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Forecasting of Bioethanol Production in the Sudan

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Abstract: Gasoline demand of the Sudanese transportation sector is increasing. To meet the demand many measures have been developed in the last few years. These included efficiency improvement and supplement with bioethanol. The latter is blended with gasoline in the range of 5-27%; the blend is also called E85 and E90. The aim of this research was to forecast bioethanol production from molasses of Sudanese Sugar Factories by assuming the design capacities of bioethanol factories in Sudan from 2016 to 2030. Data on current consumption and production of gasoline by refineries as well as the potential production were obtained from relevant sources such as Ministry of Petroleum. The data were analyzed using forecasting models. Mainly two models namely a trend model and an econometric model were used. For econometric model, data on population, gasoline prices and gross domestic product were collected as well, while the trend model is time series dependent only. The results revealed that beyond the year 2021 Sudan production of gasoline will not meet the demand. Bioethanol mixed with gasoline at 10% is a feasible option to supplement gasoline. The study also revealed that the production potential of bioethanol in sugar industry will meet the demand with a surplus in year 2021.

Keywords:*Forecasting;Gasoline demand; Bioethanol production; Trend model; Econometric model.*

1. INTRODUCTION

1.1. Energy Consumption in Sudan

Sudan considers one of the biggest consumer countries of conventional energy from wood and coal [1], like most of the least developed African countries. The biomass consumption of forest resources in the energy balance of the country's represents approximately 80% [1] of the energy consumed in the various sectors of household, service, small industries sector. This had a significant impact on the decline of forest cover in the country and the low green areas. This led to increased desertification and environmental degradation and thus low productivity in the agricultural sector, whether or pastoral.

Sudan moved in late century of an importing consuming nation to a producer and exporter of oil and its derivatives. The establishment of a number of refining units has not gone unnoticed on the minds of engineers and economist. This research effort (technically and economically) focuses on the best way for the production and consumption of oil and its derivatives. This is expected to reduce the burden on the forest sector in the country and decrease the contribution of wood energy in the energy balance to reach 62% [1].

Sugar industry in Sudan is the most important industry, where natural resources and qualified staff are available to ensure high productivity at low cost. In addition the location of Sudan is outstanding amid great demand for sugar. To meet the requirements of the global market and technological progress in the machinery industry and not to total dependence on oil resources and in order to benefit from the by-products of the sugar industry, Sudanese sugar factories resorted to produce bioethanol, particularly the Kenana Sugar factory. Kenana Sugar Company started to produce bioethanol since 2009 [1] with design capacity of 65 million liters per year [1] and other factories are gradually expected to follow like White Nile sugar factory and Sudanese Sugar Company [1].

Energy is a critical input to the growth of any economy and therefore energy demand modeling and forecasting has been a widely researched area among both academics and practitioners. These models can vary in their underlying modeling objectives, modeling philosophies, sophistication in modeling methods or requirements of data. Often, these factors can be related to each other, e.g. a sophisticated modeling method will most certainly require a larger dataset or lack of data may force the development of a simple model [2].

2. MATERIALS AND METHODS

2.1.Forecasting of Gasoline Demand

The data used for this study were collected by the Ministry of Infrastructures and a consultant in the period 2008-2011. The data included household surveys, roadside surveys, public transport surveys, traffic counts, special surveys and freight survey. For the purpose of trip production modeling, only the household surveys will be used.

The gasoline demand depends on many external drivers. These can include income of consumers, price of energy goods, environmental factors (e.g. temperature), technological breakthrough, policy changes, changes in the structure of the economy, population growth etc. Among these, income and price have long been identified as the most important parameters [2]. The positive relationship between energy and GDP or income has been well documented in numerous energy studies [3, 6].

The negative impact of price has also been well documented, especially in studies of petroleum demand in the transport sector [7, 9]. Because of the lack of information on other demand drivers, energy demand studies in developing countries often use these two variables for explaining the changes in demand [10]. Due to insufficient information, only GDP, population and price are considered as demand driver in this work [2].

Both trend and econometric models are considered in this work to forecast the gasoline demand. The functional relationship between demand and drivers can assume various forms such as linear, power series, logarithmic or semi logarithmic [11].

