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DETERMINATION OF THE POTENTIAL BIOGAS ENERGY PRODUCTION AMOUNTS AND AREAS IN THE TIGRIS BASIN USING GIS

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Abstract

The increasing world population renders the developed energy sources of the industry insufficient, and existing energy sources become expensive. It is anticipated that the energy deficit will further increase in the future. Scientists are in search of new energy sources in the face of this fact. It is considered that the cattle breeding potential of the Southeastern Anatolia Region may increase both as a result of state supports and arable lands. Determining the potential biogas energy production areas of the Southeastern Anatolia Region in terms of cattle breeding is possible with the use of today's knowledge and technology. With this study, it was aimed to determine the obtainable biogas energy fields and the current situation for the provinces in the Tigris Basin (Diyarbakir, Mardin, Siirt, Batman, Sirnak). The number of cattle in the basin for 2015 was benefited from in this framework. The boundaries of the research provinces were drawn using ARCMAP 10.0 software by making geographical corrections. In order for the inquiries of each province to be made independently from other provinces, all boundaries were divided on the basis of provinces, districts and villages as separate layers. These data constitute the main material of the study. The number of cattle was entered into the database of Geographical Information System (GIS), and the obtainable potential biogas energy production areas were determined considering the amount of waste that will be left in the environment by cattle. The finding that a total of 2809939 tons of annual wet manure can be obtained in the study area was obtained. It was determined that a total of 1175913 MJ biogas energy amount can be obtained per year from this wet manure. Further-

more, the project created with a cartographic base, the geographical correction of which was made, was assessed in accordance with the purpose of this study in the database, and the areas that are suitable, non-suitable or partially suitable for biogas energy production areas were determined.

Keywords: Biogas, Cattle Manure, GIS, Tigris Basin

INTRODUCTION

The rapid increase in the world population leads to the constant decrease in existing sources. In order for these limited sources to be used for a longer period, it is necessary to use them in an optimum way, renew them or to put into service new sources instead of these sources.

The whole world is in consensus that fossil energy sources such as petrol, coal, and natural gas that have been widely used since past to present in the fulfilment of the world energy need will become unable to fulfil the needs of human beings in a near future, and an energy shortage will occur consequently. It is necessary to determine renewable energy sources in addition to non-renewable energy sources and put them into service in order not to experience the shortage in question.

Turkey is geographically in the middle of the world, which means it is surrounded by the Middle East, Central Asia and Europe. This area is not only geographically, but also economically, very important. Turkey has a very young and increasing population. In addition to the increase in population, a growing number of city dwellers and rapid economic development are causing more energy consumption (Kilic and Kaya, 2007).

Biogas, which is shown among renewable energy sources, creates an advantage by preventing soil pollution in addition to reducing air pollution. Turkey's renewable energy sources are plentiful and extensive. Renewable energy production makes up approximately 14.4% of the total primary energy supply (TPES), i.e. 10.10 million tons of oil equivalent in 1999, and renewable sources represent the second-largest domestic energy source after coal. Primary renewable energy resources in Turkey are: hydro, biomass, wind, biogas, geothermal, and solar (Kaya, 2006).

It is possible to use biogas for direct heating and lightening purposes as a multi-directional energy source as well as turning it into electrical and mechanical energy. Furthermore, the side products that emerge as a result of biogas production can also be used for various purposes. Biogas can be used in cooking, lightening and electricity production. Biogas technology developed significantly depending on the use of organic waste other than animal waste in biogas production. That the main objective of biogas facilities develops in the direction of

producing and selling electricity increases the size and number of the facilities (Kaya and Ozturk, 2012).

Manure is utilised as biogas. Biogas is a gas mixture, which occurs as a result of the fermentation of organic based waste/wastes in an oxygen-free (anaerobic) environment, has no color and smell, is lighter than air, burns with a bright blue flame, and contains approximately 40-70% of methane, 30-60% of carbon dioxide, 0-3% of hydrogen sulphur and little nitrogen and hydrogen depending on the composition of organic substances in the composition (Anonymous, 2011).

