RESEARCH ARTICLE

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Subscale mapping of animal waste-based biogas potential and its equivalent energies using GIS: Canakkale, Türkiye

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Abstract
The study presents the first attempt of determination and mapping of recent biogas potentials (BP) at different scales from province to village level in Çanakkale using Geographic Information Systems (GIS). The BP of different scales was calculated based on animal waste amounts from bovine, ovine and poultry farming. The study area covers the ten districts of Çanakkale province with the exception of Imbros and Tenedos Islands. The inventory records of different animal types were obtained from of Republic of Turkey Ministry of Agriculture and Forestry Çanakkale Directorate of Provincial Agriculture and Forestry. GIS procedures are conducted in ArcGIS (10.3) software. Findings revealed that the annual biogas production potential of the whole province is almost 6.4×10^7 m^3. Biga district seemed to include 39 % of overall BP whereas Eceabat district presented a slight percentage of the potential production with the value of approximately 1 %. Moreover, the highest and lowest subscale-level potentials have found in Yukarıdemirci (Biga) and Bahçedere (Ayvacık), with approximately 154×10^4 m^3 and 137 m^3 BP, respectively. The overall BP of the province have concluded to be promising, and present study believed to serve as a baseline for future studies related to determination of new biogas plant suitable lands.

Keywords: Animal waste, Biogas potential, Çanakkale, GIS, Mapping, Subscale level

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INTRODUCTION

The worldwide rapid population growth together with improvements in the living standards of people has led to decline in available resources. Among these resources, one of the most important requirements of growing population is majored on energy sources such as fossil fuels, which have also several adverse effects on the environment in addition to being depletable. The continuous processes have triggered the consumption of currently insufficient sources. Moreover, the global energy consumption is predicted to be increased by approximately 30 % in the next two decades (Gülşen-Akbay, 2020). As it is cited in Ignaciuk and Sulewski (2021), initiatives such as clean energy and sustainable agriculture, plays a key role for promoting assumptions in European Green Dealt strategy, which intends use of environment-friendly approaches, and decrease of emissions from generation and use of energy (European Comission, 2019). The same report has denoted that one of the most important challenges in application of European Green Deal is considered as energy transformation since over 75 % of greenhouse gas emissions known to be sourced from energy sector. Therefore, the search for different energies instead of depletable ones, particularly, renewable sources has accelerated (Atelge et. al., 2020). Agricultural production has great importance and potential in terms of providing substance for such kind of energy. Particularly, procurement of different fuel types from agricultural biomass, which are mainly assigned to biogas production, seems significant for increasing renewable energy sources (Mirosz et al., 2015). The importance of biogas energy has arised from different points of view in terms of environment and bioeconomy, since it presents an environmental-friendly and relatively economic alternative due to related investments within in the last 20 years in different countries.

Acquisition of biogas is dependent to anaerobic decomposition of organic components in an oxygen-free medium and with existence of diverse microorganisms (Yılmaz and Gonbe, 2021). Moreover, as it is cited in Yılmaz and Gonbe (2021), biogas is referred as converted energy due to the acquirement procedure, whereas it can be obtained from not only agricultural biomass from plants and animals, but also domestic or industrial wastes (Şenol et. al, 2017; Demir-Yetiş et. al., 2019). In agricultural point of view, Turkey has significant potential of animal wastes that can be obtained from great number of different types of animals according to 2021 records of Turkish Statistical Institute (TUİK) (Figure 1) (TUİK, 2021), and Turkey known to be standing within the first twenty countries in European Continent with respect to number of installed biogas plants. However, even though there are numerous biogas plants in different regions of the country, it was denoted that there is an enormous amount of plant and animal wastes are preferred to be used as fertilizers or directly burned (Nacar-Koçer et. al, 2006; Atılgan et. al, 2021). Utilization of these amounts for biogas production would prevent the negative effects, namely, odors, diseases and different kind of pollutions, while conserving natural resources Erdal et. al, 2007; İnci et al., 2016). On the other hand, along with the total capacities of the constructed biogas plants, Marmara region takes the first place by composing approximately 40 % of total installed power (Anonymous, 2021). Rapid and reliable evaluation of the needs for new biogas plants together with determination of their locations has enabled by Geographic Information Systems (GIS), which have long been successfully used in the solutions of diverse environmental and ecological problems, as well as management and planning strategies (Bharti et al., 2021).

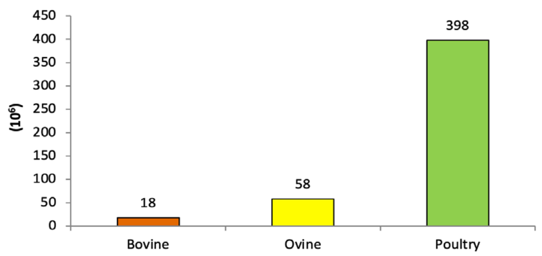

Figure 1. Number of different types of animals (NoA) in Turkey according to 2021 year TÜİK reports.

