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Investigation of Biogas Potential (Cattle, Sheep and Goat) for Electricity Generation in Baghlan province

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Abstract

This study implies to evaluate biogas potential from livestock manure (cattle, sheep and goat) as an alternative to fossil fuel for Baghlan province of Afghanistan. Furthermore, Using biogas to generate electricity. The potential of biogas has been observed as top value with 1107715.3 (m^3/ year) in Pul-I-Khumri and as the lowest with 238972.6 (m^3/ year) in Tala Wa Barfak for cattle, sheep and goats when cattle is investigated, the top biogas potential value was 927382.9 (m^3/ year) in Khost Wa Fring, then Baghlan Jadeed with 902663.3 (m^3/ year) is followed by Pul-I-Khumri with 900555.4 (m^3/ year). The highest biogas potential value was 176711.4 (m^3/ year) for sheep in Pul-I-Khumri and 45052.0 (m^3/ year) for goat in Khost Wa Fring. The study implicates that just three animals (cattle, sheep and goat) generate 12815.6 (Mwh/year) of eletrical energy with share of 83% cattle, 13% sheep and goat with 5% in the year of 2023. Finally, this paper concludes with a discussion of the environmental, social and economic benefits of biogas production and its potential role in mitigating climate change for this region.

Keywords: Biogas potential, Livestock Manure, Baghlan province, Anaerobic Digestion, Electricity

Introduction

Afghanistan is a country which has a great potential of energy resources, Renewables like hydropower with an estimated potential of 23500Mw Totally, Solar energy with having 300 days of sunlight specially in east areas, Wind energy in Herat for having 120 days' wind and Punjshir, Biogas with an estimated potential of 1172355870 m3/y and 1282692614 m3/y from 2010 to 2017. As a research, that Afghanistan biogas potential between 2010 and 2017 was between 1172355870 m3/y and 1282692614 m3/y, which could obtain, then from that the total annual heat value potential is between 29117122340 MJ/y and 26612478246 MJ/y.

(Rahimy, Laame, Acikkalp, & Kandemir, 2021) Along with it Animal husbandry is a major feature of the Afghan agriculture about 79% of rural households and 94% of Kuchi population own some kind of livestock. (IOCN Institute 2009) Animals kept by farmers include cattle, horses, donkeys, camels, goats and sheep. Baghlan is a province which has a huge potential of biogas production from livestock, located in the north of Afghanistan. This province has a population of about 1,014,634 with share of 49% female and 51% male. (NISA, 2020 & 2021) Baghlan province faces with many problems that can potentially be solved with help of anaerobic digestion of livestock waste. It's clear that livestock waste is usually a major portion of any animal wastes (AW) which are traditionally used in Baghlan province for cooking and heating requirements so it will not Create Discussion for disposed of in landfills or dumping sites that creates environmental problems. However, biogas production could provide multiple benefits to the Baghlan region by providing energy services (cooking, heating and electricity), improving local environment. And Furthermore, social benefits such as new job opportunities and a better living environment for the inhabitants of the city could result from the successful implementation of the waste to biogas project. (Naami, 2017)

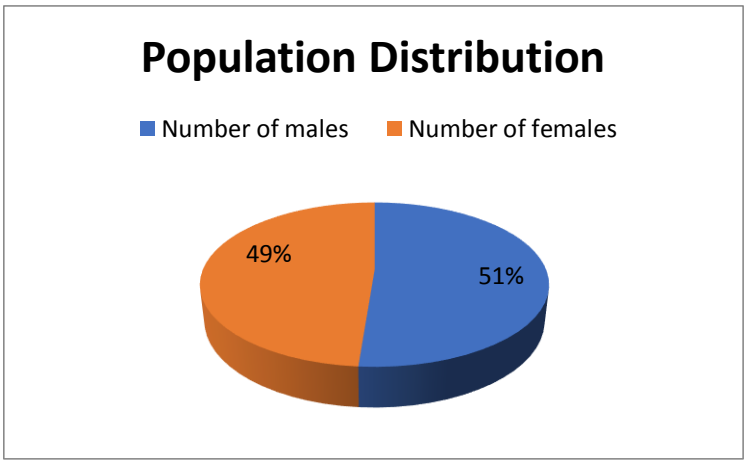

Figure 1. Population distribution for Baghlan province. (NISA, 2020 & 2021)

As a high dependency of Afghanistan to a second country for exporting energy especially in the form of electricity, so a big part it comes from neighbour countries. In 2020 & 2021, This country imports totally 10489533 MWh of electricity from its neighbours with a share of 46% from Uzbekistan followed by 21% from Tajikistan, 18% from Turkmenistan and 15% from Iran. (NISA, 2020 & 2021)

To obtain the objective of this research, we should meet following research questions.

Research question 1: What is the potential biogas production capacity from livestock waste in Baghlan Province, considering specific anaerobic digestion technologies?

Research question 2: How can the utilization of biogas from livestock waste contribute to sustainable energy access and reduce dependence on traditional fuels in Baghlan Province?

Research question 3: What are the key factors influencing the biogas yield and composition from livestock waste in Baghlan Province?

Research question 4: What are the environmental benefits, including greenhouse gas emissions reduction, associated with biogas production from livestock waste in Baghlan Province?

Literature Review

Biogas is a source of Bioenergy that play a central role in promoting renewable alternatives. Achieving the goals related to reducing the environmental impact of the energy sector is essential, as energy production and consumption are responsible for 72% of global GHG emissions. (World Resources Institute 2017) (Was, et al., 2020) In fact, bioenergy is estimated to be the fourth largest energy resource in the world (Ali & Sun, 2015). Globally only about 18% of total final energy consumption comes from renewables (Was, et al., 2020), According to the World Biogas Associations report Global Potential of Biogas, there were approximately 132 000 small, medium or large-scale digesters in operation in the world in 2017. (Lindkvist, 2020) The world's total biogas production in 2020 was 38.1 billion m3 with an equivalent energy content of 1.46 EJ. (WBA, 2022)

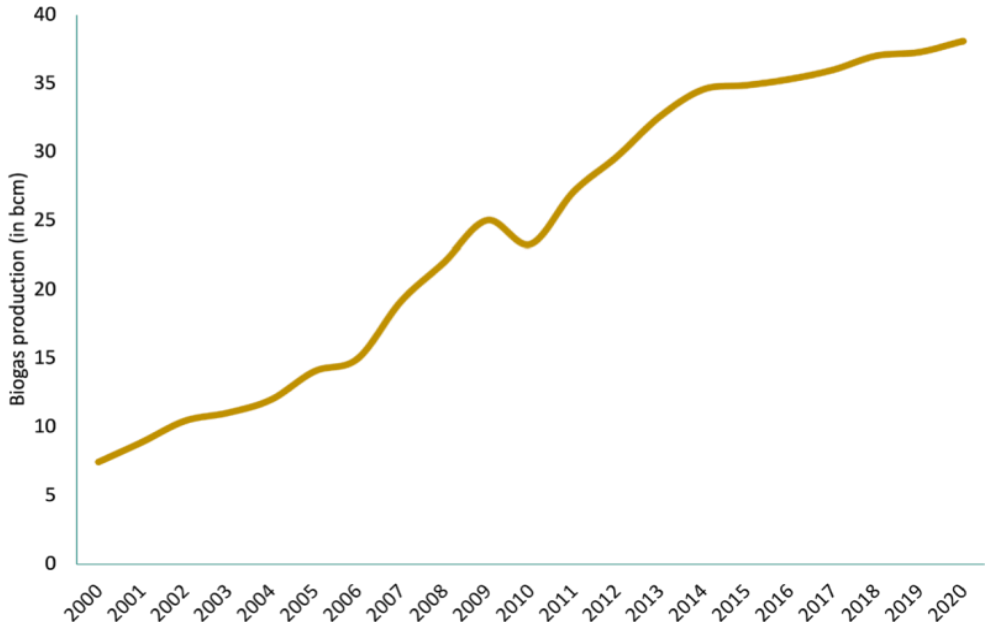

Figure 2, Globally biogas energy production. (WBA, 2022)