With the production of biogas, it will be possible to prevent water pollution, air pollution and visual pollution that result from leaving the waste randomly, fulfil the energy need of the enterprises, and use the product obtained as a result of decomposition as a soil-improver in agriculture (Dolgen et al., 2003).

Animal manure, human waste and all nutrition substances such as kitchen waste contain carbon, nitrogen and oxygen at particular amounts. The carbon in organic substances is necessary in order to fulfil the energy need of anaerobic bacteria. The most important nutrition substances apart from carbon are nitrogen and phosphor. Nitrogen is important for the growth and reproduction of bacteria (Björnsson, 2000).

One of the main reasons for soil pollution is solid waste. Solid waste should be disposed of regularly in order for it not to damage the soil. In previous years, studies were carried out in order to examine the methods that damage the environment at the least among the methods of the solid waste disposal and develop the existing facilities. Today, studies on the recycling of solid waste and obtaining energy from the organic parts of solid waste become important (Arikan, 2008)

Livestock breeding is an important economic activity in the Tigris basin. Livestock breeding is the main source of income for a majority of the population. In Tigris basin animal manure are mostly used either as fertilizer on agricultural lands or burned for energy (Kocer et al., 2006). Obtaining biogas energy from the potential animal manure in the basin will both ensure the disposal of the waste in the basin and economically contribute to the region. With this study, it was aimed to determine the biogas energy potential of all provinces and districts in the Tigris Basin and determine the most suitable biogas energy production areas in the basin.

MATERIAL AND METHOD

The study was carried out in the Southeastern Anatolia region of Turkey and includes the provinces of Diyarbakir, Mardin, Batman, Siirt and Sirnak in the Tigris basin (Fig. 1). The study is important in terms of determining the places

where biogas energy production areas can be set up in the study area, the number of animals in the region, and the amount of animal waste and biogas. The present number of cattle of 5 provinces and their districts taken from the literature data and the Veterinary Information System (VETBIS) of the Ministry of Food, Agriculture and Livestock for 2015 in the Tigris Basin, which is the subject of the research, was used in order to determine these data (Anonymous, 2015).

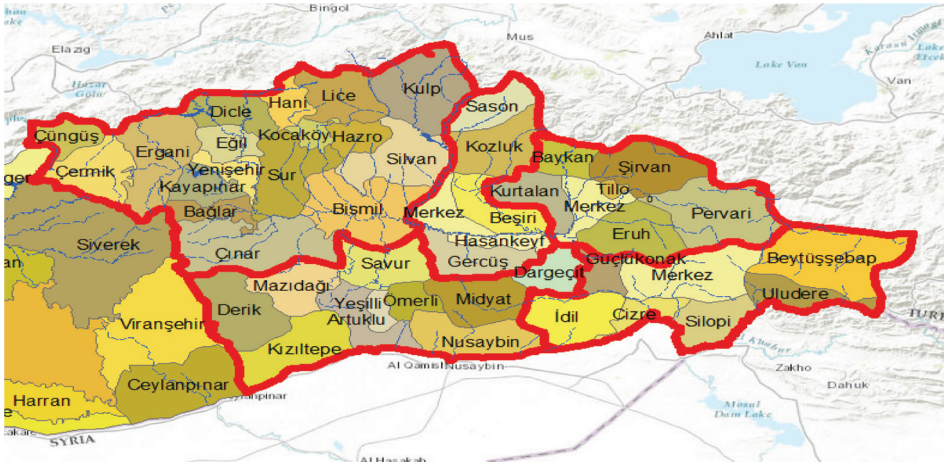

Figure 1. Districts of Tigris Basin

In this study, it was aimed to assess the presence of cattle, and animal waste and biogas amounts in the provinces in question, on the basis of districts, in the Geographical Information System environment. For this purpose, the places in question were digitized in the GIS environment as a polygon first within the limits of the province and then the district boundaries. ArcMAP 10.0 software and WGS 84 coordinate reference system were used for this purpose (ESRI, 2010). All boundaries were divided on the basis of provinces as a separate layer in order to make the examination of each province independently from other provinces. Similarly, the districts of each province were divided in the form of district boundaries as a separate layer. The database (attribute data) was created by entering the numbers of cattle supplied from VETBIS system to all these layers prepared. In this study, the places that are suitable for establishing biogas units were shown on the maps created on the basin by determining the animal waste and biogas amount on the basis of districts by means of benefiting from the present cattle number for 2015 obtained from VETBIS system (Anonymous, 2015).