2.1.1 Trend Model

Trend model is a mathematical relation between demand and time series. The model contains some constants that are estimated from historical data.
The most common trend model is the growth rate equation [11]:

$$y = y_o \exp(rt) \quad (1)$$

where: y = future value of demand.
y_o, r = constants are obtained from historical data.
t = time (1, 2, 3 … n)

2.1.2 Econometric model

The econometric model is a top down model. It is an economic model with strong theoretical background. It correlates the energy to demand drivers. The main demand drivers GDP, population, prices ..etc. similar to trend model, from a mathematical relationship between demand and drivers [2].

$$\ln(y) = \beta_1 \ln(x_1) + \beta_2 \ln(x_2) + \beta_3 \ln(x_3) + e \quad (2)$$

wherey : demand
β_n : coefficients
n : [0, 1, 2, 3]
x_i : demand drivers
i : [1, 2, 3]
x_1 : GDP, x_2= population, x_3= price
e : error

In order to determine the forecast for gasoline demand in Sudan, we need to know the values of the independent variables (GDP, population and prices) into the future.

The forecasting of GDP and prices use three prediction trend models [11]:

- Parabolic function: $a+bx+cx^2$
- Power series: $a x^b$
- Natural growth: $a e^{bx}$

a, b, c = coefficients

In general, a model fits the data well if the differences between the observed values and the model predicted values are small and unbiased [12]. In this work focus is on R-squared to determine the best fit model.

2.2 Data collection

The gasoline production and demand is obtained from Ministry of Petroleum and Gas, the GDP per capita from Sudan Central Bank and the population data is obtained from Central Statistical Organization, the local prices of gasoline are considered in this work and obtained from Sudanese petroleum ministry.

The Southern Sudan is separated from Sudan and became an independent state in July 2011 [11]. To avoid inconsistency, year 2012 is considered as the base year for two separated states [11]. That is to say the GDP for up to 2011 is considered for both countries, thereafter, 2012, is for Sudan. Table (1) shows the variation of GDP with time. It can be seen that the GDP per capita continues with the same trend after 2012.This indicates that the GDP per capita is not affected by the separation although the Sudan loses about 70% of its oil production [11]. The local prices of gasoline are varying according to the state strategy. It is constant in years 2014 and 2015, but the variation in the dollar prices with time led to a change in the prices.

The fluctuation shown in gasoline production may be due to technical problem related to operation rather than supply policy problem [11]. On the other hand, local demand in gasoline is increasing with relatively high rate, because it is consumed mainly in the transportation sector. Table (1) shows that the gasoline demand is not affected by the separation of the South Sudan in 2012 although the population of South Sudan was almost 22% of total Sudan population before separation [11].

The production of bioethanol and the design capacity of Kenana bioethanol factory and design capacity of White Nile plant factory is obtained from Ministry of Petroleum and Gas.

The design capacity of the Sennar and Halfa bioethanol plant factories is obtained from Sudanese Sugar Company.

Table 1 shows gasoline production and demand by (million liters) data together with GDP (per capita), population (million), and gasoline prices (USD/L). This data in Table 1 from 2000 to 2015 are used to forecast of gasoline demand.

Table 1. Gasoline production, demand and drivers [13] -[15]

Year	**Local Production (m lit)**	**Demand (m lit)**	**Export (m lit)**	**GDP per capita**	**Population (million)**	**Price (USD/L)**
2000	789.24	12.41	476.83	1083.10	31.08	0.30
2001	1137.53	492.63	644.90	1274.00	31.91	0.28
2002	1195.12	626.42	568.70	1457.40	32.77	0.34
2003	1159.01	641.68	517.34	1656.39	33.65	0.35
2004	1284.66	658.77	625.88	1991.24	34.51	0.47
2005	1239.65	563.56	676.09	2353.26	35.40	0.50
2006	1538.89	665.87	873.02	2661.70	36.30	0.56
2007	1628.02	742.95	885.07	2860.62	37.24	0.72
2008	1572.16	834.24	737.92	3182.53	39.15	0.70
2009	1610.93	957.59	653.34	3375.20	40.19	0.64
2010	1790.35	1080.26	710.09	3931.35	41.26	0.63
2011	1659.84	1122.14	537.70	4419.01	42.25	0.69
2012	1705.27	1186.72	518.55	6943.55	35.06	0.51
2013	1470.58	1246.05	224.52	9479.14	36.16	0.59
2014	1700.69	1308.36	392.33	12610.25	37.37	0.82
2015	2164.80	1373.78	791.03	15166.80	38.44	0.78

3. RESULTSAND DISCUSSION

3.1. Trend Model

Equation 1 is used to forecast of gasoline demand by trend model, and results are shown in **Table 2**andforecast results are presented in **Fig 1**

