Optimizing the Consumption of Products in Petroleum Industry: An Approach towards Agricultural Sustainability

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Abstract

Indian economy primarily depends on agriculture. Being a food-producing nation, it requires manual labour, fertilizers and farm machinery to produce crops for the increasing needs of the economy. For the use of fertilizers and machinery, fuel plays a vital role both in survival and development of the agriculture sector. Observing that fuel is an important ingredient for the agriculture industry, the current paper aims to study the relationship between agriculture and petroleum industry. The study undertakes both primary and secondary research. The primary research was conducted to ascertain the impact of the petroleum industry on the agricultural sector of India. The primary research is supporting and making secondary research results more robust and reliable. The empirical secondary data results depict that consumption of High-Speed Diesel (HSD) has a negative relationship with exports of HSD and a positive relationship with imports and production of HSD. However, the variable foodgrain production exhibits no impact on consumption of HSD. There is a positive correlation for two sets of variables: I-between prices of petrol and prices of urea; II-between sale of farm machinery and prices of diesel. Both intrinsically and extrinsically the agriculture industry relies on the petroleum industry. The study proposes hybrid tractors as a sustainable solution. A case study approach is adopted to compare the costs of two tractors manufactured by Sonalika International Tractors Ltd. to examine the net benefit of hybrid technology. It is concluded that neither petroleum industry nor agricultural industry can be studied in isolation. Sustainability in agricultural sector and its effective management can be attained only by the synergy effect of these two industries.

Keywords: *Agricultural sector, Consumption of HSD, Prices of fuel and Sustainability.*

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INTRODUCTION

India is a food-producing nation with a crop production of 295.67 million tonnes in 2019-20, employing 41.49% of India's total population.[1] However, in recent decades, India's food consumption has increased at a faster rate than its food production.[2] The population expansion has increased the consumption of agricultural produce. In the agriculture sector, petroleum products play an imperative role, as they provide fuel for machinery and fertilizers to promote crop production.[3] Farmers in India are already striving to get fair prices for their products. The rising prices of petroleum products are adding to the total input cost of agriculture, impacting the economic conditions of the farmers.

Many farmers have adopted diesel-powered machinery and rising diesel prices have increased the burden on farmers by increasing their costs and thereby lowering their profit margins. As an outcome, the agriculture sector is losing its significance as an income-generating sector and is no longer making a significant contribution to the economic growth rate.[4] India's agricultural sector contributed 36.40% in 1982-83 to GDP, which has reduced to 19.90% in 2019-20 primarily due to contractions in the earnings of the agricultural sector.[5] Thus, any variation in the petroleum industry affects the agriculture industry.

Several studies have been conducted to determine the relationship between price variation of petroleum products and various agriculture-related factors. These factors include agricultural productivity,[6] commodity prices,[7] total farming occupation,[8] also, the economy through its variables: namely the balance of trade, wholesale price index,[9] consumer price index, and gross domestic product.[10] The results from these studies depicted long and short-run relationships between food price and fuel price.

Some studies exhibit no relationship between the above-stated factors.[11] One reason attributed to the absence of such a relationship could be the access to a vast amount of subsidized agriculture-related facilities to the farmers. However, these subsidies are not utilized by the farmers to their maximum potential. Farm subsidies for 2019-20 were worth Rs. 2.77 lakh crores, yet only a fraction of farmers received them.[12] Despite raising Rs.75000 crores for the PM Kisan scheme in 2020-21, it failed to make headway and reach low-income farmers.[13] Therefore, another way to assist farmers is to promote sustainability.

Biofuels and Biodiesel from rapeseed oil are a few sustainable approaches that the government has employed to boost agricultural production. These solutions are not yet fully adopted due to their specific limitations. For instance, Biofuels have high production costs due to their high cost of raw materials. The food sector is also under pressure due to biofuels' reliance on edible food.[14] Biofuels also have a high viscosity level that increases with temperature.[15] To summarize, while the end-use of biofuels may be beneficial, their production has various negative environmental consequences, including soil degradation, deforestation and water depletion.[16]

On the other hand, Biodiesel produced from industrial rapeseed oil must go through an extensive process of preparation and transesterification. It involves effort, money and time, making this alternative a difficult one to implement.[17] It also has harmful after-effects on the engine, such as lowered efficiency of rubber houses, alongside the clogging effects.[18] With such a large number of drawbacks, there is a compelling need to shift to innovative technologies.[19][20]

RELEVANCE/RATIONALE OF THE STUDY

The agriculture and petroleum industries are interdependent. From 2010-11 to 2019-20, India experienced a 40.08% increase in Imports of HSD. An increasing trend was also visible in case of other

variables namely Production of HSD, Exports of HSD and Production of Foodgrains. The rise in Imports of HSD induced us to study the behavior and impact of Imports and other select variables on Consumption of HSD in agriculture sector. Furthermore, it is observed through literature that Imports are related with prices of fuel; this motivated us to examine the direct and indirect relationships of petroleum products with agriculture inputs. The study aims to find a sustainable solution for agriculture industry and provides a meaningful result with respect to choice of Hybrid tractor.