Biogas technology has recently been started to be used around Turkey. The number of biogas facilities around Turkey is quite low. There are 36 active biogas facilities (Anonymous, 2011).

It is definitely necessary to determine the capacity before projecting biogas facilities. If only animal manure will be used in the facilities, the amount of manure that is created daily, the way of animal nutrition and the amount of solid substances in manure should be known. That an average amount of 43 kg·day^{-1} of manure can be obtained from mature cattle can be taken as a basis for the calculation of the amount of manure. Accordingly, one head of mature cattle creates between 1 and 1.5 ton·month^{-1} of manure (Hill, 1982; Ekinci et al., 2010).

In this study, the volume of biogas generated by cattle waste was calculated according to Hill (1982) and Ekinci et al., (2010), classified using ArcMAP 10.0 software in three classes by the biogas energy values (MJ·year^{-1}) that can be supplied, and coloured in accordance with class values.

RESULTS AND DISCUSSION

Upon comparing the provinces in the basin in question, it was seen that Diyarbakir province has an important place in the study area both in terms of field size and animal presence. When the provinces in the basin were examined, the total number of cattle is 125029 in Diyarbakir, 25708 in Batman, 15267 in Mardin, 9412 in Siirt and 3618 in Sirnak, according to the data of 2015 (Fig. 2). It was determined that livestock breeding is performed at a significant level in Diyarbakır and Batman provinces, these provinces are followed by Mardin province. Nevertheless, livestock breeding is performed at a lower level in Sirnak and Siirt provinces. Upon examining its reason, it was seen that the number of both the villages and the number of cattle in these villages are low in the region as a result of topographic and climate conditions.

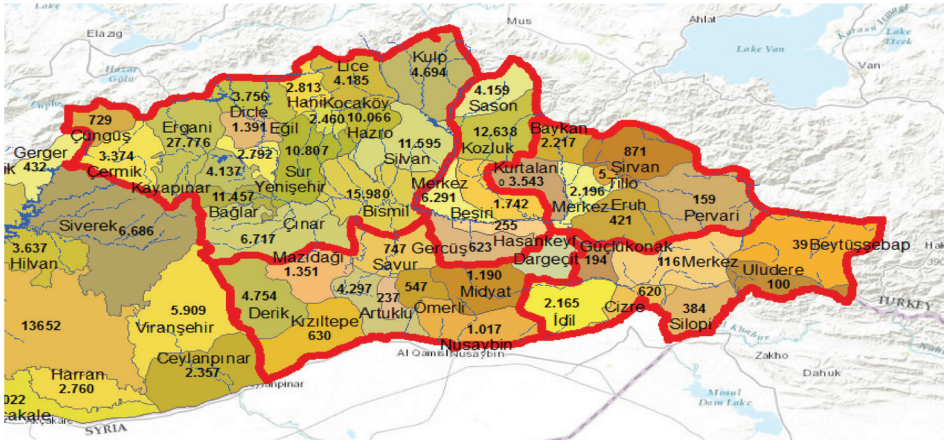

Figure 2. Number of cattle in Tigris Basin

The amount of wet manure and obtainable biogas energy were calculated according to Hill (1982) and Ekinci et al., (2010) using the number of animals in the study area, and given in table 1. In the calculation made, it was determined that the highest amount of wet manure and obtainable biogas energy are in Diyarbakir province. Diyarbakir province was followed by Batman, Mardin, Siirt and Sirnak provinces, respectively (Table 1).

