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RESEARCH ARTICLE

Disaster waste management process: The case of February 6 earthquake

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Abstract

Disaster wastes generated after earthquakes have a negative impact on the environment and living beings and cause damages that last for many years. Within the scope of the study, it is aimed to reveal the importance of the disaster waste management process. For this purpose, the disaster waste management process in the Kahramanmaraş earthquake centered on February 6, which is the world's biggest disaster in 2023, was discussed. In this context, document/record and case study methods were used. In this context, "Waste Management Regulation", "Regulation on Regular Storage of Waste" and "Regulation on the Control of Excavation Soil, Construction and Demolition Waste" were examined. Also, The Landfill Directive, which concerns all member countries of the European Union and is included in the European Union Waste Legislation, was examined in order to compare it with the Turkish Legislation. The study was supported with data from the Turkish Statistical Institute (TSI). It was determined that there was no storage or sorting area for disaster waste in this region according to TSI data, the legislation examined did not contain sufficient and detailed information on the subject, and the reports published by the Union of Chambers of Turkish Engineers and Architects (UCTEA) confirmed that the process was not managed properly in the region. It has been determined that the existing practices and legislation contradict each other, the legislation does not contain sufficient detail, the practices in the world have been investigated within the scope of the subject, and suggestions have been presented in this context. This study is important in terms of revealing the importance and correct positioning of waste storage and sorting areas in order to prevent similar situations in future earthquakes.

1. Introduction

Natural disasters (earthquakes, floods, storms, volcanic eruptions, etc.) are extraordinary events that have occurred since the beginning of the world. While these events are a part of life, they occur at any time and place. Human beings have no influence on the occurrence of natural disasters, and what they can do to prevent them is limited [1]. However, the negative effects caused by a natural disaster can be reduced with a correct management process. The development level of societies plays

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an important role at this point [2]. While underdeveloped countries are the group most affected by disasters and the damages they cause, the situation is different in developed countries. One of the prerequisites for sustainable development in these countries is proper disaster management. Earthquake management covers an important area within general disaster management [3]. Rapid increase in world population; It has created the need for urbanization and industrialization, and in this context, the rate of construction has increased rapidly. This increase in construction rates has increased the risks against natural disasters, especially earthquakes. However, the earthquake factor has not been sufficiently taken into account despite the increase in construction and the result of centuries of seismic behavior [4]. Earthquakes, which also cause various other disasters (e.g. floods, landslides, fires), can have severe environmental effects. In the study of Earthquake and environmental problems, Savcı et al. [5] "In an earthquake zone, dust from collapsing buildings, fires and waterlogging can harm living beings. After an earthquake. Asbestos is a carcinogenic substance and causes major damage to the lungs if inhaled. Fires occur as a result of the toppling of electricity poles and damage to oil and natural gas pipelines after earthquakes".

In 2023, many disasters occurred around the world. Considering the material and moral consequences of these disasters, the 5 biggest disasters are given in Table 1. In the earthquakes centered in Syria and Turkiye, which took the first place in the table and occurred on February 6, 2023, 58,000 people lost their lives and 40 billion dollars of material damage occurred. In this study, this earthquake that occurred on February 6 will be discussed in the context of Turkiye.

Turkiye has been a country where severe earthquakes have occurred throughout history. In the map showing the earthquakes and their magnitudes in Fig. 1, it is seen that the majority of the earthquakes occur in Turkiye. Since 1900, 20 earthquakes greater than magnitude 7 have occurred, as well as 269 earthquakes that caused loss of life and property. Among these earthquakes, the most severe consequences were seen in two earthquakes centered in Kahramanmaraş on February 6, 2023 [7]. In the fault line map in Fig. 2, it is seen that Turkiye is located within 3 different fault lines [8]. These are the Northern Anatolia, Western Anatolia and Eastern Anatolia fault lines [9]. The intensity and multiplicity of earthquakes occurring in Turkiye can be directly related to the geological structure of of the region.

Although located in one of the most active earthquake zones on earth, Turkiye also faces many other natural disasters [10]. The graphs in Fig. 3 show the numerical distribution of disasters in Turkiye and their effects on people. While earthquake ranks second among the most common disasters with a rate of 18%, it ranks first in terms of the rate of people being affected by a rate of 55%.

Table 1. The 5 biggest disasters of 2023 [6]

Date	Country/Region	Event	Fatalities (approx.)	Overall losses US$ bn
6.2.2023	Turkiye, Syria	Earthquake	58.000	40
12–23.5.2023	Italy, Croatia, Austria, Bosnia and Herzegovina	Flood, severe storm	15	10
10–17.6.2023	United States	Severe storm, tornado outbreaks	4	8.4
1–4.3.2023	United States	Severe storm	13	6.0
30.3–1.4.2023	United States	Severe storm, tornado outbreaks	33	5.4

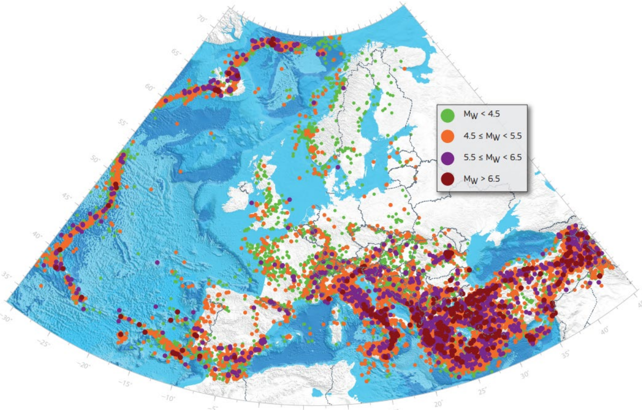

Fig. 1. Earthquake history in Europe [8]

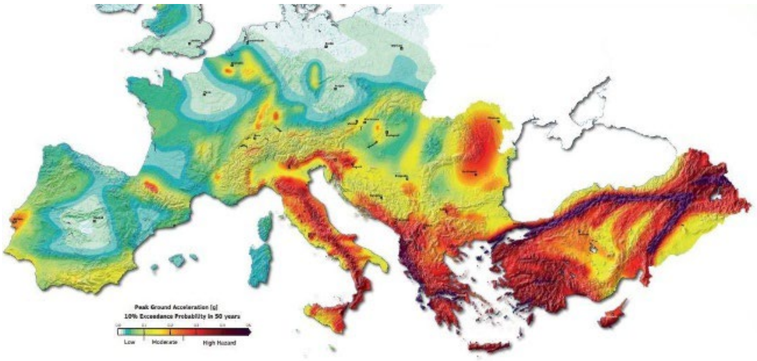

Fig. 2. Active faults in Euro-Mediterranean region [8]

