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RESEARCH ARTICLE

ASSESSMENT OF BIOGAS POTENTIAL FROM LIVESTOCK WASTE AT DISTRICT LEVEL IN PAKISTAN USING GEO-INFORMATICS

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ABSTRACT

Self-sufficiency in energy is the assurance to excel any country's economy. Energy is most important source for economic growth of a country. Unfortunately Pakistan has to face a major energy crisis in natural gas, power and oil. With the present situation of increasing energy demand, rising energy prices and reinforcement of countermeasures for global warming, renewable energy sources have taken the spotlight. Among all renewable energy sources, the most suitable option for meeting the energy requirements in developing nations is Biogas technology that has become more widespread in most recent decade. Livestock represents an important component of the agricultural sector in Pakistan which is the major contributor in biogas production process. Manure is a valuable fertilizer that improves the soil, obtained as a byproduct of biogas production process, and dung provides the basis for this process. The study identified the major biogas potential areas of Pakistan by using Geographic Information System. Livestock census data for 2006 was used. Livestock residues of cattle and buffalo out of all stock-raising animals were evaluated. The GIS software i.e. ArcView 3.2 is used as a tool for mapping of biogas potential areas. This information could help all stakeholders in deciding where to expand livestock production without putting the environment at risk.The results of the study showed that Punjab has maximum biogas potential which is followed by Sindh, KPK, Baluchistan and AJ& K.

INTRODUCTION

With ever growing population, improvement in living standards of humanity and industrialization of developing countries, global demand for energy is expected to increase rather significantly in near future. Pakistan is country with high energy demand. During the decade of the 1980s, the local energy production satisfied only 86% of domestic demand while the remaining demand for energy was met by imports. Because of higher levels of economic growth energy consumption of Pakistan in the last decade 1995-96 to 2004-05 has significantly increased; 5.1% in 2002-03, 6.4% in 2003-04 and 8.4% in 2004-05. To satisfy this growth thrust Pakistani economy would require cheap and abundant energy supplies in the next years (**Mehmood, 2007**). With the present situation of increasing energy demand, rising energy prices, and reinforcement of countermeasures for global warming, renewable energy sources have taken the spotlight. Pakistan's economy is highly dependent on the agricultural products. Being the 2nd largest sector of the country, it contributes 21% toward the Gross Domestic Product (GDP).

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Livestock is the largest shareholder to the agriculture. It parts nearly 53.2% to the agriculture value-added, consequently 11%to the GDP (**Amjad *et al*., 2011**). Pakistan is gifted with huge livestock population. In 2003, it had over 464 million livestock heads. This huge number is deployed primarily to produce food, fiber and energy for doing work. Dung is virtually an important outcome of livestock. In Pakistan, a household consuming biomass as solitary energy source uses 2325 kg of firewood or 1480 kg of dung or 1160 kg of crop residues per annum approximately. Expenses on these resources can be easily exchanged with a better and efficient source of renewable energy, i.e.biogas, which is not only socially acceptable, economically viable but also environmentally a friendly way to utilize natural resources (**Amjad *et al*., 2011**). Feedstock for biogas generation is nearly everywhere available. Biogas solves the environmental problems, which are caused by organic waste, because the byproduct i.e.; bio-rest can be used as biological Fertilizer (Walter Danner and Alexander Varghese). The biogas process is a closed biological process without addition of oxygen in which organic matter is converted to biogas by microorganisms (**Murmansk, 2008**). Feedstock for biogas generation is nearly everywhere available. Biogas solves the environmental problems, which are caused by organic waste,

because the byproduct i.e.; bio west can be used as biological Fertilizer (Walter Danner and Alexander Varghese). In developing countries biogas technology option addresses the problems of firewood scarcity, health problems related to indoor air pollution due to burning of biomass and lack of competent and affordable lighting sources. Economically, biogas can replace the chemical fertilizers, improve soil fertility and enhance agricultural production. Biogas may substitute firewood, dung, agricultural residues, petrol, diesel and electricity, relying on the nature of the task and local supply conditions and constraints. The gas can also be used to power engines, in a dual fuel mix with petrol and diesel and can help in pumped irrigation systems, (**Khoiyangbam, 2010**). For biogas technology users, health effects are tangible with regards to the smoke reduction. A clean and particulate-free source of energy also reduces the likelihood of chronic diseases that are associated with the indoor combustion of biomass-based fuels (**Khoiyangbam, 2010**). Biogas plants function as a wastes disposal and thus directly contribute to a better sanitary situation. Theoretically, decrease in the frequency of disease comprises economically a saving in medicine and consultation costs. The permanent availability of cooking energy through biogas can have effects on nutritional patterns (**Khoiyangbam, 2010**).

