Environ Res Tec, Vol. 4, Issue. 4, pp. 377–385, December 2021

Environmental Research and Technology
https://ert.yildiz.edu.tr - https://dergipark.org.tr/tr/pub/ert
DOI: https://doi.org/10.35208/ert.858528

Environmental Research & Technology

Research Article

The agricultural waste inventory on the regional basis in Turkey: Valuation of agricultural waste with zero-waste concept in the scope of circular economy

Simge SERTGÜMEÇ*, Ayşe Nur USTA, Cevat ÖZARPA

[1]*Department of Environmental Engineering, İstanbul Technical University, İstanbul, Turkey*

ARTICLE INFO

Article history
Received: 11 January 2021
Revised: 18 November 2021
Accepted: 30 November 2021

Key words:
Agro-wastes; Anaerobic digestion; Bio-energy; Circular economy; Waste-to-energy; Zero-waste

ABSTRACT

Turkey is an agricultural country. Agriculture has an important share among our livelihoods in Turkey. Apart from the parts that are used as a result of agricultural activities, which have direct economic value and are sent to various industries for processing, there are also non-consumption or unused parts of the agricultural products. Therefore, agricultural activities bring a large amount of agricultural waste with them. However, as long as agricultural wastes are not valued, they can be considered as a significant economic loss. Similar to the increase in world population, the population of Turkey increases rapidly. Of course, this growth in the population brings energy needs with it. However, environmental damage caused by greenhouse gas emissions released into the atmosphere due to the use of fossil resources and reserve shortage leads us to look for renewable energy sources. Therefore, biogas production from organic wastes as a sustainable approach allows agricultural wastes formed in high quantities in Turkey, problematic for farmers for different ways and seen as an economic loss to be converted into energy forms. In the study, biogas production was supported by the anaerobic digestion system method in order to convert various agricultural wastes in the different regions of Turkey into an energy form. While producing energy from biogas, digestate can be re-fed to agricultural lands as fertilizer. In this study, agricultural waste inventory has been created for seven different regions and suggestions for future have been given.

Cite this article as: Sertgümeç S, Usta AN, Özarpa C. The agricultural waste inventory on the regional basis in Turkey: Valuation of agricultural waste with zero-waste concept in the scope of circular economy. Environ Res Tec 2021;4:4:377–385.

INTRODUCTION

People need foods to sustain their vital activities. And, they will need these foods throughout their lives. For this purpose, human beings must provide food regularly. Agriculture is one of the basic activities that provide the foods needed for nutrition, which is the basic need of human beings. Therefore, it is very difficult to think of a life without agriculture. Also, according to the Chauhan, almost two thirds of the world's population is based on agricultural production [1].

The agricultural sector has an important place on a global scale. Even if it varies from country to country, it affects many areas such as the level of development and social lifestyle of societies [2].

***Corresponding author.**
*E-mail address: sertgumec@itu.edu.tr

This paper has been presented at EurAsia Waste Management Symposium 2020, İstanbul, Turkey

Published by Yıldız Technical University Press, İstanbul, Turkey

The agricultural sector provides many benefits such as feeding people, contributing to the national income, meeting the raw material needs of the industrial sector. Therefore, it is one of the most important sectors in all countries [3]. According to FAO [4], primary crop production in 2018 was 9.2 billion tons for globally. This amount is approximately 50% more than the amount produced in 2000 [4]. As Agamuthu [5] stated that the annual amount of agricultural waste produced is 998 million tons for globally. Considering that the human population will increase in the coming years, it is expected that agricultural production will increase to supply the nutritional needs of people. With the increase in agricultural production, the amount of waste generated is expected to increase [6].

The agricultural sector has played very important roles in the economic and social development of Turkey since the establishment of our Republic. It not only provides nutrition of the country population, but also contributes to national income and employment [7]. The agricultural sector, which has an important place for the industrial sector, also meets the need for raw materials in the industry. By the way, the agriculture sector is indispensable in terms of exports. Because it also contributes to exports directly or indirectly. Agriculture sector is even more important in Turkey. Because Turkey is one of the developing countries and the agricultural sector is effective in meeting the nutritional needs of people in the strategic sense [7].

It is known that Turkey is an agricultural country. Agriculture has an important share among our livelihoods in Turkey. Apart from the parts that are used as a result of agricultural activities, which have direct economic value and are sent to various industries for processing, there are also non-consumption or unused parts of the agricultural products. Therefore, agricultural activities bring a large amount of agricultural waste with them. As a result of different agricultural activities, agro-waste occurs. And, actually it includes wastes from farms, poultry houses and slaughterhouses, harvest waste and manure [8].

