Energy consumption forecasting: a case study on Bhashan Char island in Bangladesh

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ABSTRACT

In Bangladesh's distant regions, where dependable access to energy supplies is still an issue, effective energy consumption forecasting is essential for tackling the country's energy problems. In order to anticipate energy consumption in these neglected areas effectively, this study suggests a novel method that combines inverse matrix method (IMM) with linear regression method (LRM). The model produces accurate estimates by using historical data on energy use and relevant factors, such as weather patterns, population dynamics, economic indicators, and seasonal trends. A case study focusing on distant areas in Bangladesh shows how the proposed technique might be applied. The outcomes indicate how well the method captures the complex patterns of energy demand and how it may be used to guide sustainable energy management plans in these outlying regions. This study advances energy planning and resource allocation in areas with a limited supply of energy, paving the way for increased development and efficiency of the energy sector. Any rural or remote area in the globe can use these strategies to predict their short-term power consumption.

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1. INTRODUCTION

Forecasting energy consumption is essential to ensuring the effective use and distribution of energy resources, particularly in isolated areas where access to electricity is still a problem. Sometimes it's harder to predict energy demand accurately in remote locations because of their unique features, like poor infrastructure and isolation from other areas [1]. In Bangladesh, a nation plagued by energy disparities, precise forecasting in isolated areas is particularly important. Forecasting energy consumption is essential to resource management and sustainable development, especially in areas with particular difficulties like Bangladesh's Bhashan Char Island. Accurate forecasting is becoming more and more important as the world's energy demand rises in order to optimise resource allocation, improve energy efficiency, and guarantee a steady supply of electricity. Bhashan Char is a remote island in the Bay of Bengal that makes an interesting case study because of its unique environmental and geographical features. The main goal of this project is to present a novel method for estimating energy consumption in Bangladesh's rural areas using linear regression and inverse matrix computation. By combining historical energy consumption data with pertinent influencing factors like meteorological parameters, demographic trends, economic indicators, and seasonal variations, this approach seeks to provide a customised solution for energy forecasting that can effectively address the complexities of remote energy consumption patterns.

Bangladesh has one of the world's lowest per-capita electricity consumption rates, at 136 kWh. This implies that non-commercial sources, such as wood fuel, animal waste, and agricultural waste, account for around half of the nation's energy use. While coal and oil are scarce in the nation, natural gas is abundant [1]. Natural gas accounts for 66% of the energy used in the commercial sector, with coal, hydropower, and oil following. Most of the financial operations in the nation are powered by electricity. Only 70% of Bangladesh's population has access to electricity, despite the government's objective of 20 GW in 2019, which is anticipated to rise to 61 GW by 2041, with an average yearly consumption of just 321 kWh per person. Regrettably, there are several problems in Bangladesh's electricity industry, including substantial system losses, corruption in administration, and project delays in building new power plants. To strengthen the country's power infrastructure, these problems must be resolved [2]. For the past 10 years, the nation's capacity to produce electricity hasn't been able to keep up with demand. However, the Bangladeshi government has long-standing plans to deal with the country's energy issues, and it has started to put those plans into effect. Figure 1 depicts projected growth in power production from 2021 to 2041. Based on a review of 2021 data and communications with Bangladesh power development board (BPDB) and power grid company of Bangladesh (PGCB), this study projects reactive demand at each transmission substation under the assumption of a power factor of 90% for the transmission enquiry study for the years 2020-2041 [3].