Pakistan is a country rich in livestock population which can be assessed by the use of geographical-information system (GIS). The GIS technology is the one that benefits almost all the organizations irrespective of their size. The benefits of GIS may include; it can save cost and increase efficiency of the research that uses GIS technology, it can help in better decision making and better record keeping. GIS is the new approach that provides new way of thinking and problem solving by integrating geographic information. This research paper aims at mapping of biogas potential areas of Pakistan and AJ&K by utilizing livestock population of the districts through Arc View3.2.

MATERIALS AND METHODS

In this study Microsoft Excel was used for the assessment of biogas potential areas of Pakistan. The software of ArcView Version 3.2 was used for mapping of biogas potential areas. Pakistan Livestock Census Report 2006 was consulted for collection of livestock population (i.e.; cattle and buffaloes) data of Pakistan at district level. Available dung in the districts from livestock was estimated on the basis of source data fact that refers to 10 kg dung production daily by each livestock head.

Biogas Potential

Biogas potential of Pakistan is calculated by using following formula.

Biogas potential= Amount of dung* 0.03
Where, 1kg dung= 0.03 m^3 biogas (**Ramchandara, 2008**)

All these calculations were made on excel sheet which depicted biogas potential of different districts. ArcView is used as a tool for mapping the potential areas of Pakistan in context of livestock, biogas potential. For highlighting the potential areas, different color bands were used in the ArcView, with sharp colors showing high potential areas.

RESULTS AND DISCUSSION

To identify the biogas potential areas of Pakistan, firstly it requires the database of livestock densities of Pakistan at district level. Table 1 shows the distribution of livestock districts of Pakistan.District information of Baluchistan province showed that out of 26 districts, 24 districts lies in the range of 0-50, while, one district each in the range of 51-100 and 151-200 respectively. In the province of Khyber Pakhtoonkhwa out of 31 districts, 8 lie in range of 0-50, 9 lies in the range of 51-100, 6 lies in the range of 101-150, 5 lies in the range of 151-200, 2 lies in the range of 201-250, while one district lie in the range of 251-300. In the province of Sindh 4 districts lie in range of 0-50, 6 districts of the province of Sindh lies in the range of 51-100), 4 districts are in the range of 101-150, 3 districts are in range of 151-200, 3 districts of Sindh are covering range of 251-300, while only 3 districts are present in range > 351. In Punjab province out of 36 districts, 3 districts lie in the range of 0-50,6 districts lie in range of 51-100, 5 districts are in range of 101-150, 3 districts are in range of 151-200, 9 districts are in range of 201-250, 7 districts covers the range of 251-300, 2 districts of the province are present in the range of 301-350, while one district is present in the range of 350 and above. In Azad Jammu and Kashmir there are total 8 districts, out of which one district lie in the range of 0-50, 3 districts are present in range of 51-100, while 3 districts are present in range of 101-150, 1 district is present in 350 and above class.

Province -Wise Discussion of Parameters

The study was based on the livestock census report 2006. By using formulas, biogas potential was calculated. The detail information of above mentioned parameter in different districts of four provinces of Pakistan are given in form of tables and graphs and also displayed in the form of layouts through GIS mapping to get a quick view of high potential areas.