The world gross final energy consumption in 2019 from all energy sources was 379 EJ. (WBA, 2022). The demand for energy worldwide is expected to continue to increase in emerging market and developing economies by 1.4% per year in the STEPS through 2030. (Cozzi & Gould, 2022)

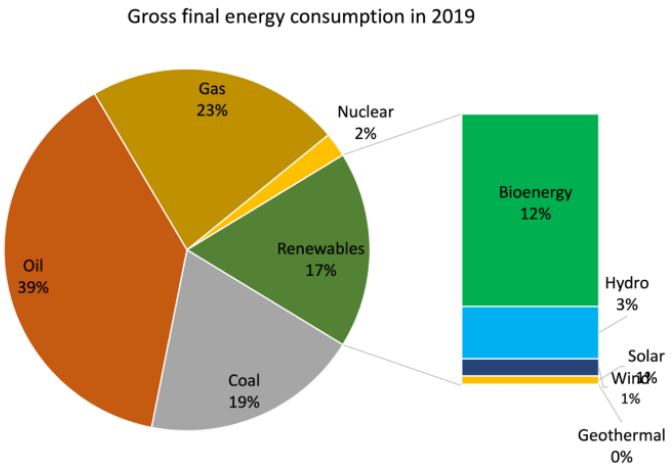

Figure 3, world final energy consumption. (Cozzi & Gould, 2022)

The 7669 TWh of renewable electricity was produced globally in 2020. Hydropower was the largest renewable electricity generating source with a share of 58%, then followed by wind with 21%. Bioenergy was the 4th largest renewable electricity generating source with production of 685 TWh in 2020. (WBA, 2022)

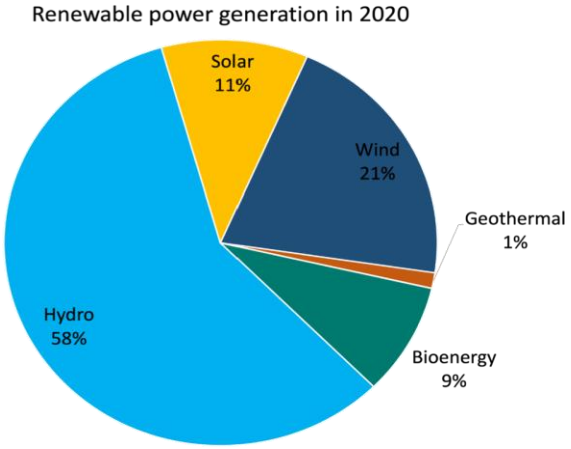

Figure 4, Electricity Generation from Renewables Worldwide. (Cozzi & Gould, 2022)

Biogas is a product of the biochemical decomposition of organic materials which gives the gas with a calorific value of about 20 MJ/m3. (Caparedo, 2014) It involves mainly of methane (50–75%), carbon dioxide (25–50%), and water vapors. It would also contain small quantities of hydrogen sulfide, nitrogen, ammonia, and other trace gases. (Makara, Lytour, & Chanmakara, 2021)

Waste generation in Baghlan Province

Afghanistan's commercial cities like Kabul, Herat, Kandahar, Mazar-shariff, Nangharhar, Takhar and Faizabad generate the largest amount of municipal waste at approximately 6300 tonnes per day. This amount of daily waste can generate 250Mw electricity, Energy and heating for the residential properties. As an information from Ministry of Water and Energy of Afghanistan in Kabul, that there is no data form completion of a biogas

energy project or operational plant in Afghanistan. Furthermore, here I want to add that a project is under work and all pre-feasibility study also has been done. (NISA, 2020 & 2021)

The actual daily waste generation in Kabul city is 4500 Sqm/day with the potential for power generation capacity of above 140Mw including heating purposes. Around 120000 people lives in the Macrorayan area of the city (Macrorayan 1,2,3 and 4) and the heating plant in this area is equipped with old technology and lower effectiveness built the Russian during king zahir khan era near to the third Macrorayan that burn around 5.7-million-liter fossil fuel annually in the three months of winter. (Bank, 2022)

One of the most agricultural province of our county is Baghlan, so for finding the justification of how much and where biogas can be beneficial for this region. According to survey from ministry of agriculture and animal husbandry of Afghanistan about population of animals (cattle, Sheep and Goat) that I receive it. After analyzing those data, the result appears as the total waste production of animals in each district for the region (kg/year), which can be seen below in the table. (Bank, 2022) (NISA, 2020 & 2021)

Table 1, Animal waste generation in term of districts.

(kg/year)	Cattle	Sheep	Goat
Pul-I-Khumri	12007405	13593184	2903173.5
Baghlan centre	12035510	9387946	1384627.5
Dahana Ghuri	4008065	8769198	2967340.5
Dushi	9184860	6528098	3579555
Khinjan	2631650	1423354	2624058
Andarab	2977670	2277746	2180473.5
Nahreen	2923285	3597148	1603627.5
Burka	1964795	8018320	2152770
Tala Wa Barfak	2571790	2254240	1600233
Pul Hisar	3323690	3131992	1736341.5
Deh Salah	2674355	2889632	1758241.5
Jalga	3266385	1647464	1556871
Khost Wa Fring	12365105	4847930	4295575.5
Fring Wa Gharu	3358730	934546	976083
Gozargah Noor	2631650	1423354	2624496
Total	77924945	70724152	33943467

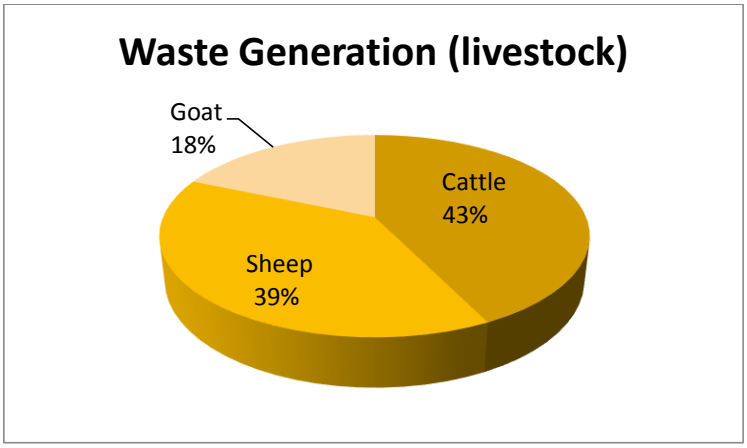

Figure 5, Waste generation from Animals (%)

Operational factors of AD

The most important operational parameters for an anaerobic digestion are, (Safari, Sahraie, & Gholamy, 1397)

Temperature

The following types of digestion are distinguished according to the temperature in the digester:

1) Psychrophilic digestion (10˚C - 20˚C, retention time over 100 days),
2) Mesophilic digestion (20˚C - 35˚C, retention time over 20 days),
3) Thermophilic digestion (50˚C - 60˚C, retention time over 8 days) (Njogu, Kinyua, Muthoni, & Nemoto, 2015).

PH

One of the main factor causing problems in the digester operations is acidity condition. In a reactor with a proper balance, by production of bicarbonates by methanogenic bacteria the pH level can be controlled. The use of alkaline substances can help to control the pH and reduce the accumulation of acidic materials. Anaerobic digestion process will face serious issues at pH levels, and this situation occurs when the organic loading exceeds the predetermined amount. A types of organic acids acidogenic bacteria that are essential in reducing the pH level of the process. Research has shown that the suitable pH range for biogas production is between 6.8 and 7.2. Any deviation outside this range disrupts the life of methanogenic bacteria and stops methane production (Safari, Sahraie, & Gholamy, 1397).