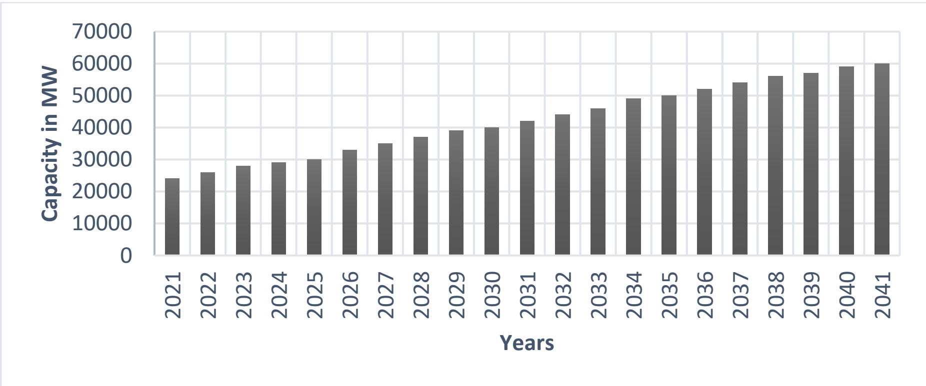

Figure 1. Plans for expansion the generation capacity of power plants

A little over 10% of people have utilized petroleum natural gas, mostly in remote locations where it is hard to come [4]. Those who live in rural regions cook and heat their food in their houses using biomass energy sources including firewood, cow manure, and agricultural waste. Lamp oil-based illumination is the most typical type of lighting in rural regions. In April of this year, after originally being planned to be finished in 2009 [5], it was decided to continue the installation of new gas connections in manufacturing businesses. New gas connections in the residential house were thus put on hold "until further notice" because they were constrained and pricey. Therefore, a large portion of household appliances in metropolitan areas are electric. There is not enough power generated to meet the nation's needs, and there is no reliable way to predict demand. Load shedding has been occurring as a result. In order to prevent disruptions in the provision of energy, Bangladesh's government is now working to build its power plant [5].

The areas being considered, Chakaria and Bhashan Char, are two most significant places for the nation of Bangladesh. Within the Cox's Bazar district in Bangladesh's southeast sits the subdistrict known as Chakaria. It is renowned for its stunning natural features, which include miles of Bay of Bengal shoreline, woods, and lush green hills. As a result of its closeness to Cox's Bazar, which features one of the world's longest natural sea beaches, and the presence of several indigenous cultures, the area has recently gained popularity as a travel destination. On the other side, Bhashan Char is a problematic island that is relatively new to Bangladesh. It is situated about 21 miles (34 kilometers) off the coast of Bangladesh's main island in the Bay of Bengal. Government measures to move Rohingya refugees from congested camps in Cox's Bazar have focused on Bhashan Char, which was produced by sedimentation. Location map of the study area is shown in Figure 2.

Bhashan Char is being developed by the Bangladeshi government as a site to house Rohingya refugees who escaped violence and persecution in Myanmar's Rakhine State [6]. The goal of the government was to improve living conditions for the Rohingya community while reducing overcrowding in the Cox's Bazar refugee camps [7]. To accommodate and help these migrants, they built facilities, infrastructure, and shelters on the island. For essential lighting in houses, public areas, and roadways, electricity is necessary in the Bhashan Char area. For their safety and well-being, it makes it possible for inhabitants to see and move around during the night [8]. To run medical equipment, chill medications and vaccinations, and offer life-saving services, medical facilities, such as hospitals and clinics, depend on electricity [9]. The population's health depends on everyone having access to healthcare. Schools and other educational facilities require electricity. It makes it possible to employ things like computers, lighting, audiovisual technology, and other educational resources that provide a good learning environment.

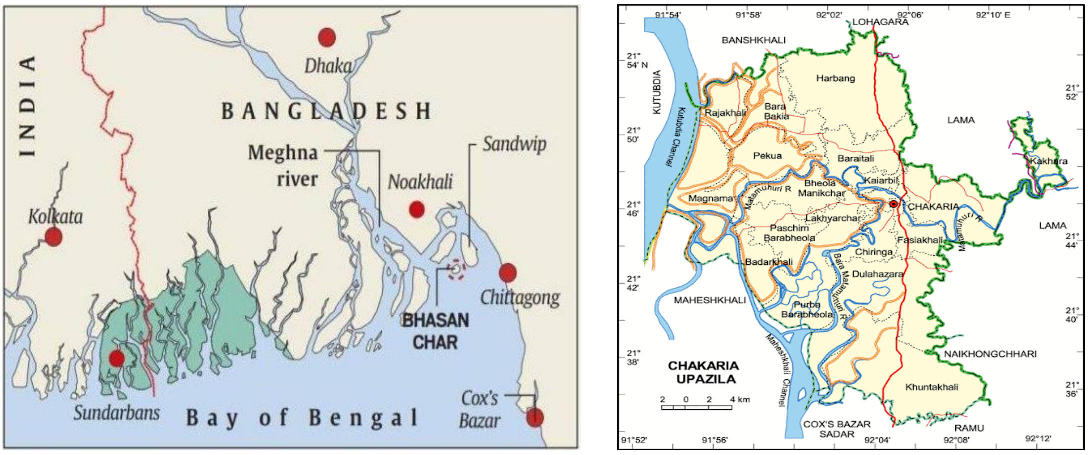

Figure 2. Location map of the study area (left: Bhashan Char, right: Chakaria)

Following is a summary of the remaining portions of the paper, in section 2 of this paper, it is briefly addressed how to anticipate energy demand using inverse matrix calculation (IMC) [10] and linear regression analysis (LRA) [10], [11]. Following that, a brief summary of the study site and the data collection is given in the section 3. Section 4 explains how to apply regression analysis and significant results with graphical representation to anticipate energy usage in an off-grid site and presents the inverse matrices analysis technique. In section 5, we give some final observations and suggestions for more research.