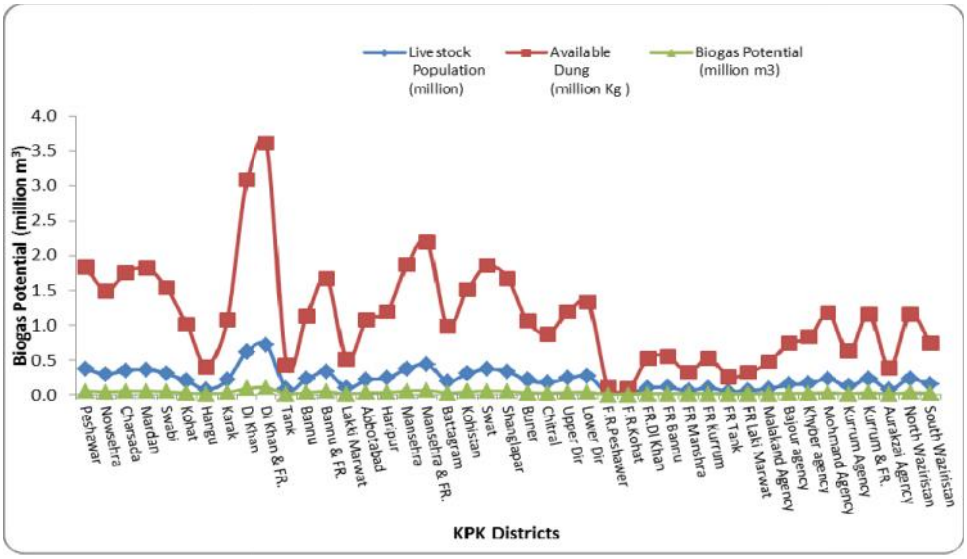
Livestock Population, Dung Availability and Biogas Potential in Punjab

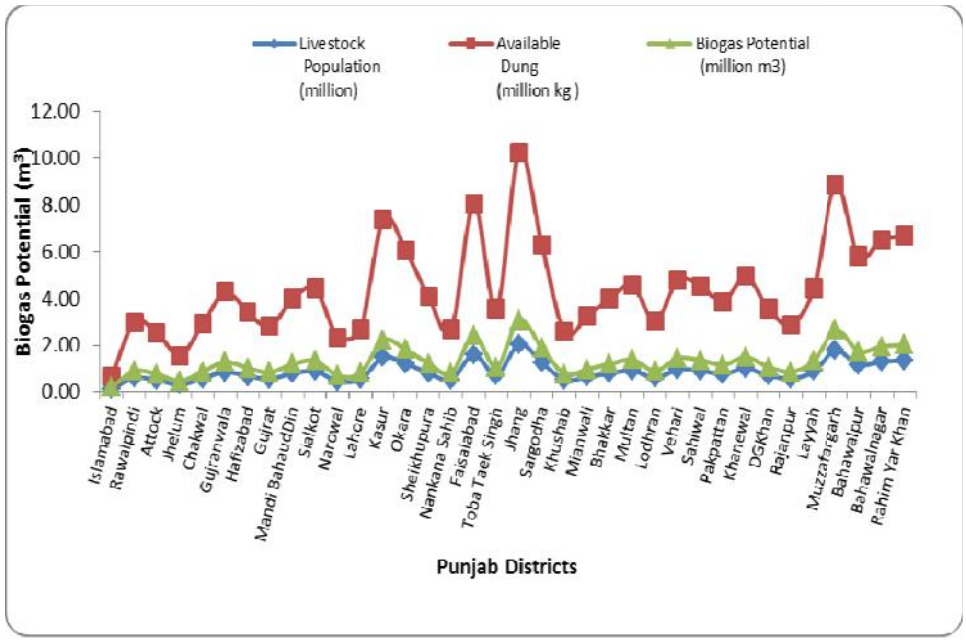
Figure 1a represents the relationship between livestock population, available dung and biogas potential in the province of Punjab.

Table 1. Livestock Population Density of Pakistan

Provinces	Districts	0-50	51-100	101-150	151-200	201-250	251-300	301-350	>351
Baluchistan	26	24	1	-	1	-	-	-	-
KPK	31	8	9	5	5	2	1	-	1
Sindh	23	4	6	4	3	-	3	-	3
Punjab	36	3	6	5	3	9	7	2	1
AJ&K	8	1	3	3		-	-	-	1

(Livestock Census Data, 2006)