Previous studies have dealt with determination of biogas potentials (BP) from different types of animals in national (Onurbaş-Avcıoğlu and Türker, 2012; Ertop et. al., 2022), and regional (Ayhan, 2016; Tınmaz-Köse, 2017; Akyürek and Coşkun, 2019) levels in Turkey using the NoA inventories of different year. Moreover, there are numerous studies conducted in local level in different regions of our country. For instance; a study was conducted in Adıyaman province by Baran et. al (2017) to determine animal waste energy potential; Polat-Bulut and Topal-Canbaz (2019) identified the BP for Sivas province, and energy potential of Samsun province from animal manure has been studied by Zenk (2019) . Furthermore, there is a limited number of studies that was conducted in Çanakkale Province (Ilgar, 2016; Özpınar, 2018), which is located within in the Marmara Region that remarked to involve major part of presently installed power. However, mentioned studies have investigated the BP of Çanakkale at upper scales of province and district level, respectively.

The study presents the first attempt of evaluation and mapping animal waste sourced BP of Çanakkale Province from province to subscale level by integrating town- and village-based inventory records into GIS, whereby up-to-date calculations were also served at district level. It was aimed to determine and designate the BP in different scales considering bovine, ovine, and poultry productions. Investigation of BP in smaller scales believed to give more precise results and may provide a strong basis particularly for site-selection studies of new biogas plant locations since determination of optimal distances to main production centers plays a key role in such studies. Moreover, differently from many biogas studies conducted in our country, use of GIS tools enabled visualization of potential production amounts at sub-scale level for manifestation of the production hotspots, whereby the production maps can be easily updated in regular intervals in respect to data from the latest reports or databases in the future.

MATERIALS AND METHODS

Study area

The study area is consisted of ten district of Çanakkale province including; the Provincial Center (PC), Ayvacık, Bayramiç, Biga, Çan, Eceabat, Ezine, Gelibolu, Lapseki, and Yenice. The province is located between the coordinates of 25° 40´- 27° 30´ E and 39° 27´- 40° 45 N. The survey area of the province is approximately 9.5 km^2 with the exceptions of Imbros and Tenedos islands. Moreover, there are over 500 subscales of townships and villages within the study area. Figure 2 represents the locations of the districts and the belonging subscales within Çanakkale Province, and Turkey. The area is mainly covered by forests, and it is followed by agricultural lands, where agricultural production has great importance for the local and regional economy since the climate, soil and topographic conditions are highly suitable. Among the different agricultural activities, animal production is known to be one of the most significant economic incomes for the area, whereby Ezine cheese presents probably the most popular product. However, the statistical reports that the majority of animal production is located in Biga district, which is located in the North-eastern part of the study area.

types, respectively. Furthermore, among these waste productions, utilizable part (UM) of each farming type denoted to be 65 %, 13 %, and 99 %, with the same order. Finally, the BP productions were calculated depending on the assumption that demonstrates 33 m^3, 58 m^3, and 78 m^3 of BP can be obtained per ton of utilizable manure (UMBP) from bovine to poultry farming type (Kaya et al., 2005; Altıkat and Çelik, 2012). The equations

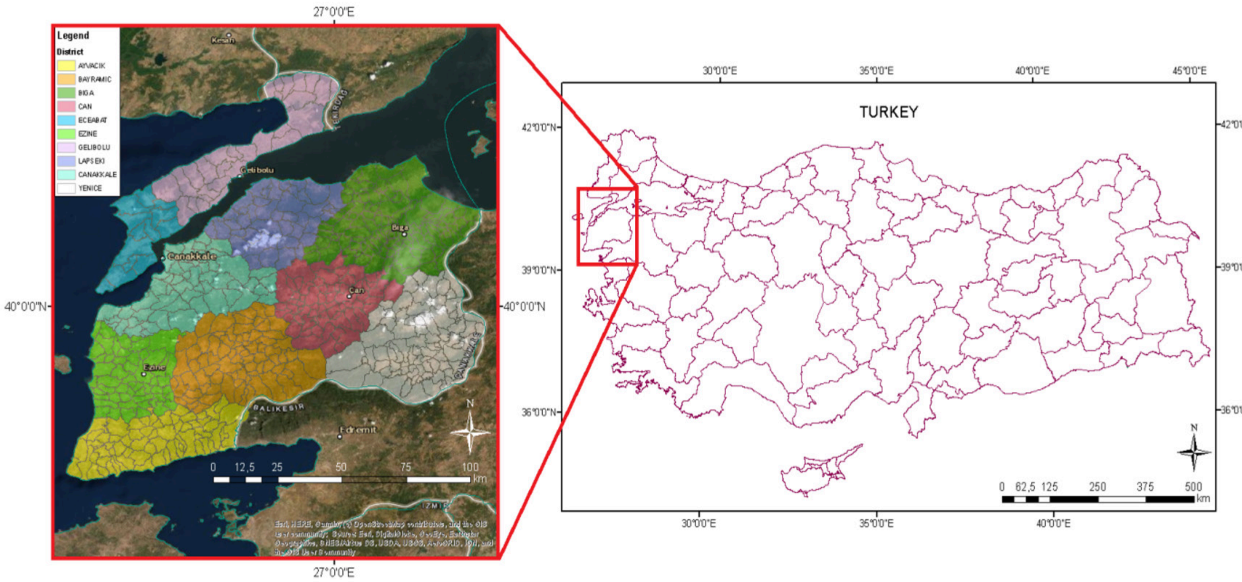

Figure 2. District-based locations of the subscales in Çanakkale and Turkey

Inventory of animal counts

Inventory records covering the number of animals in bovine, ovine and poultry farming types of all subscales are obtained from Republic of Turkey Ministry of Agriculture and Forestry Çanakkale Provincial Directorate in 2020 for preceding year of 2019, which integrated to attribute tables of created GIS layers latter.