2. LITERATURE REVIEW

2.1. Method for the energy consumption forecasting

One essential tool for guaranteeing the dependability, effectiveness, and sustainability of energy systems is energy forecasting. It enables consumers, governments, and energy providers to plan ahead, adapt to changing conditions, and make the most use of available resources. Since the energy environment is always changing, accurate load forecasting is essential to effective energy management and a major force behind the shift to a more sustainable and resilient energy future [12]. The following are examples of energy forecasting:

- Short-term energy consumption forecasts: forecasting short-term energy consumption is the process of projecting how much energy will be used over a comparatively short period of time in the future. For short-term energy consumption, the forecasting horizon usually spans several hours to several days. Energy management, grid operations, and decision-making processes in a variety of industries, including utilities, manufacturing, and transportation, depend on this kind of forecasting. Precise estimates for the near future allow interested parties to maximise the distribution of resources, organise for demand response, and guarantee the stability and dependability of the energy infrastructure [13].
- Medium-term energy consumption forecasts: forecasts of medium-term energy consumption involve making predictions about energy use over a moderate time horizon, which is usually a few weeks to a few years in the future. The creation of policies, the distribution of resources, and medium-term planning all depend on this kind of forecasting. Medium-term forecasts fill in the gaps between short- and long-term perspectives by addressing strategic planning while short-term forecasts concentrate on immediate needs and operational decisions [14].
- Long-term energy consumption forecasts: making predictions about how much energy will be used over an extended period of time—typically several years or even decades—is the task of forecasting long-term energy consumption. These projections are crucial for large-scale investment decisions, policy formation,

and strategic planning. Unlike short- and medium-term forecasts, which concentrate on more urgent matters, long-term forecasts aim to predict trends and developments that occur over a number of years [15].

Deep learning methods, such as neural networks with gated recurrent units (GRUs) and long short-term memory (LSTM) networks, have demonstrated promise in identifying intricate patterns and dependencies in time series data on energy consumption. Ensemble methods such as XGBoost and LightGBM have proven to be useful in handling high-dimensional data and capturing non-linear relationships [16]. For feature importance analysis and accurate forecasting, random forest models have been applied, especially in situations where there are many predictors. More reliable and accurate forecasts can be achieved by integrating different forecasting models, such as by combining statistical and machine learning techniques [17]. Time series can be broken down into seasonal, trend, and residual components for a more thorough pattern analysis and more accurate forecasting. Many factors contribute to the popularity of linear regression for energy consumption forecasting, including its ease of use, interpretability, and efficacy in specific situations. The relationships between the independent variables (predictors) and the dependent variable (energy consumption) can be easily interpreted using linear regression models. The marginal impact of each predictor on energy consumption is represented by the coefficients in the regression equation, which facilitates comprehension and communication of the model's conclusions. A popular and well-understood technique in machine learning and statistics is linear regression. It can be implemented with ease and needs less computing power, making it usable by a variety of users. In addition, inverse matrix operations provide a tried-and-true, computationally effective method of locating coefficients. Overall, the ease of use, interpretability, efficiency, and suitability of the underlying assumptions of linear regression and inverse matrix approaches for a wide range of real-world energy data situations serve as reasons for their application in the forecasting of energy consumption. Before depending just on the model's predictions for making decisions, it's crucial to verify the model's assumptions and performance on pertinent datasets.

3. METHOD

3.1. Linear regression method

The use of linear regression techniques for energy consumption forecasting has received extensive study in the literature. A straightforward but efficient method for capturing the linear relationships between energy consumption and different influencing factors is to use linear regression models. The relationship between energy consumption and a single predictor variable is modelled by simple linear regression [18]. This approach has been used in studies to examine the effects of variables like population growth, economic indicators, and past consumption trends. The analysis is expanded to include multiple predictor variables using multiple linear regression [19]. Scholars have examined the collective impact of variables such as temperature, economic activity, and building attributes on energy usage. Time series components can be incorporated into linear regression models to capture energy consumption patterns over time [20]. Energy demand has been predicted both in the short and long-term using this method. By introducing a probabilistic framework, Bayesian linear regression allows researchers to include uncertainty in their forecasts. This method has been used to evaluate the degree of uncertainty in estimates of energy consumption. For the purpose of creating precise linear regression models, it is essential to comprehend the variables affecting energy consumption. Scholars have investigated the effects of policy interventions, technological advancements, and changes in the population on patterns of energy consumption. It is crucial to assess how well linear regression models perform. Scholars have employed diverse metrics, including mean absolute error (MAE) and root mean square error (RMSE), to evaluate the precision of their projections regarding energy consumption [21].