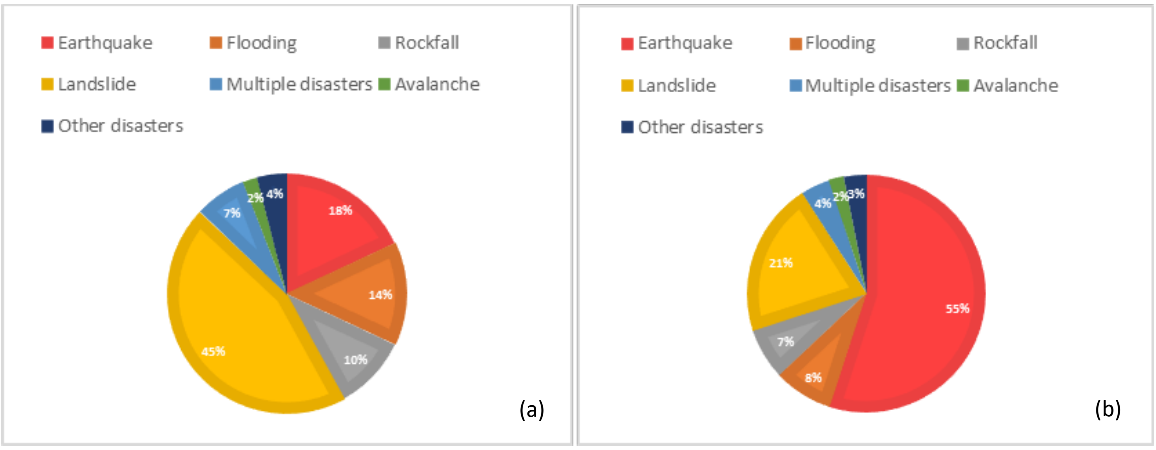

Fig. 3. (a) Disasters in Turkiye in terms of number, (b) Disasters in terms of number of people affected [10]

When we express the issue with numerical data on a provincial basis, Table 2 shows the earthquakes that occurred in Turkiye in the last 30 years and the number of damaged buildings. According to the table, many earthquakes have occurred in Turkiye and have had severe material and moral consequences [9].

Table 2. Earthquakes that occurred in Turkiye between 1993-2023 [9]

Date	Place	Magnitude	Damaged Building
1994	Manisa	5.1	44
1995	Dinar (Afyonkarahisar)	6.1	14.156
1995	Kığı (Tunceli)	5.7	-
1996	Mecitözü (Amasya)	5.6	2.606
1997	Antakya	5.4	1.841
1998	Karlıova (Bingöl)	5.0	148
1998	Ceyhan (Adana)	6.2	31.463
1999	Gölcük (Kocaeli)	7.8	73.342
1999	Düzce	7.5	35.519
2000	Orta (Çankırı)	6.1	1.766
2000	Sultandağı (Afyonkarahisar)	5.8	547
2001	Osmaniye	5.5	66
2002	Çay (Afyonkarahisar)	6.4	622
2003	Pülümür (Tunceli)	6.2	50
2003	Bingöl	6.4	6.000
2004	Kandilli-Aşkale (Erzurum)	5.6	1.280
2004	Doğubeyazıt (Ağrı)	5.1	1.000
2010	Başyurt (Elazığ)	6.1	-
2011	Simav (Kütahya)	5.9	-
2011	Van	7.2	17.005
2011	Edremit (Van)	5.6	-
2020	Seferihisar (İzmir)	6.6	633
2023	Pazarcık-Elbistan (Kahramanmaraş)	7.7-7.6	240.000

The amount of buildings damaged in earthquakes is directly proportional to the amount of waste generated. These buildings have generated millions of tons of hazardous waste in different ways [5, 11]. Some earthquakes and waste amounts are given in Table 3.

Table 3. Some earthquakes and waste amounts in the world [14]

Date	Place	Amount of Waste (10^6 Mg)
1995	Japan	2.000
1999	Taiwan	20
1999	Kosovo	10
1999	Marmara	13
2008	Wenchuan	380
2010	Haiti	23
2010,2011	New Zealand	9
2011	Great East Japan	Not Known Exactly
2015	Nepal	Not Known Exactly
2020	Elazığ	Not Known Exactly
2023	Pazarcık-Elbistan (Kahramanmaraş)	100-138

Accordingly, although the majority of the resulting wastes are construction debris, chemicals, radioactive substances, bituminous mixtures, furniture, living and animal corpses, etc. may also be included in this process [12]. Especially in regions with intense urbanization, rubble and other solid wastes greatly negatively affect living life. Moreover, considering the fact that some wastes contain asbestos, it is inevitable that different negative consequences will occur in the short and long term [13].

Table 3 shows that approximately (100-138)x10^6Mg of disaster waste was generated during the 6 February Kahramanmaraş Pazarcık-Elbistan earthquakes. So how were disaster wastes disposed of in this region? Inspections were made in the region by Istanbul Technical University [15] and the The Union of Chambers of Turkish Engineers and Architects [16] and reports were prepared accordingly. According to these reports, it is stated that disaster waste management is not managed correctly in the region. In the reports prepared by the Union of Chambers of Turkish Engineers and Architects [16] "It has been observed that the work to remove the rubble and debris of collapsed or severely damaged buildings in the region is carried out as construction waste, debris and rubble removal work without taking the necessary measures such as irrigation and waste separation. It has been observed that hazardous chemicals as well as harmful components such as asbestos and dust have been released into the air; it is also known that the debris and wreckage of damaged or collapsed buildings are discharged into nearby agricultural areas, protected areas and industrial zones without the necessary supervision and precautions".

It was desired to determine data for problem detection and solution, Turkish Statistical Institute [17] was requested for location information of waste storage and separation facilities in the region. No information about the existence of storage and separation facilities for disaster waste was found in the Turkish Statistical Institute database. Legislation regarding disaster waste has been examined, but no detailed content regarding the construction of waste storage facilities and waste management could be obtained.

Considering the damage that waste causes to the environment and living beings, it is extremely important to manage the pre- and post-earthquake process correctly. This importance is a critical issue not only in the physical sense but also in the mental context. For this purpose, waste is expected to be collected, stored, separated and recycled at the planned time and methods. Storage and separation areas should be constructed in accordance with detailed regulations in the light of the criteria determined within the scope of planning. The concept of sustainability is another important issue at this point. It ensures that waste is disposed of appropriately at an acceptable cost and that recyclable materials are reused [4, 11, 13, 18].