Determination steps of BP

As it was reported by Salihoğlu et. al. (2019), BP can be calculated using different assumptions and constants depending on the formulations in the literature. Using different aspects and formulations would result in varied amounts of obtainable and utilizable manure, and thus, different BPs. In this study, the calculation procedures of Agro-Waste project have adopted. Identification of BP regarding to Agro-Waste Project includes implementation of three main steps, as it was explained in Kaya et al. (2005). The first step presents determination of hypothetically produced manure from different animal types, whereas the second step designates the calculation of utilizable manure amounts dependently to hypothetically produced manure. On this account, some assumptions were considered on prediction of these manure amounts (Table 1). Accordingly, 9.94 ton, 0.82 ton, and 0.029 ton wastes (PM) per year are assumed to be produced by bovine, ovine and poultry farming types, respectively.

implemented to each rural settlement for calculating total BP from bovine, ovine, poultry, and are given below (Equation 1-4).

$$\sum BP_{Bovine}(m^3 year^{-1}) = NoA_{Bovine} \times UM_{Bovine} \times UMBP_{Bovine} \qquad \text{(Eq. 1)}$$

$$\sum BP_{Ovine}(m^3 year^{-1}) = NoA_{Ovine} \times UM_{Ovine} \times UMBP_{Ovine} \qquad \text{(Eq. 2)}$$

$$\sum BP_{Poultry}(m^3 year^{-1}) = NoA_{Poultry} \times UM_{Ovine} \times UMBP_{Poultry} \qquad \text{(Eq. 3)}$$

$$\sum BP_{Total}(m^3 year^{-1}) = \sum BP_{Bovine} + \sum BP_{Ovine} + \sum BP_{Poultry} \qquad \text{(Eq. 4)}$$

Determination of equivalent energies for BP

Subsequent to determination of BP, the equivalents of biogas (m^3) in terms of fire wood (FW) (kg), gas oil (GO) (L), butane (B) (kg), electric (E) (kW h^{-1}), gasoline (G) (L), and coil (C) (kg) were calculated using the values given below (Table 2) (Akbulut and Dikici, 2004; Gümüşçü and Uyanık, 2010; Lüle, 2019).

RESULTS AND DISCUSSION

Distribution of animals in different farming systems

The inventory records have revealed that the poultry farming composes the majority of farming systems with 88 % of the total number of animals (NoA) within the province, and it is followed by ovine (9 %) and bovine (3 %) type, respectively (Figure 3). Moreover, district level distribution of total NoA, NoA_{bovine}, NoA_{ovine}, and $NoA_{poultry}$

Table 1. Considered assumptions for BP calculation.

Assumption	Bovine	Ovine	Poultry
Potential Manure (PM) (ton year^{-1})	9.94	0.82	0.029
Utilizable Manure (UM) Constant	0.65	0.13	0.99
Utilizable Manure (UM) (ton year^{-1})	6.4610	0.1066	0.0287
Unit UM BP (UMBP) (m^3 year^{-1})	33	58	78

Table 2. Equivalent values of different energy sources.

BP (m^3)	FW (kg)	GO (L)	B (kg)	E (kW h^{-1})	G (L)	C (kg)
1	3.47	0.63	0.43	4.7	0.8	1.46

types can be seen on Figure 4 a-d. Depending on Figure 4a, b and d, it was again emphasized that Biga district have a great part of total number of animals, together with bovine and poultry, whereby the highest number of ovine type is found in Ezine district (Figure 4c). The lowest NoA from all farming types have obtained from Eceabat. In fact, this situation is expected due to relatively small survey area of the district, together with the limitations arised from protection of cultural and historical heritage of the area.

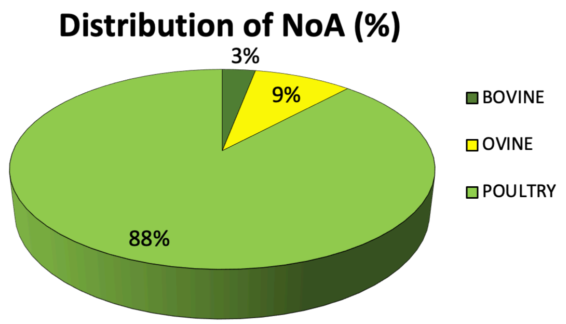

Figure 3. Percent distribution of NoA in respect to different farming systems.