Similar to the increase in world population, the population of Turkey increases rapidly. According to the latest data of Turkey Statistical Institute (TUIK), Turkey's population in 2018 compared to the previous year increased by 1 million 193 thousand 357 people [9]. This number represents a significant population increase and is expected to increase in the coming years. With this population increase, the amount of nutrients that will be needed for nutrition will also increase. This situation will bring with it an increase in agricultural activities. Along with agricultural activities, an increase in the amount of agro-waste can be expected. However, as long as agricultural wastes are not valued, they can be considered as a significant economic loss.

In the developing and changing world, waste production and increase, presence of people, population growth, technological developments etc. is a natural result. Considering the world population of 7.2 billion and the fact that it continues to increase day by day, the main issue is not waste disposal, but management. It is same for the agricultural wastes of course. By adopting the concept of waste to energy (WtE) -and so zero-waste concept- we are not only choosing a sustainable and clean energy for our future, but also expanding our perspective on waste disposal and waste management. Thus, the management shows the potential to make the transition from linear economy to circular economy.

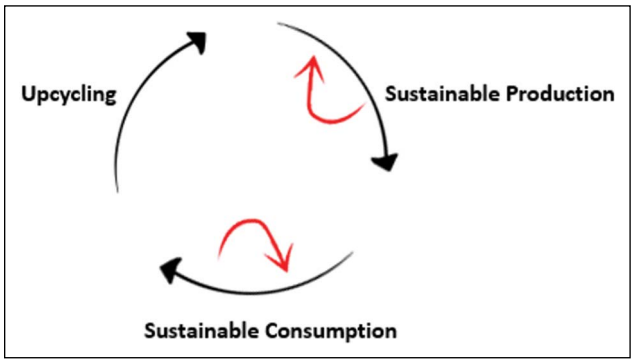

Figure 1. Economy chain according to the circular economy model [11].

Unlike waste disposal; circular economy concept handles the design of waste, changing the way of production and usage with a holistic approach. Thus, it aims to reduce the use of raw materials and reduces the amount of waste. It tells us that recycling and reuse technologies should be developed and implemented effectively, therefore it aims to ensure resource efficiency and achieve zero waste [10]. As it is shown in Figure 1, in this way sustainable production and sustainable consumption can be available in the economy chain according to circular economic model.

Removal and disposal of agricultural wastes resulting from agricultural activities or agro-industrial wastes from industries using agricultural products is only a classic solution. However, this should not be seen as a solution. Because these agricultural wastes are actually substances with "economic value". With the circular economic approach, this type of wastes will be valued, the principle of zero waste will be followed and contribution will be made to the national income.

Another issue is, the growth in the population brings energy needs with it. However, environmental damage caused by greenhouse gas emissions released into the atmosphere due to the use of fossil resources and reserve shortage leads us to look for renewable energy sources.

The issue of obtaining energy from fossil fuels is important due to the damage it has caused to nature. In the light of the work of Coban and Kilinc [12], the use of fossil fuels in energy production significantly increases the pressure on natural resources. In addition, fossil fuels are one of the main causes of climate change. Therefore, considering the

conditions such as limited reserves, pressure on resources and causing climate change, it turns out that the use of renewable energy resources is a must.

According to the energy report published by WWF [13], it is not impossible to meet almost all of the universal demand for energy in 2050 by renewable energy. In this context, the world and in Turkey, is continuing efforts for efficient use of renewable energy sources, aimed at increasing the total energy production in the share of renewable energy sources. In 2014, by the Ministry of Energy and Natural Resources "Turkey's National Renewable Energy Action Plan" was prepared. Also, by 2023, the energy used across the country share of renewable energy sources used in Turkey is aimed to increase to 30% in total.

Recently, the concepts of circular economy and energy production from waste have come to the fore and are important. As D'Amato [14] states that circular economy and bio-economy concepts are sustainable concepts that are put forward in place of the fossil-based economy currently in existence. So, agricultural wastes can be converted into a form of energy and can be evaluated in Turkey. Thus, agricultural wastes, which are a big problem for agricultural fields and farmers, will not be a problem anymore but will also be valued.

If effective management for agro-wastes and correct control for pollution effects on the environment and climate change are provided, all types of waste assessed under waste-to-energy (WtE) technologies tend to have the opportunity to be an important source of energy and to display fuel for a sustainable future. In particular, according to UNEP [15], with the biomass, the investment increase in the waste to energy sector only in 2011–2012 is around 186% and there is a total investment of 1 billion USD in this sector.