Table 1. The amount of potential wet manure and obtainable biogas energy in the Tigris basin provinces

Province	Total Number of Cattle	Annual Average Amount of Wet Manure (ton year^{-1})	Annual Amount of Obtainable Biogas Energy (MJ year^{-1})
Diyarbakir	125029	1962330,2	821202,3
Batman	25708	403487,1	168852,6
Mardin	15267	239615,6	100275,1
Siirt	9412	147721,3	61818,9
Sirnak	3618	56784,5	23763,4

The same calculation method was used separately for the districts of all provinces in the basin, and the amounts of wet manure and potential biogas energy of these districts were calculated. As a result of these calculations, the places where biogas energy production areas can be established in the provinces of the basin were tried to be determined and mapped. Upon examining the study area, the district with the highest number of animals in Diyarbakir province is Ergani (22.22%). Ergani district is followed by Bismil (12.78%), Silvan (9.27%) and Baglar (9.16%) districts, respectively. Hence, these are the districts with the highest amount of wet manure and obtainable potential biogas energy (Fig. 3).

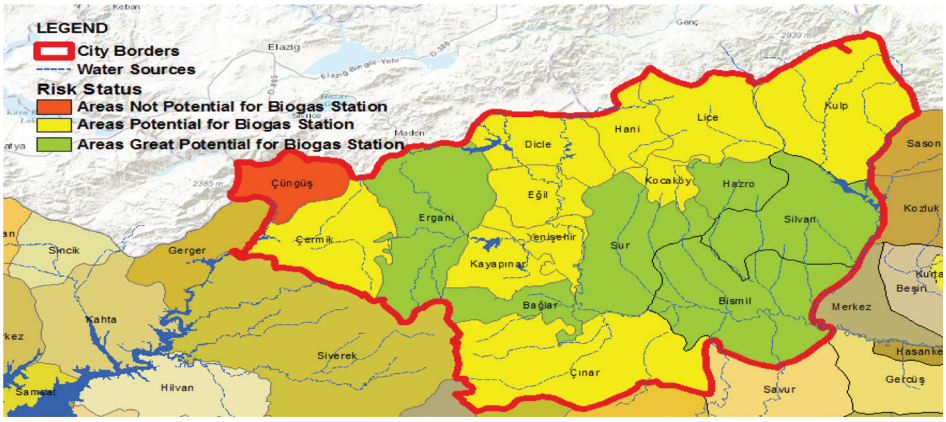

Figure 3. Potential Biogas Energy Fields in Diyarbakir province

The district with the highest number of animals in Mardin province is Derik (31.14%). Derik district is followed by Artuklu (28.15%) and Midyat (7.79%) districts, respectively (Fig. 4). The most suitable biogas energy production areas in Mardin province and region could not be determined.

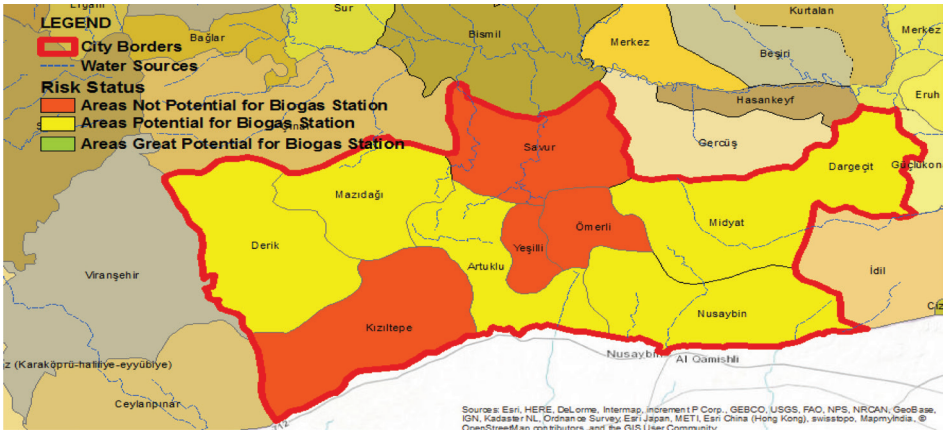

Figure 4. Potential Biogas Energy Fields in Mardin province

When Batman province is examined, Kozluk district has the half of a total number of animals. Kozluk district is followed by the Central (24.47%) and Sason (16.18%) districts, respectively (Fig. 5). Upon examining Figure 5, it was determined that Kozluk district is the most suitable biogas energy production area.