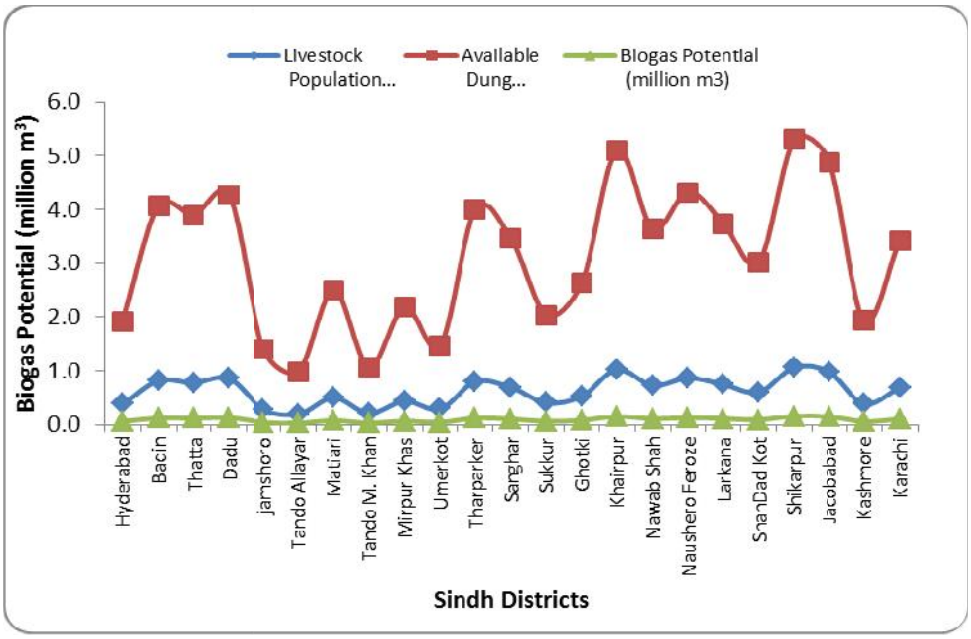


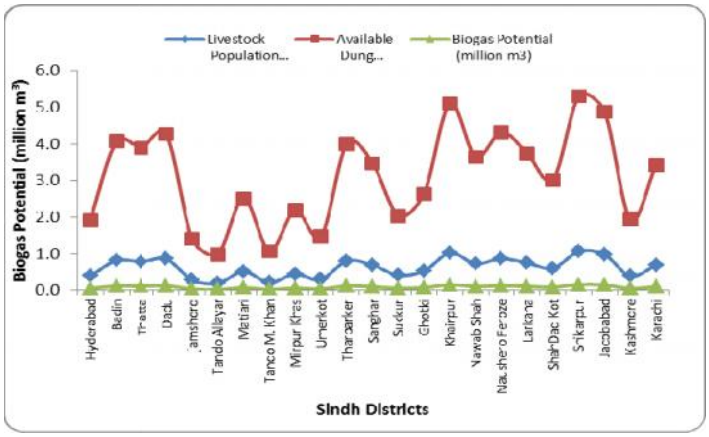
Fig. 1. Districtwise Biogas Potential Areas of Pakistan

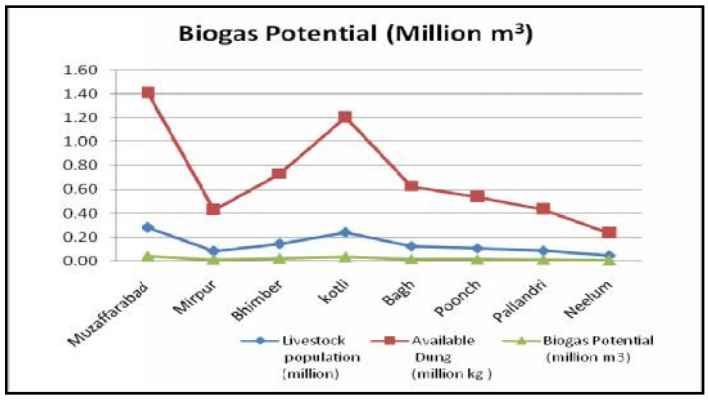
It is clear that out of 36 districts of Punjab, highest biogas potential districts are Jhang, Muzzafargarh, Faisalabad, Kasur, Rahim Yar Khan, and Bhawalnager. While minimum biogas potential districts are Islamabad, Jhehlum, Narowal, Attock, and Lahore.Livestock population ranges from 0.7-10.2 million in Punjab. Least livestock lies in the range of 0.7-3.075 million populations (14 districts) while maximum livestock population lies in the range of 7.825-10.2 (2 districts). Available dung of 36 districts of Punjab lies in the range of 0.7-10.2 million kg/day.The 12 districts lie in the range of 0.7-3.075 with minimum availability of dung. In the highest range of 7.825-10.2 there lie 3 districts. Likewise, Biogas potential areas of Punjab are depicted in the range of 0.20-3.068 million m^3. Least potential areas of Punjab lies in the range of 0.20-0.917 while highest biogas potential areas of Punjab lies in the range of 2.351-3.068 million m^3.