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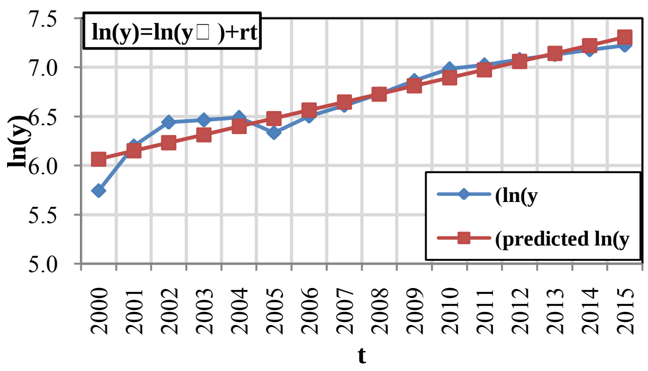


Fig. 1. Demand of gasoline trend model forecast

Table 2. Demand of gasoline trend model forecast

Time(t)	year	Production (million lit)	demand (million lit)(y)	Export (million lit)	ln(y)
1	2000	789.24	312.41	476.83	5.74
2	2001	1137.53	492.63	644.90	6.20
3	2002	1195.12	626.42	568.70	6.44
4	2003	1159.01	641.68	517.34	6.46
5	2004	1284.66	658.77	625.88	6.49
6	2005	1239.65	563.56	676.09	6.33
7	2006	1538.89	665.87	873.02	6.50
8	2007	1628.02	742.95	885.07	6.61
9	2008	1572.16	834.24	737.92	6.73
10	2009	1610.93	957.59	653.34	6.86
11	2010	1790.35	1080.26	710.09	6.99
12	2011	1659.84	1122.14	537.70	7.02
13	2012	1705.27	1186.72	518.55	7.08
14	2013	1470.58	1246.05	224.52	7.13
15	2014	1700.69	1308.36	392.33	7.18
16	2015	2164.80	1373.78	791.03	7.23

The general form of straight line equation:

$$y = a+rt$$

a = intercept
r = slope

From Fig. 1:
ln (y)= ln(y□)+rtrepresents a straight line equation.

After estimation by program

ln(y)= 5.984+0.083t
r= slope = 0.083
a= ln(y□) = intercept = 5.984, y□ = 397.025
R^2= 0.91

The model is strong in forecast because the coefficient of determination R^2= 0.91.
The slope is represented by 0.083. This value is positive. That means the demand of gasoline increases with time when using trend model forecast.

3.2. Econometric Model

Equation 2 is used to forecast the gasoline demand by econometric model, and results are shown in **Table 3**.Forecast results are presented in **Figs 2** to **4**.

Table 3. Demand of gasoline econometric model forecast

Year	(y)	(x_1)	(x_2)	(x_3)	ln(y)	ln(x_1)	ln(x_2)	ln(x_3)
2000	312.41	1083.10	31.08	0.30	5.74	6.99	3.44	-1.20
2001	492.63	1274.00	31.91	0.28	6.20	7.15	3.46	-1.27
2002	626.42	1457.40	32.77	0.34	6.44	7.28	3.49	-1.08
2003	641.68	1656.39	33.65	0.35	6.46	7.41	3.52	-1.05
2004	658.77	1991.24	34.51	0.47	6.49	7.60	3.54	-0.76
2005	563.56	2353.26	35.40	0.50	6.33	7.76	3.57	-0.69
2006	665.87	2661.70	36.30	0.56	6.50	7.89	3.59	-0.58
2007	742.95	2860.62	37.24	0.72	6.61	7.96	3.62	-0.33
2008	834.24	3182.53	39.15	0.70	6.73	8.07	3.67	-0.36
2009	957.59	3375.20	40.19	0.64	6.86	8.12	3.69	-0.45
2010	1080.26	3931.35	41.26	0.63	6.99	8.28	3.72	-0.46
2011	1122.14	4419.01	42.25	0.69	7.02	8.39	3.74	-0.37
2012	1186.72	6943.55	35.06	0.51	7.08	8.85	3.56	-0.67
2013	1246.05	9479.14	36.16	0.59	7.13	9.16	3.59	-0.53
2014	1308.36	12610.25	37.37	0.82	7.18	9.44	3.62	-0.20
2015	1373.78	15166.80	38.44	0.78	7.23	9.63	3.65	-0.25

