90 million tons, has reached 5.30 million tons. This indicates that the UK is converting more organic waste into compost and supporting sustainable agricultural practices.

4.2.8. Compost Rate%

The compost rate indicates how much of the collected organic waste is used for compost production. The data regarding composting rates are presented in the table below.

Table 9. Compost Rate%

Year	Turkey	EU	UK
2000	0,74	10,45	2,65
2005	1,10	11,76	8,57
2010	0,63	13,06	14,69
2015	0,44	15,42	16,45
2020	0,36	18,53	17,10

Source:
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 19.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 19.09.2023).
https://data.tuik.gov.tr/Bulten/DownloadIstatistikselTablo?p=NUv/MRWqsrmNSBVZcggq5hJNlRWs/aKZFA0AatKwsWYga24JgC0jYEd425oldoNv (Date of Access: 19.09.2023).

The compost rate in Turkey decreased between 2000 and 2020. The rate, which was 0.74% in 2000, decreased to 0.36% in 2020. This decline indicates that either less organic waste in Turkey is being converted into compost or that compost production processes have become less effective.

In the EU countries, the compost rate increased from 10.45% in 2000 to 18.53% in 2020. This increase indicates that EU countries are converting more organic waste into compost and implementing sustainable waste management strategies.

In the UK, the compost rate has also increased. The rate, which was 2.65%, rose to 17.10%. This indicates that the UK is converting more organic waste into compost and supporting sustainable agricultural practices.

4.2.9. Amount of Solid Waste Sent to Regular Storage Facilities (Million Tons)

Sanitary landfill refers to the controlled subsurface disposal of waste. The quantity of solid waste sent to sanitary landfills is shown in Table 10.

Table 10. Amount of Solid Waste Sent to Regular Storage Facilities (Million Tons)

Year	Turkey	EU	UK
2000	23,9	112	27,5
2005	25,9	88	22,5
2010	24,9	79	14,7
2015	27,4	57	7,2
2020	27,9	54	2,60

Source:
https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Municipal_waste_statistics#Municipal_waste_treatment (Date of Access: 19.09.2023).
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 19.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 19.09.2023).
https://data.tuik.gov.tr/Bulten/Index?p=Atik-Istatistikleri-2020-37198 (Date of Access: 19.09.2023).

The amount of landfilling in Turkey increased from 23.9 million tons in 2000 to 27.9 million tons in 2020. This increase is considered indicative of Turkey's development of waste management facilities.

The amount of landfilling in the EU countries decreased from 112 million tons in 2000 to 54 million tons in 2020. This indicates that the EU countries have improved their waste management strategies and directed more waste towards recycling and energy production.

The amount of solid waste sent to landfill in the UK has also decreased. It decreased from 27.5 million tons to 2.60 million tons. This indicates that the UK has improved its waste management policies and has directed more waste towards recycling and energy production.

4.2.10. Landfill Rate %

The rate of landfilling indicates the proportion of collected waste that is sent to landfill facilities. The rates of regular storage are illustrated in Table 11.

Table 11. Landfill Rate %

Year	Turkey	EU	UK
2000	77,10	50,91	80,88
2005	83,55	39,82	64,29
2010	83,00	35,59	45,94
2015	80,59	26,64	23,23
2020	84,55	23,28	8,39

Source:
https://stats.oecd.org/index.aspx?DataSetCode=MUNW (Date of Access: 19.09.2023).
TÜİK, Atık İstatistikleri Bülteni (2000-2020) (Date of Access: 19.09.2023).
https://data.tuik.gov.tr/Bulten/DownloadIstatistikselTablo?p=NUv/MRWqsrmNSBVZcggq5hJNlRWs/aKZFA0AatKwsWYga24JgC0jYEd425oldoNv (Date of Access: 19.09.2023).

In Turkey, the rate of landfilling has increased from 77.10% in 2000 to 84.55% in 2020. This increase indicates that Turkey has developed its waste management facilities, possibly in response to the increasing amount of waste generated.

In EU countries, the rate of landfilling has decreased from 50.91% in 2000 to 23.28% in 2020. Similarly, in the UK, the rate of landfilling has also decreased, dropping from 80.88% to 8.39% over the same period. These declines indicate a shift towards alternative waste management methods and possibly an increase in recycling and waste reduction efforts in both the EU and the UK.

5. RESULTS AND DISCUSSION

5.1. Model Comparison Tests

The empirical analysis in the study utilized panel data analysis, and for the analysis of panel datasets, the "R" programming language was employed.

Panel data analysis combines cross-sectional data with time series, providing the opportunity to work with both dimensions simultaneously. This method offers more data, greater variability, lower linear relationships between variables, more degrees of freedom, and increased analytical power (Gujarati, 2016: 406). Cross-sectional data with a time dimension, or panel data, are used as a method in econometric analysis through panel data models to predict economic relationships. Panel data analysis involves observing specific sample units over a defined period, and it is employed to examine and forecast economic relationships (Hsiao, 2003).