The above Figure 9a reveals that biogas production is dependent on dung availability which in turn is dependent upon livestock population. Areas lying in the range of maximum livestock population would be source of maximum biogas production.

Livestock Population, Dung Availability and Biogas Potential of Sindh

Figure 1b shows the relationship between livestock population, available dung and biogas potential in the province of Sindh. Out of 23 districts of Sindh, highest biogas potential districts are Shikarpur, Khairpur, Jacobabad, Naushehro Feroze, Dadu, Badin, Tharparkar and Thatta, while minimum biogas potential areas are Tando Allayar, Tando M.khan, Jamshoro, Umerkot, Hyderabad and Kashmore.





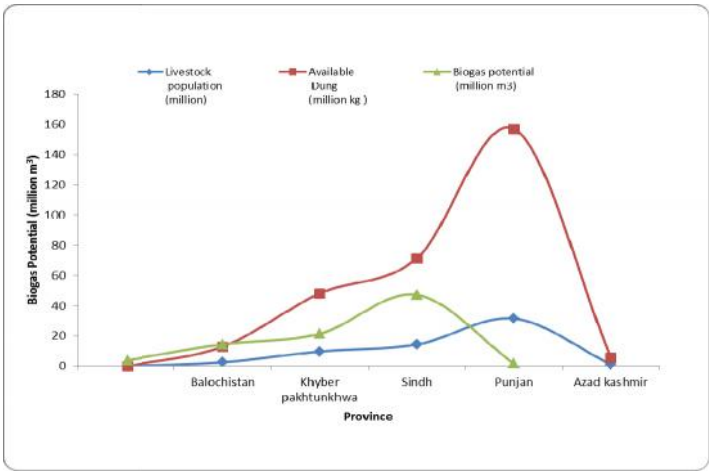


Fig. 2. Povincewise Biogas Potential of Pakistan

Livestock population of 23 districts of Sindh lies in the range of 0.2-1.1. Four in the range of 0.2-0.4 and eight in range of 0.8-1.1. Dung availability in different districts of Sindh lies in the range of 1.0-5.3 million m^3. Least amount of dung is available in the range 1.0-2.0 in 6 districts of Sindh. Tando Allayar is district with very least availability of dung. In the highest range there are 5 districts. Highest biogas potential in Sindh range is 0.12-0.16 in 8 districts. 4 districts lie in range of 0.03-0.06.

Livestock Population, Dung Availability and Biogas Potential of Baluchistan

Figure 1c shows that how biogas potential increases with increase in livestock population and available dung. Out of 26 districts of Baluchistan; jafferabad, Naseerabad, Musakhel, Kohlu, Dera Bugti are the maximum potential areas, while areas of Baluchistan with minimum livestock population are Ziarat, Chagai, Mastang and Gawadar.Livestock population of 26 districts of Baluchistan lies in the range of 0.002-0.425. 15 districts lie in the range 0.002-0.1078, with least livestock population. In highest range 0.319-0.425, one district is present. Dung availability in different districts of Baluchistan lies in the range of 0.01-2.13. Least amount of dung is available in the range 0.01-0.54. Ziarat is the district with very least availability of dung. The highest dung production (ranging from 1.6-2.13 million kh) is produced in Jaffarabad. As depicted in Table 6 and Figure 9c, districts having low livestock population and low availability of dung also have low biogas potential while district like Jaffarabad has highest biogas potential of 0.638 million m^3.

Livestock Population, Dung Availability and Biogas Potential of Khyber Pakhtonkhwa

Figure 1d shows the relationship between livestock population, available dung and biogas potential in the province of Khyber Pakhtunkhwa. Out of 43 districts of Khyber Pakhtunkhwa, highest biogas potential districts are DI Khan and FR. DI Khan, Mansehra and FR. Mansehra, Swat, Mardan. While minimum biogas potential areas are F.R. Kohat, F.R.Peshawar, F.R.Tank, F.R Mansehra, and F.R Laki Marwat.Livestock population ranges from 0.001-0.7 million in KPK. Least livestock lies in the range of 0.001-0.175 million populations while maximum livestock population lies in the range of 0.525-0.7.

