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A prospective estimate of electricity generation from livestock manure in Bihar, India

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ABSTRACT

Throughout the country. Organic waste incineration and rubbish disposal have resulted in the production of organic or municipal solid wastes such as cattle and buffalo dung., a major political and environmental concern in a number of countries. The production of biogas from manure was an environmentally appropriate answer to this problem, which helps to reduce global warming while also increasing the supply of sustainable energy. The recent study on the generation of green electricity from cattle and buffalo dung was undertaken in Bihar. Cattle manure has the potential to be utilized to generate biogas, which is described as "organic waste fermented in the absence of oxygen." Reduced greenhouse gas emissions aid in solid waste control of air pollution, management and less reliance on fossil fuels. The three foundations of long-term sustainability are economic, environmental, and social development- are all supported by biogas. The Sustainable Development Goals and other faces of sustainable development benefit greatly from biogas. In this research paper a famous statistical model named as ARIMA has been used to forecast the cattle population till the year 2040. The model is developed using sophisticated statistical technique. Future study will be conducted to improve the accuracy of the developed model..

Key words: *ARIMA, Energy, Sustainable, Greenhouse.*

Introduction

Biogas is a gas mixture composed of methane, CO2, and trace amounts of other gases produced by the anaerobic digestion of organic materials in an oxygen-free environment. The type of feedstock and the production method, which comprises the key technologies described below, define the exact composition of biogas.Biogas typically includes 45% to 75% methane by volume, with CO_2 accounting for the majority of the remaining. The energy content of biogas can vary due to this variation; the lower heating value (LHV) fluctuates between 16 and 28 megajoules per cubic metre (MJ/m^3 Biogas can be used to generate electricity and heat, as well as to provide gastronomic energy. Biomethane (also known as "renewable natural gas") is a near-pure methane source that is created either by "upgrading" biogas (removing any CO_2 and other contaminants in the biogas) or by gasifying solid biomass by methanation:biomethane is known as gobar gas; alternative names for biomethane include biofuel, biomass, and wet gas (Eswaran *et al.*, 2021). 50%-70% methane, 26%-40% carbon dioxide, 0%-11% nitrogen, a trace of ammonia, 0%-1% hydrogen, and 0%-0.5% oxygen (Zhang *et al.*, 2016; Tian *et al.*, 2017).

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Biomethane is also known as biofuel, biomass, and wet gas (Eswaran *et al*., 2021). Biogas plants contribute to a reduction in dependency on non-renewable fuel sources such as oil, natural gas, and coal. As a result of the negative effects of greenhouse gases discharged into the environment, the use of renewable energy is gradually becoming more significant (Abbasi *et al*., 2011) Biogas plants have an important role in reducing greenhouse gas emissions (Chuanchai and Ramaraj, 2018; Desta *et al*., 2020). Another reason for producing biogas in the future is because we already know how long non renewable energy sources can last (Liu *et al*., 2021). The global potential for biogas. Biogas for power generation is a well-established and commonly used process all over the world. An estimated 344,000 people are employed directly or indirectly by the biogas sector (Devaraj *et al*., 2022). China has 110,448 biogas facilities capable of producing 700,000 m^3 of gas per year, with 8,576 of them being large-scale plants (Huang *et al*., 2022). There are 17,781 biogas plants in Europe, the vast majority of which are in Germany. Germany has the most plants in Europe, with 10,973, followed by Italy (1655), France (742), and the United Kingdom (613). There are now 2,200 biogas facilities in the United States (Torrijos 2016)."Bihar is a country of opportunity, with abundant resources for producing CBG from agri-residue, animal waste, and other waste products." Climate warming has driven us to use cleaner fuel, which creates an opportunity for entrepreneurs and customers. Methane makes up the majority of compressed bio gas (more than 90%).