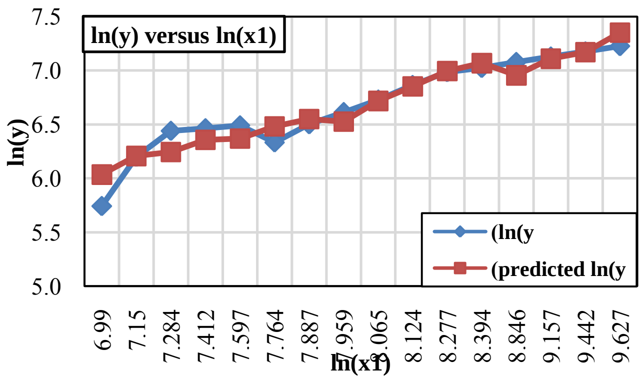


Fig. 2. Demand of gasoline econometric model forecast (ln(y) versus ln(x1))

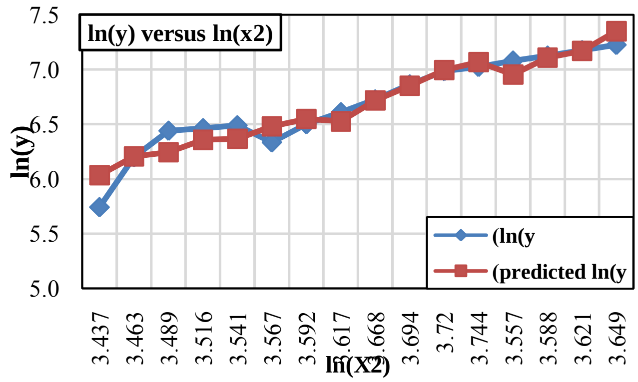


Fig. 3. Demand of gasoline econometric model forecast (ln(y) versus ln(x2))

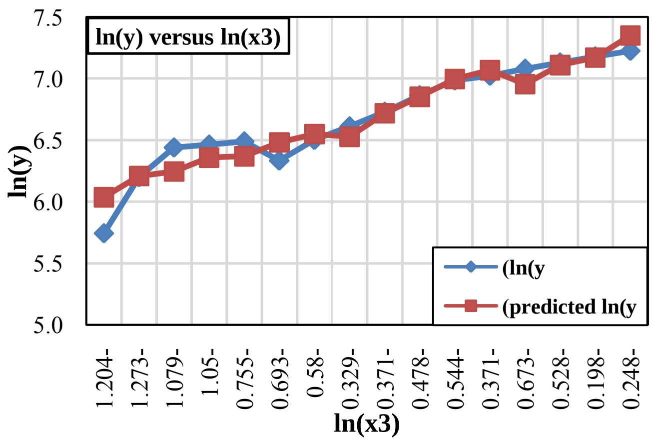


Fig. 4. Demand of gasoline econometric model forecast (ln(y) versus ln(x3))

x1 = GDP, x2 = population, x3 = price
From figures (2, 3, and 4):
ln(y)=β0+β1*ln(x1)+β2*ln(x2)+β3*ln(x3) represents a straight line equation

After estimation by program

ln(y) = -6.386+0.468*ln(x1)+2.497*ln(x2)-0.471*ln(x3)
Intercept = β0 = -6.386
Slope (1) = β1 = 0.468
Slope (2) = β2 = 2.497
Slope (3) = β3 = -0.471
R^2= 0.92
Absolute error = 0.13

The $R^2$of the econometric model is (0.92) larger than $R^2$of the trend model (0.91). According to econometric model, gasoline demand in the national level increases with an increase in income, when expressed through total GDP per capita. It was found that a 1% increase in GDP per capita increases aggregate demand for gasoline by 0.47%. There are numerous studies in energy demand which suggested a positive relationship between GDP and energy demand; therefore our results are consistent with those in the literature. Economic theory dictates that the demand has a negative correlation with price.

It is believedthe price elasticity is statistically insignificant because of two reasons. Firstly, the price is already very low; therefore consumers are not sensitive to any changes around this very low level. Secondly, there is a large suppressed demand for energy in Sudan, which again implies that consumers are less concerned about the price and are more inclined to increase consumption.The econometric model is the best fit model to forecast gasoline demand.

3.3. Forecasting of GDP

GDP is to be forecasted by using three prediction models: power series, natural growth and parabolic function. The results are shown in **Table 4.**Forecast results are presented in **Fig5**.

- Parabolic function: $a+bx+cx^2$
R^2= 0.94
- Power series: a x^b
R^2= 0.57
- Natural growth: a e^{bx}
R^2= 0.96

The regression of the parabolic model is 94% of the variance while the power series is 57% and the natural growth is 96%. The more variance that is accounted for by the regression model the closer the data points will fall to the fitted regression line. The GDP per capita by natural growth is increase the trend in the future and is more realistic than the power series. But parabolic function almost gives a constant GDP Therefore the best fit model is natural growth and therefore is considered in this work.