In summary, correct management of the process requires calculating the amount of damage and waste that may occur and building appropriate storage and separation structures [19, 20]. When the earthquake management process is considered under two headings as pre-earthquake and post-earthquake, before the earthquake, it covers the process of engineering and architecture disciplines taking the necessary precautions and suggestions to ensure the safety of structures and living beings, while after the earthquake, it covers the process of taking debris safely while protecting the health and safety of living beings. It includes continuing the removal operations.

In this study, the waste management process in the earthquake that centered in Kahramanmaras on February 6, 2023 and affected 11 provinces, and the adequacy and applicability of the legislation for this process in Turkiye and Europe were compared and discussed. Based on the Kahramanmaras earthquake example, it includes evaluating debris waste in the context of sustainability and determining the necessary criteria and measures.

For this purpose, it is aimed to ensure that Turkiye, located in the earthquake zone, is prepared for future earthquakes and to minimize the damages caused by earthquakes. In this context, the European Union and Turkish Legislation examined was intended to be a guide, but its adequacy was re-discussed at this point. In order for the study to be an inspiration first to Turkiye and then to other countries, it is aimed to determine certain criteria and rules, as well as to draw attention to the importance of the subject in the context of sustainability and to inspire future studies.

2. Research Methodology

In this study, Pazarcık and Elbistan-centered earthquakes, which occurred approximately 9 hours apart on February 6, 2023, were discussed. It is known that approximately (100-130)x10^6Mg of disaster waste was generated, as it was one of the disasters that caused the greatest damage in world history.

Within the scope of the study, document/record and case study methods, which are one of the qualitative data collection methods, were used.In this context, firstly, a literature review was conducted on the earthquakes that occurred in the world and in Turkiye, the magnitudes of the earthquakes, the information about the structures damaged after the earthquakes and the amount of harmful waste generated after the earthquake; the results were presented as numerical data and tables were prepared.

Some important reports were analyzed in order to understand the waste management process carried out after the earthquake. These are; a joint report prepared by the Union of Chambers of Turkish Engineers and Architects (UCTEA) and the Chamber of Environmental Engineers (CEE) [21] "Chamber of Environmental Engineers Technical Investigation Report: Examination of Asbestos in Post-Earthquake Construction and Demolition Wastes: Hatay Example"; and repared by the UCTEA [16] "6 February 2023 earthquakes report – 2 determinations, evaluations and recommendations”; [22] "February 6, 2023 Earthquakes 8th month Evaluation Report " and prepared by the [20] Strategy and Budget Directorate of the Presidency of the Republic of Turkiye "Evaluation of February 6, 2023 Kahramanmaraş Earthquakes in terms of Infrastructure and Waste Management" and published by Istanbul Technical University [15] "Kahramanmaraş (Pazarcık, Türkoğlu), Hatay (Kırıkhan) and 13.24 Mw 7.7 Kahramanmaraş

(Elbistan/Nurhak-Çardak) Earthquakes Final Report". In line with the data obtained from these reports and other scientific studies, the "average construction and demolition waste found after the earthquake" in 11 provinces in the earthquake zone is expressed numerically in Table 4.

It was seen in the waste management process carried out in the region after the earthquake; The resulting construction and demolition wastes were removed and dumped in random places in a way that threatened living and environmental health. The fact that the process was managed in this way aroused concern in the country, and the same concern was experienced in this study; The direction of the research was shaped to identify the source of the problem. For this purpose, it was aimed to determine why the waste management process was not carried out correctly after the February 6 earthquake and whether this process complies with Turkish Legislation. For this purpose, first of all, to learn the existence and locations of waste storage areas; The number and location information of temporary storage areas on a provincial basis in the earthquake zone were requested from the Turkish Statistical Institute (TSI) [17].

In order to understand how the post-earthquake waste management process should be carried out and to compare how it is carried out in other European countries and our country; Disaster waste legislation of Europe and Turkiye was examined, and then a comparison method was used. However, one of the limitations of the study is that; This study does not have enough time and scope to examine the legislation in all European countries separately. This study is a scientific article that reveals how the post-earthquake waste management process is carried out. For this reason, the " The Landfill Directive " [23], which concerns all European Union member states and is included in the European Union Waste Legislation, was examined to compare it with the Turkish Legislation. In addition, the waste management legislation in force in Turkiye was discussed; In this context, "Waste Management Regulation" [24], "Regulation on Regular Storage of Waste" [25] and "Regulation on the Control of Excavation Soil, Construction and Demolition Waste" [26], were examined.

Examining the legislation changed the direction of the study. While the study was initially started with the aim of discussing the waste management process in detail and investigating waste disposal, in the following process the study turned into a research in which the issue of waste storage came to the fore. For this reason, within the scope of the study, data on the location selection criteria of waste storage areas were mainly included.

Table 4. Current building damage status [15]

The Current Situation	Number of Buildings
Undamaged	860.006
Slightly damaged	431.421
Moderately damaged	40.228
Badly damaged	179.786
Ruined	35.355
Will be demolished urgently	17.491
Couldn’t be detected	147.895
Total	1.712.182

Additionally, in addition to the legislation, two different scientific studies article [27] and thesis [19] conducted in different countries were used. According to these scientific studies, it has been seen that 8 variables such as "geology, distance from settlements, distance from road networks, distance from surface streams, vegetation, slope, elevation and aspect" are important and the location of waste storage areas is chosen according to the locations of these variables. These two different scientific studies found similar criteria. The place of these criteria in Turkish Legislation was examined and numerical data, if any, were presented in this study.

In the last part of the study, evaluations and suggestions were made for the disaster waste management process in order to prevent a similar process from being carried out in earthquakes that are likely to occur in the future.

3. Findings and Discussion

Turkiye, an earthquake country, has experienced many earthquakes throughout history. Earthquakes recorded since 2000 are given in Fig. 4. According to the graph, the year with the fewest earthquakes was 2001, with 599 earthquakes, and the year with the most earthquakes (between January and November) was 2023, with approximately 70,000 earthquakes. Although the number of earthquakes in 23 years has varied, there is an increasing trend over the years and a sharp increase in 2023.

Altunisik et al [28] stated that “The country sits on the boundary between the Eurasian and Arabian Plates, resulting in complex geological dynamics contributing to its earthquake activity”. At this point, considering the geographical location of Turkiye, future earthquakes are inevitable. In this context, pre and post-earthquake management process is extremely important in a country where the earthquake factor plays an active role. Within the scope of the study, the post-earthquake management process is discussed and evaluated in the context of the February 6 Kahramanmaraş earthquake.

Collecting and managing waste in the post-earthquake management process is a critical process for emergency management and disaster response. Failure to manage the process correctly leads to different problems. If construction and demolition wastes are not disposed of correctly, health problems such as cancer and reproduction may occur and the number of deaths may increase.