A straightforward and intelligible method of projecting energy consumption is provided by load forecasting using the LRM when there is a clear correlation between the load and the predictor variables. Assuming a linear relationship between the independent and dependent variables is the simplest form of linear regression [22]. A linear regression line's equation is frequently shown as (1):

$$y = b_0 + b_1 x + \epsilon \tag{1}$$

The dependent variable is y. The intercept is b_0, and x is the independent variable. The coefficient b_1 for the unrelated variable x. ϵ represents the error term LRM is the flexible and popular method for identifying the connections between variables and generating predictions based on past data. Despite its ease of use, LRA is nevertheless an effective tool for data analysis, hypothesis testing, and decision-making in a variety of fields [23]. The assumptions, limitations, and appropriate applications of the data must be fully understood for it to produce meaningful insights. Even when working with time series data, linear regression (LR) is frequently taken into consideration for modelling energy consumption because of its ease of use, interpretability, and capacity to identify specific linear trends and relationships. Results from linear regression are simple to understand. When all other variables are held constant, the coefficients in a linear regression model show how the dependent variable changes for every unit change in the corresponding independent variable. This interpretability is helpful in figuring out how various factors affect energy usage. When there is a consistent, straightforward pattern in the energy consumption over time, linear regression is a useful tool for capturing these trends. A linear model might offer a reasonable approximation, for instance, if energy consumption is steadily increasing or decreasing. Linear regression can be a good option for short-term forecasting where the focus is on capturing immediate trends and patterns. Overall, it has been demonstrated that linear regression methods are effective in forecasting energy consumption.

3.2. Inverse matrix method

An intriguing method for projecting long-term electricity demand forecasting is the pseudo-inverse matrix model, which uses linear algebraic methods to forecast future energy usage. The pseudo-inverse matrix model offers a rigorous framework for estimating electricity demand and is based on sound mathematical principles [24]. A methodical and precise approach to modelling is made possible by the application of matrix operations and linear algebra. This model is especially helpful in situations where there are several variables affecting the demand for electricity because it can effectively manage intricate relationships between different factors. The inverse relationship between dependent and independent variables is taken into account by the pseudo-inverse by default, giving rise to an estimation method for the effects of each factor on the demand for electricity. It is possible that the model incorporates historical data into the matrix, which allows it to identify patterns and trends over time.

Inverse matrix method (IMM) is a fundamental concept in mathematics and linear algebra. Among other fields, physics, engineering, computer science, and statistics are among those where it is crucial to finding solutions to a number of problems [25]. The mathematical process of determining a square matrix's inverse is essential to the study of transformations, systems of linear equations, and data analysis. Square matrices are those that have an equal number of rows and columns. The identity matrix, represented as I, is produced by multiplying the square matrix's inverse, marked as A^{-1}, by the original matrix, designated as A.

$$A * A^{-1} = I \tag{2}$$

In several studies, IMCs are used [26]–[28]. Every site has four different types of loads, which are separated into irrigation loads, industrial loads, commercial loads, and domestic loads. The quantity of labour required is also determined by taking into account variables like population, per capita income, and adult literacy rate [10]. For the purpose of estimating long-term electricity demand forecasting, the pseudo-inverse matrix model provides a systematic and mathematical method. Its capacity to manage numerous variables and offer an organised framework is one of its strongest points. However, given the dynamic and intricate nature of energy markets, it is imperative to recognise the model's assumptions and limitations. It would probably be more reliable and useful if this method was combined with other forecasting techniques and took long-term prediction uncertainties into account.