Table 4.GDP per capita trend forecast

Year	Time(x)	GDP (per capita)(y)	ln(y)	ln(x)	x^2
2000	1	1083.10	6.99	0	1
2001	2	1274.00	7.15	0.69	4
2002	3	1457.40	7.28	1.10	9
2003	4	1656.39	7.41	1.39	16
2004	5	1991.24	7.60	1.61	25
2005	6	2353.26	7.76	1.79	36
2006	7	2661.70	7.89	1.95	49
2007	8	2860.62	7.96	2.08	64
2008	9	3182.53	8.07	2.20	81
2009	10	3375.20	8.12	2.30	100
2010	11	3931.35	8.28	2.40	121
2011	12	4419.01	8.39	2.49	144
2012	13	6943.55	8.85	2.57	169
2013	14	9479.14	9.16	2.64	196
2014	15	12610.25	9.44	1.61	225
2015	16	15166.80	9.63	2.77	256

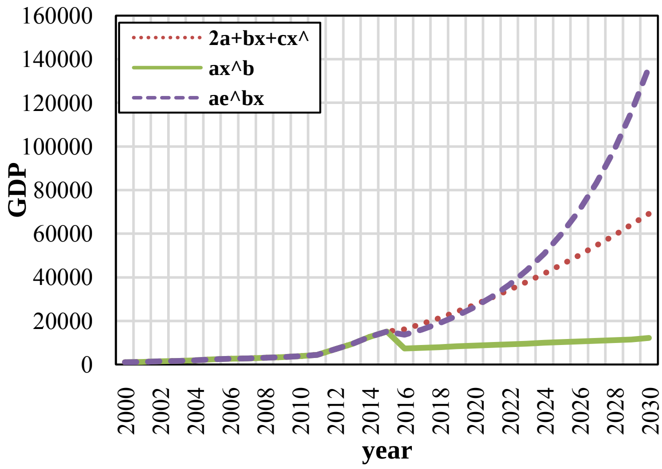


Fig. 5. Sudan's GDP per capita trend forecast

3.4. Forecasting of Prices

To forecast prices using three prediction models: power series, natural growth and parabolic function. The results are shown in **Table 5.**Forecast results are presented in **Fig 6**.

Table 5. Prices (USD/L) trend forecast

Year	Time(x)	Prices (USD/L)(y)	ln(y)	ln(x)	x^2
2000	1	0.30	-1.20	0	1
2001	2	0.28	-1.27	0.69	4
2002	3	0.34	-1.08	1.10	9
2003	4	0.35	-1.05	1.39	16
2004	5	0.47	-0.76	1.61	25
2005	6	0.50	-0.69	1.79	36
2006	7	0.56	-0.58	1.95	49
2007	8	0.72	-0.33	2.08	64
2008	9	0.70	-0.36	2.20	81
2009	10	0.64	-0.45	2.30	100
2010	11	0.63	-0.46	2.40	121
2011	12	0.69	-0.37	2.49	144
2012	13	0.51	-0.67	2.57	169
2013	14	0.59	-0.53	2.64	196
2014	15	0.82	-0.20	1.61	225
2015	16	0.78	-0.25	2.77	256

- Parabolic function: $a+bx+cx^2$
R^2= 0.77
- Power series: ax^b
R^2= 0.65
- Natural growth: a e^{bx}
R^2= 0.73

The regression of the parabolic model is 77% of the variance while the power series is 65% and the natural growth is 73%. The more variance that is accounted for by the regression model, the closer the data points will fall to the fitted regression line.

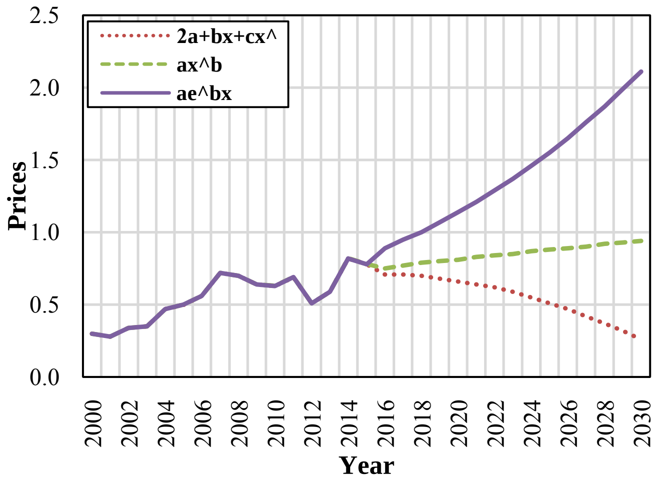


Fig. 6. Gasoline historical and forecast prices

The fitted values are near to the observed values for the parabolic model and are thus considered the best fit model but the natural growth is more realistic as the power series yield decreasing trend in future. The parabolic model tends to decrease the prices. Hence the natural growth is considered in this work.

