2nd Online Symposium on Circular Economy and Sustainability, Online Event, Alexandroupolis, Greece, 14-16 July, 2021

Optimal Siting for A New Bioenergy Power Plant in Turkey: An Intuitionistic Fuzzy Multi-Criteria Decision Analysis under Circular Economy Perspective

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All organisms in the world, especially human beings, generate many wastes as recyclable or non-recyclable. This situation increases pollution on the planet and affects healthy environments and living spaces. In particular, the economic, environmental, and social effects of people have led to serious problems with industrialization. Environmentally, the melting of polar glaciers, inequalities in social understanding, the gigantic effects of economic crises can be presented as some examples. Thus, governments, industry partners and researchers have focused on the concept of sustainability in recent years. Since limited resources are of great importance for future generations, it is planned to overcome the problems with the concept of sustainability. Therefore, the linear economy models adopted in the industrialization period are replaced by the circular economy models for all sectors. In the circular economy model, some of the wastes generated can be reused in different areas or serve for different purposes. Thus, both saving in terms of reproduction are achieved and resource consumption is reduced.

The agricultural industry is also one of the main areas in terms of the circular economy. For this reason, the circular economy model, in which zero waste is targeted and waste is tried to be minimized, has become widespread in the agricultural sector. The energy obtained as a result of using agricultural products, forest plants and animal wastes is called bioenergy, and the wastes that cause this and mentioned wastes are called biomass. Conversion of biomass to bioenergy with different methods and technologies is to be used in vehicle fuels, heat and electrical energy generation. In addition, carbon emissions from the use of bioenergy fuels are lower than existing fossil fuels. For this reason, energy resources obtained by recycling agricultural wastes offer a more sustainable environment.

It is seen that, sustainability is of great importance in the context of circular economy, since biomass and bioenergy can play a crucial role in different areas. In this study, agricultural circular economy is handled, and it is aimed to decide on the most suitable bioenergy facility location in Turkey depending on the biomass resources. In this context, the locations determined in our country are considered as alternatives and these are evaluated in the light of the criteria weighted by the Best Worst Method (BWM). Then, alternatives are sorted with Intuitionistic Fuzzy TOPSIS. As a result, the best location is selected for a bioenergy facility location to be established in Turkey, depending on the biomass source.

In a more general sense, it is aimed to present a study as a guide to the managers in terms of agricultural recycling awareness in Turkey. In addition, the literature is quite untouched in terms of the number of studies in this field.

The main research questions as a motivation of this study are listed below.

1. What are the biomass sources used and can be used for bioenergy?

2. What are the criteria for choosing the best location for a new bioenergy plant in Turkey?
3. Which is the best location among the bioenergy power plant locations in Turkey by using a multi criteria decision method?

The criteria in our study are determined by examining biomass and energy studies in the literature and tha alternatives are given in Table 1. Considering the list of bioenergy power plants in Turkey, 6 cities with the highest number of power plants are selected as an alternative.

Table 1. Criteria to select the best location for Bioenergy

Abbreviations of Criteria	Name of the Criteria	Name of the Alternatives
C1	Agricultural Products Diversity	Ankara
C2	Agricultural Area Locations and Types	Balıkesir
C3	Forest Area Amount	Bursa
C4	Urbanization Rate	Kocaeli
C5	Livestock Activities	Konya
C6	Agricultural Products Production Capacity	Mersin
C7	Food Industry Development Rate	

The results presented in Table 2 that presented the set of {A2, A5, A3} seen suitable alternatives than the others. IF TOPSIS methodology sorted the alternatives A2 and A5 as the highest, where A3 is closer to the ideal according to the ‘‘Agricultural Products Diversity’’ criteria. Alternative A4 has the additional ‘‘Agricultural Products Production Capacity’’ so that it would not be preferred. The most important criteria considered are C2 (Agricultural Area Locations and Types) and C7 (Food Industry Development Rate). These two criteria are seen as the most effective criteria in determining the most suitable location.

Table 2. Rank of alternatives

Rank of Alternatives	Name of the Alternatives
5	Ankara (A1)
1	Balıkesir (A2)
4	Bursa (A3)
6	Kocaeli A(4)
2	Konya A(5)
3	Mersin A(6)

Keywords: Circular Economy; Bioenergy Power Plant; Best-Worst Method; Intuitionistic Fuzzy TOPSIS; Optimal Site Selection