3.3. Data collection

The Chakaria Upazila's diversified landscape, which includes hilly hills, woods, and coastal regions, is what makes it unique. Hills and trees are present, which enhances the area's natural splendor. Muslim Bengalis make up a large portion of the population of Chakaria Upazila [29]. The area is renowned for its cultural richness, and a number of different ethnic populations call it home. Agriculture is the mainstay of Chakaria Upazila's economy, with the cultivation of rice, betel leaves, and a variety of fruits and vegetables. Aquaculture and fishing both support the regional economy. Additionally, as Cox's Bazar draws a sizable number of tourists, tourism contributes to the region's ability to generate money. Although the majority of visitors go to Cox's Bazar's main city, Chakaria Upazila also has its fair share of natural features. Hills and woodlands in the gorgeous scenery provide chances for hiking and eco-tourism [30]. Visitors may discover the area's biodiversity and natural beauty. Chakaria Upazila is split into a 66 of Mauzas and 17 administrative unions. The Upazila administration is in charge of local governance, public services, and development projects in the region. Chakaria, like many other coastal areas, is subject to erosion and the consequences of climate change. Rising sea levels and extreme weather may endanger local communities and ecosystems. Efforts are being made to address these obstacles through a variety of initiatives. Chakaria Upazila adds to the attractiveness of Bangladesh's Cox's Bazar District with its unusual combination of natural beauty and cultural variation. It is a destination for those who prefer to explore the less-traveled but no less intriguing sections of the area.

Bhashan Char, also known as Thengar Char, is an isolated island in the Bay of Bengal, close off the coast of Bangladesh [31]. It has lately received a lot of attention due to its use as a resettlement site for

Rohingya refugees fleeing persecution in Myanmar. Bhashan Char is located in southern Bangladesh, around 60 kilometers (37 miles) from the continent's coast. It is located in the estuary of the Bay of Bengal. Bhashan Char is a young continent produced by sediment and silt deposits delivered by rivers in the delta region. It is a dynamic, disintegrating continent prone to sedimentation. Bhashan Char was established by the Bangladeshi government as a resettlement place for Rohingya refugees fleeing violence and persecution in Myanmar's Rakhine State [32]. This was accomplished in collaboration with foreign organizations. The relocation occurred in reaction to the overcrowding in the refugee camps at Cox's Bazar on the mainland.

The process of collecting data is a methodical way to compile information for study, analysis, or decision-making. In order to collect pertinent and accurate data, strategies must be planned, designed, put into action, and managed. The integrity and quality of the data acquired are guaranteed by a successful data gathering procedure. An essential first step in carrying out precise and insightful regression analysis is gathering high-quality data. The analysis's findings and key insights will be directly impacted by the data. There are three steps in the data gathering process. In the first place, I went to the Chakaria and Hatia UNO office to collect the time-invariant data such as population (P_O), adult literacy rate (R_L), per capita income (R_P), In land communication strength (L_R) and agricultural land (L_F), distance from main land (T_D) tourist visitor (T_V). After that, we went to the Chakaria REB office to get the maximum and average loads for the community. I then went to the Bangladesh Statistical Bureau to find more reliable information and learn about per-capita income. While the Bhashan Char region is not linked to the grid, Chakaria is. The outcomes of the data gathering for time-invariant variables are displayed in Table 1. Table 2 displays the regression table for Chakaria (Ch) and Bhashan Char (Bh). The average demand/load and maximum demand/load for Chakaria town from 2020 to 2023 are shown in Tables 3 and 4, respectively.

To calculate the weighted average value of these variables, one has to be aware of the region's past. Another option is to choose a place that resembles an isolated region in some way. The main contribution of this paper is this. This issue will be clarified by how the suggested plan is actually put into practice.

Table 1. The data collected from UNO office of Hatia and Chakaria

Data	Chakaria (on-grid)	Bhashan Char (off-grid)
P_O (1000)	544320	21838
R_L (%)	57.60%	36.60%
R_P (USD)	5854.69 taka	3671.45 taka
L_R (KM)	180.7 km	3.570 km
L_F (Hector)	27142 hectors	1830 hectors
T_D (KM)	49 km	60 km
T_V (1000)	400	200

Table 2. Regression table of Chakaria and Bhashan Char

Ch	Bh	Ch^2	ChBh
544.32	21.838	296284.262	11886.86
57.6	36.6	3317.76	2108.16
69.69	43.71	4856.6961	3046.1499
112.28	2.22	12606.7984	249.2616
104.8	7.06	10983.04	739.88
49	60	2401	2940
0.4	0.2	0.16	0.08
∑Ch=938.09	∑ Bh=171.628	∑Ch^2=330449.72	∑ChBh=20970.39

Table 3. The average demand/load of Chakaria from 2020-2023 by month

Month	Average demand/load (KW)			
	2023	2022	2021	2020
Jan	4362.4	4362.4	4132.8	3788.4
Feb	4305.1	4247.6	4305.1	3845.8
Mar	4592.1	3329.2	4018.1	3845.8
Apr	4362.4	4477.2	3903.2	4362.4
May	4132.8	3845.8	4362.4	4477.2
Jun	4132.8	3788.4	3960.6	4362.4
Jul	4362.4	4018.1	4649.4	3960.6
Aug	4362.4	4592.1	4305.1	3845.8
Sep	4247.6	4190.2	4592.1	4132.8
Oct	4305.1	3673.6	3558.8	4247.6
Nov	4132.8	3788.4	4305.1	4190.2
Dec	4132.8	4155.1	4105.1	4305.1