Use econometric model to predict gasoline demand:

$\ln(y) = \beta_0+\beta1*\ln(x1)+\beta2*\ln(x2)+\beta3*\ln(x3)$

$\beta_0 = -6.386$

$\beta1 = 0.468$

$\beta2 = 2.497$

$\beta3 = -0.471$

Table 6. Population (million) from 2016 to 2030 [16]

Year	Number of population (million)
2016	39.60
2017	40.80
2018	41.99
2019	43.22
2020	44.21
2021	45.21
2022	46.22
2023	47.26
2024	48.32
2025	49.41
2026	50.50
2027	51.62
2028	52.77
2029	53.94
2030	55.14

Table 7. The GDP (per capita), the population (million), and prices (USD/L), from 2016 to 2030

Year	GDP (per capita)	Population (million)	Prices (USD/L)
2016	13645.98	39.60	0.89
2017	16085.01	40.80	0.95
2018	18959.97	41.99	1.00
2019	22348.85	43.22	1.07
2020	26343.32	44.21	1.14
2021	31051.74	45.21	1.21
2022	36602.07	46.22	1.29
2023	43144.06	47.26	1.37
2024	50855.32	48.32	1.46
2025	59944.84	49.41	1.55
2026	70659.65	50.50	1.65
2027	83288.85	51.62	1.76
2028	98175.31	52.77	1.87
2029	115722.46	53.94	1.99
2030	136407.23	55.14	2.11

Substituting x1, x2, x3 = GDP, population and price respectively from 2016 to 2030.

I.e.:

$\ln(y)=-6.386+0.468*\ln(13645.98)+2.497*\ln(39.6)-0.471*\ln(0.89)= 7.311$

y= 1500.35 m lit

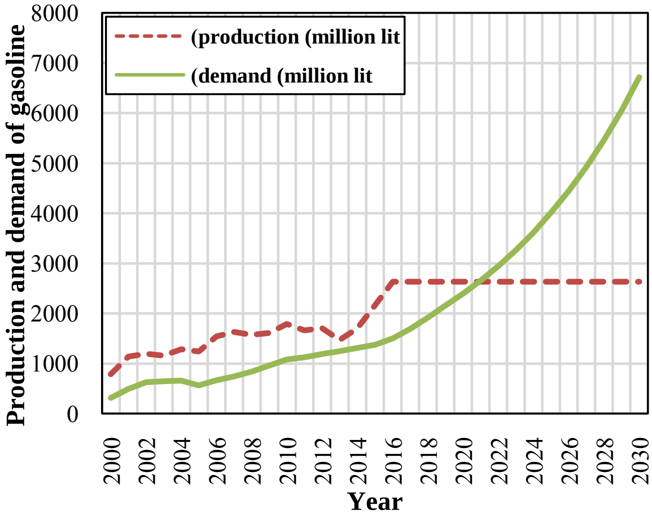
Table 8. Production and gasoline demand for the years 2000 to 2015 (million liters) [13]

Year	Production (million lit)	Demand (million lit)(y)
2000	789.24	312.41
2001	1137.53	492.63
2002	1195.12	626.42
2003	1159.01	641.68
2004	1284.66	658.77
2005	1239.65	563.56
2006	1538.89	665.87
2007	1628.02	742.95
2008	1572.16	834.24
2009	1610.93	957.59
2010	1790.35	1080.26
2011	1659.84	1122.14
2012	1705.27	1186.72
2013	1470.58	1246.05
2014	1700.69	1308.36
2015	2164.80	1373.78

Table9. Production and forecasting of gasoline demand for the years 2016 to 2030 (million liters)

Year	Production (million lit)	Demand (million lit)
2016	2632.23	1500.35
2017	2632.23	1691.46
2018	2632.23	1917.47
2019	2632.23	2157.22
2020	2632.23	2392.80
2021	2632.23	2656.24
2022	2632.23	2942.51
2023	2632.23	3265.57
2024	2632.23	3618.34
2025	2632.23	4016.44
2026	2632.23	4449.51
2027	2632.23	4924.52
2028	2632.23	5460.31
2029	2632.23	6050.20
2030	2632.23	6715.12

Table 9 showsthe production and forecast of gasoline demand for the years 2016 to 2030. Assuming the stability of gasoline production locally, as it is now for the coming years it is expected to halt gasoline export in the year 2021. Gasoline will be imported to cover the expected shortage, unless many options are considered such as increasing refining capacities and investment on bioethanol. This result matches with previous study [11] which states that, the current supply of gasoline can continue to meet demand up to 2022.