Raw material properties C: N ratio

The range of C/N ratio between (20 – 30:1) would help to yield optimum biogas production. The variation of the C/N values can affect the pH of slurry. The increase in carbon content will give rise to more carbon dioxide formation and lower pH value, while high value of nitrogen will enhance production of ammonia gas that could increase the pH to the detriment of the micro-organisms (EFFECT OF CARBON TO NITROGEN RATIO ON BIOGAS PRODUCTION, 2013).

Organic loading rate (OLR)

The representation of substrate quantity introduced into the reactor volume in a given time is called Organic Loading Rate (OLR). It is a measure for biological conversion capacity. This is a parameter that is particularly important in continuous systems. Overloading leads to an increase in volatile fatty acids which leads to acidification and can therefore lead to a system failure because of an increase in the pH level. The optimal OLR should be between 4-8 kg VS per m3 reactor and day, an example of continuous AD system in industrialized countries where describe that the reactors is continuously stirred. (Naami, 2017)

Material mixing

The composition of waste or substrate is crucial in the AD process. Generally, the concentration of lipids, proteins and carbohydrates in the substrate gives a general idea about its behavior in the AD process. Due to high degradability and rapid transformation of Carbohydrates Will resulted in higher biogas yield. (Al-Wahaibi, et al., 2020)

Raw material retention time (HRT)

HRT is defined as the volume of the sludge (m^3) in the digester divided by the volume of the digester sludge (m^3/day). It's also defined as the amount time that a given amount of sludge is remained in the reactor. (Souza, et al., 2022)

Digester Size (m^3) = HRT (Day) * Digester sludge volume (m^3/day)

Failure to regulate the two of them temperature and ph is the most common problems with a digester. So I really admire of finding the suitable condition for digester system, which I got it from reference.

Table 2, Suitable condition for anaerobic digestion. (Al-Rousan & Zyadin, 2014)

Parameter	Hydrolysis/acidogenesis	Methane synthesis
Temperature	25˚C - 35˚C	Mesophilic 32˚C - 42˚C Thermophilic 50˚C - 58˚C
pH value	5.2 - 6.3	6.7 - 7.5
C:N ration	10 - 45	20 - 30
Dry matter content	<40% DM	<30% DM
required C:N:P:S ratio	500:15:5:3	600:15:5:3
Trace elements	No requirements	Essential: Fe, Mn, Zn, Cu, Ni, Co, Mo, Se

Biogas feedstock (Recourses)

The substrates used in practice for biogas production are selected based on their suitability and availability. Significant sources of biogas feedstock's are agricultural (animal

manures and slurries, vegetable by-products and residues, energy crops), industrial (organic wastes, by-products, and residues from agro-industries, food industries, fodder, and brewery industries, organic-loaded wastewaters and sludge's from industrial processes, organic by-products from biofuel production and bio refineries, etc.), and municipal (source separated household waste, sewage sludge, municipal solid waste, and food residues) operations. (Makara, Lytour, & Chanmakara, 2021)

Generally, the feedstock is divided into three main types:

Agriculture waste

Municipal waste

Industrial waste

Two feeding models are generally used in anaerobic digestion process. These are batch system and continuous system. In batch system, digesters are filled once with fresh feedstock, with or without addition of inoculum and sealed for complete retention time. In continuous system, fresh feedstock continuously enters the digester and equal amount of digested material is removed which may be referred as Hydro retention time. (Mr.S.Sathish, 2015) The biogas production process occurs in the digester; anaerobic digestion is a series of biological process in which microorganism breaks down biodegradable material in the absence of oxygen.

The continuous feeding system has three different biogas digester.

1. Fixed dome plant (Hemisphere, Deenbandhu and Chinese designs)
2. Floating drum plant
3. Balloon/bag digester (Elsayed, Officer, & Statistics, 2016)

Type of Digester

A biogas plant consists of three main components, namely: mixing chamber, digester and expansion chamber. The required quantity of dung and water is mixed in the mixing chamber and this mix in the form of slurry is allowed to flow and be digested inside the digester. (Macharial & W.N.Musungu, 2008)

Fixed dome plant

The most known biogas digester, Therefore the most used type of digester plants in the world. The first fixed dome digester has been launched in China in 1936, The digester in a fixed dome plant consists of an underground pit lined with concrete or brick, with an inlet pipe that is used to add feed to the digester. The gas will produce under pressure and is stored under the dome at the top of the digester. Biogas is removed from the digester using a pipe attached to the top of the dome. The typical Chinese fixed dome plant often consists of a cylindrical digester with a round top and flat or curved bottom. Other variations of the fixed dome plant developed in India include the Deenbandhu and Deenbandhu 2000 model biogas plants, which have a dome at the top and a curved base. (Elsayed, Officer, & Statistics, 2016)

Construction Material:

- Natural material (Cement, Sand, Gravel, Water)
- Cobblestones
- Rubber hose
- Galvanized iron pipe
- Valve
- Pipe
- Bricks
- High density polyethylene pipe (HDPE)
- Brass nipple
- Biogas burner

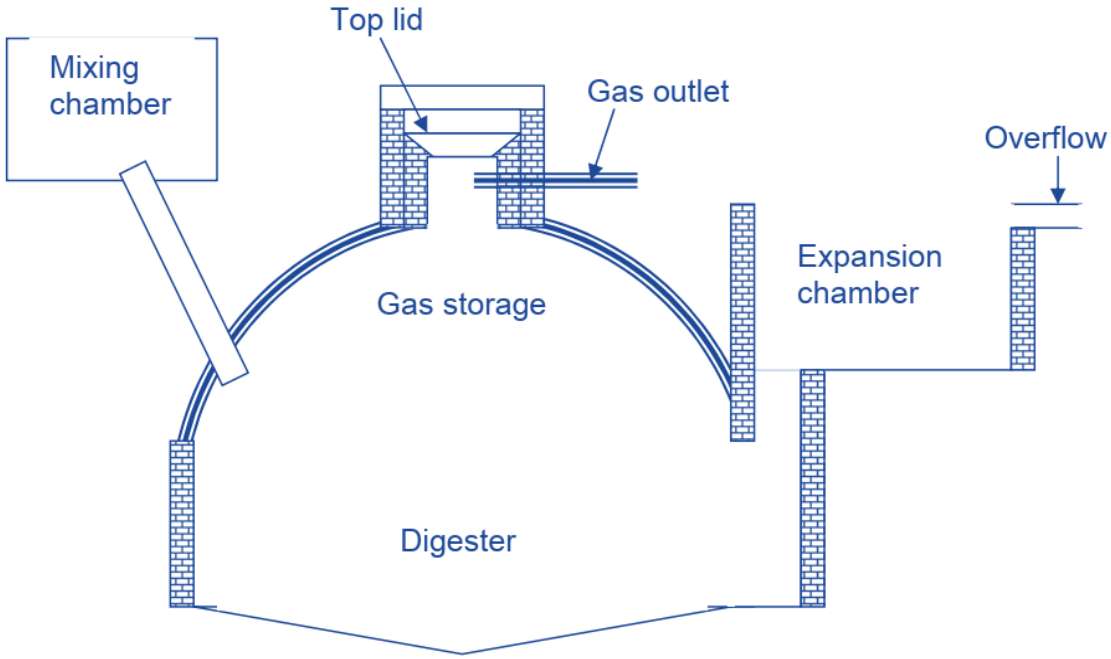

Figure 6, Fixed dome biogas plant. (Macharial & W.N.Musungu, 2008)