Table 4. The maximum demand/load of Chakaria from 2020-2023 by month

Month	Maximum demand/load (KW)			
	2023	2022	2021	2020
Jan	4838.8	4716.9	4683.8	4313.1
Feb	4799.8	4610.4	4910.1	4417.5
Mar	4972.1	3688.5	4527.7	4513.9
Apr	4743.5	4945.6	4402.6	4965.1
May	4551.8	4288.9	4919.2	5151.1
Jun	4516.2	4245.3	4569.1	4906.6
Jul	4733.2	4686.1	5424.3	4694.2
Aug	4719.4	5317.5	4919.2	4496.7
Sep	4907.7	4634.5	5171.7	4758.5
Oct	4902.1	4197.1	4160.4	4959.4
Nov	4478.3	4339.4	4822.7	4782.6
Dec	4615.1	4773.4	4998.4	5317.5

4. RESULTS AND DISCUSSION

4.1. Energy consumption forecasting using LRM

We provide the findings of our load forecasting study using regression analysis in this section. We concentrate on the main conclusions drawn from the regression model and talk about how they relate to precise load prediction. The coefficient of determination, which measures the percentage of variance in the load data that can be accounted for by independent variables, was used to assess the effectiveness of the regression model. This shows that the predictors and the load have a significant short-term connection. Load forecasting using regression analysis of:

$$Bh = \alpha + \beta Ch \tag{3}$$

$$\beta = \frac{(\sum ChBh - \frac{\sum Ch \sum Bh}{n})}{(\frac{\sum Ch^2 - (\sum Ch)^2}{n})}$$
$$= \left(\frac{20970.39 - \frac{938.09*171.628}{7}}{330449.72 - \frac{938.09^2}{7}}\right) = 0.0099 \tag{4}$$

$$\alpha = \sum Bh/n - \beta \sum Ch/n = 24.52 – 0.0099 * 134.01 = 23.19 \tag{5}$$

For (3), $Bh = \alpha + \beta Ch = 23.19 + 0.0099 * Ch$
when *Ch*=4362.4 KW (Average load of January 2022 of Chakaria).
=23.19+0.0099*4362.4
=66.38 KW (average load of January 2023 of Bhashan Char)

Table 5 summarizes the average and maximum demand of Bhashan Char for 2023 based on Chakaria's 2023 load using regression analysis and shown in Figure 3. In regression analysis was used in this work to estimate short-term load patterns, and the findings have shed important light on the dynamic nature of energy demand. Our research highlights the need of taking important predictor variables into account to produce precise short-term load projections.

Table 5. The estimated average and maximum load of Bhashan Char

Month	Average demand/load (KW) 2023	Maximum demand/load (KW) 2023
Jan	66.3778	71.0941
Feb	65.8105	70.708
Mar	68.6518	72.4138
Apr	66.3778	70.1506
May	64.1047	68.2528
Jun	64.1047	67.9004
Jul	66.3778	70.0487
Aug	66.3778	69.9121
Sep	65.2412	71.7762
Oct	65.8105	71.7208
Nov	64.1047	67.5252
Dec	66.3778	71.0941

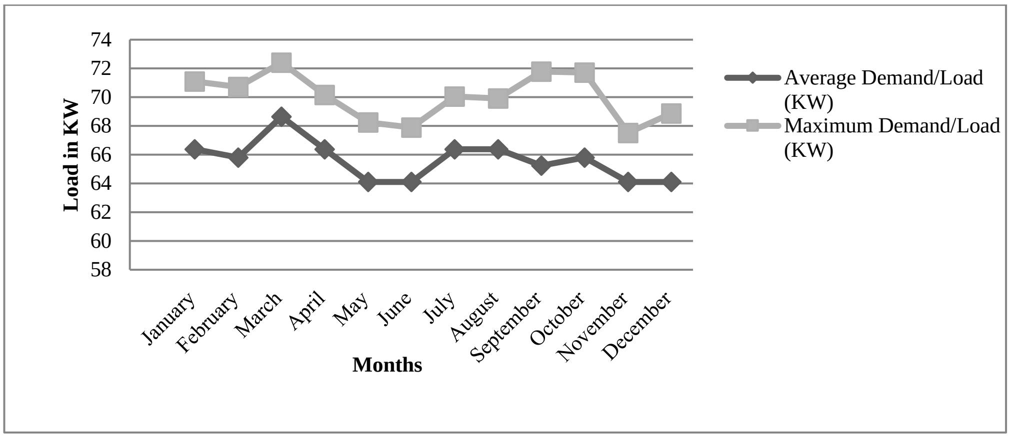

Figure 3. The graphical diagram of estimated average and maximum load of Bhashan Char