The study is important for farmers, policy makers, researchers and academicians. The results of the study facilitate decision making of the farmers in evaluating and selecting most appropriate type of tractor. Also, findings are relevant for policy makers as it helps in achieving sustainable solution. Policy makers must consider and promote use of hybrid tractors as they are leading to benefits for the environment by emitting lower carbon dioxide and at the same time they are pocket-friendly for the farmers. Additionally, the researchers and academicians are relevant contenders of information of the current study as the existing literature on assessment of appropriate tractor as a sustainable solution is meagre for emerging markets including India. The study contributes to agriculture literature.

RESEARCH GAP

The studies in India and abroad have examined the relationship between agriculture and petroleum industry. The proxies for agriculture industry used in different studies are income of farmers, price of agriculture commodities such as prices of soybean, wheat and corn. The proxies for petroleum industry used in different studies are limited to energy prices such as crude oil prices. Notably, the current paper uses select variables which have not been used in any study so far. Consumption of High-Speed Diesel in agriculture sector and foodgrain production are taken as measures to gauge agriculture industry. Imports of High-Speed Diesel, Exports of High-Speed Diesel, Production of High-Speed Diesel are taken as measures to gauge petroleum industry.

Identification of hybrid tractor as a solution for sustainability in agriculture sector is virtually absent from the Indian literature. In order to identify the measures for ensuring sustainability in agriculture sector, the current paper adopts a case study approach and does the comparative cost benefit analysis between a hybrid and a diesel-based tractor.

OBJECTIVES OF THE STUDY

Objectives of the current study are as follows:

1) To examine the relationship between agricultural industry and petroleum industry. Consumption of High-Speed Diesel in the agriculture sector and Foodgrain Production are taken as measures to gauge agriculture industry and variables, namely Imports of High-Speed Diesel, Exports of High-Speed Diesel and Production of High-Speed Diesel are taken as a measure to gauge the petroleum industry.
2) To analyze the relationship for two sets of variables: I- between Prices of urea and Prices of petrol; II- between Sale of farm machinery and Prices of diesel.
3) To identify the measures for ensuring sustainability in agriculture sector.
4) To conduct a primary research for ascertaining the impact of petroleum industry on the agriculture sector of India.

Materials and Methodology

Data and methodology corresponding to objective 1:

Variables: Consumption of High-Speed Diesel (HSD) in the agriculture sector in India (Thousand Metric Tonnes-TMT) is taken as dependent variable. Production of High-Speed Diesel (Thousand Metric Tonnes), Exports of High-Speed Diesel (Thousand Metric Tonnes), Imports of High-Speed Diesel

(Thousand Metric Tonnes) and Foodgrain Production (Million Tonnes) are employed as independent variables.

Time period: The period covered is 10 years, from F.Y. 2010-11 to F.Y. 2019-20. The data frequency is annual and is according to the availability of data from different government sources.

Sources of Data: For data collection, the official websites of Petroleum Planning and Analysis Cell (PPAC), Agricultural Statistics at a glance and Indian Petroleum & Natural Gas Statistics (IPNG) are used.

Software: Microsoft Excel (MS office version 2019), has been used to carry out statistical techniques-multiple linear regression and for forecasting the consumption of HSD.

Methodology: Multiple Linear Regression, a parametric test, is employed to study the relationship between one dependent variable and multiple independent variables. It is a statistical test that uses several explanatory variables (independent variable) to predict the outcome of a response variable (dependent variable). Multiple Linear Regression analysis is conducted using Ordinary Least Squares (OLS) to estimate the consumption of High Speed Diesel in agriculture sector on an annual basis by regressing it on independent variables namely Production of HSD, Exports of HSD, Imports of HSD, and Foodgrain Production. The statistical significance of the parameters is tested at 5% level of significance (two-tailed basis).

Equation 1: Multiple regression equation

$$Y_t = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e_t$$

where,

U_t is Consumption of High-Speed Diesel (in TMT) in period t.

β_0 is the intercept.

β_1, β_2, β_3 and β_4 are the sensitivity coefficients.

X_1 is the Production of HSD (in TMT)

X_2 is the Exports of HSD (in TMT)

X_3 is the Imports of HSD (in TMT)

X_4 is the Foodgrain Production (in Million Tonnes)

e_t is the error term.