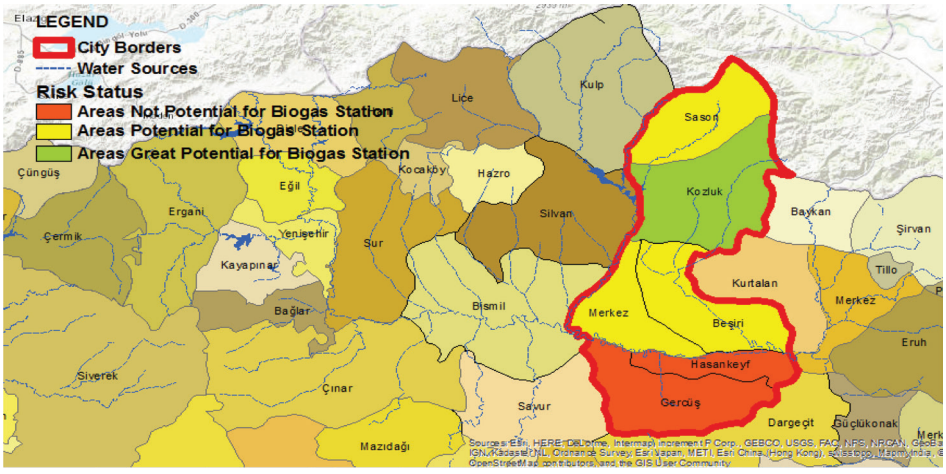

Figure 5. Potential Biogas Energy Fields in Batman province

Upon examining Siirt province, Kurtalan district (37.64%) has more than 1/3 of the total number of animals. Kurtalan district is followed by Baykan (23.56%) and Central (23.33%) districts, respectively (Fig. 6). Kurtalan, Central, and Baykan districts were determined as suitable biogas energy production areas in Siirt province and region.