4.2. Energy consumption forecasting using IMM

In order to find a "best fit" (least squares) solution to a collection of non-unique linear equations, the Moore-Penrose pseudoinverse is typically used. Another use is to determine the lowest (Euclidean) norm solution to a system of linear equations with numerous solutions [10], [33]. The pseudoinverse simplifies the formulation and proof of results [34]–[36] in linear algebra. The capacity to precisely estimate load values for a certain time period was used to evaluate the IMC-based load forecasting approach. It was discovered that the estimated RMSE between the predicted load values and the actual load data was quite low. Matrix study estimates the average and maximum load for Bhashan Char, with Chakaria representing the on-grid area and Bhashan Char representing the off-grid territory. Table 6 is shown the estimated average and maximum load of Bhashan Char using inverse matrix analysis and shown in Figure 4

Table 6. The estimated average and maximum load of bhashan char

Month	Average demand/load (KW) 2023	Maximum demand/load (KW) 2023
Jan	70.3605	78.2035
Feb	69.7591	77.7788
Mar	72.7709	79.6552
Apr	70.3605	77.1657
May	67.951	75.0781
Jun	67.951	74.6904
Jul	70.3605	77.0536
Aug	70.3605	76.9033
Sep	69.1557	78.9538
Oct	69.7591	78.8929
Nov	67.951	74.2777
Dec	67.951	75.7674

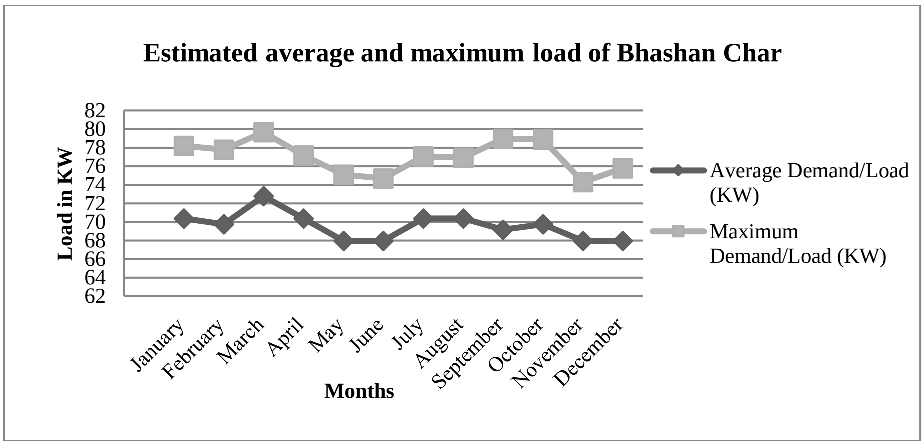

Figure 4. The graphical diagram of estimated average and maximum load of Bhashan Char

As a result, our load forecasting strategy leveraging IMC provides a useful and precise way to foretell load fluctuations. Our method adds to the armory of tools available for improving energy management and maintaining a steady and dependable energy supply by successfully adding external elements like temperature and the day of the month. Accurate load forecasting is essential as the energy environment changes, and our work advances an important aspect of contemporary energy systems.

4.3. Energy consumption forecasting comparison between LRM and IMM

In this particular area of work, the volume of traffic is predicted using two different methods. The comparison's findings show that the estimations of power usage produced by the two approaches were quite comparable. The estimated average load of Bhashan Char using the two approaches is compared in Figure 5. In this instance, short-term forecasting was applied. If other factors were included, such as time, temperature, location, peak and off-peak hours, and people's lifestyles the findings would be more accurate and precise. However, because it is based on on-load data, the demand predicted by this study is rather reasonable. With the use of this knowledge, electric utility firms will be able to purchase and generate electricity [37]–[39], swap loads, and build infrastructure. The mathematical model is most importantly applicable to any off-grid or remote island environment. The study can assist Bhashan Char in incorporating renewable energy sources, such as wind, solar, and tidal power, into his energy mix [40].