We applied the Forecast.ets function to forecast the values of independent factors in Microsoft Excel 2019 to estimate the values for the next five years starting from F.Y. 2020-21 to F.Y. 2024-25. The projections are based on an annual data collection. These values are placed into equation 1 to obtain the estimated value of the dependent variable for the period F.Y. 2020-21 to F.Y. 2024-25.

RESEARCH HYPOTHESIS

A. Null hypothesis: Production of HSD has no significant impact on Consumption of HSD in agriculture sector.

Alternative hypothesis: Production of HSD has significant impact on Consumption of HSD in agriculture sector.

B. Null hypothesis: Imports of HSD have no significant impact on Consumption of HSD in agriculture sector.

Alternative hypothesis: Imports of HSD have significant impact on Consumption of HSD in agriculture sector.

C. Null hypothesis: Exports of HSD have no significant impact on Consumption of HSD in agriculture sector.

Alternative hypothesis: Exports of HSD have significant impact on Consumption of HSD in agriculture sector.

D. Null hypothesis: Foodgrain production of HSD has no significant impact on Consumption of HSD in agriculture sector.

Alternative hypothesis: Foodgrain production of HSD has significant impact on Consumption of HSD in agriculture sector.

Data and methodology corresponding to objective 2:

Variables: Prices of petrol, Prices of urea, Sale of farm machinery and Prices of diesel.

Time Period: Monthly data from April 2018 to March 2021. The choice of the period is attributed to the availability of the data.

Software: Statistical Package for Social Sciences (IBM SPSS Statistics) version 1.0.0.1406 software is employed to perform Karl Pearson's Correlation technique and to test whether the correlation is significant or not.

Sources of Data: Databases of Ministry of Chemicals and Fertilizers (Department of Fertilizers, Government of India: Monthly Bulletin); Tractor & Mechanization Association and Petroleum Planning & Analysis Cell (PPAC) are used to collect data for the variables Prices of petrol, Prices of urea, Sale of farm machinery and Prices of diesel respectively.

Methodology: Karl Pearson's correlation coefficient is employed to estimate the relation for two sets of variables: I -between Prices of petrol (in Rupee litre^{-1}) and Prices of urea (in Rupees Metric tone^{-1}); II – between Sale of farm machinery (No. of tractors) and Prices of diesel (in Rupees litre^{-1}). The significance of the variables is tested at 5%level of significance.

Equation 2: Karl Pearson's Correlation coefficient

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where:

r_{xy} – Karl Pearson's linear correlation coefficient

x_i – variable 1

$\bar{x}$ – mean of variable 1

y_i – variable 2

$\bar{y}$ – mean of variable 2

Data and methodology corresponding to objective 3:

Variables: A case study of two tractors manufactured by Sonalika International Tractors Ltd.

Sources of data: The official website of Petroleum Planning and Analysis Cell (PPAC) has been used for the data of average diesel price for F.Y. 2019-20. The official website of Delhi Electricity Regulatory Commission is used to collect the electricity cost per unit (in INR) for the agriculture sector. The data related to the daily wage rate of labour is collected from the Government of the National Capital Territory of Delhi (Labour Department). Data on carbon emissions from tractors has been procured from Intergovernmental Panel On Climate Change (IPCC 2006) guidelines. The official websites of Sonalika International Tractors Ltd. (https://www.sonalika.com/) and News18 (https://www.news18.com/amp/) have been used to gather details regarding tractors.

Time Period: F.Y. 2019-20.

Methodology: A case study approach is adopted to compare the costs of two tractors manufactured by Sonalika International Tractors Ltd. (henceforth, Sonalika tractors) to examine the net benefit of hybrid technology. Tractor 1 is Sonalika RX 47 Sikander (Type: Diesel-based) and Tractor 2 is Solis Hybrid 5015 (Type: Hybrid, Diesel and Electricity based). Both tractors are of 50 Horse Power. The cost of tractors has been estimated by adopting the standard IS 9164-1979 entitled 'Guide for estimating cost of farm machinery operation [FAD 21: Farm Implements and Machinery]'.

Computation is made in accordance with standard IS 9164-1979 and IPCC 2006 guidelines.