Available dung of 43 districts of KPK lies in the range of 0.1-3.6 tons per day. 17 districts lie in the range of 0.1-0.0.975. Two districts in the lie range 2.725-3.6 i.e. D.I Khan and FR. D.I Khan lie dung availability of 3.1 and 3.6 tons/day respectively. Biogas potential areas of KPK are depicted in the range of 0.002-0.108 million m^3. Least potential areas of KPK lies in the range of 0.002-0.0285, while is 0.0815-0.108.Combined results of these three parameters show that with increasing livestock population, there would be more amount of dung available, which would be utilized for biogas production. So areas lie in the range of maximum livestock population would be source of maximum dung availability having greater potential for biogas systems installation and production.

Livestock Population, Dung Availability and Biogas Potential of Azad Jammu & Kashmir

Figure 1e shows the relationship between livestock population, available dung and biogas potential in the districts of Azad Jamu and Kashmir. Out of 8 districts of AJ and K, highest biogas potential districts are Muzzafarabad, Kotli, and Bhimber. Areas with minimum biogas potential are Neelum, Mirpur, and Palandri.There are 8 districts in AJ and K, out of which 1 district has the highest livestock population that lies in highest range 0.22-0.28. Out of these 8 districts, 3 districts lie in lowest range 0.05-0.107 including Neelum with 0.05 million livestock population smallest than all other regions of AJ and K. Muzaffarabad has the highest livestock of 0.28 million, On the basis of livestock population, lowest amount of dung is available in range 0.2-0.5 and highest amount of dung is available in range 1.1-1.4 with Muzaffarabad having 1.4 million kg dung available/day. Since biogas potential is dependent on the availability of dung, so potential is highest in Muzaffarabad with 0.04 million m^3 of biogas generation.

Livestock Population, Dung Availability and Biogas Potential of Pakistan

Figure 2 illustrates the relationship between livestock population, available dung and biogas potential in the four provinces of Pakistan and AJ and K. The figure 1 deplicts how dung availability and biogas production increases with increase in livestock population. It is clear from the graph that maximum livestock population is present in the province of Punjab followed by Sindh. Minimum livestock population exists in the AJ and K.

This increased livestock population will in turn contribute towards increased dung availability increasing the potenial of biogas systems installation and production.Table 2 illustrates relationship between livestock population, dung availability and biogas production in Pakistan.

Table 2. Biogas Potential of Pakistan

Province	Livestock (Million)	Dung Availability (Million kg)	Biogas Potential (Million m^3)
Baluchistan	2.6	12.9	0.4
Sindh	9.6	48.1	1.4
KPK	14.3	71.3	2.1
Punjab	31.4	157.1	4.7
AJK	1.1	5.6	0.2
Total	59	295	8.8

Table shows that maximum livestock population (31.4 million) is present in the province of Punjab followed by Sindh with livestock population of 14.3 million. Minimum livestock population of 206 and 1.1 million was recorded in Balochistan and AJ and K respectively. Similarly maximum dung availability was calculated in Punjab i.e. 157.1 million kg, followed by Sindh, with 71.3 million kg. Least dung availability comes from Baluchistan and AJ and K with dung availability of 12.9 and 5.6 million kg respectively. The results showed that Punjab has potential of biogas generation around 4.7 million m^3 per day, followed by Sindh with 2.1 million m^3. Minimum biogas potential province is Baluchistan with 0.4 million m^3 per day and AJ and K, with 0.2 million m^3.