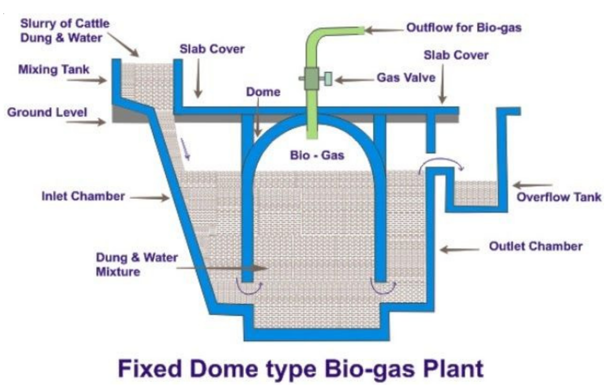


Fig. 1. Bio-Gas Plant Image Source Internate

Study Area

Bihar's climate is humid subtropical, and it is entirely contained inside the Temperate Zone's Subtropical zone. Overall, the climate is subtropical, with warm summers and chilly winters. Only 26 °C is the average daily high temperature in Bihar, while 26 °C is the average annual high temperature. There are very few tropical and humid months despite the extremely warm environment overall. It is consistently warm too hot for several months of the year, with highs of over 25 °C and occasionally as high as 29 °C. October through April are the ideal months to go because of less rain. The months of May through September have the most rainy days.

25.54% of the population speaks Hindi natively, which is the state's official language. Urdu, with 8.42%, is the state's second official language in 15 districts. The majority of inhabitants, however, speak one of the Bihari languages, the bulk of which were identified as Hindi dialects during the census. The three most common ones are Magahi (10.87%), Maithili (12.55%), and Bhojpuri (24.86%). Two more languages spoken in Bihar, Angika and Bajjika, are included in the census under the heading "Other Hindi dialects." According to the Eighth Schedule of the Indian Constitution, maithili is a recognized regional language in India. Advocates have demanded that Angika, Bajjika, Magahi, and Bhojpuri be accorded the same status.

Fig. 2. Bihar Map (Source Internate)

Materials and Methods

Data on the calorific values of various fuels.

Wood	Coal	Bio gas	Diesel	Natural Gas
2500 Kcal/Kg	3500 Kcal/Kg	5500 Kcal/Kg	10000 Kcal/Kg	12500 Kcal/Kg

Fig. 3.
Phases in the biogas generation process.

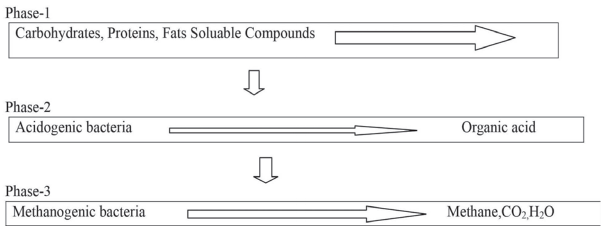


Fig. 4

The chemical process for producing biogas is divided into three stages, as indicated in Fig. (Deepanraj *et al.*, 2014).

Utilize biogas for electricity production

45 m^3 of biogas are produced daily from 100 cattle dung. Per kilogram, cattle manure produces 0.05 m^3 of biogas (Amon *et al.*, 2007). Depending on the composition and ratio of their diet, cattle discharged 8 to 12 kg of dung per day (Palma, 2019). After handling and collection losses, about 9 kg of manure can be gathered (Smith and Williams, 2016). As can be seen in Fig. 1 cattle dung creates 0.45 m^3 of biogas per day; therefore, 100 cattle manures produce 45 m^3 of biogas per day.

Fig. 5
A 100-cow farm's total biogas production.

1 kg cattle manure contain	0.05m^3 biogas
A cattle can produce manure	8-10 kg/day
100 cattle manure produce biogas in 1 day	100 x 9 x 0.05 = 45 m^3

Calorific values of biogas.

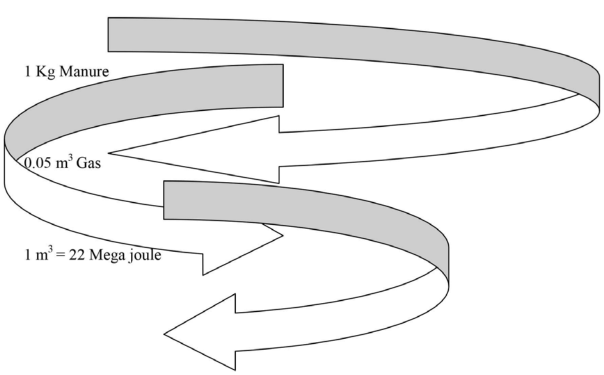
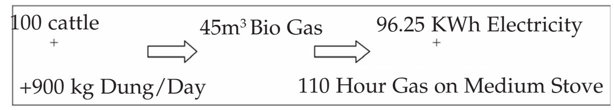


Fig. 6.