Balloon/bag digester

A balloon plant, also called tube digester or ball type digester is a digester plant that consists on a long tube generally made in plastic. It is very popular and is widely used around the world for it is cheaper than the other technologies and easier to construct. Taiwan was designed the first balloon plant in the 1960s with the aim of avoiding some problems encountered with the classical fixed dome and floating drum digesters. (Lahlou, 2017)

Construction Material

- Plastic tubes
- Smaller drum (for the gas holder)
- Valve

- Gallon drums
- PVC pipes

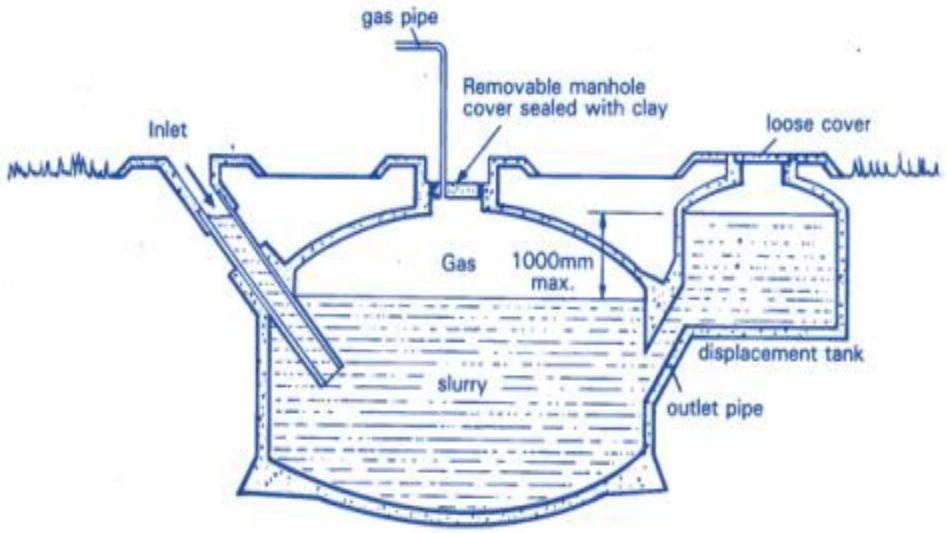

Figure 7, Balloon type Biogas digester. (Saleh, 2012)

Floating dome system

India was originally developed the floating dome system. It consists of an underground reactor in brick or concrete, and a gas holder in metal or plastic that floats on top. (the floating dome) This type is generally not constructed beyond the household scale (approx. $15m^3$) due to the practical size of the gas holder. A metal floating dome is often used as gas holder in India. Because of limited availability and high material costs. (Mertins & Wawer, 2022)

Construction Material:

- Safety valves
- Long tube made of PVC (Polyvinyl Chloride)

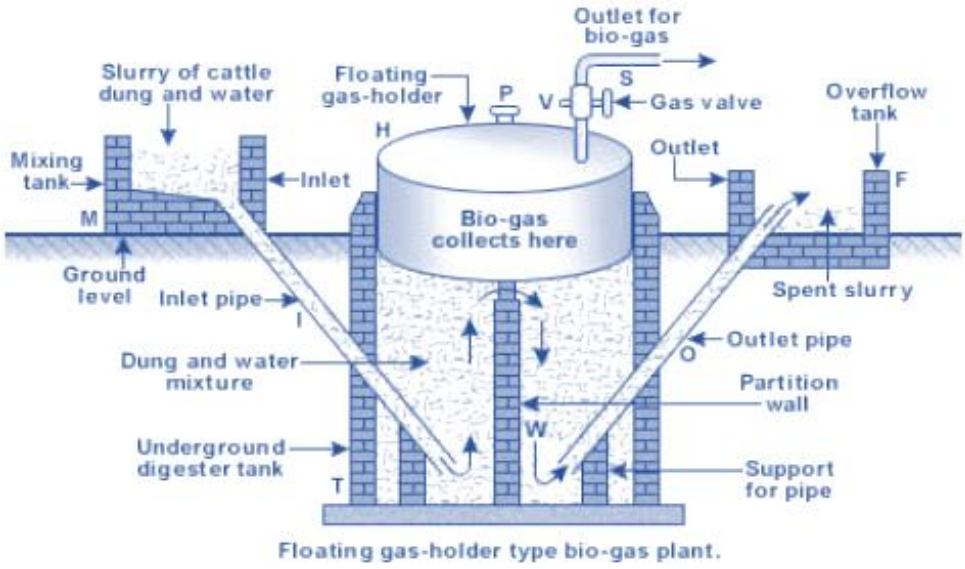

Figure 8, Floating dome Biogas digester. (Saleh, 2012)

Benefits of anaerobic digestion

- Renewable Energy Production
- Climate Change Mitigation
- Contributing Towards a Circular Economy
- Improving Urban Air quality
- Contributing Towards Food Security
- Economic Development and Job Creation
- Improving Health and Sanitization Through Better Solid Waste Management. (Jain & Newman, 2019)

The world can be mitigating 570 Mt CO2 eq. emissions by 2030 while 2,047 TWh energy from livestock should be generated and 4798 TWh energy and 1193 Mt CO2 eq. emissions by 2050 as shown in the charts below. While most energy generation benefits increase with time, they are countered by the falling global emission factors for electricity and heat generation from the generation of cleaner energy resulting from the deployment of renewable energy technologies. (WBA, 2022)

Research Method

Data Collection

The data used in this research, is secondary date that collected from Ministry of water and energy and Ministry of Agriculture and Livestock of Afghanistan in Kabul, aside of that the reliable resources, such academic research papers, books, reports. The secondary data primarily collected by survey, laboratory tests, and investigations. For analysis and finding, we used form quantitative approach as well as form formulas and tables.

Study of area

Baghlan province is located north of the Kabul and surrounded by Bamian, Parwan, Takhar, Kunduz and Samangan provinces. It lies on the main route to the north and Northeastern regions of Afghanistan. The province covers an area of 20362 km2. Around 79% of the population of Baghlan lives in rural districts while 21% lives in urban areas. (NISA, 2020 & 2021)

Figure 9, Baghlan province geographical map. (https://easylibrary.org/product/534/)

This beautiful province has 15 districts which Pul-I-Khumri district is the center of this province.

Table 3, Population of Baghlan province, AFG. (NISA, 2020 & 2021)

Population of Baghlan by District			
District	**Number of males**	**Number of females**	**Total population**
Provincial Capital (Pul-e-Khumri)	119,343	123,516	242,859
Dahana-e-Ghuri	32,372	34,246	66,618
Dushi	36,914	38,683	75,597
Nahreen	38,177	40,261	78,438
Baghlan-e-Jadeed	98,543	99,839	198,382
Khinjan	16,864	17,547	34,411
Andarab	14,075	14,755	28,830
Deh Salah	17,394	18,743	36,137
Khwaja hejran (Jalga)	13,013	13,958	26,971
Burka	28,947	30,574	59,521
Tala Wa Barfak	16,465	17,679	34,144

Pul -e-Hisar	15,004	16,218	31,222
Khost Wa Firing	34,656	36,689	71,345
Gozargah-e-Noor	5,444	5,982	11,426
Firing Wa Gharu	9,162	9,571	18,733
Total	**496,373**	**518,261**	**1,014,634**

Phase 1: Livestock Density map

To estimate animal population, I review the livestock density map for Afghanistan. Dataset at 1 km resolution from FAO's Animal Production and Health Division was used. (Gilbert *et al.*, 2022a–c)

Density of cattle, goats and sheep are shown in below Figure.

Data were then reclassified into three classes:

- Low (0–9 heads of livestock)
- Medium (9–30 heads of livestock)
- High (30–753 heads of livestock)

Figure 20, Shows the density map of total (Cattle, Sheep and Goat) for baghlan province.