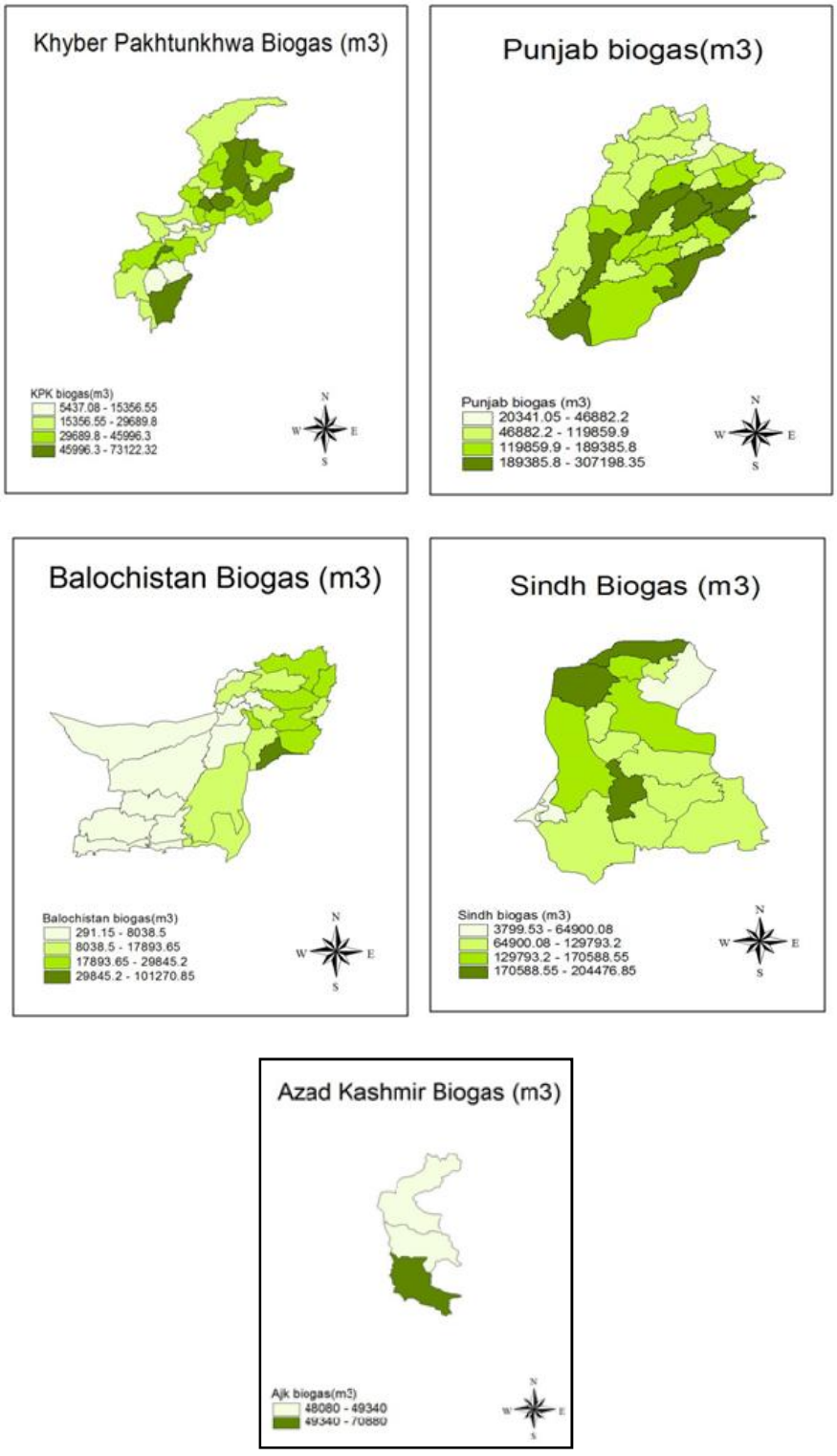


Fig. 3. Geographical Representation of Biogas Potential Areas of different Districts

Combined result shows that Punjab has maximum livestock population which results in maximum dung availability and biogas potential of the province Table 2. While the province with minimum biogas potential is Baluchistan and AJ&K, which leads towards minimum dung availability and biogas production.Geographical representation of biogas potential areas of different districts are showed in Figure 3.

Conclusion

According to livestock census 2006, total livestock population of Pakistan is 58.997342 Million. By analyzing livestock population all over Pakistan and AJ&K, study reveals that province of Punjab has the maximum potential for biogas production as compare to all other provinces, followed by Sindh, KPK, Baluchistan and AJ&K.

Therefore, highest biogas potential contributes to highest electricity generation capacity, NPK and methane production

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