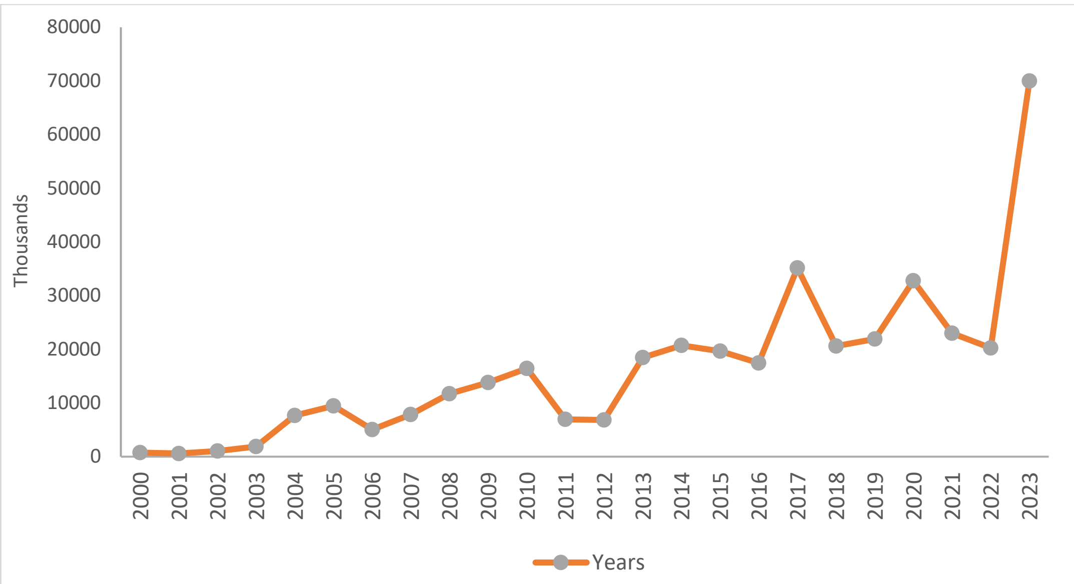

Fig. 4. Number of earthquakes occurring in Turkiye by years [29]

Hazardous chemicals such as methane, radon gas and asbestos, which consist of wastes, pollute the air, soil and water, adversely affecting the environment and human health, endangering marine life and wildlife. If the waste is to be disposed of by unsafe methods such as open incineration, it poses health risks to those living in settlements close to these points [30]. In addition, water channels may become clogged, which may cause an increase in environmental and marine pollution. As a result, floods can occur and lead to malaria, dengue fever and cholera [31]. Improper disposal of organic wastes, an ideal environment is provided for the development of microbial pathogens. In case of direct contact with such solid wastes, chronic diseases and infections occur. Again, failure to manage solid waste safely will lead to the invasion of mice, mosquitoes and cockroaches. Such creatures are disease-carrying pests and these pests cause blood infections and skin irritation in humans [32]. Another factor that causes health problems is that wastes produce bad odors and toxic components leak into water sources [33]. This results in health problems such as bacterial infections, inflammation of the throat and nose, asthma, allergies, difficulties in breathing, and decreased immunity [34].

As can be seen, the waste management process is important for human and environmental health. In this context, the amount of waste generated during the earthquakes centered in Kahramanmaraş on February 6 was analyzed. In Doğdu and Alkan's study [12], the average amounts of construction and demolition wastes were determined (Table 5). According to the table, disaster wastes are classified according to material type.

The average total amount of mass waste, which is $97x10^8$ Mg at the highest rate, includes different construction materials, especially concrete. The second highest is mineral fraction waste with $57x10^8$ Mg. This column refers to concrete, brick, tile and ceramic mixtures that have a high potential for recycling. Hazardous substance waste in the table with the number of $1.5x10^7$ Mg stands out as an alarming amount. It is extremely important to consider the amount and ratio of waste types during debris removal work. As stated in Table 4, the existing wastes in the field should be classified according to their properties, separated and removed from the area, taking into account their chemical effects. In particular, substances that may harm the health of living beings, such as asbestos, dust and smoke, should be handled separately by experts and equipment. Otherwise, it will cause irreversible damage to groundwater, agricultural lands, vegetation and living beings.

There are historical and cultural buildings (mosques, inns, madrasahs, residences, bazaars, streets, etc.) with hundreds of years of history in the region. Turkish cultural heritage was also damaged due to the earthquake. Some of the masonry structures here were severely damaged due to the earthquake, and some were completely destroyed. Considering that these structures are representatives of the past and a source of information for the future, it is thought that they should be evaluated separately in the waste category [20]. In this context, historical building elements intertwined in debris studies should be separated from other debris wastes, documented and stored safely for later use in restoration works. In addition, considering that there are archaeological and urban archaeological sites in the region, the importance of conducting research in the area beforehand, considering it separately from other construction and demolition waste found there (especially underground), and carrying out debris removal work in a way that does not damage the historical texture should be taken into consideration.

When the reports of UCTEA and ITU [15, 16, 22] regarding the waste management process in the region are examined, it is clearly seen that the debris removal process is not managed correctly and there is a lack of coordination.

Table 5. Average construction and demolition waste in the region [12]

Province	Approximate amount of mass waste (Mg)	Dangerous materials (Mg)	Mixture of soil and stone (Mg)	Bituminous mixtures and wood waste (Mg)	Mineral fraction waste (Mg)	Amount of reinforced concrete waste (Mg)	Amount of scrap iron waste (Mg)
Adana	553x10^3	8.3x10^2	93x10^3	124x10^3	326x10^3	220x10^3	5.3x10^2
Adıyaman	11x10^6	158x10^3	1.8x10^5	2.4x10^5	6.2x10^5	4.2x10^5	102x10^3
Diyarbakır	1.7x10^5	24x10^3	270x10^3	360x10^3	949x10^3	643x10^3	16x10^3
Elazığ	1.9x10^5	28x10^3	319x10^3	425x10^3	1.2x10^5	759x10^3	18x10^3
Gaziantep	5.5x10^5	82x10^3	916x10^3	1.2x10^5	3.2x10^5	2.2x10^5	53x10^3
Hatay	4.1x10^6	604x10^3	6.8x10^5	9.1x10^5	24x10^6	16x10^6	389x10^3
Kahramanmaraş	1.9x10^6	279x10^3	3.1x10^5	4.2x10^5	11x10^6	7.4x10^5	179x10^3
Kilis	470x10^3	279x10^3	79x10^3	105x10^3	277x10^3	188x10^3	4.5x10^2
Malatya	13x10^6	201x10^3	2.2x10^5	3.0x10^5	7.9x10^5	5.3x10^5	129x10^3
Osmaniye	3x10^6	45x10^3	506x10^3	675x10^3	1.8x10^5	1.2x10^5	29x10^3
Şanlıurfa	1.2x10^5	17x10^3	194x10^3	258x10^3	680x10^3	461x10^3	29x10^3
Total	96x10^6	1.5x10^5	16x10^6	22x10^6	57x10^6	39x10^6	935x10^3