Gasoline historical and forecasted demandwith production are presented in **Fig7**.

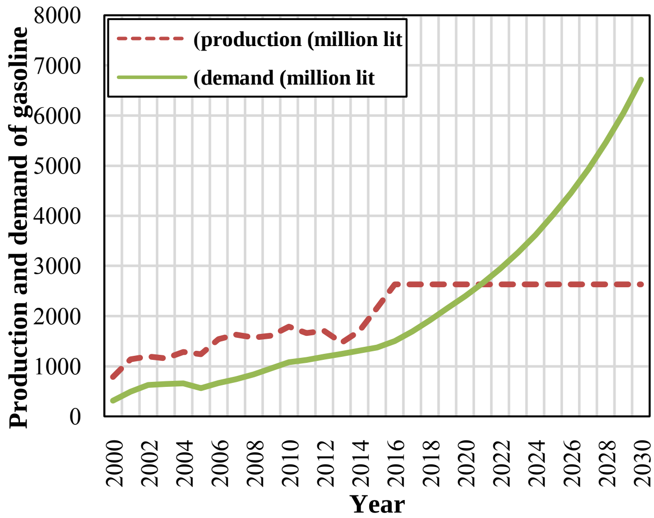


Fig. 7. Gasoline historical and forecasted demand

Assuming the production of gasoline= 2632.23 million liters is constant from 2021 to 2030 the deficit between production and gasoline demand are presented in **Table 10**.

Table10. Deficit (The quantity to be supplied)between the production and gasoline demand since 2021 until 2030 (million liters)

Year	Demand (million lit)	Deficit (Thequantity to be supplied)
2021	2656.24	24.01
2022	2942.51	310.28
2023	3265.57	633.34
2024	3618.34	986.11
2025	4016.44	1384.21
2026	4449.51	1817.28
2027	4924.52	2292.29
2028	5460.31	2828.08
2029	6050.20	3417.87
2030	6715.12	4082.89

Take the bioethanol mixing with gasoline as one solution to cover demand of gasoline, thus forecasting of bioethanol production to calculate the amount of bioethanol mixing with gasoline.

3.5 Forecasting of bioethanol production

Assuming the designed capacity of the bioethanol of kenana factory from 2016 to 2030 (65 million lit), designed capacity of White Nile factory (46 million lit) will begin in 2017, designed capcity of Sennar factory (27 million lit) will begin in 2018, and the designed capacity of Halfa factory (5.4 million lit) will begin in 2021[1, 17].**Table 11** shows the total production of bioethanol and the results are presented in **fig 8**.

Table 11. The total production of bioethanol (million liters) from Kenana factory, the White Nile factory and the Sudanese Sugar Company [1] [17]

Year	Kenana	White Nile	Sennar	Halfa	Total
2009	9.23	-	-	-	9.23
2010	35.22	-	-	-	35.22
2011	36.18	-	-	-	36.18
2012	32.76	-	-	-	32.76
2013	46.88	-	-	-	46.88
2014	38.70	-	-	-	38.70
2015	25	-	-	-	25
2016	65	-	-	-	65
2017	65	46	-	-	111
2018	65	46	27	-	138
2019	65	46	27	-	138
2020	65	46	27	-	138
2021	65	46	27	5.4	143.4
2022	65	46	27	5.4	143.4
2023	65	46	27	5.4	143.4
2024	65	46	27	5.4	143.4
2025	65	46	27	5.4	143.4
2026	65	46	27	5.4	143.4
2027	65	46	27	5.4	143.4
2028	65	46	27	5.4	143.4
2029	65	46	27	5.4	143.4
2030	65	46	27	5.4	143.4