Total BP of Çanakkale province

The previous studies have revealed the BPs of different years have ranged between 9.7×10^7 m^3 and 1.8×10^7 m^3 respectively by Ilgar (2016) and Özpınar (2018). The discrepancies have arised from two main reasons in these studies. Primarily, selection of different calculation methods have resulted in amended results, and secondly, consideration of less animal types and distinguishing ages of different animals led to variations in BP. The total BP of whole province was calculated as 6.4×10^7 m^3 in present study, and it was more consistent with the study conducted in 2016. The difference mainly occurred due to changes in the NoA in years, together with disregarding of the BPs in Imbros and Tenedos islands. The calculated BP is found to be respectable in comparison with different studies. The contribution of bovine, ovine and poultry farming systems to BP is another important parameter for such studies. Thereby, the amounts of BP from different farming types are given in Figure 5 in percentages (%). Accordingly, the major part of BP found to be obtained from bovine farming (71.8 %) within the whole province while the ovine and poultry have 6.2 % and 22.1 % of total potential, respectively. Even though the NoA in the ovine farming were higher than bovine, the highest BP found to be obtained from bovine farming and it was followed by poultry. The situation has arised due to the fact that the utilizable part of produced manure of ovine farming was significantly lower with a value of 13 % when compared to bovine (65 %) and poultry farming (99 %).

Moreover, the province level BP for 2020 and 2021 years were also calculated considering more recent NoA from TÜİK reports to show the latest status in the whole area due to the fact that data of 2022 is not available in the TÜİK database yet, since the sub-scale level data was covering 2019 inventory records. It was seen that total BP was 6.8×10^7 in 2020 and 6.9×10^7 in 2021. The NoA_{Bovine}, NoA_{Ovine}, and $NoA_{Poultry}$ were given as 221235, 784664 and 7030701 for 2020, and 222691, 850466, 7121413 for 2021 years, respectively. The portions of bovine, ovine, and poultry farming within total BP were calculated as 69.6 %, 7.2 %, and 23.2 % for 2020, and 69.1 %, 7.7 %, and 23.2% for 2021 years.

Equivalents of province-level BP

The equivalents of the BP in other energy sources are given in Figure 6. Dependently, it was seen that highest annual value has obtained for electrical energy with a value of over 300×10^6 kwh^{-1}. Conversely, the lowest equivalent value is calculated for butane as approximately 28×10^6 kg year^{-1}.The findings are important in terms of further calculations for cost savings on energy consumptions. On this account, a study was conducted by Demir-Yetiş et. al (2019) in Bitlis Province and it was denoted that the highest and lowest savings could be obtained from GO (L) and natural gas (m^3), respectively, considering the economic conditions and energy costs in 2017. Additionally, the equivalent values for 2020 and 2021 years are calculated and given in Table 3.

Table 3. The equivalents of BP in other energy sources based on 2020 and 2021 TUİK records

Year	BP (m^3)	FW (kg)	GO (L)	B (kg)	E (kW h^{-1})	G (L)	C (kg)
2020	68×10^6	235×10^6	43×10^6	29×10^6	319×10^6	54×10^6	99×10^6
2021	69×10^6	238×10^6	43×10^6	30×10^6	323×10^6	55×10^6	100×10^6