Fig. 5. Historical buildings in Hatay and Kahramanmaraş that collapsed and were heavily damaged after the earthquake [16]

The necessary and sufficient amount of machinery and equipment was not used in the area. Construction and demolition wastes are buildings and construction elements of historical and cultural importance, collected without taking into account their physical and chemical properties, together with other wastes, dust etc. of trucks carrying disaster waste. It was removed from the area quickly and unsupervised without the necessary separation. Since it is not covered with any material that will prevent the spread of substances, there is almost no irrigation in the area and the necessary precautions are not taken, asbestos, silica, smoke, dust, etc. Dangerous chemicals such as have been released. It was observed that these substances were mixed into the air. It appears that even spending short periods of time in the area poses the risk of exposure to asbestos. This pollution in the city has increased the risk of respiratory tract, cancer and skin diseases in living beings. Fig. 6 shows the debris removal efforts that occurred after the earthquake.

In addition to not being separated according to their physical, chemical, historical significance and characteristics, the wastes were dumped in agricultural and valley areas, empty plains, roadsides, stream beds, olive groves and places close to living spaces, without taking any precautions. This situation causes pollution of water resources, agricultural areas and air, and endangers the health of living beings. In the study conducted by the Chamber of Environmental Engineers [21] on 2 and 3 September 2023, approximately 7 months after the earthquake, a total of 45 solid and dust samples were taken from storage areas, building debris, residential areas, fauna, soil surface and the vehicle used during the study. Asbestos fibers were detected in 16 of the samples taken. This situation is extremely worrying. In addition, in the context of the region's important agricultural lands, polluted soil, water and air will affect not only today but also future generations. Fig. 7 shows the debris dump area in Adıyaman and Malatya. One of the storage areas selected in the earthquake zone is an area found to be 20 meters away from one of the tributaries feeding the Asi River [37]. However, according to the Water Pollution Control Regulation [38], where RTMEUCC (Republic of Turkiye Ministry of Environment Urbanization and Climate Change) was published in 2004, "Short-distance protection area is a 700 meters wide strip starting from the absolute protection area border of drinking and utility water reservoirs. "Storage and disposal of all kinds of solid waste and residues cannot be allowed within the short-range protection area." According to this article, the area to be selected for waste storage areas must be at a distance of 700 meters closest to the ground waters. In this context, it was wanted to examine whether there were suitable areas for waste storage 700 meters away from the Asi River.

Fig. 6. Debris removal works after the earthquake in the region [35, 36]

Fig. 7. Adiyaman and Malatya debris dump area [16]

Google Earth images with a radius of 700 meters were taken from different points in the part of the Asi River within the borders of Turkiye (Fig. 8).

In image number 1 in Fig. 8, it is seen that the Asi River opens to the sea and there are agricultural lands around the river; In images 2, 4, 5, 6, 7 and 8, there are both settlements and agricultural land around the river; In image number 3, it can be seen that there are green areas and the slope is high in this area. It is important that the products produced in agricultural lands are not affected by heavy metals and chemicals found in earthquake wastes and that wastes are not stored in these areas and their surroundings in order not to negatively affect the health of living beings. In addition, waste should not mix or leak into the river in order not to pollute the habitats of underwater creatures where the river opens to the sea. Waste storage in areas with high slopes may cause waste leaks along with rainwater to mix with the river, and storing waste in areas where there are many trees will endanger the living beings and tree stocks in natural areas. For all these reasons, storing waste in the Asi River, near the river and near the tributaries feeding the river is not in compliance with the standards and regulations and the health of living beings.

Research continued to identify and solve problems in the region. Firstly, waste storage and separation areas in the earthquake zone were investigated. In this context, "number and location information of temporary storage areas on a provincial basis in the earthquake zone" was requested from TSI [17]. The answer given to our request is as follows: "The provincial numbers and location information of the temporary storage areas in the earthquake zone you requested are not produced by our institution. It is unknown from which institution it will be covered. For treatment facilities (drinking water and wastewater), a link to the Water and Wastewater Statistics 2020 Bulletin is provided. However, there is no location information for the treatment facilities."

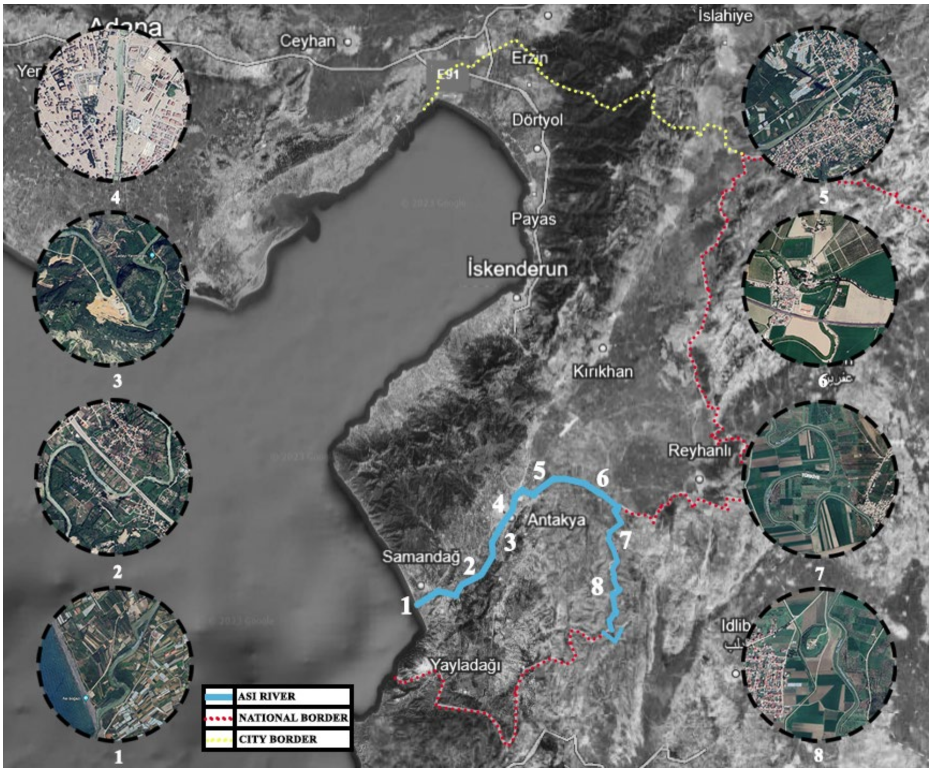

Fig. 8. Detection analysis of the Hatay-Asi River environment [39]

After this answer, it was seen that although the phrase "drinking water and wastewater" was included for the treatment plant, there was no statement in the context of Disaster Waste; It was revealed that in 11 provinces affected by the earthquake, no special storage and/or separation area for waste storage was built or was not included in the records.