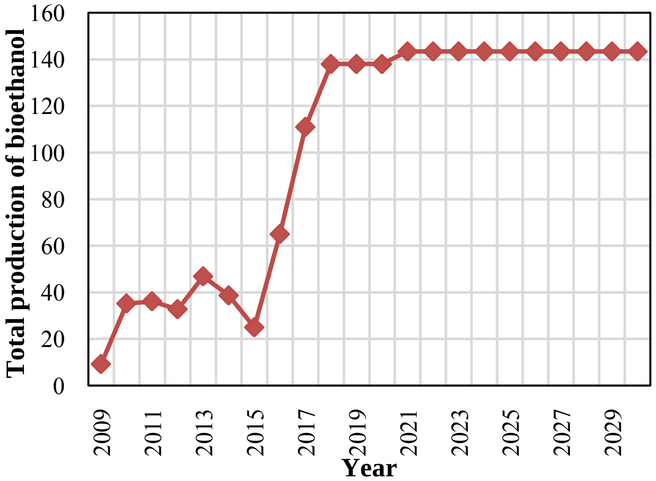


Fig. 8. Total production of bioethanol from 2009 to 2030 [1, 17]

The amount of bioethanol mixing with gasoline from 2021 to 2030 = 10% from demand of gasoline.

Table12. The total available bioethanol, the amount of bioethanol mixing with gasoline and the deficit in bioethanol production (million liters)

Year	Total available bioethanol (m lit)	Demand of gasoline (m lit)	Amount of bioethanol mixing with gasoline (m lit)	Deficit in bioethanol production
2021	143.4	2656.24	265.624	122.224
2022	143.4	2942.51	294.251	150.851
2023	143.4	3265.57	326.557	183.157
2024	143.4	3618.34	361.834	218.434
2025	143.4	4016.44	401.644	258.244
2026	143.4	4449.51	444.951	301.551
2027	143.4	4924.52	492.452	349.052
2028	143.4	5460.31	546.031	402.631
2029	143.4	6050.20	605.020	461.620
2030	143.4	6715.12	671.512	528.112

Table 12 shows the amount of bioethanol in 2021 to 2030 must be increased to cover the amount of bioethanol mixing with gasoline.

Table 13. The demand of gasoline, 10% of bioethanol, 90% of gasoline demand, deficit and export of gasoline (million liters)

Year	Production [13]	Demand	10% bioethanol production	90% of gasoline demand	Deficit	Export
2021	2632.23	2656.24	265.624	2390.616		241.614
2022	2632.23	2942.51	294.251	2648.259	16.029	-
2023	2632.23	3265.57	326.557	2939.013	306.783	-
2024	2632.23	3618.34	361.834	3256.506	624.276	-
2025	2632.23	4016.44	401.644	3614.796	982.566	-
2026	2632.23	4449.51	444.951	4004.559	1372.329	-
2027	2632.23	4924.52	492.452	4432.068	1799.838	-
2028	2632.23	5460.31	546.031	4914.279	2282.049	-
2029	2632.23	6050.20	605.020	5445.180	2812.950	-
2030	2632.23	6715.12	671.512	6043.608	3411.378	-

Table 13 shows that the quantity to be supplied of gasoline after the bioethanol mixing with gasoline decreases from the quantity to be supplied before bioethanol mixing

withgasoline.

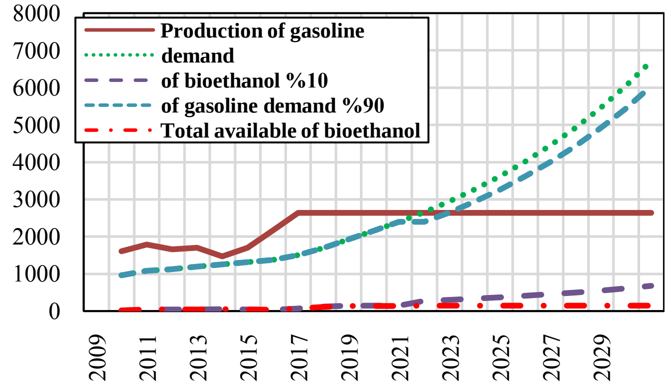


Fig.9. Total available bioethanol, production of gasoline and compared to expected demand of gasoline and 90% of gasoline demand with production of gasoline (million lit)

Fig 9 shows that 90% of gasoline demand in 2022 exceeds the production of gasoline which requires increasing the production of gasoline and more production of bioethanol.

4. CONCLUSIONS

Gasoline is the most important indigenous energy resource in Sudan. It is necessary to understand the evolution of gasoline demand in future. When predicting demand of gasoline it is found that in the year 2021 gasoline demand will surpass its production. The use of bioethanol blended with gasoline by 10% is expected to bridge the demand gap based on the production of bioethanol available. It was found that the ratio of bioethanol is not available, which requires increasing the expected production to completion of that percentage. After blending gasoline with bioethanol (10%) and finding the difference between production and demand, it turns out that it can cover the demand in the year 2021 with a surplus of production. However gasoline production and quantities produced from bioethanol must increase to cater for the future demand gap in the country. This requires further study.

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