Among the many technologies included in the concept of energy production from waste, biogas production through the anaerobic treatment process is a very popular subject.

As Askari [16] states that, biogas production is carried out through microorganisms due to the fact that they don't meet with the air after long periods and create anaerobic conditions. In addition, biogas production can be produced anaerobically via reactors or naturally in landfill areas. Biogas production with the help of anaerobic process is a logical approach for the evaluation of agricultural wastes. In particular, an agricultural country like Turkey, considering that serious agricultural waste has occurred, it is necessary to evaluate agricultural waste through anaerobic digestion.

As it is explained in perspective of Lier, Mahmoud & Zeeman [17], the anaerobic treatment (AD) of complex wastes involves two main stages; the first stage is basically called the "Acid Fermentation" and in this stage, large compounds, such as carbohydrates, fats, proteins, are broken down into smaller components, namely monomers. And the second stage of the anaerobic treatment (AD) is called the "Methane Fermentation" [17]. In the second stage, end products of the acid fermentation stage are converted to gaseous form which includes mostly methane.

In the first stage, complex components of the waste, including fats, proteins and polysaccharides, are hydrolyzed to their component subunits. According to Wilkie [18], this is accomplished by a heterogeneous group of facultative and anaerobic bacteria and these bacteria then subject the products of hydrolysis (triglycerides, fatty acids, amino acids and sugars) to fermentation and other metabolic processes leading to the formation of simple organic compounds. After this step, the large substances are separated into smaller units, which are converted to Volatile Fatty Acids (VFA) during the Acidogenesis step. The overall process up to now is called acid fermentation. After the Acid Fermentation stage, the resulting Volatile Fatty Acids (VFAs) are converted to Acetate. In the second stage, the end products of the first stage are converted to gases (mainly methane and carbon dioxide) by several different species of strictly anaerobic bacteria. Thus, it is here that true stabilization of the organic material occurs. This stage is generally referred to as methane fermentation and this is how biogas production occurs. In addition, the digestate formed as a result of the anaerobic digestion process where biogas is produced can also be used as fertilizer [19].

Activity in the fertilizer sector in Turkey is increasing every year. In fact, it is observed that fertilizer production increases on a yearly basis, but the need increases as consumption is very intense [20]. This means that production cannot meet consumption in our country. And, those needs are tried to be met by means of imports in Turkey and less than about 10% of the production is also exported [20].

Turkey may show little change from year to year in fertilizer consumption because of climatic conditions, product range, economy, etc. But in general, the annual average is 5–6 million tons [20] for the consumption of fertilizer. By the way, sources of raw materials for chemical fertilizers, especially in Turkey are not available; therefore, the chemical fertilizer sector is more than 90% foreign dependent in our country [20]. Considering the statistics, only in 2017 there was 6.3 million tons of chemical fertilizer consumption, and 85% of it was imported [20]. This means approximately 5.4 million tons.

Turkey's import needs to be done to meet the fertilizer means a significant cost. In our country, serious costs arise for the import of chemical fertilizers every year. For example, according to different fertilizer types the cost varies from 170 USD to 370 USD per ton [21]. Considering that there is an average of 5.5 million tons of imported chemical fertilizers per year, the amount of money we export for a year is serious.

With the approach of evaluation of agricultural wastes through anaerobic digestion, not only energy is obtained by producing biogas from agricultural wastes; but also Turkey