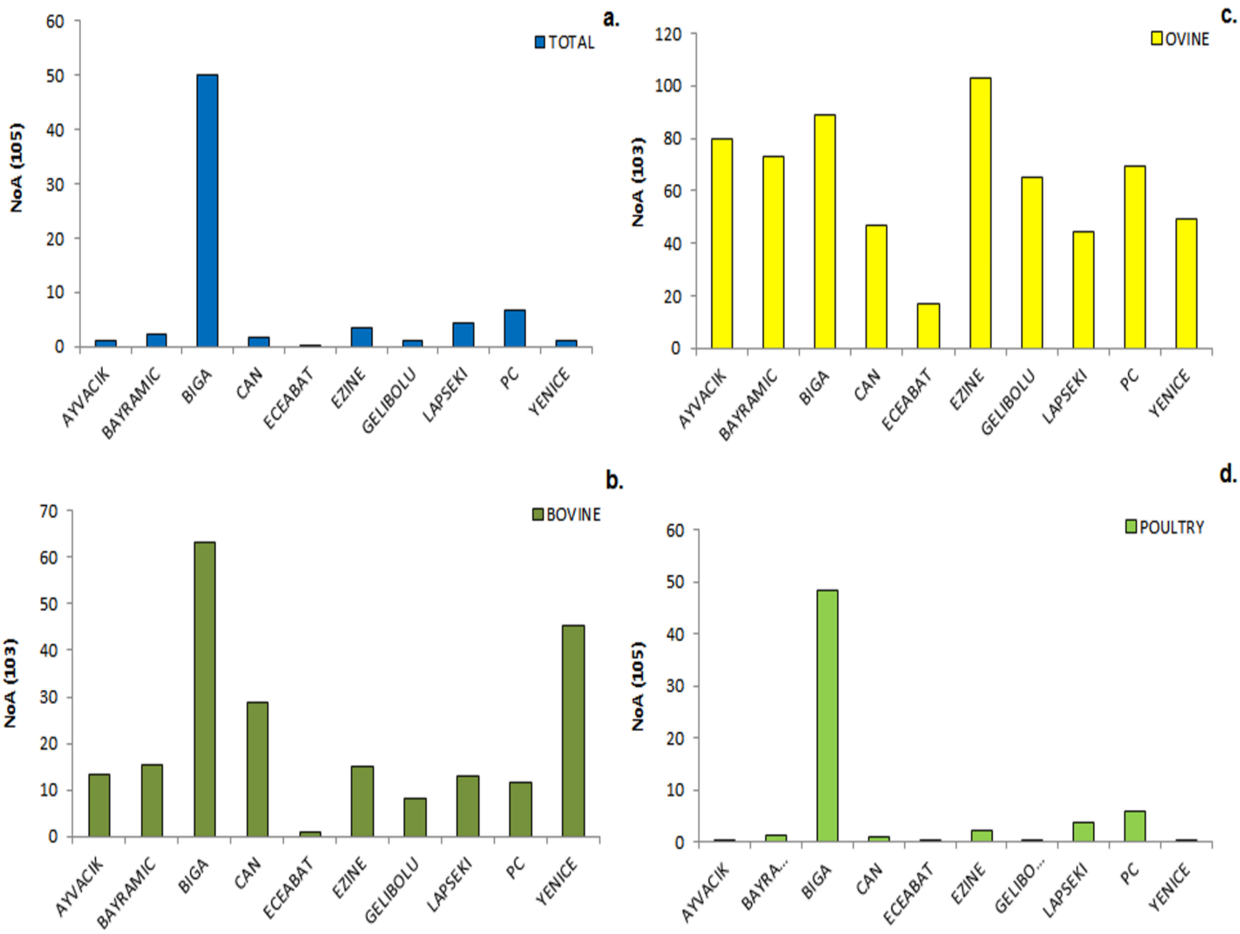

Figure 4. a. NoA_{Total}, b. district-level NoA_{Bovine}, c. district-level NoA_{Ovine}, d. district-level $NoA_{Poultry}$ farming.

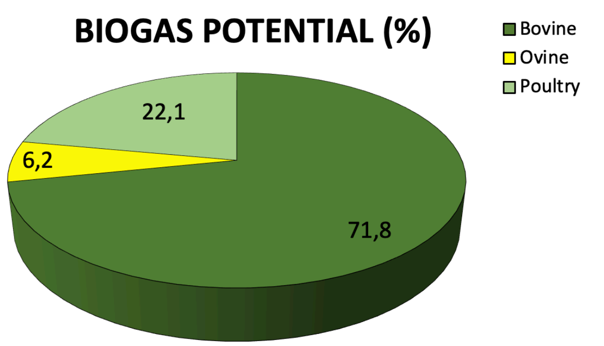

Figure 5. Distribution of total BP from bovine, ovine and poultry farming

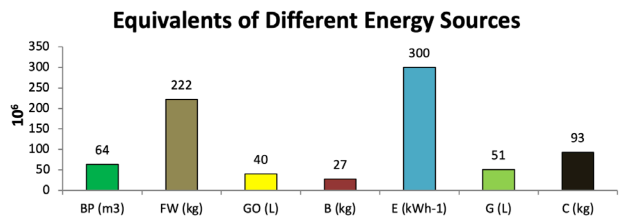

Figure 6. The equivalents of total BP in different energy sources.

District-level BP

The district based distribution of total BP (%) can be seen on Figure 7. Findings have revealed that Biga district owns the highest BP with 39 % of the total potential of whole province, and it was followed by Yenice district with a value of 15.7 % while the lowest potential found to be obtained from Eceabat district. The respectably high proportion of Biga district in the whole province BP was an expected result, which is directly sourced from comparatively higher NoA with the exception of the relatively small difference in NoA_{ovine} of Ezine district. Similarly, the situation in Eceabat was inevitable since the district included the least NoA in terms of all farming types.

The BP values of districts were investigated dependent to farming types (Figure 8). Accordingly, BP of each district was dominantly obtained from bovine farming, and it was generally followed by ovine farming except Biga, Lapseki and Provincial Centre (PC), where the poultry farming sourced BP was higher than the BP can be obtained from ovine farming.

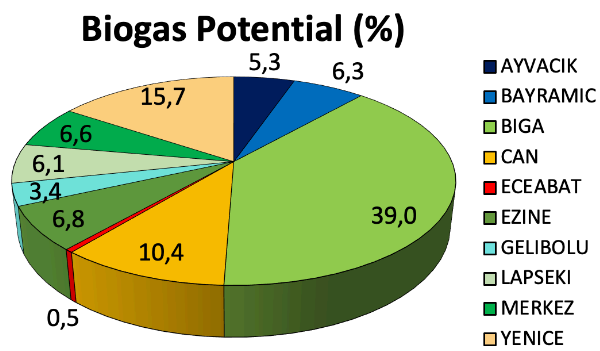

Figure 7. Proportions of total BP according to districts.

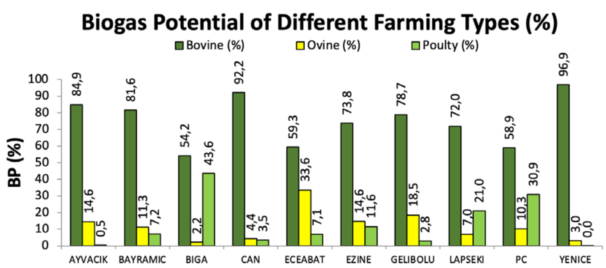

Figure 8. District level distribution of BP in terms of farming type.

Equivalents of district-level BP

The equivalents of district-level BPs can be seen on Figure 9. The distribution patterns of both potential biogas and its equivalents are similar to each other whereby highest potentials can be obtained from Biga district and corresponds to highest amount of electrical energy in all districts.