Salvage value	$\frac{\text{purchase price of the machine} \times 5}{100}$
Depreciation	$\frac{\text{purchase price of the machine} - \text{salvage value}}{\text{useful life of the machine (in years)}}$
Average purchase price	$\frac{\text{purchase price of the machine} + \text{salvage value of the machine}}{2}$
Interests	$\frac{\text{average purchase price} \times 1.2}{100}$
Insurance	$\frac{\text{average purchase price} \times 2}{100}$
Housing	$\frac{\text{average purchase price} \times 1.5}{100}$
Repair and Maintenance	purchase price ×percentage of accumulated repair cost
Fuel Cost	0.15× Price of diesel per litre × Power take off HorsePower × Number of hours for which tractor is used
Lubricant Cost	$\frac{\text{fuel cost} \times 2.5}{100}$
Labour cost	Labour rate per day × 1.1 × Number of hours for which tractor is used
Electricity	Battery capacity × Electricity Rate in agricultural sector × Battery charging hours in a year
Carbon dioxide emission	Fuel consumed in litre × emission factor of carbon dioxide

Data and methodology corresponding to objective 4:

Sources of Data: Primary source has been used for the purposes of data collection. Farmers Respondents are farmers located in state of Punjab, mainly producing wheat and cotton.

Sample Size: The sample size is 20 farmers.

Methodology: A telephonic interview was conducted (refer Annexure for questions). Descriptive analysis- a qualitative approach was employed to a set of opinions gathered from the farmers. Farmers responded through their expertise and knowledge in agriculture sector. These

responses were examined to infer meaning from farmers' opinions by summarizing them constructively and identifying common patterns in their responses.

Results and Discussion

Findings corresponding to objective 1:

Table 1 provides the descriptive statistics of the variables used in the study. The variables used are Consumption of High-Speed Diesel (HSD) in the agriculture sector, Production of HSD, Exports of HSD, Imports of HSD and Foodgrain Production.

Table 1 : Descriptive statistics for the period April 2010-March 2020

	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation
Consumption of HSD in Agriculture Sector (in thousand metric tonnes)	603.03	683.59	429.24	66.87	0.11
Production of HSD (in thousand metric tonnes)	97024.90	111120.00	77685.00	11340.04	0.12
Exports of HSD (in thousand metric tonnes)	25577.60	31653.00	20335.00	3788.70	0.15
Imports of HSD (in thousand metric tonnes)	968.10	2796.00	77.00	885.61	0.91
Foodgrain Production (in million tonnes)	267.15	296.65	244.49	17.41	0.06

It has been observed that the average consumption of HSD in the agricultural sector during the 10 years period is 603.03 TMT. During the year 2011-12 consumption of HSD reached the highest level and during 2013-14 it touched its minimum. With respect to Production of HSD in India, it is observed that highest production is in the year 2019-20. Imports of HSD have shown an increasing trend, the lowest value was observed in the year 2013-14 compared to the maximum value of imports in the year 2019-20. The descriptive statistics of the variable Foodgrain Production do not show much variation during the

study period with maximum value in 2019-20 and minimum value in 2010-11. The Foodgrain Production has a standard deviation of 17.41. On comparing the coefficient of variation for all variables, it is observed that the variable Foodgrain Production is the most consistent variable as it shows the least variation (0.06) in data.

Table 2 reports R square, Adjusted R square, F statistic, F significance, intercept term (β0) and the coefficients $\beta_1,\beta_2,\beta_3,\beta_4$ of variables namely Production of HSD (X_1), Exports of HSD (X_2), Imports of HSD (X^3) and Foodgrain production (X_4) respectively.

Table 2 : Multiple Linear Regression Analysis

Model Summary	R square	Adjusted R Square	F statistic	F significance
	0.79	0.62	4.80	0.05

$Y_t = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e_t$

	Intercept (β_0)	β_1	β_2	β_3	β_4
Coefficient	436.91	0.01	0.04	0.05	-0.23
P-value	0.24	0.02	0.01	0.04	0.91

The multiple regression for the sample period of 10 years is estimated. The F statistic is 4.80 with the significance F=0.05. This suggests that F statistic is statistically significant at 5% level of significance reflecting the overall efficacy of the model. The value of Adjusted R Square is found to be 0.62. It means that the independent variables account for and explain 62% variance in the dependent variable.

The slope coefficient β_1 associated with production of HSD is 0.01 and P-value is 0.02. We do not accept the null hypothesis at 5% level of significance. The β_1 coefficient is found to be statistically significant at 5% level of significance suggesting that the consumption of HSD in the agriculture sector in India is driven by the production of HSD in India. Every 1-unit increase in production of HSD is attended by 0.01 units increase in the consumption of HSD in the agriculture sector.