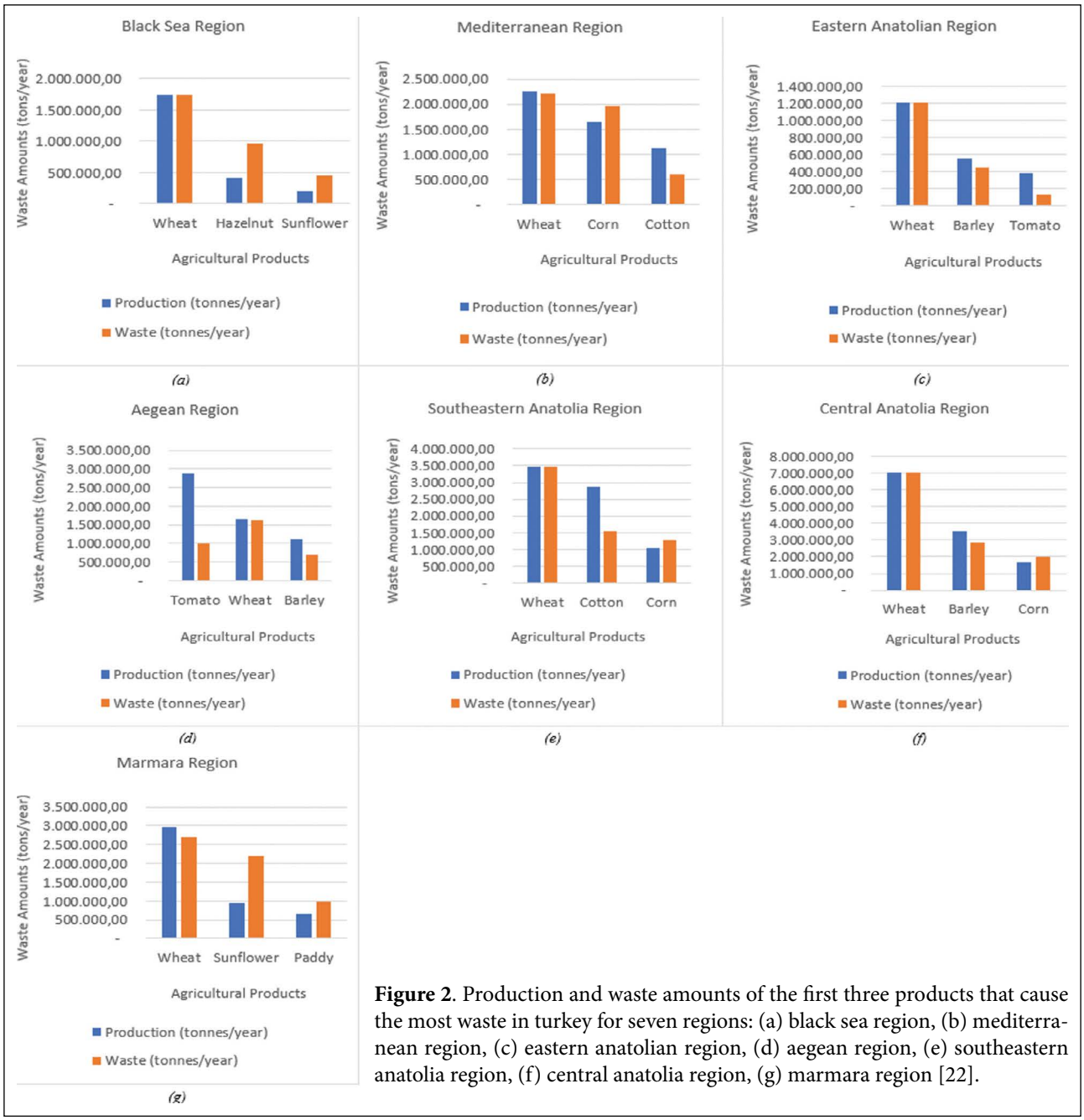

Figure 2. Production and waste amounts of the first three products that cause the most waste in turkey for seven regions: (a) black sea region, (b) mediterranean region, (c) eastern anatolian region, (d) aegean region, (e) southeastern anatolia region, (f) central anatolia region, (g) marmara region [22].

can contribute to the need of fertilizers with digestate resulting from the process.

Biogas production from organic wastes as a sustainable approach allows agricultural wastes formed in high quantities in Turkey, problematic for farmers for different ways and seen as an economic loss to be converted into energy forms.

Regarding the execution of all these studies, crops grown in seven different regions of Turkey is important. There is a need for an inventory containing current production data and information on the amount of agricultural residues arising from production for Turkey.

MATERIALS AND METHODS

There are seven different regions in Turkey. Different agricultural activities are observed in these regions due to different climatic features.

First of all, in the scope of the study, the agricultural products causing the most agricultural waste generation were identified for seven different regions and an inventory of agricultural waste on a regional basis has been established in Turkey. This is one of the first studies in detail for this kind of inventory in Turkey.

Detailed research has been done on the current fate of agricultural wastes determined on a regional basis and at the same time, farmers were contacted and information about the situation was obtained by done surveys to them. 3 farmers from each region were surveyed about their problems of residues. Firstly, they rated the problems from 1 to 10. Then, 2 main questions were asked to them.

Especially by contacting farmers from each region, the problems caused by agricultural wastes were learned and information about the fate of agricultural wastes was obtained.

Within the scope of the study, firstly, a large literature review was conducted. The importance of agriculture from past to present is at the forefront. While agricultural activities are indispensable for people, they also bring some problems. Therefore, extensive research has been done on agro-wastes arising from agricultural activities. Based on the zero waste approach, information was obtained on methods for the evaluation of these wastes.