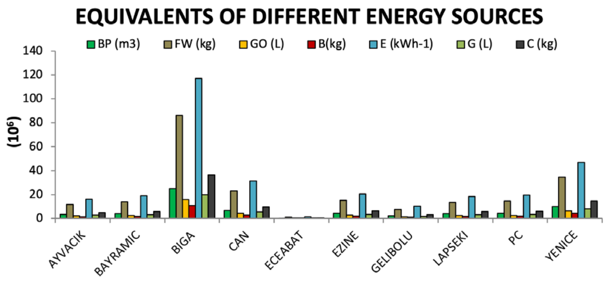

Figure 9. District-level amounts of equivalences for different energy source of BP.

Mapping distribution of subscale BP

Although, there are a few studies on BP mapping, they represented province or district potentials, for instance; Aybek et. al. (2015), and Atılgan et. al. (2020). Thence, present study differs from the previous researches conducted in other regions of Turkey. Also, it should be noticed that the records of two settlements located in the Southern part of Yenice district have included missing values, and thus, they were excluded and not considered within the frame of the study. The subscale distribution of BP can be seen on the BP map given in Figure 10. As it can be seen from the figure, majority of the subscales with higher BP is found in North-eastern part of the study area, where Biga district is located. The highest and lowest BP of each district is given in Table 4. Depending on the findings of the study, it was seen that the lowest BPs of different districts were ranged between 136.6 m^3 and 8336.0 m^3. Likewise, the highest BPs of districts has taken values between 99027.1 m^3 and 1543904.0 m^3. Namely, the lowest BP value can be obtained from Bahçedere village of Ayvacık district whereas the highest BP have found in Yukarıdemirci village of Biga. Accordingly, these values correspond to 0.0002 % and 2.4 % of total BP. Moreover the maximum value of lowest BP that can be obtained in different districts was from Güzeloba of Yenice district. On the other hand, the minimum value of highest BP has calculated as for Central Eceabat.

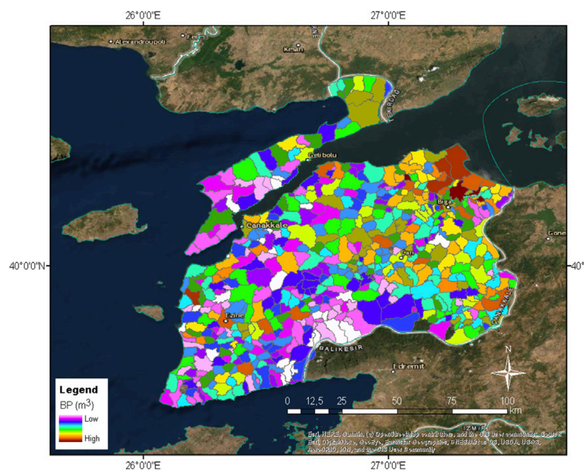

Figure 10. Digital map for distribution of subscale-level BP.

Table 4. Highest and lowest BP from the subscales of the districts.

DISTRICT	Lowest BP		Highest BP	
	Subscale	BP (m^3)	Subscale	BP (m^3)
AYVACIK	Bahçedere	136.6	Center	535614.4
BAYRAMİÇ	Osmaniye	1653.7	Türkmenli	574535.8
BİGA	Ilıcabaşı	5141.4	Yukaridemirci	1543904.0
CAN	Kazabat	6099.3	Yaykın	503326.4
ECEABAT	Bigalı	4834.0	Center	99027.1
EZİNE	Bozköy	474.8	Üvecik	737833.3
GELİBOLU	Burhanlı	2915.2	Yeniköy	192696.9
LAPSEKİ	Sındal	1658.9	Çardak	524953.7
PC	Güzelyalı	353.8	Gökçalı	344961.2
YENİCE	Güzeloba	8336.0	Pazarköy	474951.1

Table 5. The different energy equivalents of lowest BP from each district.

DISTRICT	Subscale	FW (kg)	GO (L)	B (kg)	E (kWh^{-1})	G (L)
AYVACIK	Bahçedere	474.0	86.1	58.7	642.0	109.3
BAYRAMİÇ	Osmaniye	5738.3	1041.8	711.1	7772.3	1322.9
BİGA	Ilıcabaşı	17840.8	3239.1	2210.8	24164.7	4113.2
CAN	Kazabat	21164.7	3842.6	2622.7	28666.9	4879.5
ECEABAT	Bigalı	16774.0	3045.4	2078.6	22719.9	3867.2
EZİNE	Bozköy	1647.4	299.0	204.2	2231.4	379.8
GELİBOLU	Burhanlı	10115.6	1836.6	1253.5	13701.2	2332.1
LAPSEKİ	Sindal	5756.2	1045.1	713.3	7796.6	1327.1
PC	Güzelyalı	1227.8	222.9	152.1	1663.0	283.1
YENİCE	Güzeloba	28926.1	5251.7	3584.5	39179.4	6668.8

Investigation of BP in smaller scales has several advantages, especially for selection of convenient sites using coordinates and their energy values. Such kind of analysis may be conducted by undertaking different approaches ranging from consideration of accumulated values for upper-scales to accounting of individual inclusions of each singular establishment. In this context, a study was conducted in Düzce province by Yürük and Erdoğmuş (2015) to determine optimum biogas plant locations within eight districts using coordinates of poultry farming establishments via k-means clustering algorithym. In that study, it was reported that the capacities of the establishments should be considered in addition to their proximities to obtain more precise results. Therefore, the findings of present study seemed to provide valuable information for further evaluations on selection of possible biogas plant locations using appropriate statistical analysis since the capacities are considered together with boundaries of subscales. Moreover, the advancements in BP can be captured annually by updating NoA data at the end of each year. Although there is currently biogas plant within the area, integration of latest data is expected to designate new locations for latter investments rapidly, due to the fact that the BP patterns may change in response to changes in NoA.