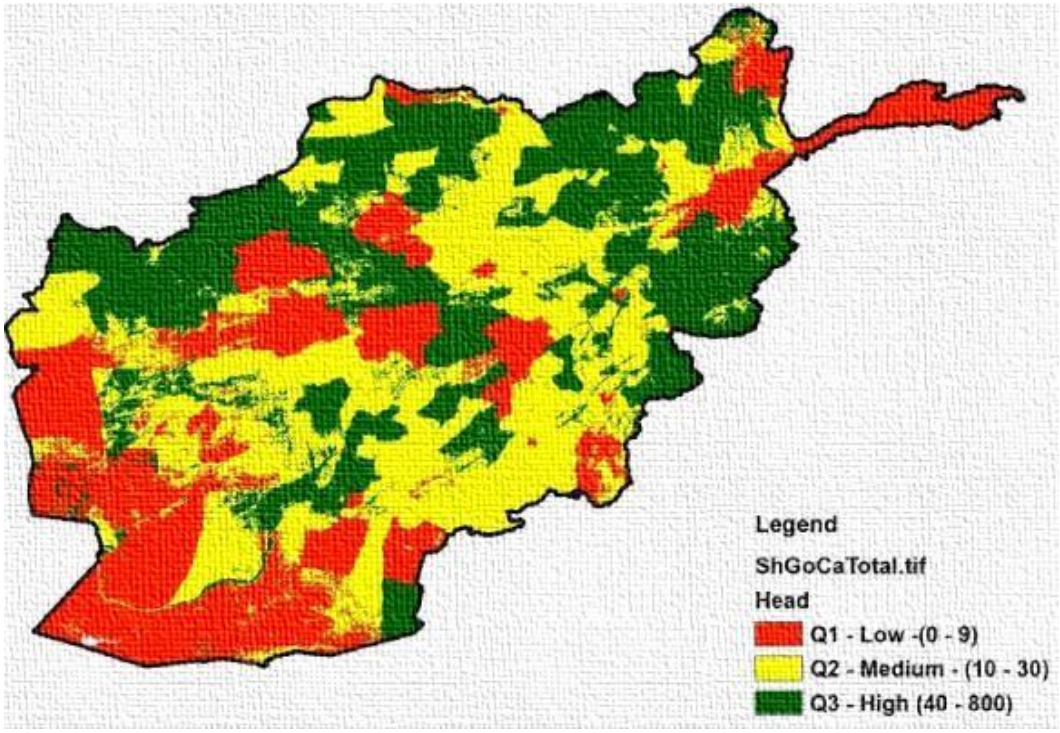

Figure 10, Livestock (cattle, sheep and goat) density map of the Afghanistan. (Nations, 2023)

By focusing on the density map and historical data 2017 which predicate the region has the third most livestock population in the country.

Phase 2: Ministry of Agriculture and Animal husbandry

Apart from that, after I passed and going throughout some governmental regulations finally I received the datasheet of Animal population for this region from Ministry of Agriculture and Animal husbandry of Afghanistan in Kabul.

Table 4, Livestock population in term of district for Baghlan province. *(https://mail.gov.af/en)*

	Cattle	Sheep	Goat
Pul-I-Khumri	32897	93104	26513
Baghlan centre	32974	64301	12645
Dahana Ghuri	10981	60063	27099
Dushi	25164	44713	32690
Khinjan	7210	9749	23964
Andarab	8158	15601	19913
Nahreen	8009	24638	14645
Burka	5383	54920	19660
Tala Wa Barfak	7046	15440	14614
Pul Hisar	9106	21452	15857
Deh Salah	7327	19792	16057
Jalga	8949	11284	14218
Khost Wa Fring	33877	33205	39229
Fring Wa Gharu	9202	6401	8914
Gozargah Noor	7210	9749	23968
Total	**213493**	**484412**	**309986**

The comparison form of livestock (Cattle, Sheep and Goat) distribution for each district of this province can be seen by the below chart,

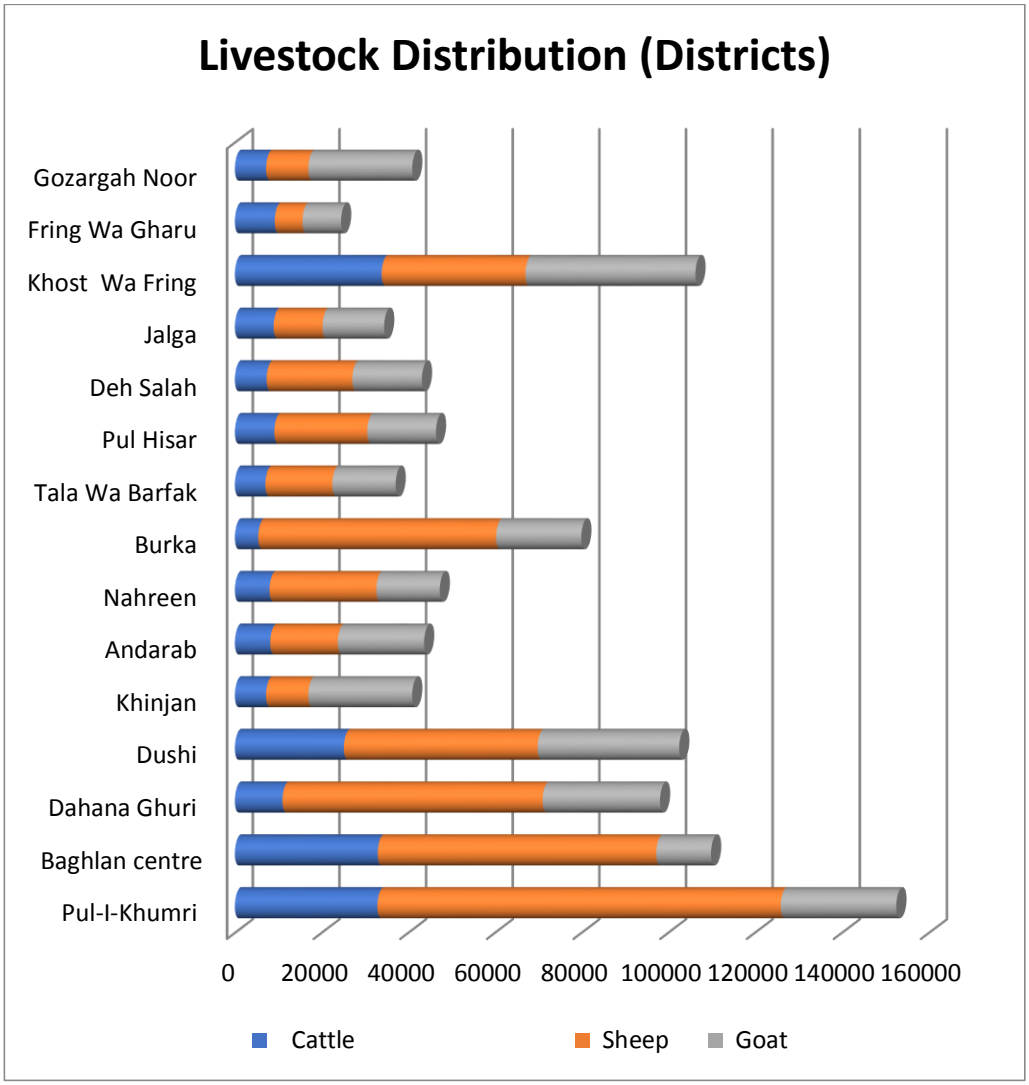

Figure 11, Comparison Schematic of livestock distribution in term Region (Districts). (https://mail.gov.af/en)