After detecting this deficiency in the practice in our country; First of all, a literature review was conducted on disaster waste storage, which is one of the most important issues of the post-earthquake process. Turkish Legislation was examined in order to obtain information about why the post-earthquake waste management process is so difficult in practice in our country, what criteria should be taken into account when choosing the location of waste storage areas, and what the standards in the legislation are. “The Landfill Directive” produced by the European Union in 2018 [23] was examined in order to understand how the post-earthquake waste storage process of the European Union member countries is in practice and to compare it with the storage process in Turkiye.

3.1. European Union Waste Legislation

The European Union is a resource that determines the most ideal rules on "Energy, Climate Change, Environment" and these rules cover all EU member countries. For this reason, instead of examining the waste storage legislation of each country one by one, EU rules were examined. According to the EU's “Waste Hierarchy” landfill is the least preferred option and is limited to a minimum amount (Fig. 9). The most preferred application is the prevention of waste. In fact, the EU commission limits the share of municipal waste thrown into landfills to 10% by 2035. In other words, it is aimed to recycle and reuse 90% of the waste. In addition, Joint Research Center has developed separate statutes and regulations for “iron, steel and aluminum scrap”, “glass cullet” and “copper scrap” in order to transform waste in a correct process [37].

“The Landfill Directive” prepared by the EU and published in 2018 [23] aims to protect both human health and the environment [24].

According to this directive;

- Without endangering human health and harming the environment,
- Without posing a risk to water, air, soil, plants or animals,
- Without causing any disturbance due to noise or odor,
- Waste needs to be managed without adversely affecting the countryside or places of special interest [38].

3.2. Turkish Waste Legislation

In 2015, the "Waste Management Regulation" [24] was prepared by the Ministry of Environment and Urbanization to reduce waste generation, ensure recovery and ensure waste management without harming the environment and human health. According to this regulation, "under normal conditions", the codes of wastes should be determined first. Waste codes are listed in Annex-4 of this regulation.

Fig. 9. EU Waste Hierarchy [37]

According to this list of waste codes, wastes are defined and then their codes are determined. This regulation states that "Wastes are stored in temporary storage areas in accordance with the criteria determined according to their types (so that the wastes do not react with each other)". This statement explains how wastes generated under normal conditions should be separated before being delivered to temporary storage facilities. However, after unexpected natural disasters such as earthquakes, the wastes need to be removed as soon as possible and often the wastes cannot be separated according to their codes at the site of the earthquake (i.e. at the site of the earthquake). There is no description in the legislation on on-site sorting of wastes after unexpected natural disasters such as earthquakes. This shows that there is a gap in the legislation on how to segregate waste in sudden shock situations. Published in 2010 in the Official Gazette, the "Regulation on the Landfilling of Wastes" [25] sets out the rules for the landfilling of wastes after sorting. According to this regulation, landfill facilities are classified as class I, II and III. In the relevant regulation, general criteria for the distance of landfills from settlements are also mentioned. The location decisions of landfills according to settlements are as follows: "Class I landfills must be at least one kilometer away from settlements; Class II and Class III landfills must be at least two hundred and fifty meters away from settlements". According to this information, class II and III landfills can be located within 5 minutes walking distance from settlements (250 meters = 5 minutes walking distance). However, this distance is close enough for a child to walk to the settlements. When the location selection criteria of storage areas are examined;

- Whether the sanitary storage facility affects air transportation safety,
- Distance to areas protected for special purposes such as forest areas, afforestation areas, wildlife and vegetation protection,
- The status of underground and surface water resources and protection basins in the region, groundwater level and groundwater flow directions,
- Topographic, geological, geomorphological, geotechnical and hydrogeological condition of the site,
- Flood, landslide, avalanche, erosion and high earthquake risk,
- Prevailing wind direction and rainfall,
- Natural or cultural heritage status, and the absence of pipelines or high voltage lines used to transport fuel, gas and potable water on the site are taken into account.

EU and Turkish Waste Legislation has been examined from the above framework. While the EU's legislation consists mostly of goal-targeted strategies; In Turkish Legislation, general goals and objectives are conveyed through regulations. After this general review, the criteria to be considered in choosing a waste storage facility location were examined in the national and international literature. In the study of Sekulović and Akovljević [27] there are 8 criteria for location selection of storage areas. These are: geology, distance from settlements, distance from road networks, distance from surface streams, vegetation, slope, elevation and aspect [27]. According to the thesis prepared by Kipel, there are 6 criteria. These; main roads, railways, rivers, settlement, slope and aspect [19]. These criteria have a significant impact on the location selection of waste storage areas. In line with these determined criteria, the standards given in the legislation have been examined and explained below;

3.2.1. Geology

The sanitary landfill should be located in areas where the possibility of groundwater contamination is low, that is, the layer under the landfill will have low permeability (clayey soils) [27].

3.2.2. Distance to settlements

Landfills should not be built near urban or rural areas due to the negative impact on people's health, odor and noise. In Turkish Legislation, according to the Regulation on Landfilling of Wastes published in the Official Gazette in 2010, landfill facilities are classified as class I, II and III. According to the relevant regulation, the location of landfills in relation to settlements should be as follows: Class I landfills should be at least 1 kilometer away from settlements; Class II and Class III landfills should be at least 250 meters away from settlements. The EU Waste Landfill Directive defines the minimum distance to residential areas as 500 m [40].

3.2.3. Distance to road networks

Landfills should be located close to existing road networks [27]. Because building new roads causes new costs. If this distance had to be expressed numerically, storage areas should not be located closer than 200 meters and not further than 10 km from main roads [19]. Additionally, taking into account all weather conditions; Alternative routes should be planned to reach the site.

3.2.4. Distance to water presence

According to the Water Pollution Control Regulation published by the Ministry of Environment, Urbanization and Climate Change in 2004, "Short-distance protection area is a 700 meter wide strip starting from the absolute protection area border of drinking and utility water reservoirs. "Storage and disposal of all kinds of solid waste and residues cannot be allowed within the short-range protection area." According to this statement, the area to be selected for waste storage areas should be at least 700 meters from groundwater and the absolute protection area boundary of drinking and potable water reservoirs. The EU Waste Landfill Directive defines the minimum distance to permanent water streams and water sources as 500 meters. Additionally, the storage area should be in a location without flood risk [40].