Panel data regressions typically employ three main approaches: Pooled Ordinary Least Squares (POLS), Fixed Effects Model (FEM), and Random Effects Model (REM) (Judge et al., 1985); (Greene, 2003); (Gujarati, 2003). The R program is a free, code-based, open-source software mainly used in statistical analysis and data mining, which is a continuation of the S program developed at Bell Laboratories in the late 1970s. Developed by Ross Ihaka and Robert Gentleman in 1991, the program was released in 1993 and obtained an open-source license in 1995 (GNU General Public License). Version 1.0.0 was published in 2000, making it available for widespread use. In the study, abbreviations for the dependent and independent variable datasets used are as follows:

Table 12. Table of Abbreviations for Data Sets

GDP	Gross Domestic Product
twa	Total Waste Amount
swa	Solid Waste Amount
ra	Recycling Amount
rr	Recycling Rate
iswa	Incinerated Solid Waste Amount
iswr	Incinerated Solid Waste Rate
ca	Compost Amount
cr	Compost Rate
aswsl	Amount of Solid Waste Sent to Landfills
lr	Landfill Rate

F test

F test for individual effects
data: gsyih ~ tam + kam + gkm + gko + ykam + ykao + km + ko + ddtgkam + ddo
F = 1.0727, df1 = 2, df2 = 2, p-value = 0.4825
alternative hypothesis: significant effects
According to the results, the null hypothesis (H0) indicating the adequacy of the pooled model against fixed effects cannot be rejected at the significance level of α=0.05 (it is accepted). Therefore, it can be statistically inferred with 95% confidence that the fixed effects in the model are not significant.

Breusch-Pagan Test

Lagrange Multiplier Test - (Breusch-Pagan)
data: gsyih ~ tam + kam + gkm + gko + ykam + ykao + km + ko + ddtgkam + ddo
chisq = 1.7944, df = 1, p-value = 0.1804
alternative hypothesis: significant effects

According to the results, the null hypothesis (H0) indicating the adequacy of the pooled model against random effects cannot be rejected at the significance level of α=0.05 (it is accepted). Therefore, it can be statistically inferred with 95% confidence that the random effects in the model are not significant.

Hausman Test

Failed to generate data

Wooldridge's test

Wooldridge's test for unobserved individual effects
data: data: gsyih ~ tam + kam + gkm + gko + ykam + ykao + km + ko + ddtgkam + ddo
z = -1.3481, p-value = 0.1776
alternative hypothesis: unobserved effect
According to the results, the null hypothesis (H0) indicating the adequacy of the pooled model against random effects cannot be rejected at the significance level of α=0.05 (it is accepted). Therefore, it can be statistically inferred with 95% confidence that the random effects in the model are not significant.

The evaluation conducted in the R program revealed a significant relationship between the independent variable, Gross Domestic Product (GDP), and the dependent variables, such as the amount of collected waste, solid waste quantity, recycling amount, recycling rate, incinerated waste amount, incinerated waste rate, compost amount, compost rate, amount of solid waste sent to landfill facilities, and landfill rate.

6. CONCLUSION

As seen from the data provided, Turkey's Gross Domestic Product (GDP) per capita was reported as 4,278 USD/person in 2000, 10,615 USD/person in 2010, and 8,561 USD/person in 2020. Meanwhile, the European Union average GDP per capita was recorded as 16,947 USD/person in 2000, 32,969 USD/person in 2010, and 34,330 USD/person in 2020. In the United Kingdom, where the highest GDP per capita was reported, it was 28,290 USD/person in 2000, 39,693 USD/person in 2010, and 40,318 USD/person in 2020.

Gross Domestic Products (GDP) have experienced fluctuations over the years due to both the conjunctural conditions of the countries where they are measured and global influences. The global economic crisis in 2008 and the COVID-19 pandemic spreading after 2019 have been observed to have effects on the subject countries, while Brexit, especially, has had striking effects on GDP in the UK.

The approximately 5-10% increase in solid waste generation in Turkey and EU countries over the past 20 years, as well as the 5-10% decrease in the UK, is assessed to be attributed to changes in population growth. No significant impact of Gross Domestic Product (GDP) on the total solid waste generation has been detected.

The per capita solid waste generation, which is an important indicator for evaluating a country's waste production and waste management performance, was 465 kg in Turkey in the year 2000, decreasing to 415 kg in 2020, with a change rate of around 10%. In EU countries, it was recorded at 513 kg in 2000, decreased to 480 kg in 2015, and measured at 521 kg in 2020. It is observed that the increase in the last 5 years is attributed to the COVID-19 effect, stemming from home confinement and increased consumption. In the case of the United Kingdom, the per capita solid waste generation was 577 kg in 2000, showing a significant decrease to 463 kg in 2020. This decline is considered to be the success of the UK in reducing waste production or implementing more effective waste management strategies. It can be stated that as the gross domestic product increases, the per capita solid waste generation decreases in all evaluated countries within the scope.