Fig. 7.
Total daily energy extracted from a 100-cow farm.

Total manure to 100 cattle	9 kg x 100 = 900 kg
Total biogas from 900 kg manure	900 x 0.05 = 45m^3
Total energy extracted from 45 m^3	45 x 22 = 990 mega joule

Electricity and gas generation from 100 cattle manure.
Fig. 8



Time line Stationarity check Operation of differentiation Determine the correlation coefficient. Recognition of patterns estimate of parameters Model evaluation Model improvement Forecasting.

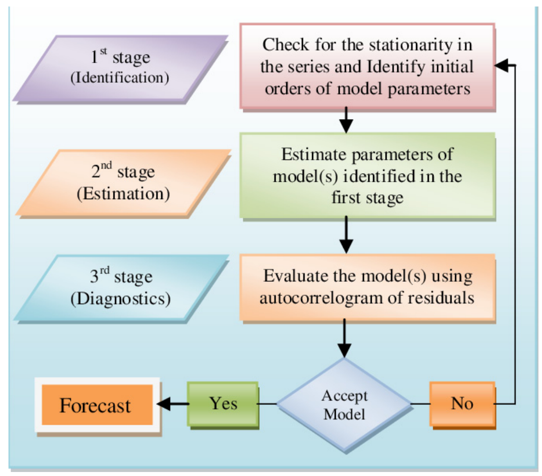


Fig. 9. Flowchart of ARIMA Model source internate

Live stock forecasting using B-J methodology

Stationarity test
ADF test for stationarity in level form

Null Hypothesis: TOTAL___LIVESTOCK has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag =9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-0.268976	0.9888
Test critical values:1% level	-4.219126	
5% level	-3.533083	
10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

P-value is greater than 0.05. We accept null hypotheses and conclude that this series is non-stationary in level form. Further we apply ADF test in first difference below:

ADF in first difference

Null Hypothesis: D(TOTAL___LIVESTOCK) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

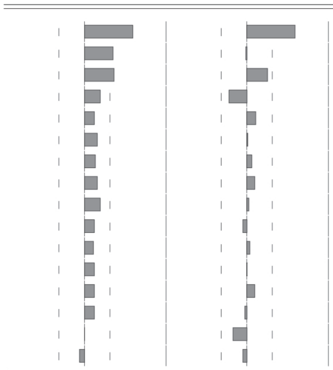
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.182106	0.0110
Test critical values:	1% level	-4.219126	
	5% level	-3.533083	
	10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

it become stationary in first difference. According to p-value.

correlorgame in first difference to identification of best ARIMA (p, d, q) model

Date: 09/03/23 Time: 19:50
Sample: 1983 2022
Included observations: 39



Lag	AC	PAC	Q-Stat	Prob
1	0.610	0.610	15.654	0.000
2	0.365	-0.011	21.407	0.000
3	0.383	0.262	27.907	0.000
4	0.204	-0.223	29.801	0.000
5	0.127	0.107	30.558	0.000
6	0.162	0.011	31.837	0.000
7	0.132	0.062	32.710	0.000
8	0.165	0.098	34.114	0.000
9	0.197	0.027	36.191	0.000
10	0.126	-0.055	37.066	0.000
11	0.118	0.035	37.865	0.000
12	0.126	-0.002	38.799	0.000
13	0.127	0.103	39.790	0.000
14	0.126	-0.024	40.798	0.000
15	0.007	-0.179	40.801	0.000
16	-0.061	-0.051	41.060	0.001

The correlograme suggest three model ARIMA (1, 1, 1), (1, 1, 2) and (1, 1, 3). After estimating all these models we select one best model on the basis of higher R-square, lower Akaike info criterion and lower Schwarz criterion.