The coefficient of exports of HSD (β_2 measure) is -0.04 and P-value is 0.01. Therefore, the alternative hypothesis is accepted. The β_2 coefficient is found to be statistically significant at 5% level of significance. It can be seen that the coefficient of exports of HSD is statistically significant and exhibits a negative sign which is consistent with the proposition that "India's economic growth in recent years has been 'too much driven' by domestic demand and its exports were about one-third of its potential".[21] The World bank official has said that "the focus of the next government should be on reducing the stimulus of domestic demand". [21] The government should take initiatives to shift the country's growth away from domestic demand and towards exports, because "that's where productivity increases when a country competes in the international market, gaining knowledge by interacting with competitors and with customers abroad".[21] Such initiatives by the government to boost exports may result in decreased consumption of HSD in domestic agricultural sector. More so, exporting HSD to neighboring countries such as Singapore, Malaysia, United Arab Emirates (UAE) at a competitive price is adding to the

government's initiatives for increasing exports. With such increased exports, domestic consumption of HSD may witness a decline.

The β_3 coefficient associated with imports of HSD is found to be statistically significant at 5% level of significance. The measure of β_3 is 0.05 and P-value is 0.04. Thus, we accept the alternative hypothesis. Rate of change in consumption of HSD with respect to imports of HSD is 0.05 units showing a positive impact on the dependent variable. β_3 is greater than β_1 indicating that the dependent variable is influenced more by imports of HSD than production of HSD, which can be explained because of limited oil reserves in India and India's inclination towards expansion of exports.

The β_4 coefficient of the variable Foodgrain production is -0.23 and P-value is 0.91. The beta coefficient is found to be statistically insignificant at 5% level of significance. Here, we accept the null hypothesis that foodgrain production does not have any impact on consumption of HSD in the agriculture sector in India. The coefficient is statistically insignificant and shows a negative sign. The negative sign reflects that with increase in foodgrain production, the consumption of HSD declines. This negative relationship may be attributed to more reliance on labour intensive techniques of farming than capital intensive techniques. More so, the farm machinery such as power tillers, irrigation pumps employed in production of foodgrain utilizes light diesel oil instead of high speed diesel(HSD).

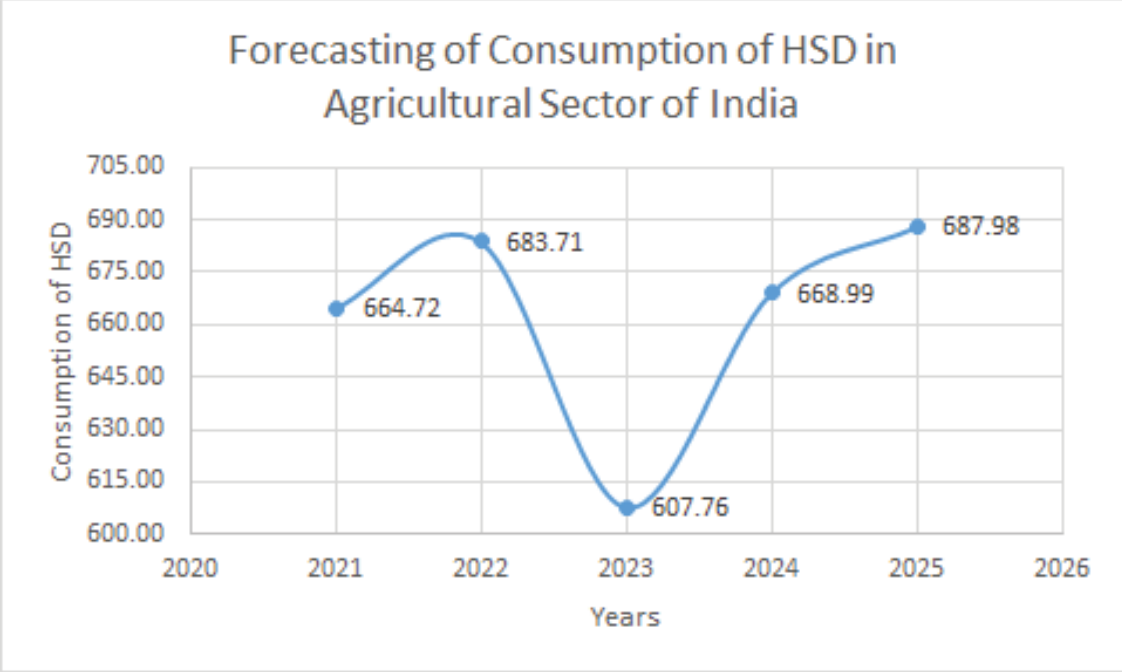

Figure 1: Forecasting of consumption of HSD in agriculture sector in India for the period of 5 years (F.Y. 2020-21 to F.Y. 2024-25).