Fertilizer sector of Turkey is examined in detail. Starting from the findings, the relationship between Turkey's fertilizer production and consumption were observed.

Detailed research has been done on anaerobic processes. Studies on the evaluation of agricultural wastes through anaerobic digestion have been examined worldwide and their contribution to the national income has been examined.

In the study, biogas production was supported by the anaerobic digestion system method in order to convert various agricultural wastes in the different regions of Turkey into an energy form. As a result of the process, besides biogas production, nutrient-rich digestate is formed. While producing energy from biogas, digestate can be re-fed to agricultural lands as fertilizer.

An agricultural waste inventory has been created for seven different regions.

With the amount of waste generated depending on the waste inventory, the potential for biogas is reached. This potential is introduced to contribute to energy production in Turkey. In addition, it has been revealed to what extent the digestate formed as a result of the anaerobic digestion process can meet the fertilizer requirement used in agricultural areas.

RESULTS AND DISCUSSION

Turkey shows a big density of agricultural activity and a high amount of agricultural waste is produced. According to the Ministry of Energy and Natural Resources General Directorate of Energy Affairs of Turkey-Biomass Energy Potential Atlas (BEPA) [22], the current crop production amount is 184.6 million tons/year in Turkey; and the residues generated from this side is averagely 62.2 million tons/year. Such residues may come from wheat, corncob, nut, legumes, citrus, wheat, sunflower, tobacco, mulberry, cotton, rose, rice, sugar beet, olive, peanuts, tea, sesame, fruits, etc.

Table 1. Shares of Turkey's regions within the country's area [23]

Regions	Area ratio by area of Turkey (%)
Black Sea Region	18
Marmara Region	8,5
Aegean Region	12
Mediterranean Region	16
Central Anatolia Region	18
Eastern Anatolia Region	21
Southeastern Anatolia Region	7,5

Products that cause the most waste generation, their production and waste amounts in tons/year unit were determined for each region in Turkey and they can be seen in Figure 2. In the inventory created within the scope of the study, updated data on BEPA's official site was used.

Looking at the Black Sea region, the most generated wastes in terms of agricultural waste are wheat, hazelnut and sunflower respectively and the amount of wastes are averagely 1.8 million tons per year for wheat, 965.797 tons per year for hazelnut and 452.035 tons per year for sunflower. It can be seen in Figure 2a that the wheat production and waste amounts are nearly similar. However, hazelnut and sunflower production amounts are lower than the waste amounts for each product. That means production is important but actually there are even more agricultural residues after agricultural activities. For the Mediterranean Region, the most generated three wastes are wheat, corn and cotton respectively. Waste amount of wheat, corn and cotton in Mediterranean Region is averagely 2.2 million, 2 million and 612.794 tons per year respectively. In this region, wheat production and waste generation values are similar again like Black Sea Region. Actually, this similarity can be seen in all regions. Waste generation is higher than the production for corn and lower for the cotton. In Eastern Anatolian Region, wheat, barley and tomato are the products that generate most wastes. There are 1.2 million, 445.587 and 123.795 tons residues per year for wheat, barley and tomato, respectively. It can be seen that wheat amount of production and waste generation is too high but the amounts for tomato is very low. Also, the amount of waste generated is much lower than the amount of production for tomato. Wheat ranks first for the production in all regions except the Aegean Region. For Aegean Region, the first product that generates most waste is wheat but the product that has the highest production is tomato. Barley is the third one that generates most waste in this region. There are nearly 1 million, 1.6 million and 697.380 tons residues per year comes from tomato, wheat and barley, respectively. Data for other regions can be seen in Figure 2e–g.

Table 2. Turkey's geographical regions' areas and agricultural areas in regions [24]

Regions	Area (km²)	Agricultural area (%)	Agricultural areas (km²)
Black Sea Region	146.624,04	16	23.459,85
Marmara Region	69.239,13	30	20.771,74
Aegean Region	97.749,36	24	23.459,85
Mediterranean Region	130.332,48	18	23.459,85
Central Anatolia Region	146.624,04	27	39.588,49
Eastern Anatolia Region	171.061,38	10	17.106,14
Southeastern Anatolia Region	61.093,35	20	12.218,67

Turkey has an area of 814,578 km² [23]. Seven different geographical regions of Turkey have different areas. The shares of these geographical regions in Turkey's area are given in Table 1.

According to Table 1 [23], Eastern Anatolia Region covers the largest area in Turkey with a rate of 21%. This is followed by the Central Anatolia Region and the Black Sea Region with 18%. The Mediterranean region constitutes 16% of the country. In addition, the Aegean region accounts for 12% of the country, and the Marmara region for 8.5%. The smallest region in terms of surface area in the country is the Southeastern Anatolia region.