Results of all these three models are given below:

ARIMA (1, 1, 1)

Dependent Variable: D(TOTAL___LIVESTOCK)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 09/03/23 Time: 19:29
Sample: 1984 2022
Included observations: 39
Convergence achieved after 60 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	131998.8	388651.2	0.339633	0.7362
AR(1)	0.683588	0.281892	2.424996	0.0206
MA(1)	-0.092173	0.305450	-0.301760	0.7646
SIGMASQ	3.28E+11	8.24E+10	3.984724	0.0003

R-squared	0.393546	Mean dependent var	112652.1
Adjusted R-squared	0.341564	S.D. dependent var	745459.0
S.E. of regression	604895.7	Akaike info criterion	29.57344
Sum squared resid	1.28E+13	Schwarz criterion	29.74407
Log likelihood	-572.6822	Hannan-Quinn criter.	29.63466
F-statistic	7.570839	Durbin-Watson stat	1.929441
Prob(F-statistic)	0.000497		

ARIMA (1, 1, 2)

Dependent Variable: D(TOTAL___LIVESTOCK)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 09/03/23 Time: 19:35
Sample: 1984 2022
Included observations: 39
Convergence achieved after 29 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	142924.0	437561.0	0.326638	0.7459
AR(1)	0.842869	0.169358	4.976844	0.0000
MA(2)	-0.427626	0.150392	-2.843399	0.0074
SIGMASQ	2.98E+11	7.74E+10	3.853667	0.0005

R-squared	0.449238	Mean dependent var	112652.1
Adjusted R-squared	0.402030	S.D. dependent var	745459.0
S.E. of regression	576452.3	Akaike info criterion	29.48765
Sum squared resid	1.16E+13	Schwarz criterion	29.65827
Log likelihood	-571.0092	Hannan-Quinn criter.	29.54887
F-statistic	9.516119	Durbin-Watson stat	2.232041
Prob(F-statistic)	0.000098		
Inverted AR Roots	.84		
Inverted MA Roots	.65	-.65	

ARIMA (1, 1, 3)

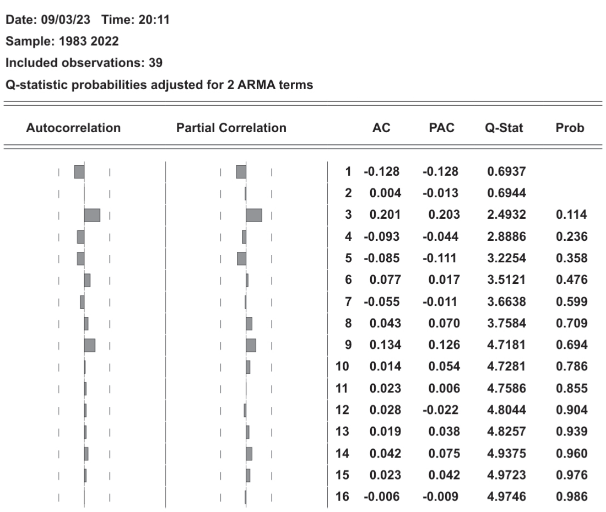
Dependent Variable: D(TOTAL___LIVESTOCK)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 09/03/23 Time: 19:32
Sample: 1984 2022
Included observations: 39
Convergence achieved after 29 iterations

Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	134624.8	372010.6	0.361884	0.7196
AR(1)	0.592788	0.147670	4.014273	0.0003
MA(3)	0.299799	0.163937	1.828751	0.0760
SIGMASQ	2.97E+11	7.04E+10	4.219656	0.0002