Mapping energy equivalents of subscale BP

Finally, the equivalents of the BP is mapped and given in Figure 11 a-e. As the result of higher BP, the patterns of hotspots for different energy sources are consistent. Even though these patterns were similar, the magnitude of collectable energy differs. On the other hand, it should be noticed that identifying the proportion of potential amounts within actual consumptions would be effective for better understanding of the necessity for collecting

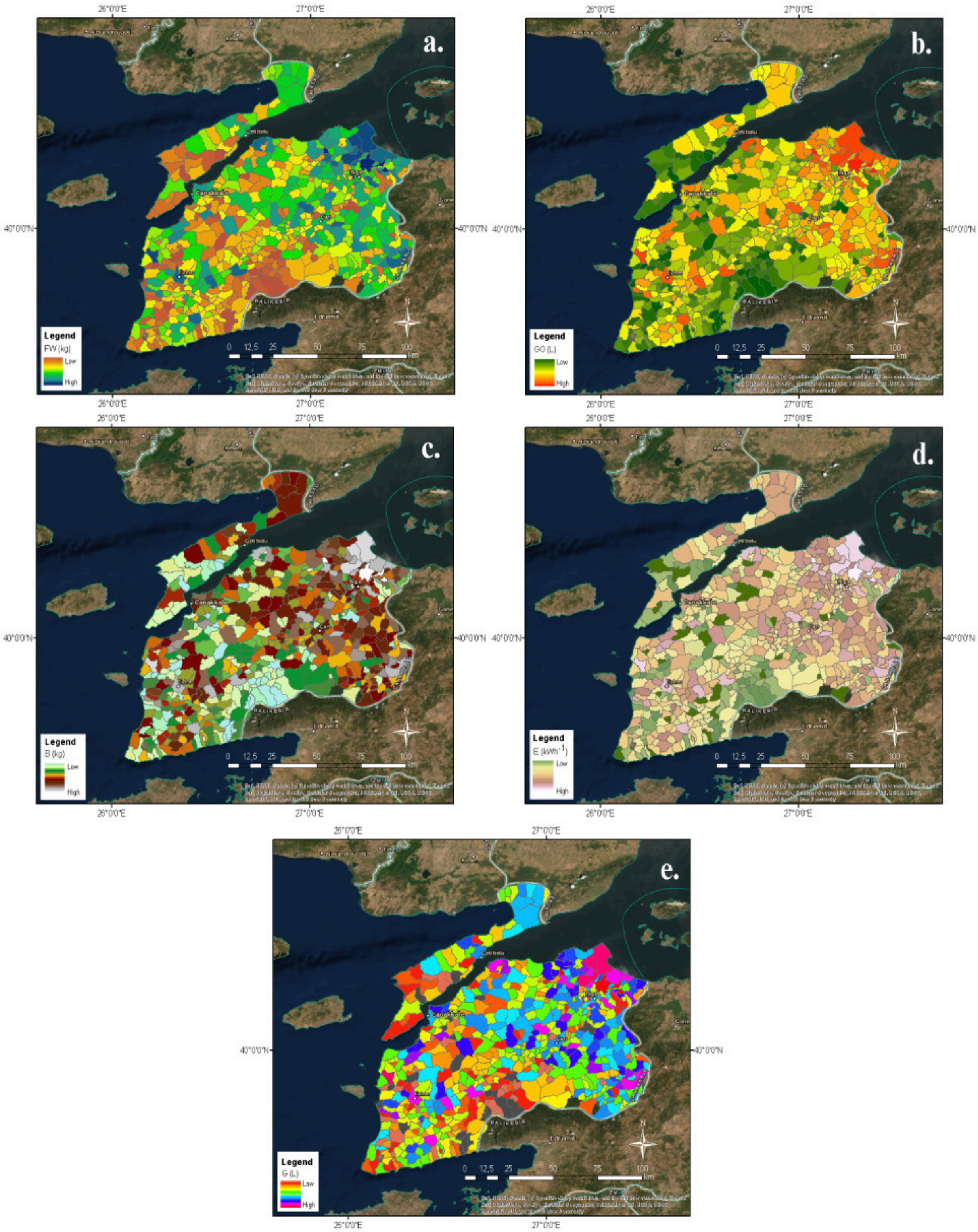

Figure 11. Subscale distribution of BP equivalents a. FW (kg), b. GO (L), c. B (kg), d. E (kWh^{-1}), and e. G (L).

the animal wastes in each settlements since the process will also contribute to avoiding from adverse effects of such wastes on natural resources like surface and ground water, as well as soil, in different ways.