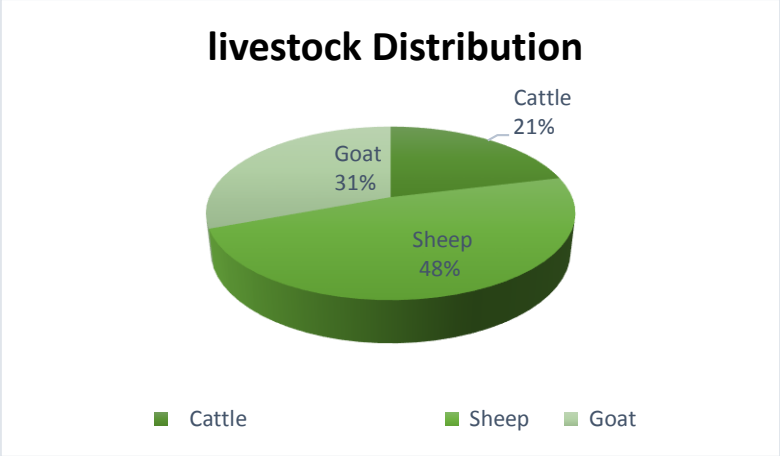

Figure 12, Distribution of Livestock (%). (https://mail.gov.af/en)

Data Analysis

Phase 1: Manure Generation analysis

Firstly, for determining the manure generation, whenever the livestock have to produce a per day waste of like table 6,

Table 5, Animals per day manure generation

Animals	per day waste Generation
Cattle	*1kg*
Sheep	*0.4kg*
Goat	*0.3kg*

The waste generation for each district from animals (Cattle, Sheep and Goat) can be estimate from formula below.

- Waste generation from Cattle (Kg/day) = Num.Cattle (District) * 1 kg/per.cattle
- Waste generation from Sheep (Kg/day) = Num.Sheep (District) * 0.4 kg/per.sheep
- Waste generation form Goat (Kg/day) = Num.Goat (District) * 0.3 kg/per.goat

Phase 2: Biogas potential analysis

So for obtaining theoretical amount of biogas production from livestock manure;

It's accepted that:

Manure density: 975 kg/m^3

Biogas production:

TPB=M*TS*AC*EBTS (ERTÜRK1 & ÖZDİL, 2019)

TPB Total theoretical potential of biogas production (m3/ year)

M Total amount of the animal waste which produced for each district (kg/year)

TS Ratio of the total strict of the animal waste

AC Availability Coefficient

EBTS Total strict of the biogas produced per kilogram (m3/kgTS).

Secondly, the analysis from phase 1 is helpful for estimation and finding the theoretical biogas potential for a district in (m3/year).

For Example: The process for finding theoretical biogas potential for pul-I-Khumri,

TPB.Cattle (m3/year) = 0,25 * 0,5 * 0,6 * 365 day * Waste generation from Cattle (Kg/day) in pul-I-Khumri

TPB.Sheep (m3/year) = 0,25 * 0,13 * 0,4 * 365 day * Waste generation from Sheep (Kg/day in pul-I-Khumri

TPB.Goat (m3/year) = 0,23 * 0,12 * 0,38 * 365 day * Waste generation form Goat (Kg/day) in pul-I-Khumri

The result of biogas production from each animal in Pul-I-Khumri will add up together for the total biogas generation for the district.

TPB (m3/year) = TPB.Cattle (m3/year) + TPB.Sheep (m3/year) + TPB.Goat (m3/year)

Table 6, Theoretical value. (ERTÜRK1 & ÖZDİL, 2019)

Animal Type	Ratio of the total solids TS (%)	Availability coefficient AC (%)	Estimated biogas produced EBTS(m^3TS/kg)	Estimation animal weight (kg)	Estimation manure ratio (%)	1years
Cattle Animal	0,25	0,5	0,6	250	0,09	365
Sheep	0,25	0,13	0,4	40	0,04	365
Goats	0,23	0,12	0,38	38	0,04	365

Phase 3: Electricity Generation analysis

Additionally, some parameter is needed to calculate generated electricity. Calorific value of biogas is 6 KWh/m3 for all animal species. Similarly, efficiency of the conversion (%) is 0,3 for all animal species. Also, potential of biogas has been calculated separately for each animal species.

TPB Potential of biogas (m3/year)

CV Calorific Value of biogas (KWh/m3)

E Efficiency of the Conversion (%)

EG Electricity Generation (kwh/year).

EG (kwh/year) = TPB (m3/year) * CV (KWh/m3) * E (%)

Result

As show Table 6, potential of biogas is analyzed for all three animal type. Firstly, when cattle is investigated, the top biogas potential value is with 927382.9 (m^3/ year) in Khost Wa Fring in year 2023, Baghlan Jadeed is followed Khost Wa Fring with 902663.3 (m^3/ year). Furthermore, potential of biogas has been observed as top value with 1107715.3 (m^3/ year) in Pul-I-Khumri and as the lowest with 238972.6 (m^3/ year) in Tala Wa Barfak for cattle, sheep and goats. The highest biogas potential value is with 176711.4 (m^3/ year) for sheep in Pul-I-Khumri and 45052.0 (m^3/ year) for goat in Khost Wa Fring.

Table 7, Biogas potential (m^3/year) for each district

m^3/ year	Cattle	Sheep	Goat
Pul-I-Khumri baghlan Centre	900555.4	**176711.4**	30448.5
Baghlan Jadeed	902663.3	122043.3	14522.0
Dahana Ghuri	300604.9	113999.6	31121.5
Dushi	688864.5	84865.3	37542.4
Khinjan	197373.8	18503.6	27521.1
Andarab	223325.3	29610.7	22868.8
Nahreen	219246.4	46762.9	16818.8
Burka	147359.6	104238.2	22578.3
Tala Wa Barfak	192884.3	29305.1	16783.2
Pul Hisar	249276.8	40715.9	18210.7
Deh Salah	200576.6	37565.2	18440.4
Jalga	244978.9	21417.0	16328.5
Khost Wa Fring	**927382.9**	63023.1	**45052.0**
Fring Wa Gharu	251904.8	12149.1	10237.2
Gozargah Noor	197373.8	18503.6	27525.7
Total	**5844370.9**	**919414.0**	**355399.1**

The figure 21, Goat have 5% share less biogas potential than cattle with 83% and sheep 13%, because goat has a low weight.