The above line graph forecasts the consumption of HSD in the coming years considering the change in the independent variables. F.Y. 2022-23 would witness a drop of 75.95 TMT from 683.71 TMT to 607.76 TMT. The corresponding percentage decline would be 11.10%. On the other hand, the maximum rise in the consumption of HSD is expected in the F.Y. 2023-24 of 61.23 TMT where the consumption will grow from 607.76 TMT to 668.99 TMT. The corresponding percentage increase would be 9.15%. The average upward trend for the next 5 years in consumption is ascertained to be 3.49%. Accordingly, the overall increase is expected in the consumption of HSD over the next 5 years.

Findings corresponding to objective 2:

Table 4 throws light on the descriptive statistics used in the objective 2 of the study. The variables are Prices of petrol, Prices of urea, Sale of farm machinery and Prices of diesel for 3 years.

Table 4 : Descriptive statistics for the period April 2018- March 2021

	Mean	Maximum	Minimum	Standard Deviation
Price of Petrol (in Rupees Litre^{-1})	76.30	91.06	69.59	5.47
Price of Urea (in Rupees MT^{-1})	19846.43	27372.68	16199.73	2294.79
Sale of Farm Machinery (No. of Tractors)	66234.72	115155.00	11827.00	23418.80
Price of Diesel (in Rupees Litre^{-1})	69.18	81.36	62.29	4.91

The above table elucidates the mean, maximum value, minimum value and standard deviation of the variables used in the study. With respect to Prices of petrol, the minimum rate was observed in April 2020 and the maximum rate was observed in March 2021. An upward trend can be seen in the Prices of urea with a minimum value in May 2018 and a maximum in March 2021. The descriptive statistics of the variable Sale of Farm Machinery (No. of tractors) has a standard deviation of 23418.80. From April 2018 to March 2021, whereas the Prices of diesel have reached the highest in March, 2021 and lowest in April, 2020.

Table 5 exhibits correlation between Prices of petrol and Prices of urea.

Table 5 : Karl Pearson's Correlation Coefficient between Prices of petrol and Prices of urea

		Price of Petrol	Price of Urea
Price of Petrol	Pearson Correlation	1	0.652**
	Significance (2-tailed)		0.000
	N	36	36
Price of Urea	Pearson Correlation	0.652**	1
	Significance (2-tailed)	0.000	
	N	36	36

** Correlation is significant at the 0.05 level (2-tailed).

According to the above correlation, there is a positive relationship between the Prices of petrol and Prices of urea. This means if the price of petrol rises, so does the cost of producing urea, because petrol is required to produce ammonia which is further used to produce urea. Thus, an increase in the price of petrol is accompanied by an increase in price of urea and vice-versa.

Table 6 exhibits correlation between Sale of Farm machinery and Prices of diesel.

Table 6 : Karl Pearson's Correlation Coefficient between Sale of farm machinery and Prices of diesel

		Sale of Farm Machinery	Price of Diesel
Sale of Farm Machinery	Pearson Correlation	1	0.500**
	Significance (2-tailed)		0.002
	N	36	36
Price of Diesel	Pearson Correlation	0.500**	1
	Significance (2-tailed)	0.002	
	N	36	36

** Correlation is significant at the 0.05 level (2-tailed).

The correlation coefficient between Sale of farm machinery and Prices of diesel is 0.50 depicting a positive relationship between the said variables. This suggests that an increase or decrease in the sale of farm machinery will impact an increase or decrease in the price of diesel and vice-versa. An increase in the consumption of foodgrains in the economy necessitates the use of fuel for harvesting, cultivating and transporting which may trigger an increase in the sale of farm machinery and demand led increase in the prices of diesel.

Findings corresponding to objective 3:

Table 7 provides a Comparative Cost Analysis of Diesel-based tractor and Hybrid type tractor.

Table 7 : Comparative Cost Analysis of Diesel Tractor and Hybrid Tractor

Name	Sonalika RX 47 Sikander	Solis Hybrid 5015 tractor
Type	Diesel engine	Hybrid engine(diesel and electricity)
Total fixed Cost(A)	Rs.112527.25	Rs.127166.37
Total Variable Cost(B)	Rs.448000.49	Rs.418526.13
Total Cost(A+B)*	Rs.560527.74	Rs.545692.50

Net benefit	-	**Rs.14835.24**
Carbon dioxide emitted (in Kg)	16388.46	14297.85
Net benefit	-	**2090.61 Kg**

*Computation of total cost is given in Table 8.

Assumptions for computation of total cost:

1. It is assumed that tractors are newly purchased and are used for only 1 year. Thus, the cost computation is limited to the first year usage of the tractors.
2. The capacity of the battery for Sonalika Solis hybrid 5015 is 25.5KWh.
3. The amount of electricity used is 540 hours (3 hours charging time*15 days per month charge*12 months).
4. Analysis is based on annual figures.