3.2.5. Flora

Pastures, irrigated and non-irrigated productive areas are not suitable lands for waste storage [27].

3.2.6. Slope and elevation

Areas with high slopes and altitudes are not suitable for landfills. Because slope affects the possibility of erosion rate, groundwater, surface runoff and the amount of water in the soil. For this reason, the most suitable places for storage areas are areas with a slope of less than 20%, surrounded by hills and at medium altitudes [27].

3.2.7. Slope exposure

Wind plays an important role in dispersing odors from landfills and transporting them to surrounding urban areas. Therefore, the prevailing wind direction and speed are critical for landfill location [27]. Since odors arising from storage areas should not be felt in urban areas; The aspects of waste storage areas facing the direction of the prevailing winds are not suitable for landfills. In addition, the speed of the wind should also be taken into account. High wind speeds can cause odors to be carried further afield. The distance of the landfill to residential areas and land characteristics should also be taken into consideration during the planning process.

3.2.8. Railways

Since solid waste is not transported by rail, there is no harm in waste storage areas being far from these roads. On the contrary, it is beneficial for these storage areas to be far away in order to avoid visual and odor pollution on the railways. The ideal distance of waste storage areas for railways has been determined as 1000 meters [19].

When the criteria determined in the literature review are blended; It has been observed that 8 criteria, including "geology, distance from settlements, distance from road networks and railways, distance from surface streams, vegetation, slope and height and aspect", are important in choosing the location of waste storage areas and each criterion has certain numerical or qualitative standards.

3.3. Some procedures for managing construction waste worldwide

Analytical approaches to waste management have been investigated worldwide and some of them are listed in Table 6. There are some explanations about the procedures in the table content.

New South Wales (NSW) Environmental Protection Agency (EPA) Specifications for Supply of Recycled Materials for Pavement, Earthworks, and Drainage, developed in Australia in 2010 encouraging the recycling of construction waste, Australia recycled 13.6×10^6 Mg of waste in 2016 and 2017. This amount corresponds to a recycling rate of 67% [47].

The Green Building Plan, developed in China in 2013, aims to improve environmentalism in cities whose priority themes are energy efficiency. There is increasing interest in the development of green building technology in China [48].

The Comprehensive Information Platform for Construction and Demolition Waste developed in China in 2014, aims to management examples of the principles of reduce, reuse and recycle were analyzed. In China, the lack of building design standards to reduce construction and demolition waste has been found to include low costs and inappropriate urban planning for their disposal. It has been observed that there is a lack of guidance regarding the collection and classification of waste, and a lack of information and standards regarding the reuse of waste. In this context, this article offers suggestions to improve the current situation based on the 3R principle [43].

The Circular Economy Promotion Plan, developed in China in 2015, aims to create an effective circular economy model is important construction waste can be used not only for buildings but also for other industries. In the construction industry, concrete, bricks, and mortar can be converted into recycled materials such as concrete, aggregate [43].

In the study of Ma et al. [42] “In recent year, Chinese government spent a great effort to encourage waste reduction.

Table 6. Average construction and demolition waste in the region [41]

Country	Year	Construction and Demolition Waste (CDWM)
Australia [47]	2010	New South Wales (NSW) Environmental Protection Agency (EPA) Specifications for Supply of Recycled Materials for Pavement, Earthworks, and Drainage
China [42]	2013	Green Building Plan
China [43]	2014	Comprehensive information platform for Construction and Demolition Waste
Japan [42]	2014	Construction Recycling Plan
China [43]	2015	Circular Economy Promotion Plan
Spain [45]	2015	Incorporation of Construction and Demolition Waste Plans in Detailed Building Design
EU countries [44]	2015	Europe Union Action Plan for Circular Economy
USA [46]	2016	Resource Conservation and Recovery Act
China [42]	2016	Environmental Protection Law
Australia [47]	2016	NSW Road and Maritime Services Technical Guide for Management Road Construction and Maintenance Wastes
China [42]	2017	Circular Development Plan
Australia [47]	2018	National Waste Policy
Japan [42]	2019	Government Funding for Construction and Demolition Waste Research and Recycling Businesses
USA [46]	2019	Deconstruction of Building Law
Australia [47]	2019	NSW EPA CDWM Standarts

Issue of Plan for comprehensive utilization of solid waste (2011), Green building plan (2015), Circular Development Plan (2017) and Notice of Trials on Construction Waste Management (2018) represents the national awareness of detrimental effects from construction and demolition waste, aiming to reduce the waste from designing, extend recycling scale and promote development of recycling technology. As for the promotion of corresponding standards and regulations, adequate regulatory system of waste recycling is one of the main challenges. Recycling of construction and demolition waste is voluntary. In addition, landfill or dumping are considered as the first choice for contractors to dispose waste, because of low landfill charging fee".

The Europe Union Action Plan for Circular Economy developed in Europa in 2015, aims for construction and demolition activities in the European Union produce $850x10^6$ Mg of construction and demolition waste annually. The Waste Framework Directive has set a recovery target to achieve 70% CDW recycling by 2020 [44].

The Deconstruction of Building Law developed in USA in 2019, different waste processes are followed in the USA. The focus areas of these processes are waste, management and their enforcement, reduction, recycling, reuse and disposal within the scope of sustainability [46].

4. Conclusions

Within the scope of the study, the waste management process of the earthquakes that took place on February 6, 2023 and affected 11 provinces, centered in Pazarcık and Elbistan, was discussed. As a result of the studies carried out in the region, it has been seen that the process is carried out in a way that endangers living and environmental health, and its effects will continue not only today but also for years to come. The information revealed in this review will be valuable to researchers and practitioners in revealing disaster waste management and helping them understand the realities in the context of the inadequacy of the current system. Although the study covers the example of the earthquake that occurred in Kahramanmaraş on February 6, rapid urbanization and population growth around the world, directly related to the amount of waste, shows that the problem is universal. There are studies all over the world to separate, store and reuse waste. However, these do not contain sufficient and applicable details and studies. It is aimed to improve existing legislation and practices, and to raise awareness for a more livable world in the future.