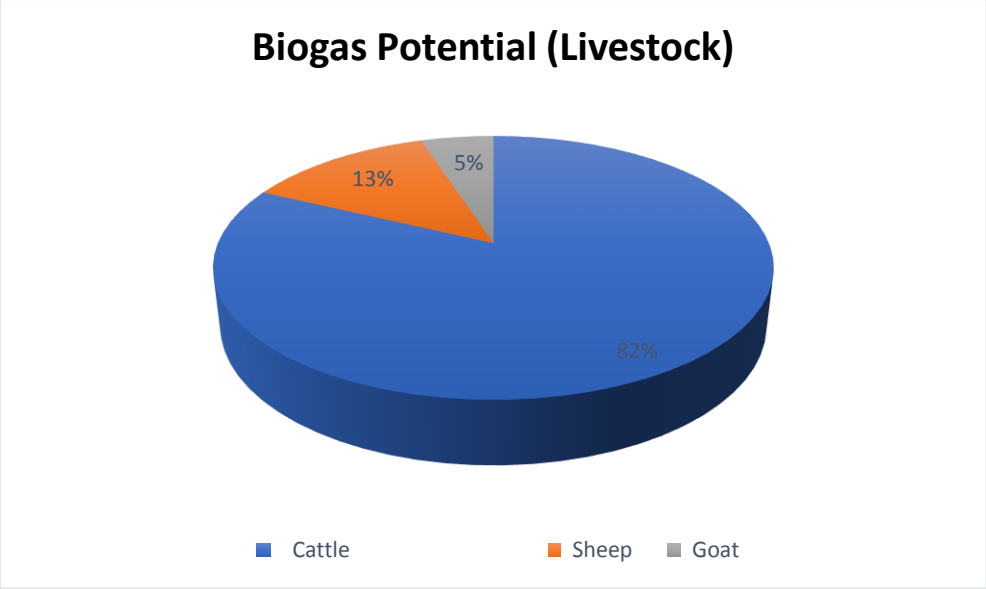

Figure 13, Distribution of Biogas potential for Baghlan province

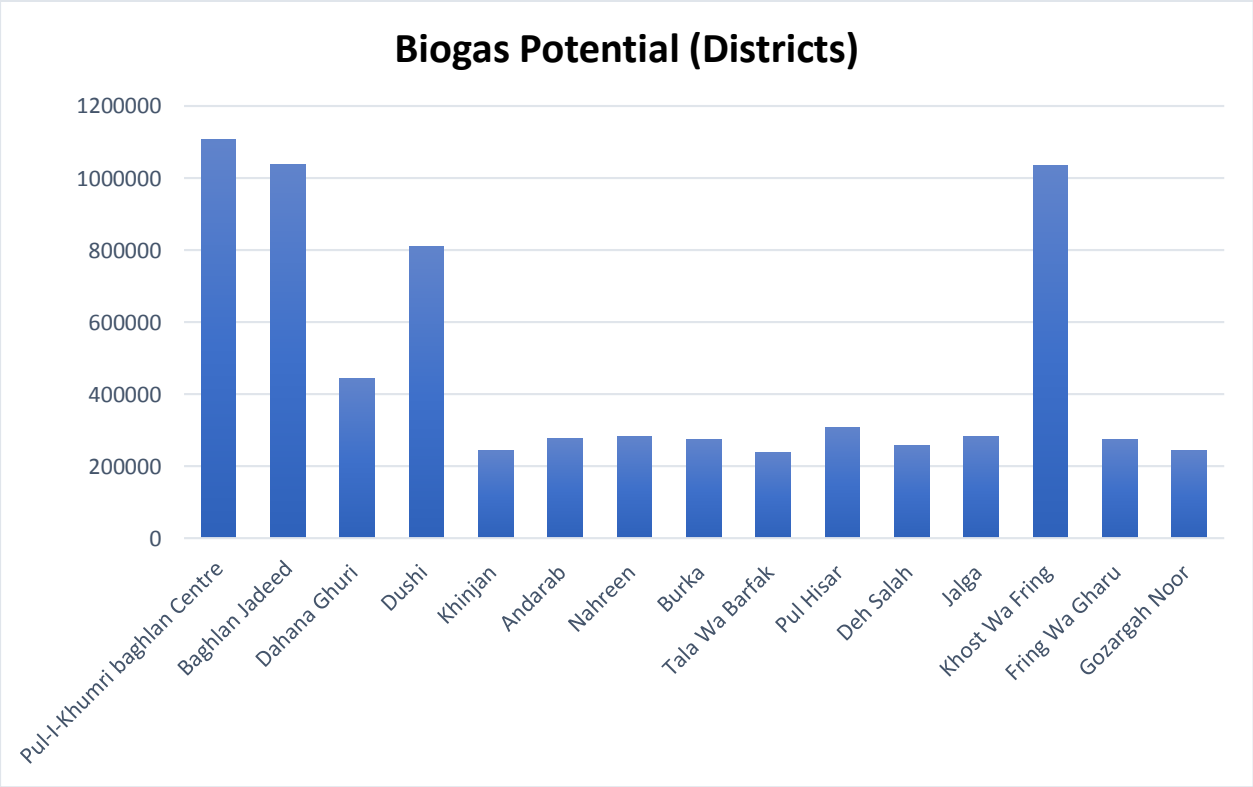

Figure 14, Schematic of biogas potential for each district

The electricity generation from huge amount biogas potential is attached in to Table 7. By doing an assumption that the produced gas has a calorific value of about 20 MJ/m3, Then the evaluation and analysis will appear as electricity in (kwh/year).

Table 8, Electricity Gneeration (Kwh/year) for Baghlan province, Afg

(kwh/year)	**Cattle**	**Sheep**	**Goat**
Pul-I-Khumri baghlan Centre	1620999.72	**318080.52**	54807.3
Baghlan Jadeed	1624793.94	219677.94	26139.6
Dahana Ghuri	541088.82	205199.28	56018.7
Dushi	1239956.1	152757.54	67576.32
Khinjan	355272.84	33306.48	49537.98
Andarab	401985.54	53299.26	41163.84
Nahreen	394643.52	84173.22	30273.84
Burka	265247.28	187628.76	40640.94
Tala Wa Barfak	347191.74	52749.18	30209.76
Pul Hisar	448698.24	73288.62	32779.26
Deh Salah	361037.88	67617.36	33192.72
Jalga	440962.02	38550.6	29391.3
Khost Wa Fring	**1669289.22**	113441.58	**81093.6**
Fring Wa Gharu	453428.64	21868.38	18426.96
Gozargah Noor	355272.84	33306.48	49546.26
Total	**10519868.34**	**1654945.2**	**640798.38**
12815.6 Mwh/year			

The above table can be interpreted in the comparison figure 23, which seen that Pul-I-Khumri has the highest share of electricity generation 16% with 1993887.54 Kwh/year, Then Khost wa fring and Baghlan jadeed has an equal share of electricity generation with 15%.