Table 8 presents Fixed and Variable Costs of Diesel and Hybrid tractor.

Table 8 : Computation of Total Cost of Diesel and Hybrid Tractor

Name	Sonalika RX 47 Sikander	Solis Hybrid 5015 tractor
Type	Diesel Engine	Hybrid engine(diesel and electricity)
HorsePower	50 HP	50 HP
Salvage value	31900.00	36050.00
Depreciation	60610.00	68495.00
Interests	40194.00	45423.00
Insurance	6699.00	7570.50.00
Housing	5024.25	5677.87
Total Fixed Cost(A)	Rs.112527.25	Rs.127166.37
Repair and Maintenance	20416.00	23072.00
Fuel Cost	403696.26	352198.35

Lubricant Cost	10092.40	8804.95
Labour cost	13795.83	13795.83
Electricity	0.00	20655.00
Total Variable Cost(B)	Rs.448000.49	Rs.418526.13
Total Cost(A+B)	Rs.560527.74	Rs.545692.50

Source: Computation as per IS 9164-1979. The table is self-constructed.

Table 7 exhibits that the total cost of Solis Hybrid 5015 tractor is less than Sonalika RX 47 Sikander. Although a hybrid tractor has a high purchase price, yet this is the tractor that will benefit farmers in the long run. The fixed cost in the first year for diesel tractor is Rs.112527.25 and for hybrid tractor is Rs.127166.37. The variable cost in the first year for diesel tractor is Rs. 448000.49 and for hybrid tractor is Rs.418526.13. It demonstrates that using hybrid tractors in farming will reduce farmers' total cost by Rs.14835.24 in the first year of its purchase. Additionally, a hybrid tractor will emit 2090.61 Kg less carbon dioxide in a year than a diesel tractor. It is concluded that hybrid tractor is pocket-friendly for the farmer's as shown by its lower variable cost as well as environment-friendly since it is fuel-efficient and emits lower carbon dioxide. Thus, the study proposes hybrid tractors as a sustainable solution for agriculture industry.

Findings corresponding to objective 4:

The findings pertaining to primary research are given below:

With respect to the question on impact of change in foodgrain production on consumption of diesel in the agriculture sector, all farmers stated that change in the production of foodgrain does not result in change in consumption of diesel. The empirical results of our study using secondary data also show that foodgrain production does not have any impact on consumption of HSD in agriculture sector in India since the coefficient is found statistically insignificant.

According to all the farmers, the fluctuations in price of petroleum products, particularly diesel, have no impact on the quantity of foodgrain production. However, they stated, the cost of production of foodgrain changes with change in prices of diesel but there is marginal or no change in the selling price of foodgrains.

Majority of the farmers (90% of the sample), make use of diesel operated machinery in production process. These machineries consist of both high-speed diesel and light diesel oil based equipment. Even though these machines are fuel based, sometimes manual labour is required for their proper functioning.

70% of the farmers considered for the study were aware about the usage of petrol in the production of urea fertilizer. However, all the farmers were indifferent towards the positive correlation between prices of petrol and prices of urea fertilizer.

Interestingly, all the farmers knew that government provides subsidies on fertilizers but they were not aware of the amount of benefit received in the form of subsidy.

When asked about acquiring the tractors, 13 out of

20 farmers prefer purchasing the tractor rather than hiring it, as they were of the opinion that no proper hiring services are being provided to them. They further opined that there are government-run societies established for helping small and marginal farmers but either the quality of tractors provided is not suitable or services are not available when required.

Additionally, 70% of the farmers were familiar with the presence of newly launched electric tractor in the market and none of them had information about news of launch of hybrid tractor. Although, they are affirmative with environmental and economic benefits that the electric or hybrid tractor provides, yet they are looking forward to the research analysis providing detailed information about effective utilization of electric and hybrid tractor.

With respect to the question on preference and purchase of electric or hybrid tractor over diesel-based tractor given that the former is associated with higher purchase price and lower variable cost, 65% of the farmers expressed preference for the purchase of electric and hybrid tractor. They gave importance to technological advancement, provided they are well informed about its operations. On the other hand, the remaining 35% of the farmers were of the opinion that it is expensive and were apprehensive that it would not function like a diesel-based tractor.

According to the farmers, there is no subsidy or relief provided by the government of state of Punjab on purchase of fuel or purchase of tractors. However, 9 out of 20 farmers mentioned that they receive subsidies from the government on purchase of small farm implements such as cultivators, rotavators, disc harrows etc.