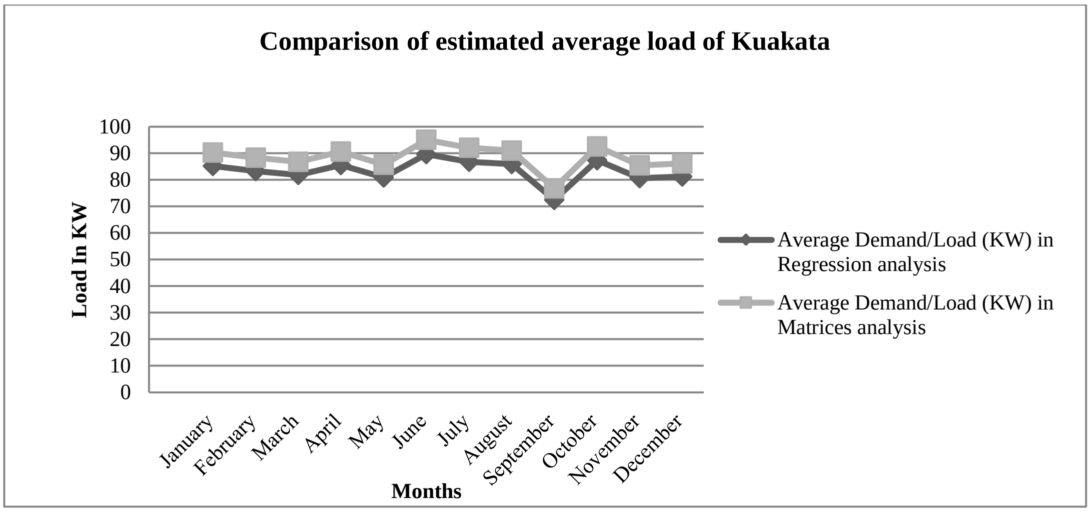

Figure 5. The comparison of estimated average load of Bhashan Char using two methods

5. CONCLUSION

In this study, linear regression and inverse matrix analysis were used to anticipate the energy demand for Bangladesh's Bhashan Char Island and the results provided useful information and projections for developing sustainable energy. Through the analysis of relevant variables and historical data, we can estimate the energy required for the island's future growth. This forecasting methodology allows for better resource allocation and planning. It supports informed decisions on infrastructure development, including the construction of power plants, distribution networks, and the integration of renewable energy sources, by policymakers and energy providers in order to meet the island's growing energy needs. The study can assist Bhashan Char in incorporating renewable energy sources, such as wind, solar, and tidal power, into his energy mix. It might be investigated to integrate renewable energy sources, like solar and wind power, into the smart grid in light of the need for sustainability and environmental awareness. This would lessen the impact on the environment and improve energy efficiency. By estimating demand, we can select the optimal location and capacity for renewable energy projects to promote sustainability and reduce reliance on fossil fuels. Accurate energy demand projections are useful for disaster preparedness and response planning. Since Bhashan Char Island is susceptible to natural disasters, knowing how much energy is consumed will help ensure a consistent supply of electricity when needed. Financial benefits effective energy planning could support the island's economic growth. By offering consistent energy access, it might entice businesses and investors, create job opportunities, and improve the general standard of living for the community. By lowering greenhouse gas emissions, accurate energy demand forecasting can help lessen dependency on fossil fuels and lessen the negative environmental effects of energy production and use. It is crucial to consider the forecasting model as a dynamic tool that requires regular updates and modifications to take into account changing circumstances like population growth, environmental changes, technological advancements, and adjustments to energy policies.

In conclusion, a helpful tactic for resilient development is the use of inverse matrix analysis and linear regression to forecast energy consumption on Bhashan Char Island. It offers a foundation for making informed decisions, promoting the incorporation of renewable energy, and improving the general well-being of the island's residents while considering environmental concerns and preparedness for disasters. The forecasting model must be regularly reviewed and adjusted in order to remain effective over time. To estimate the energy demand for Bangladeshi islands in the future, a multidisciplinary approach that includes data-driven modelling, the integration of renewable energy, regulatory support, and community participation is recommended. Reliability and sustainability of the energy supply for island communities rely on continuous development and flexibility in response to shifting conditions.

Further research could focus on fine-tuning model parameters, incorporating ever-more-complex features, and addressing the limitations associated with linear correlations in complex energy flows. Investigate the efficacy of hybrid models that blend machine learning approaches like neural networks or ensemble methods with conventional time series models. By combining the best features of both methodologies, these hybrid models could produce forecasts that are more reliable and accurate.

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