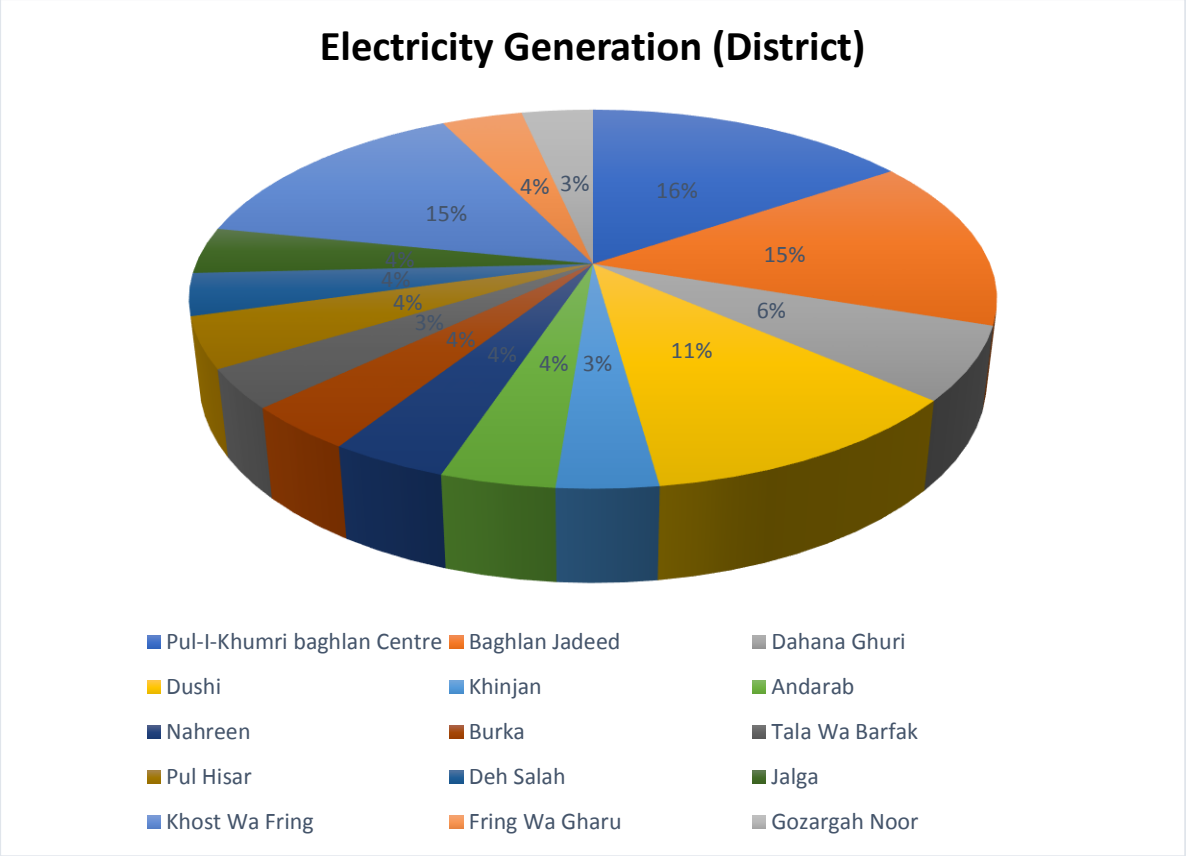

Figure 15, Electricity generation in term (%) for entire Districts

If the electricity generation of the region were analyzed as comparison between livestock (Cattle, sheep and goat), Then the cattle has 10519868.34 (Kwh/year) highest potential followed by sheep with 1654945.2 (Kwh/year), finally the goat with lowest potential has a share 640798.38 (Kwh/year). Below chart will indicate that,

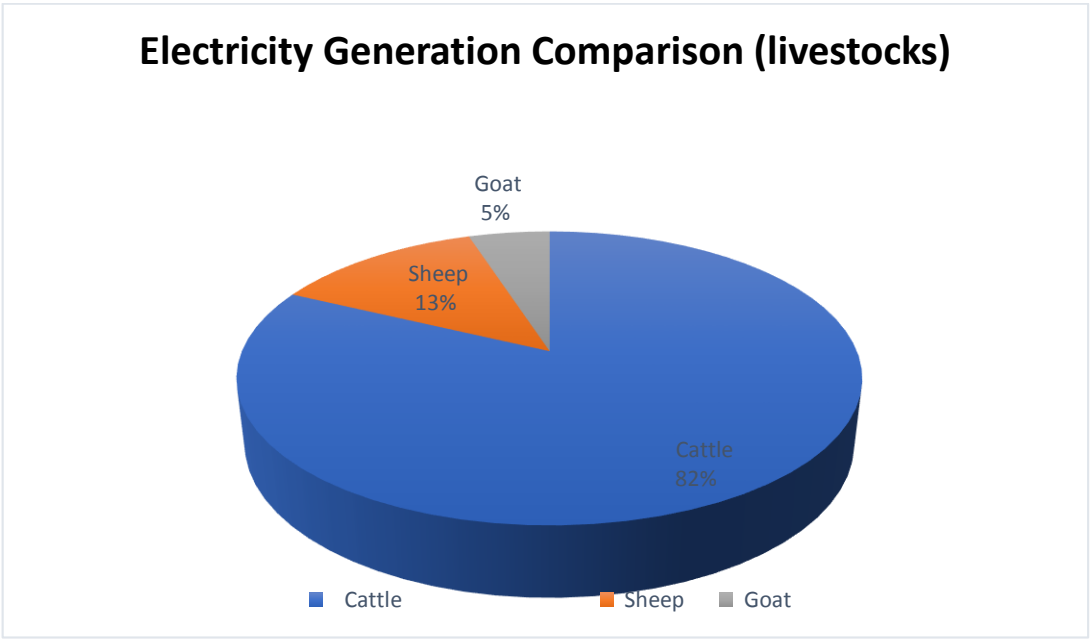

Figure 16, Electricity generation comparison between livestock (%)

Discussion

Environmental benefits can be conducted as Reduction of Greenhouse Gas Emissions, Improved Air Quality and Waste Management. Biogas energy production is a process that involves anaerobic digestion of organic waste, such as animal manure, crop residues and kitchen waste. By capturing and utilizing methane, a potent greenhouse gas released during the decomposition of organic matter, biogas systems can significantly reduce greenhouse gas emissions. So it can be a secure energy choice for our mother's, sisters, and children which are the most attached people during cooking, Generating heat and etc.

The traditional cooking and heating methods which used by Baghlan people often rely on burning biomass fuels like wood, animal waste and crop residues, which release harmful pollutants, including particulate matter, carbon monoxide, and volatile organic compounds. Biogas provides a cleaner alternative, reducing indoor and outdoor air pollution, which improves respiratory health and reduces the risk of related diseases. These mature type renewable systems promote proper waste management by utilizing organic waste that would otherwise be left untreated or disposed of inappropriately. By converting waste into biogas and digestate, it systems help to address waste management challenges in rural areas.

Socially the advantage of biogas is about utilization in every technology having brought Economic Opportunities, Access to Clean Energy, Health and Safety Benefits, Education and Awareness. Biogas energy offers a reliable and sustainable source of clean energy for rural communities. In areas without access to electricity grids, biogas can be used for cooking, heating, and lighting, improving the quality of life for households. This eliminates the dependence on traditional biomass fuels. Aside Local communities can engage in the construction, operation, and maintenance of biogas plants, generating employment and income.

The use of biogas as a cooking fuel reduces indoor air pollution, which is a significant health concern, particularly for women and children who spend a significant amount of time indoors, implementing biogas systems in rural areas often involves training and capacity-building programs, raising awareness about renewable energy, environmental sustainability, and waste management. These initiatives can contribute to knowledge transfer, skill development, and empower local communities.

As an economic source of income, Biogas is a sustainable system offer variety of benefits like Cost Savings, Job Creation, Revenue Generation, Agricultural Benefit, Energy Security, Technology and Innovation.

Once a biogas system is set up and operational especially for farmers, the primary fuel source organic waste is often readily available and inexpensive or even free. This reduces the reliance on costly imported fossil fuels, leading to long-term cost stability and predictable energy expenses for the energy sector. The development and operation of biogas projects create employment and work opportunities across various sectors. These involve the construction of biogas plants, waste collection and transportation, plant operation and maintenance, as well as research and development.

Biogas systems can be helpful about generation of revenue through the sale of biogas for Baghlan people as a fuel source or through the production and sale of electricity, heat, or biomethane. Furthermore, the final product of biogas systems generates a byproduct called digestate, which is a nutrient-rich organic fertilizer. This digestate can be used in agriculture for improvement of soil fertility, nutrient cycling, and crop yields.

However, it offers a decentralized energy solution, reducing dependency on imported fossil fuels like (Gas from Uzbekistan and Turkmenistan) and enhancing energy security. Finally, the development and implementation of biogas systems drive technological advancements and innovation in the energy sector, like improvements in anaerobic digestion technologies, gas purification and upgrading techniques, and energy conversion technologies.

Conclusion

The study conducted that biogas system can offer a sustainable energy, furthermore the Baghlan province has a good potential of biogas energy. After that the analysis prove the animals (cattle, Sheep and Goat) could generate a total manure of 182592564 Kg/year, which cattle generate more waste between livestock for the region with a 43% share. This study implicates that just three animals (cattle, sheep and goat) generate **12815.6 (Mwh/year)** of eletrical energy with share of 82% cattle, 13% sheep and goat with 5%. This can a prove that Baghlan province aside of other agricutural regions has a huge potential, But why we still has to bring and use imported gas and futher electricity from other neighbor counties with a big capital investment for buying and transportation distance of hunderd miles.

Finally, Biogas is a type of renewable energy which is going to develop aside of technology advancement in the world like India, china and European countries like Germany, because it promotes a sustainable future for whole planet and generations that will be lived here.

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