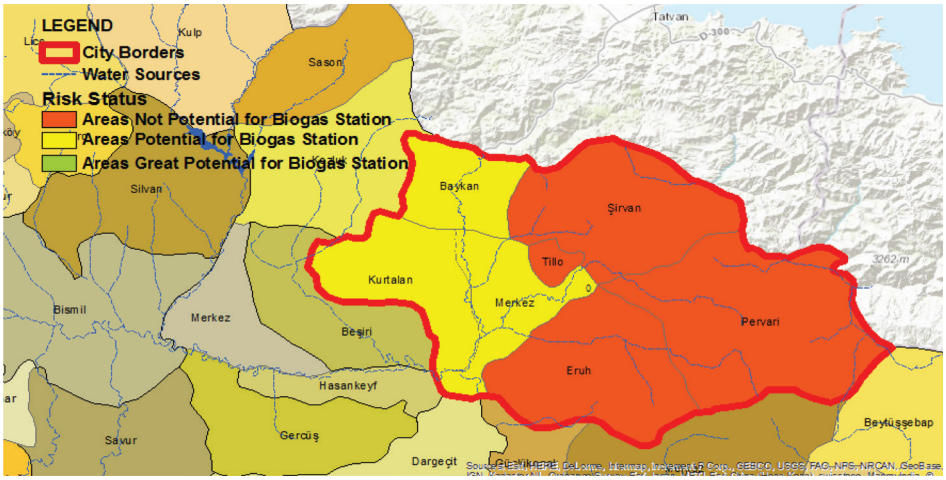

Figure 6. Potential Biogas Energy Fields in Siirt province

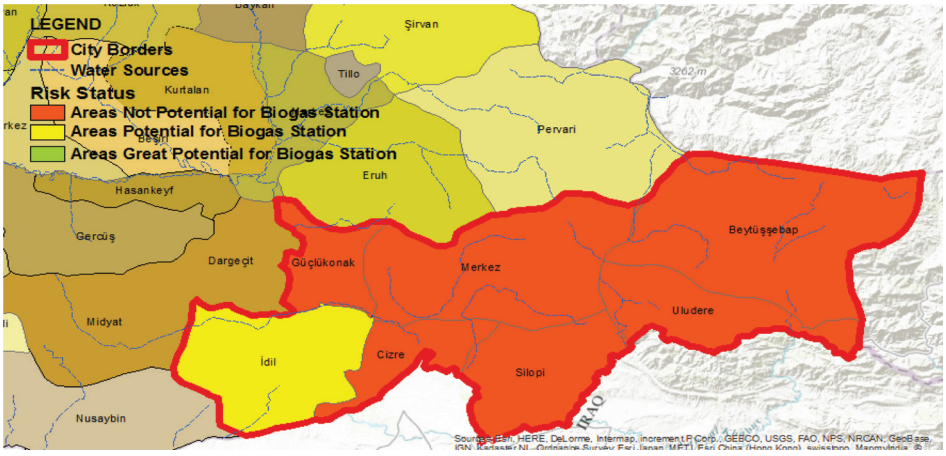

Figure 7. Potential Biogas Energy Fields in Şırnak province

It is observed that the limited animal breeding is performed in Sirnak province. It was observed that Idil (59.83%) district in Sirnak province has approxi-

mately 2/3 of the total number of animals in Sirnak province. Idil district is followed by Cizre (17.14%) and Silopi (10.61%) districts, respectively (Fig. 7). The most suitable biogas energy production area in Sirnak could not be determined.

Researchers indicate that biogas is not economical for enterprises with less than 100 heads of cattle (Yaldiz and Sozer, 2005). It is indicated that the home-type facility to be established in enterprises with 12 heads of cattle can only meet the kitchen needs of the family, and 60% of the manure obtained from the animals is collectable (Anonymous, 2013). In the mapping in the study area, the districts with animals between 0 and 1000 were colored in red (), and the districts with animals between 1000 and 10000 were determined as potential biogas production areas and colored in yellow (). Again, the districts with more than 10000 cattle were determined as high potential biogas production areas and coloured in green (). The map of the potential biogas production areas of the study area was created in relation to these animal numbers.

The study area has the cattle manure potential of 2809939 ton per year generated by the cattle. Also, it was determined that a total of 1175913 MJ biogas energy amount can be obtained per year from this wet manure. In case these are used, an input can be provided to enterprises economically in terms of biogas energy production. Biogas production facilities are not widely used in our country. According to Anonymous (2011), it is indicated that 2000 biogas facilities that can operate only on animal waste can be established in our country. However, there are 85 biogas facilities in our country, and 36 of them are active. The number of biogas facilities established on animal and plant waste is only 12. Hence, biogas energy production can be performed in these areas by informing and guiding the producers in the study area.

CONCLUSIONS

Upon examining the animal capacities of the provinces in the study area, Diyarbakır (69.84%) and Batman (14.36%) provinces are those with the highest number of animals in the basin. Thus, biogas energy production studies can be prioritized in these two provinces starting from Diyarbakır province. Upon examining the districts in the study area, the districts with the highest number of animals in Diyarbakır province are Ergani, Bismil, Silvan, and Baglar districts. There are 66608 heads of cattle for the biogas energy production areas to be established in this region. Considering that cattle manure can be collected from these animals, the number of animals needed for biogas energy production areas can be easily fulfilled from this region. Thus, the information that Diyarbakir province is the most suitable area for biogas energy production was obtained. Furthermore, Kozluk district of Batman province was also determined as one of the most suitable regions for biogas energy production with a total number

of cattle of 12638. It was concluded that biogas energy production facilities to be established in this area will prevent the random collection of animal manure, as well as provide input for the enterprises in an economic sense. Furthermore, it was also observed that there were enterprises with a low number of animals when the study area was examined in a detailed way. In such a non-economic case for a biogas facility, family-type enterprises may establish biogas energy production facilities by becoming cooperatives.

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