In terms of the parameter of recycling amount, a noticeable positive increase is observed in all countries evaluated within the scope. As gross domestic product increases, it can be interpreted that countries improve their waste management and recycling processes or engage in more recycling activities.

In the examination of the parameter of recycling rate, it is observed that in 2020, Turkey achieved a rate of 12.57%, while in the same year, this rate was reported as 28.89% for EU countries and 25.8% for the UK. Although this rate remains low on the scale of Turkey, it is observed that there is a positive correlation between gross domestic product and the recycling rate.

Under the title of solid waste management, the parameters of incineration, composting, and landfilling of solid waste were evaluated, and the results obtained are as follows:

In Turkey, the amount of solid waste incinerated decreased from 0.36 million tons in 2000 to 0.02 million tons in 2020. This situation is considered indicative of Turkey improving its waste management policies or beginning to adopt alternative waste disposal methods. In EU countries, the amount of solid waste incinerated increased from 36 million tons in 2000 to 60 million tons in 2020. In the UK, the amount of solid waste incinerated also increased from 2.5 million tons to 13.8 million tons. This increase suggests that both EU countries and the UK are employing strategies to burn waste for energy production or waste disposal.

In Turkey, the incineration rate of solid waste decreased from 1.16% in 2000 to 0.06% in 2020. This indicates that Turkey has started to reduce the burning of waste for energy production or waste disposal and has begun to adopt alternative waste management strategies. In EU countries, the incineration rate of solid waste increased from 16.36% in 2000 to 25.86% in 2020. The incineration rate of solid waste in the UK also increased. The rate rose from 7.35% to 44.52% in 2020. These increases in both EU countries and the UK indicate that they have adopted strategies to burn more waste for energy production or waste disposal and have changed their waste management practices.

When examining the compost quantity and rates; In Turkey, both the compost quantity and rate decreased overall between 2000 and 2020. The quantity decreased from 0.23 million tons in 2000 to 0.12 million tons in 2020, and the rate dropped from 0.74% to 0.36%. In EU countries, the compost quantity increased from 23 million tons in 2000 to 43 million tons in 2020 (an increase from 10.45% to 18.53% proportionally). In the UK, the compost quantity also increased. It rose from 0.90 million tons to 5.30 million tons, with the rate increasing from 2.65% to 17.10%.

Landfilling refers to the controlled disposal of waste underground. In Turkey, the amount of solid waste sent to landfills increased from 23.9 million tons in 2000 to 27.9 million tons in 2020. In EU countries, the amount of waste sent to landfills decreased from 112 million tons in 2000 to 54 million tons in 2020. It is also observed that the amount of waste sent to landfills in the UK has decreased. The quantity of solid waste sent to landfills, which was 27.5 million tons, has decreased to 2.60 million tons.

On the other hand, when the landfilling rates of solid waste are examined, it is observed that the landfilling rate in Turkey increased from 77.10% in 2000 to 84.55% in 2020. In EU countries, the landfilling rate decreased from 50.91% in 2000 to 23.28% in 2020 over the 20-year period, while in the UK, the landfilling rate decreased from 80.88% to 8.39%.

While solid waste management approaches such as landfilling quantity and rate have increased in Turkey over the past 20 years, it has been observed that in EU countries and the UK, there has been a rapid shift away from these policies towards incineration and energy generation policies. Additionally, it has been noted that compost production has increased in these countries as part of supporting sustainable agriculture.

Although the impact of Gross Domestic Product (GDP) on solid waste management elements appears limited, from a holistic perspective, its effect on the solid waste management system is positive. This is because in the EU and the UK, which adopt different policies, the quantities and rates of incineration and composting have increased, while the rates and quantities of landfilling have decreased. In Turkey, a different policy has been adopted, leading to an increase in the quantities and rates of landfilling and a decrease in the quantities and rates of incineration and composting. However, the quantity and rate of recycling have increased in all countries in proportion to GDP.
The regression analysis conducted in the study demonstrates the collective impact of the independent variables on the dependent variables in a comprehensive approach. Within the scope of the study, Pooled Least Squares

(PLS), Fixed Effects, and Random Effects Model Estimations and Tests were utilized. Analysis of Gross Domestic Product (GDP) as an independent variable revealed that according to the results of the Classical Model, namely Pooled Least Squares (PLS), all variables were found to be statistically significant. However, it was observed that the Fixed Effects and Random Effects Models were not statistically significant.

According to the results of the study, there is a positive relationship between Gross Domestic Product (GDP) and solid waste management in EU countries, the United Kingdom, and Turkey. In other words, as economic growth increases, solid waste management generally becomes more effective. This indicates that environmental awareness and solid waste management policies develop parallel to economic growth.

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