Table 2 [24] shows that the region with the most cultivated agricultural area among the regions of Turkey is the Central Anatolia region with 39.588,49 km². In addition, the lowest region in terms of cultivated agricultural area is the Southeastern Anatolia region with 12.218,67 km².

Waste amounts from the most produced products for all regions were collected and the total waste values for main three products are given in Table 3.

In addition, based on the amount of waste given in Table 3, the amount of waste belonging to the most produced agricultural product per km² per year has been determined for all regions in Table 4.

The most generated waste amounts for all regions were collected on a regional basis and a comparison was made for seven different regions (Fig. 3).

The lowest waste amount is nearly 1.8 million tons per year and is from Eastern Anatolia Region. After this, 3.1 million tons waste per year comes from Black Sea Region and 3.3 million tons waste per year comes from Aegean Region. Mediterranean Region follows them with 4.8 million tons waste per year. Waste amount starts to get higher in Marmara Region and Southeastern Anatolia Region. The waste amount is nearly 6 million tons per year for Marmara Region and 6.3 million tons per year for Southeastern Anatolia Region, respectively.

As can be seen in Figure 3, the region where the most waste is generated in the general inventory prepared considering the products where the most production is made was the Central Anatolia Region. Nearly 12 million tons waste per year comes from the most generated wastes from Anatolia Region.

Table 3. Total waste for main 3 products (tons/year) [22]

Regions	Amount (tons/year)
Black Sea Region	3.156.385,90
Mediterranean Region	4.786.749,96
Eastern Anatolia Region	1.780.030,74
Aegean Region	3.305.485,06
Southeastern Anatolia Region	6.299.627,64
Central Anatolia Region	11.856.853,60
Marmara Region	5.908.637,80

Table 4. Total waste for main 3 products (tons/km²/year)

Regions	Waste amount (tons/km²/year)
Black Sea Region	134,5
Marmara Region	284,5
Aegean Region	140,9
Mediterranean Region	204,0
Central Anatolia Region	299,5
Eastern Anatolia Region	104,1
Southeastern Anatolia Region	515,6

As can be seen in Figure 4, the annual waste per km² in agricultural areas is mostly in the Southeastern Anatolia region. In the Eastern Anatolia region, this value is the lowest.

For the continuity of agricultural activities, it is necessary to ensure the disposal of waste in the fields. As a result of interviews with farmers, it was concluded that agro-waste is a serious problem in agricultural areas. When the new harvest period comes, it is necessary to clean the field from waste. For this purpose, it has been learned that farmers generally try to dispose of these wastes by burning them. It is obvious that the soil has been severely damaged as a result of incineration.

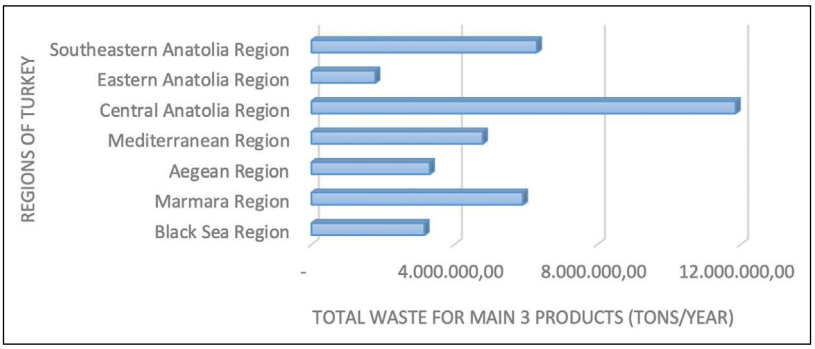

Figure 3. Total of three most generated waste amounts per year for all regions.

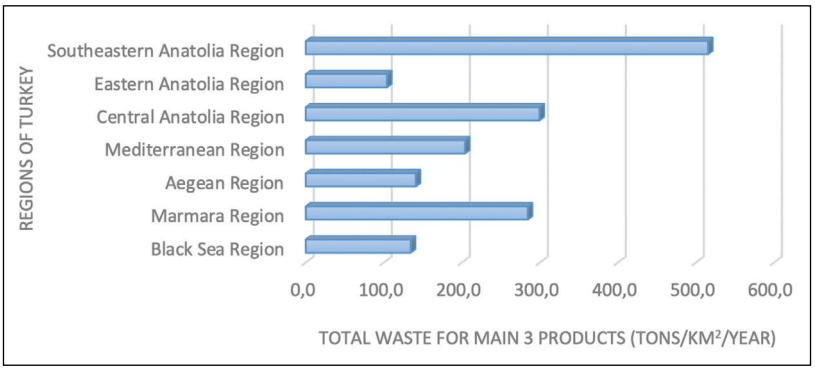

Figure 4. Total of three most generated waste amounts per km² per year for all regions.