During the debris removal works in the earthquake that was within the scope of the study and affected 11 provinces (Kahramanmaraş, Gaziantep, Şanlıurfa, Diyarbakır, Adana, Adıyaman, Osmaniye, Hatay, Kilis, Malatya and Elazığ),

- Necessary measures such as irrigation and waste separation are not taken in the region,
- Without carrying the harmful materials to a safe area, all the debris was dumped together in a hasty and uncontrolled manner and spread to the dumping area through construction equipment,
- No sorting process was carried out while the debris was being evacuated,
- The preferred dumping areas are productive agricultural areas, and they are dumped in areas where fruit and olive trees are located and in areas close to living spaces,
- High and widespread platforms of thousands of square meters consisting of debris and ruins formed in dump areas; is exposed to external factors uncontrolled and unprotected, and mixes with the air, water and soil through factors such as rain, snow, wind, etc.,
- Debris and ruins of damaged or collapsed structures were dumped into agricultural areas, conservation areas and industrial zones in the nearby regions without taking the necessary inspections and precautions,
- Trucks carrying debris load and unload without speed control, causing security and transportation problems in city centres,
- In addition to hazardous chemicals, harmful components such as asbestos and dust are released into the air,

- It was determined that historical and cultural structures were removed along with other debris without any sorting or taking precautions.

Again, within the scope of the study, existing storage areas were investigated to solve the problems, but no information could be obtained from TSI (Turkish Statistical Institute) regarding the existence of waste storage and separation areas. The study continued by focusing on the deficiencies in the legislation and the following determinations were made, debris removal operations after the earthquake in Turkiye are under the responsibility of the relevant municipality under the coordination of the Disaster and Emergency Management Presidency (DEMP) and the Ministry of Environment, Urbanization and Climate Change (MEUCC). These municipalities were first mentioned in article 13 of the Regulation on the Control of Excavated Soil, Construction and Demolition Wastes published in the Official Gazette in 2004 [26] "recovery, disposal and/or disposal of construction/demolition waste and all other waste outside permitted facilities; It is forbidden to pollute the environment by dumping, filling and storing into soil, seas, lakes, streams and similar receiving environments." must be aware of the statement. However, according to the reports, publications and news regarding the disaster management process carried out after the earthquake, river banks, agricultural areas, orchards, olive groves and places very close to forest areas were chosen as waste storage areas for the waste generated after the collapse. In addition, the Regulation on the Control of Excavation Soil, Construction and Demolition Wastes states that [26] "it is essential to minimize construction and demolition waste at the source in a way that does not harm the environment". However, it has been stated in many news sources and scientific publications that this principle was not followed in the February 6 earthquake, and that the entire ruin was generally accepted as a single type of construction/demolition waste, and that household waste was transported to vehicles. This shows that the process was acted without adhering to the legislation from the very beginning. Again, in paragraph E of Article 5 of the same regulation, there is a statement: [26] "Separation of wastes at the source and selective destruction are essential for the establishment of a healthy recovery and disposal system". Since the principle of on-site and selective destruction, which is the first step to be taken after the earthquake, is not taken into account, it has become clear that the healthy recovery and disposal of waste will not occur.

- According to the EU's Waste Hierarchy, the first decision is to create essentially no waste. After waste is generated, the second goal is to transform and reuse these wastes. The EU commission has created separate statutes and regulations for the recycling of waste. The same study was not carried out in Turkish Legislation; Additionally, in practice, it has been observed that earthquake wastes are taken directly to landfills without being sorted. Just as the EU Commission created to ensure waste recycling, a separate statute or regulation should be prepared for each waste in Turkish Legislation.
- According to the EU's Waste Landfill Directive, the distance of landfill areas to residential areas should be at least 500 meters. However, according to Turkish Legislation, the minimum distance is 250 meters. This situation actually shows that the decision taken in Turkiye is not in line with the EU and that the development direction of the urban macroform is ignored in the location selection criteria of these facilities. Because for Class II and III storage facilities, it is stated that they can be located within 250 meters of residential areas. However, considering the growth rate of cities, cities can spread to a distance of 250 meters towards their periphery within a few years. It can be understood that the growth directions and speeds of cities were not evaluated while preparing the legislation, and this is contrary to reality.
- According to the EU's Landfill Directive, the distance of landfills to all water bodies must be at least 500 meters. According to Turkish Legislation, it is stated that drinking and utility water must be at a minimum distance of 700 meters from the protection band. However, no additional explanation was made about the presence of all

water. In practice, it has been observed that the 700 meter standard is not complied with in the Hatay Asi River example mentioned above. In order to eliminate this uncertainty, it is necessary to clearly determine the distance of storage areas to all water resources.

• The geology and vegetation of cities are one of the most important criteria affecting storage areas. Especially, as in the case of the Asi River, places surrounded by agricultural lands, that is, irrigated fertile lands and with preserved natural vegetation, should not be used as storage areas, and thus the negative effects of waste on living beings and human health should be minimized. Additionally, there is information on the official website of Hatay Governorship that the clay level in the south and southwest of the city has reached a thickness of 100 m [49]. Since these regions contain clay, which is an impermeable soil, they can be taken into consideration when choosing the location of storage areas.

• It has been mentioned that slope, height and aspect are important in choosing the location of storage areas. When choosing a location for storage areas, the slope should be less than 20% to prevent waste leaks; Medium-altitude areas where erosion is unlikely to occur should be chosen. In addition, in order to prevent the waste in storage areas from spreading to urban and natural areas by wind, storage areas should not be chosen parallel to the prevailing wind direction.

• Using existing highways to transport waste, preventing the cost of new road construction, and designing them close to alternative roads ensures that waste storage areas are accessible under all weather conditions. For this reason, storage areas are far from railways; It must be close to existing highways.

5. Recommendations

The debris removal process is a matter that requires expertise and planning. Many earthquakes have occurred around the world and it is inevitable that they will occur in the future. Every disaster that occurs unplanned and without foresight, where science is disabled, will be the product of a conscious choice with heavy material and moral consequences. Some suggestions for the disaster waste management process are given below.

• It is necessary to raise awareness of communities about disaster wastes.

• Legislation should be developed to include detailed plans for pre- and post-earthquake construction processes, especially in earthquake zones and legislation should include all details covering the storage and recycling of disaster waste,

• In order to manage the process correctly, waste storage and sorting areas should be constructed and debris should be transported to these areas safely with experts and appropriate equipment,

• Storage areas should not be close to agricultural areas, water bodies and habitats,

• Plans for recycling should take into account environmental, health and economic factors,

• Safe storage areas should be established for non-recyclable wastes and they should be disposed of in a way that does not harm the environment and human health,

• The recycling of waste, the correct use of recycled materials, specialised recycling plants should produce economic and environmental advantages,

• Renewable energy sources and environmentally friendly technologies should be developed and sustainability should be ensured

• An area-specific conservation approach and plans should be developed for the historic buildings area,

• A national and international co-operation network should be developed.

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Author Contributions

M. Kasapoglu: Conceptualization, Methodology, Investigation; Y. D. Ercek: Investigation, Writing-Original Draft; M. T. Aslan: Formal Analysis, Writing-Original Draft, Visualization.

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