Suggestions by farmers to promote sustainability in the agriculture sector in India are that the government should encourage the agricultural sector towards organic farming as it will increase the quality of the products. Another important suggestion by one of the farmers is that all facilities provided for free to the farmers such as free or subsidized electricity or food should be continuously assessed, as it reduces their work efficiency. In addition, one farmer also proposed hydrogen-based tractors over diesel-based tractors.

CONCLUSION

The current study establishes a relationship between petroleum industry and agricultural industry. The results based on secondary data analysis make it evident that the consumption of petroleum products is considerably impacted by agriculture industry. The results of our study are in alignment with that of Anand, M. K. 2014., Akpaeti, A. 2018.and Taghizadeh-Hesary, F., Rasoulinezhad, E., and Yoshino, N. 2019. In particular, the study establishes a significant relationship between consumption of HSD in the agriculture sector in India and production of HSD, imports of HSD, exports of HSD. The study adequately comprehends the importance of optimizing consumption pattern of petroleum products in agriculture sector and emphasizes on adoption of a sustainable solution.

Furthermore, the study estimates the correlation between variables of petroleum industry and variables of agricultural industry. The variables namely prices of petrol and prices of urea are found to be positively correlated. Ammonia, a petroleum product, is used in preparation of urea. Accordingly, price of petrol will have an indirect relationship with price of urea and the secondary results show that these prices move in the same direction. The second set of variables namely sale of farm machinery and prices of diesel also show a positive correlation suggesting that the two series move in tandem.

The information collected on ground-level (primary research) justifies the results shown by our secondary research. Our secondary results reveal for example, the variable foodgrain production has no significant impact on the consumption of HSD in the agriculture sector and the same answer was observed during the primary research while

interacting with the farmers. Also, the secondary results of our study show that Sale of farm machinery and Prices of diesel are positively correlated which is consistent with our primary research. Farmers confirmed that farm machinery is directly linked with foodgrain production. Further, quantity of food grain production is determined by exogenous factors and it is not affected by diesel price fluctuations. Farmer's preference for purchasing tractors rather than hiring them leads to increase in demand and, therefore, sale of farm machinery resulting in increased consumption of diesel and further increase in prices of diesel.

The study suggests a sustainable solution after reviewing various alternatives available such as Biodiesel, Biofuel and Hybrid tractor. It is concluded that adopting hybrid tractor as a sustainable solution outweighs the other two substitutes. Results from secondary research demonstrate that use of hybrid tractor over a diesel-based tractor would reduce the variable cost as well as would emit lower carbon dioxide. Use of hybrid tractor would be economically beneficial to the farmers at micro level and environmentally beneficial for the country at macro level.

In a nutshell, it can be concluded that neither petroleum industry nor agricultural industry can be studied in isolation. Sustainability in agricultural sector and its effective management can be attained only by the synergy effect of these two industries.

POLICY IMPLICATIONS:

Utilization of Agriculture Infrastructure and Development Cess (AIDC), which was introduced in the budget of 2020-21 by the policy makers to promote hybrid technology amongst the farmers. The earmarked cess is expected to have a significant impact on agricultural infrastructure and development.

1. Use of Cess for Initiating awareness campaigns for the farmers to provide them practical knowledge about the Hybrid tractors that will limit the dependence on Imports of HSD by balancing out the Consumption of HSD in agriculture sector.

2. Use of Cess on providing farm implements at a subsidized rate. This subsidy can be provided by digital transfer of said amount to the farmers as a tradeoff. This will promote equal distribution of government funds among the farmers.

3. Use of hybrid tractor be promoted since it has benefits for the environment as it emits lower carbon dioxide and also it is pocket-friendly for the farmers as it reduces the variable cost.

4. Enabling charging stations at various locations in the state for facilitating the use of hybrid tractors by farmers.

5. Promotion of small entrepreneurs working towards research and development in agriculture sector by providing resources and funding to them.

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ANNEXURE:

List of Questions:

1. What is the impact of change in foodgrain production on consumption of diesel in the agriculture sector?
2. How does the change in price of diesel affect the foodgrain production?
3. What type of equipment or machinery is used in the production process?
4. Do you know that petrol is used in the

production of Urea fertilizer?
5. Do you get any subsidies or benefits on purchasing Urea fertilizer?
6. What do you prefer hiring a tractor or purchasing a tractor?
7. Do you know about the availability of Electric Tractor and Hybrid Tractor in the market?
8. Do you think Electric Tractor and Hybrid Tractor will be beneficial?
9. Would you prefer and purchase an Electric or Hybrid Tractor to a Diesel-based tractor given that the former tractor is associated with a higher purchase price and a lower variable cost?
10. Do you get any subsidies or relief on purchasing fuel and tractors?
11. Give suggestions to promote sustainability in the agriculture sector of India.

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