Farmers also say that it affects the yield of the soil. Some of the farmers spoken say that they do not prefer to burn, they prefer to store. When they store it, they explain that they have problems such as odor, insect and parasite caused by decay. Especially farmers who grow hazelnuts in the Black Sea region say that the fresh hazelnut shell is laid in the fields because it is moist, but because of the decay, it creates a problem in agriculture. Before starting the interview with the farmers, they were shown a table (Table 5) numbering the difficulty of the problems from 1 to 10. And, farmers were asked to number their problems by difficulty level.

The average rates that farmers give to their problems can be seen in Table 6.

Three farmers from each region gave averagely eight and nine point to their problems occur from agricultural residues. These farmers are well-known persons working in this field. Also, they are asked two questions. First one is "What kind of problems do you have with regard to agricultural waste?" and the second one is "What do you do to the residues that are formed as a result of agricultural activities?" The farmers' answers can be seen in Table 7.

Table 5. Difficulty level and the numbers

Difficulty	Numbers
Low	1
Middle	5
High	10

Table 6. Average rate of farmers' problems with the agricultural residues

Regions	Number of farmers surveyed	Average rate of problems
Marmara	3	9
Black Sea	3	8
Aegean	3	9
Mediterranean	3	9
Central Anatolia	3	8
Eastern Anatolian	3	8
Southeastern Anatolia	3	8

CONCLUSIONS

Considering the amount of agricultural waste generated in Turkey, it is seen that an effective waste management approach is needed in the agricultural sector. Because agricultural wastes negatively affect the quality of the production process and create problems for farmers. For example, as the amount of waste increases, farmers have problems in disposing of the waste. Wastes remaining in production areas cause

Table 7. Answers of farmers

Regions	Answer 1	Answer 2
Marmara	High amount of residues, no enough space to stack , inhomogeneous soil	Bale making, burning, animal feed, use as kindling
Black Sea	Insect problem, rotting of residue piles, excess moisture retention of soil	Use as fuel in the stove, burning, animal feed, bale making, use as kindling
Aegean	Machine channels closing during new planting, too much workforce to collect, insect problem, inhomogeneous soil	Bale making, burning, animal feed, use as kindling
Mediterranean	High amount of residues, damage to the machine, no enough space to stack	Bale making, burning, animal feed, use as kindling
Central Anatolia	Machine channels closing during new planting, high amount of residues, inhomogeneous soil	Bale making, burning, animal feed, use as kindling
Eastern Anatolian	Rotting of residue piles, high amount of residues, damage to the machine	Bale making, burning, animal feed, use as kindling
Southeastern Anatolia	Machine channels closing during new planting, high amount of residues, no enough space to stack	Bale making, burning, animal feed, use as kindling

problems such as insect infestation and damage to agricultural tools. In addition, while the need for agricultural production increases over time, environmental problems such as climate change cause a decrease in agricultural production. For these reasons, agricultural wastes can be used as raw materials for biogas and organic fertilizers. Thus, agricultural wastes are no longer a problem and can be managed in an economical and environmentally friendly way.

The energy requirement is very low in agricultural activities. At the same time, the share of bioenergy in renewable energy in Turkey is also not high. Therefore, providing agricultural waste management for each region with biogas plants to be built on a regional basis, and conversion of existing agricultural wastes to energy has been proposed.

Electric vehicles can be used during the collection and transportation of agricultural wastes to be used in biogas production to the relevant facilities. These vehicles with low carbon footprint and noise level allow waste collection and transportation to be carried out without harming the environment. Harmful formations such as odor and pathogens can also be prevented by storing agricultural wastes in sufficiently ventilated and air-conditioned storage areas prepared according to the amount of waste.

It is known that most of the fertilizer used in agricultural land in Turkey are bought abroad and is also contain chemicals. Another product that comes out of the proposed biogas plants is nutrient-rich digestate. With the use of digestate as fertilizer on farmland, it could be saving money paid to fertilizer in Turkey. On the other hand, organic fertilizers provide the nutrients required for agricultural production, such as chemical fertilizers. The most important advantage of organic fertilizers is that they provide soil regulating effects as well as nutrients. Thus, agricultural wastes are valued with the zero-waste concept. In addition, it contributes to the country's economy with the energy from biogas and digestate to be obtained through the biogas plants proposed to be established on a regional basis.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that

support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] Chauhan, D.S. (1952), "Agricultural Economics," Agra, Lakshmi Narain Agarwal Educational Publishers, India, pp. 354, 1952.