The equivalents of BP in different energy sources are given in Table 5 and Table6, according to the lowest and highest BP of each district, respectively. Dependent to Table 5, the minimum and maximum values from the lowest BP of each district seemed to be obtained from Ayvacık and Yenice districts. On this account, annual minimum and maximum values of FWs were calculated as 474 kg and 28926 kg, GOs were 86 L and 5252 L, Bs were 59 kg and 3585 kg, Es were 642 kWh^{-1} and 39179 kWh^{-1}, and G were 109 L and 6669 L.

The minimum and maximum equivalent values from the highest BPs of each district have shown that the minimum and maximum values of equivalents from highest BP of each district were calculated for Eceabat and Biga districts (Table 6). The maximum and minimum amounts of FWs were 343624 kg and 5357347 kg, GOs were 62387 L and 972660 L, Bs were 42582 kg and 663879 kg, Es were 465428 kWh^{-1} and 7256349 kWh^{-1}, Gs were 79222 L and 1235123 L.

Table 6. The different energy equivalents of highest BP from each district.

DISTRICT	Subscale	FW (kg)	GO (L)	B (kg)	E (kWh^{-1})	G (L)
AYVACIK	Center	1858584.0	337437.4	230314.4	2517390.0	428491.9
BAYRAMİÇ	Türkmenli	1993639.0	361957.5	247050.4	2700318.0	459628.6
BİGA	Yukaridemirci	5357347.0	972659.5	663878.7	7256349.0	1235123.0
CAN	Yaykın	1746543.0	317095.6	216430.4	2365634.0	402661.1
ECEABAT	Center	343624.1	62387.1	42581.7	465427.5	79221.7
EZİNE	Üvecik	2560281.0	464835.0	317268.3	3467816.0	590266.6
GELİBOLU	Yeniköy	668658.4	121399.1	82859.7	905675.6	154157.6
LAPSEKİ	Çardak	1821589.0	330720.8	225730.1	2467283.0	419963.0
PC	Gökçalı	1197015.0	217325.5	148333.3	1621318.0	275968.9
YENİCE	Pazarköy	1648080.0	299219.2	204229.0	2232270.0	379960.9

Consequently, identifying the proportions of all energy types within their consumption amounts for all considered settlements may represent a finer illustration for actualization of these potentials. Thereby, the ratio of concurrently used energy to obtainable energy believed to provide valuable information in further studies. Moreover, inclusion of population data is highly suggested to compare the percentages of a certain population's needs met through the obtainable energies. At this point, collection of subscale level socio-economic data through surveys is necessary, which is not yet publicly available. Additionally, the geographic distribution of NoA in different farming systems such as livestock or poultry would also presents vital knowledge for determining availability of biogas feedstock (Scarlat et. al., 2018; Levstek and Rozman, 2022). In this point of view, GIS tools provide simultaneously consideration of several environmental, technical, and economical phenomenon and concepts including, nature and water conservation, proximities to settlements, water resources, transportation networks, and costs (Sliz-Szkliniarz and Vogt, 2012).

CONCLUSION

As it is well known, Turkey includes a wide variety of agricultural production due to suitability of soil, topography, and climate conditions. Increments in the use of agricultural wastes, particularly manure, for producing renewable energy would provide more efficient plans, initiatives, and investments for a sustainable future. For this purpose, the potential contribution of Çanakkale Province seems promising with an amount of 6.4×10^7 m^3 BP. The district level highest and lowest BPs were predicted for Biga and Eceabat. Moreover, the study presented the first subscale biogas investigation initiative in the area, and provided highly precise results by consideration of smaller settlements such as townships and villages in addition to districts. District level results have relealed that highest BP can be obtained from Biga district, while the lowest BP was calculated for Eceabat. However, subscale level distribution patterns were quite different. On this account, even though the highest BP is found in a sublevel settlement of Biga district, namely, Yukarıdemirci village (154×10^4), the lowest BP was found to be obtained from Bahçedere village of Ayvacık district with a value of 137 m^3 instead of Eceabat. Usage of the whole potentials from each settlements would enable to overcome many environmental issues, contributes to maintanance of soil and water resources. Also, it is known that treatment of agricultural level in energy production provides the advantages of purification of anumal waste from weed seeds and undesirable levels odour before using as manure. Furthermore, such attempts will help to reduce the emissions of greenhouse gasses. In another point of view the process would led to economic and social welfare, in return. In conclusion, the BP of Çanakkale Province seemed noteworthy when compared to studies conducted in other relatively small cities of our country. Utilization from GIS tools for biomass evaluation provided labour effective and rapid demonstration for geographic distribution of energy potentials. In addition, integration of inventories into GIS have allowed expeditious update of the data conveniently by considering the latest annual reports, due to it's dynamic structure. The results believed to serve as a baseline for further studies, particularly for site selectioion by denominating the capacities of each settlement since the transport costs of produced wastes comprise a challenge in determination of appropriate areas for biogas plant construction. Currently, a study is ongoing to identify the proper locations for optimizing financial support allocation using topographic data, soil properties, latest land use and land cover data, current status and future predictions of NoA, socio-economic data and relevant statistical analysis.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The author declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

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Ethics committee approval is not required.

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