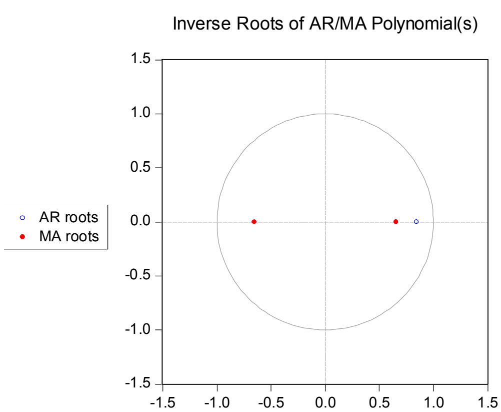
R-squared	0.451340	Mean dependent var	112652.1
Adjusted R-squared	0.404312	S.D. dependent var	745459.0
S.E. of regression	575351.5	Akaike info criterion	29.48172
Sum squared resid	1.16E+13	Schwarz criterion	29.65234
Log likelihood	-570.8935	Hannan-Quinn criter.	29.54293
F-statistic	9.597254	Durbin-Watson stat	1.777530
Prob(F-statistic)	0.000092		

After comparing all these three ARIMA estimates we can conclude that ARIMA (1, 1, 2) is best estimates. Its satisfy all the criterion. Now we can go for further steps.
correlogram of ARIMA (1, 1, 2) residuals are stationary.

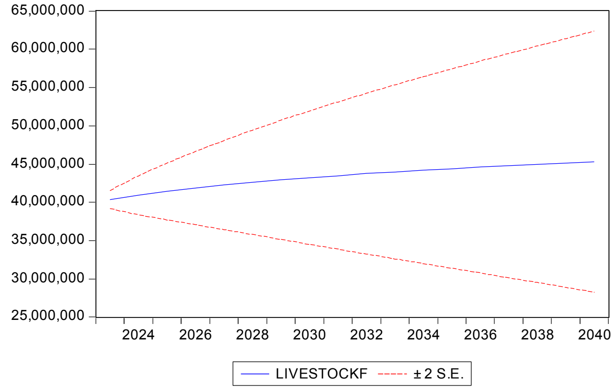


	AC	PAC	Q-Stat	Prob
1	-0.128	-0.128	0.6937	
2	0.004	-0.013	0.6944	
3	0.201	0.203	2.4932	0.114
4	-0.093	-0.044	2.8886	0.236
5	-0.085	-0.111	3.2254	0.358
6	0.077	0.017	3.5121	0.476
7	-0.055	-0.011	3.6638	0.599
8	0.043	0.070	3.7584	0.709
9	0.134	0.126	4.7181	0.694
10	0.014	0.054	4.7281	0.786
11	0.023	0.006	4.7586	0.855
12	0.028	-0.022	4.8044	0.904
13	0.019	0.038	4.8257	0.939
14	0.042	0.075	4.9375	0.960
15	0.023	0.042	4.9723	0.976
16	-0.006	-0.009	4.9746	0.986

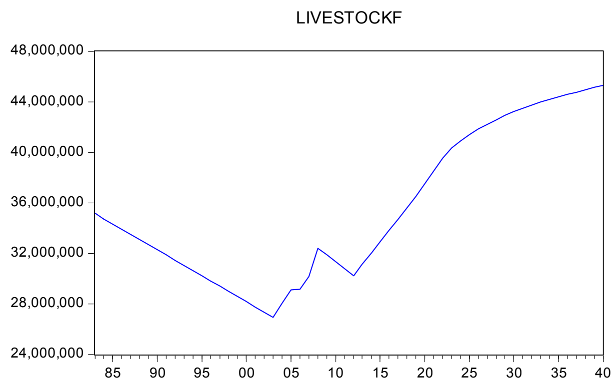
AR and MA roots are also within the range. Now we can go for forecasting



Forecasted graph



forecasted graph of dataset



Conclusion and Future work

According to a study on green power obtained from cattle dung, Organic waste is omnipresent, and with a true push from the government, it has the potential to be a reliable source of renewable and green energy. Biogas is more cost-effective than coal and wood, has a smaller environmental impact, and has a higher calorific content. Biogas is a simple energy source that may be used for cooking and heating. A model for prediction has been developed and tested in this work the livestock population of Bihar till the year 2040 by using simple and famous statistical time model ARIMA. After comparing all these three ARIMA estimates we can conclude that ARIMA (1, 1, 2) is best estimates. Its satisfy all the criterion. Finally, this work can be used as a foundation for future research into animal population forecasting..

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Conflict of Interest- None

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