[2] E. Kılavuz, and İ. Erdem, "Agriculture 4.0 applications in the world and transformation of Turkish agriculture," Social Sciences, Vol. 14, pp. 133-157.

[3] S. Doğan, Türkiye için tarımın önemi. Available at: http://www.tesav.org.tr/wp-content/uploads/2018/03/SON-T%C3%9CRK%C4%B0YE-%C4%B0%C3%87%C4%B0N-TARIMIN-%C3%96NEM%C4%B0-VE-TARIMA-BAKI%C5%9E-SAM%C4%B0-DO%C4%9EANIN-SUNU%C5%9EU.pdf. Accessed on Oct 25, 2021.

[4] Food Security and Nutrition. Food and Agriculture Organization of the United Nations Available at: https://www.fao.org/3/cb1329en/online/cb1329en.html#chapter-3. Accessed on Dec 15, 2021.

[5] Agamuthu, P. Challenges and opportunities in Agro-waste management: An Asian perspective. Inaugural meeting of First Regional 3R Forum in Asia 11 -12 Nov., Tokyo, Japan. 2009.

[6] Toop, T.A. Ward, S. Oldfield, T. Hull, M. Kirby, M. E. and Theodorou, M.K. "AgroCycle–developing a circular economy in agriculture," Energy Procedia, Vol. 123, pp. 76-80, 2017.

[7] S. Doğan, Presentation of The Importance of Agriculture for Turkey, 2018

[8] Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997

[9] TUIK, Address Based Population Registration System Results, 2019

[10] J. Malinauskaite, H. Jouhara, D. Czajczyńska, P. Stanchev, E. Katsou, P. Rostkowski, and L. Anguilano, "Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in Europe. Energy, Vol. 141, pp. 2013-2044, 2017.

[11] Republic of Turkey Ministry of Environment and Urbanization, Agriculture Symposium Handbook, 2017

[12] O. Çoban, and N.Ş. Kılınç, "Investigation of energy use of environmental impact," Marmara Geographical Review, Vol. 33, pp. 589-606, 2016.

[13] World Wide Fund for Nature (WWF), Energy Report, 2011

[14] D. D'Amato, S. Veijonaho, and A. Toppinen, "Towards sustainability? Forest-based circular bioeconomy business models in Finnish SMEs," Forest Policy and Economics, Vol. 110, Article 101848, 2020.

[15] United Nations Environment Programme (UNEP), Bloomberg New Energy Finance Report, 2012

[16] M. Javad Asgari, K. Safavi, and F. Mortazaeinezahad, "Landfill biogas production process," In International Conference on Food Engineering and Biotechnology IPCBEE IACSIT Press, Singapoore. Vol. 9, 2011.

[17] J.B. Van Lier, N. Mahmoud, and G. Zeeman, "Anaerobic wastewater treatment," Biological Wastewater Treatment: Principles, Modelling and Design, 415-456, 2008.

[18] A. C. Wilkie, "Anaerobic digestion: biology and benefits," Dairy manure management: treatment, handling, and community relations, Cornell University, New York, pp. 63-72, 2005.

[19] Celignis Analytical Website. Available at: http://www.celignis.com/anaerobic-digestion.php. Accessed on Dec 15, 2021.

[20] The Ministry of Agriculture and Forestry, Fertilizer Sector Policy Document 2018-2022, TAGEM R&D and Innovation, Ankara, 2018

[21] The Ministry of Agriculture and Forest of Republic of Turkey. Available from: www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Bitki-Besleme-ve-Tarimsal-Teknolojiler/Bitki-Besleme-Istatistikleri?Ziyaretci=Ihracat-Ithalat. Accessed on Dec 15, 2021.

[22] Atlas of Biomass Energy Potential Website. Available from: https://bepa.enerji.gov.tr/. Accessed on Dec 15, 2021.

[23] Bölgeler ve İller - Fiziki Coğrafya - Makale - Türk Coğrafya Kurumu. Available at: https://tck.org.tr. Accessed on Dec 15, 2021.

[24] Türkiye'de TARIM Genel Tarımsal Faaliyetler Raporu. Available at: https://ereglitb.org.tr/wp-content/uploads/2019/10/T%C3%9CRK%C4%B0YEDE-TARIM.pdf. Dec 15, 2021.